Proceedings of 79th Cumberland-Shenandoah Fruit Workers Conference

November 20 & 21, 2003
Winchester, Virginia

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Cumberland-Shenandoah Fruit Workers Conference
Minutes of the Business Meeting
Winchester, Virginia
Friday November 21, 2003

The Annual Business Meeting was called to order at 8:00 am by Chris Walsh of the University of Maryland, who was serving as General Secretary for 2003.

Chris commented on the excellent quality of the presentations for the meeting and thanked participants for their well-prepared presentations, and efforts to make the meeting run smoothly. He also thanked a number of people who have helped him organize the meeting, including Session Moderators, former Secretaries Peter Shearer and Chris Bergh as well as the CSFWC Treasurer Steve Miller.

Don Ganske of DuPont, and Rick Schmenk of Sygenta Crop Protection were also recognized for their continued support of the Thursday night mixer. This industry-supported evening has proved to be a very popular event with CSFWC participants.

Dr. Walsh also mentioned that the Winchester Holiday Inn staff had been quite helpful in organizing the 2003 meeting, and that the Inn is also willing to host this meeting in 2004.

Attendees mentioned that the 'Call for States' had been omitted from the opening program on Thursday morning. Dr. Walsh apologized for that unfortunate oversight. He suggested that participants should submit their State Reports, and that the reports would be included in the Proceedings.

Participants were asked to leave a copy of all presented papers at the close of the meeting. A December 12 deadline for papers to be included was proposed for inclusion in the *Proceedings*. Some discussion took place on that deadline, with many in the audience suggesting that additional time be given to participants. A motion was made by Henry Hogmire and seconded by a number of participants to change the final date to December 31. The motion was approved on a voice vote.

Treasurer's Report. Steve Miller then presented the Treasurer's Report. Total expenses for last year's meeting were $3256.59 leaving a balance in the CSFWC account of $1539.12. As of the end of Thursday afternoon, Steve reported that 50 participants had registered, at $50 per person. Income for the 2004 meeting stood at $2,500, increasing the checking account balance to $4,039.12. Steve also presented information outlining costs and registrations for the past five meetings.

	Registrations	Facilities and Food	Proceedings	Total Cost
1997	69	$1617.15	$946.58	$2563.73
1998	58	1624.40	867.55	2491.95
1999	73	1916.78	888.77	2805.55
2000	67	2134.64	1461.67	3596.31
2001	86	2453.93	1481.17	3935.10
2002	71	2055.61	999.60	3055.21

With a paid registration of only 50 as of 4 pm on Thursday, attendance for 2004 will probably be less than 2002, when 71 people registered for the CSFWC meeting. Attendance was particularly sparse this year in the Horticulture Section, where there were not enough papers for a concurrent session on Friday morning. Steve Miller suggested that we each encourage our colleagues to attend in the future.

Future Meetings. North Carolina is slated to be the host state for the CSFWC in 2004. Next year's meeting dates and the names of the organizers were then discussed. Jim Walgenbach from North Carolina State University indicated that he would serve as General Secretary, and be able to name moderators to run the concurrent sessions. Steve Miller is to continue as CSFWC Treasurer. A motion to this effect was made and approved by the participants.

The following lists the projected hosts for future CSFWC meetings.

2004-North Carolina	2005-USDA
2006-Pennsylvania	2007-West Virginia
2008-NJ and SC	2009-Virginia

Chris noted that New York was particularly well-represented in 2003, and was pleased that Cornell faculty was willing to make such a long trip to participate. Art Agnello indicated that New York would continue to support the CSFWC, and encouraged the group to continue its program. RAMP will continue to meet in conjunction with CSFWC. This appears to increase attendance, especially in entomologists.

Some discussion took place about trying to get more small fruit specialists to participate. It was suggested that the General Session include topics of interest to a wider range of fruit workers.

Planning the 2004 meeting dates was the final order of business. It was noted that there would be conflicts with other programs if CSFWC were held on its traditional time, the Thursday and Friday before Thanksgiving. The dates of December 2 and 3 was suggested by Larry Hull and approved. Chris agreed to communicate this information to Jim Walgenbach, and to meet with Jane Obst of the Winchester Holiday Inn to reserve the rooms needed for the 2004 meeting.

Chris asked for any new items of business, and not hearing any then closed the meeting at 9 am.

Minutes submitted by Richard Heflebower, Utah State University

Financial Report

2002/2003 Cumberland-Shenandoah Fruit Workers Conference

Balance Preceding the 2002 Meeting (Dec. 4) -	**$1,008.26**
<u>Income</u> (2002/2003) –	
Receipts from registration (74)	3,700.00
Interest on Account, Dec 2002	0.33
Sale of Proceedings (2002)	40.00
Total Assets (12/5/02)	**$4,748.59**
<u>Expenses</u> (2002-2003)–	
Room rental and luncheon for 2002 meeting, Jimmy's Holiday Inn	$2,055.61
Registration refunds (overpayments)	100.00
Proceedings, 2002 (copy, bind, etc.)	896.00
Laminate covers	103.60
Postage and meeting costs	101.38
Total Expenses (2002-'03)	**$3,256.59**
<u>Additional Income</u> (2003)	
Sale of 2002 Proceedings	45.00
Interest on Account	2.12
Balance as of 11/14/03	**$1,539.12**
Paid Registrations, '03 (50)	**$2,500.00**
Balance as of 11/21/03	**$4,039.12**

List of Participants

First Name	Last Name	Organization Name
ARTHUR	AGNELLO	NYS AG EXP STATION
ROBB	ALLEMAN	USDA-ARS-AFRS
RICHARD	BELL	USDA-ARS-AFRS
CHRIS	BERGH	VA TECH AHS-AREC
ANGELA	BERRY	USDA-ARS-AFRS
DAVID	BIDDINGER	PENN STATE – FREC
DEBORAH	BRETH	CORNELL CES
MARK	BROWN	USDA-ARS-AFRS
RICHARD	COLBURN	BIGLERVILLE PA
LARRY	CRIM	USDA-ARS-AFRS
PAUL	DAVID	GOWAN COMPANY
ANNE	DEMARSAY	RUTGERS - MARUCCI CENTER
JEAN	ENGELMAN	VA TECH AHS-AREC
MARY ANN	ERICKSON	CERTIS COMPANY
KATHLEEN	FOSTER	RUTGERS AREC
DONALD	GANSKE	DUPONT
PATRICIA	GUNDRUN	USDA-ARS-AFRS
LARRY	GUT	MICHIGAN STATE
BILL	HANLIN	NC STATE – CES
RICK	HEFLEBOWER	UTAH STATE U – CES
HENRY	HOGMIRE	WVU
JEFF	HUETHA	CEVEXAGRI INC
LARRY	HULL	PENN STATE - FREC
BOB	IENAGA	CBC AMERICA
PETER	JENTSCH	CORNELL HUDSON VALLEY LAB
GREG	KRAWCZYK	PENN STATE
MICHAEL	LACHANCE	VA CES
NORMAN	LALANCETTE	RUTGERS AREC
KATHLEEN	LEAHY	UNIV OF MASS
TRACY	LESKEY	USDA-ARS-AFRS
SHU-FEI	LIN	UNIV OF MD
GAIL	LOKAJ	RUTGERS AREC
KENNER	LOVE	VA CES
MATT	MAHONEY	BAYER CROPSCIENCE
CLARISSA	MATHEWS	USDA-ARS-AFRS
PETER	MCGHEE	MICHIGAN STATE
STEPHEN	MILLER	USDA-ARS-AFRS
CLAYTON	MYERS	PENN STATE
MIKE	NEWELL	UNIV OF MD WREC
ANDREA	OTTESEN	UNIV OF MD
DOUG	PFEIFFER	VA TECH
HARVEY	REISSIG	NY STATE - AES
DAVID	ROSENBERGER	CORNELL HUDSON VALLEY LAB
BOB	ROUSE	UNIV OF MD
ANN	RUCKER	RUTGERS AREC

List of Participants

First Name	Last Name	Organization Name
RICK	SCHMENK	SYGENTA
GUIDO	SCHNABEL	CLEMSON
PETER	SHEARER	RUTGERS AREC
GREG	STAMM	CBC AMERICA
GREG	STAMM	CBC AMERICA
DICK	STRAUB	CORNELL HUDSON VALLEY LAB
HARRY	SWARTZ	UNIV OF MD
DARIUSZ	SWIETLIK	USDA-ARS-AFRS
GAR	THOMAS	BASF
THOMAS	TWORKOSKI	USDA-ARS-AFRS
RAUL	VILLANUEVA	NC STATE
JIM	WALGENBACH	NC STATE
CHRIS	WALSH	UNIV OF MD
STARKER	WRIGHT	USDA-ARS-AFRS
KEITH	YODER	VA TECH AREC

Cumberland Shenandoah Fruit Workers Conference
November 20-21, 2003
Winchester, Virginia

Thursday Morning, November 20

8:00 am Registration

9:00 am General Session I. Globalization of Research and Education Programs
Chris Walsh, University of Maryland, Moderator

Five Aces Breeding Program
Harry J. Swartz, University of Maryland

Food Safety Training in Hispanoamerica
Chris Walsh, JIFSAN, University of Maryland

10:15 am Break

10:30 am General Session II. Integrated Orchard Management
Rick Heflebower, Utah State University, Moderator

Potato leafhoppers, fireblight and Apogee: A look at their interaction under field conditions
K.P. Leahy, D.W. Greene, W.R. Autio, J.L. Norelli and T.C. Leskey
University of Massachusetts, Amherst and USDA-AFRS

Presentation Title-TBA
Jan Nyrop, Alan Lakso and Kuo-Ton Li
Cornell University

Assessing individual components of a monitoring system for plum curculio
Tracy C. Leskey
USDA-ARS, Appalachian Fruit Research Station

Pheromone trapping of *Halyomorpha halys* (Hemiptera: Pentatomidae) in the Northeast
Peter W. Shearer, Rutgers AES, Bridgeton, New Jersey and
J.R. Aldrich, A. Khrimian, A. Rucker, and K. Bernhard

Stink bug preferences for apple cultivars and preliminary evidence for trap cropping for control
Mark W. Brown and Stephen S. Miller, USDA, ARS Appalachian Fruit Research Station

Evaluation of 1-MCP and new fungicides for controlling *Penicillium expansum* in stored apples
D.A. Rosenberger, F.W. Meyer and K. L. VanCamp

12 Noon Group Luncheon at the Holiday Inn

Cumberland Shenandoah Fruit Workers Conference
November 20-21, 2003
Winchester, Virginia

Thursday Afternoon, November 20

1:00 pm Plant Pathology Session
Andrea Ottesen, University of Maryland, Moderator

The canker in the bud: how *Colletotrichum acutatum* survives in dormant flower buds of highbush blueberry.
Anne DeMarsay and Peter V. Oudemans, Rutgers University

Results of apple fungicide trials in the Hudson Valley
D. A. Rosenberger, F.W. Meyer and K.L. VanCamp

Highlights of apple fungicide tests, 2003
K.S. Yoder, A.E. Cohcran II, W.S. Royston, Jr, and S.W. Kilmer
Virginia Tech AREC, Winchester, VA

2003 fungicide evaluations on peach and nectarine
K.S. Yoder, A.E. Cohcran II, W.S. Royston, Jr, and S.W. Kilmer
Virginia Tech AREC, Winchester, VA

Management of peach diseases using mixtures and combinationhs of DMI and Qol fungicides
N. Lalancette, K.A. Foster and K. Stoms
Rutgers University, Bridgeton AES

Influence of Fludioxonil rate and application volume on postharvest development of peach brown rot in a commercial setting
N. Lalancette and K.A. Foster
Rutgers University, Bridgeton AES

Fungicide efficacy trials for brown rot control and DMI fungicide resistance issues
Guido Schnabel and Phillip M. Brannen
Clemson University

Characterization of Armillaria root rot pathogens from South Carolina and elsewhere
Guido Schnabel and P. Karen Bryson
Clemson University

3:00 pm Break

3:30 pm Attend Entomology or Horticulture Concurrent Sessions

Cumberland Shenandoah Fruit Workers Conference
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Thursday Afternoon, November 20

3:30 pm Horticulture Session
Mike Newell, University of Maryland, Moderator

Blossom thinning of peach and apple trees with essential oils
Thomas Tworkoski and Stephen Miller
Appalachian Fruit Research Station, USDA-ARS

Strawberry trials at Wye. 2001, 2002 and 2003
Mike Newell, Wye Research and Education Center, AES

Long-term use of apogee for Nittany apple on M.9 rootstock – The first year
Stephen S. Miller, Appalachian Fruit Research Station, USDA-ARS

Peach tree production and culture as affected by growth habit, spacing and pruning
Stephen S. Miller and Ralph Scorza, Appalachian Fruit Research Station, USDA-ARS

5:00 pm Adjourn

5:30 pm CSFWC Social at the Holiday Inn
Kindly provided by Sygenta and DuPont

Cumberland Shenandoah Fruit Workers Conference
November 20-21, 2003
Winchester, Virginia

Thursday Afternoon, November 20

1:00 pm Entomology Session I
Bob Rouse, University of Maryland, Moderator

Response of tortricid moth species to high-dose pheromone dispensers
Larry Gut, Lukasz Stelinski and James Miller
Michigan State University

Mortality, survival and oviposition of Panonychus ulmi in response to reduced-risk insecticides
Raul T. Villanueva and J. F. Walgenbach

Medley of Rainy Day Bioassays
Jim Walgenbach, North Carolina State University

What's this hole in my apple ? Chemical efficacy against internal worms
David Combs and Harvey Reissig
NYSAES

A why, when and what approach to San Jose scale
David Combs and Harvey Reissig
NYSAES

Progress in management of internal lepidopteran pests of apple using reduced risk pesticides and pheromone disruption
Art Agnello, H. Reissig, J. Nyrop and R. Straub
NYSAES, Geneva, New York

NJ tree fruit entomology research results: 2003
Peter W. Shearer, Ann Rucker and Atanas Atanassov
Rutgers AREC

NJ peach RAMP results, year 2: 2003
Atanas Atanassov, Peter W. Shearer and Ann Rucker
Rutgers AREC

3:00 pm Break

3:30 pm Resume Entomology Session

Cumberland Shenandoah Fruit Workers Conference
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Thursday Afternoon, November 20

3:30 pm Entomology Session II
Peter Shearer, Rutgers University, Moderator

Mating disruption for internal feeders in apple – 2003
Douglas G. Pfeiffer, C. Laub and X. Zhang
VPI and SU

Parasitism of oriental fruit moth in Pennsylvania apple orchards and RAMP ecotoxicology
D.J. Biddinger, L.A. Hull and G. Krawczyk
Penn State University FREC, Biglerville

Seasonal changes in Oriental fruit moth oviposition behavior on peach and apple hosts
Clayton Myers and Larry Hull
Penn State University FREC, Biglerville

Efficacy of various mating disruption formulations and application methods for CM and OFM control
L.A. Hull and G. Krawczyk
Penn State University FREC, Biglerville

Larvicidal and ovicidal activity of selected insecticides against OFM and CM
Greg Krawczyk
Penn State University FREC, Biglerville

Management of leafhopper and aphid pests of apple using reduced rates of idimacloprid
R. W. Straub and J. Jentsch
Cornell University, Hudson Valley Lab

5:00 pm Adjourn

5:30 pm CSFWC Social at the Holiday Inn
Kindly provided by Sygenta and DuPont

Cumberland Shenandoah Fruit Workers Conference
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Friday Morning, November 20

8:00 am CSFWC Business Meeting
Chris Walsh, University of Maryland, Moderator

9:00 am Entomology Session III
Henry Hogmire, West Virginia University, Moderator

NY grower trials of internal Lepidoptera management programs
H. Reissig, A. Agnello, and J. Nyrop
NYSAES, Geneva, New York

Adult bioassays of susceptibility of OFM from problem commercial orchards to Guthion
H. Reissig and Cindy Smith
NYSAES, Geneva, New York

Extra-floral nectarines in insect-hostplant dynamics
C.R. Mathews and M.W. Brown
USDA-ARS Appalachian Fruit Research Station

Stink bug response to five trap types in apple and peach
Henry Hogmire, Tracy C.Leskey and Starker E. Wright
West Virginia University and USDA-ARS, AFRS

10:00 am Coffee Break

10:30 am Additional submissions in Horticulture, Entomology, and Plant Pathology

12 noon Adjourn

CUMBERLAND-SHENANDOAH FRUIT WORKERS CONFERENCE
Call of the States Report - New York 2003

Art Agnello, Dept. of Entomology, NYSAES - Geneva

Despite the fact that the rest of the growing season was rainy and cool, we actually enjoyed one of the most gradual and normal spring periods experienced in NY in many years. Rain was frequent, but the main problem was that there was never a transition into a true summer pattern. The rain actually helped to oppose many of the potential early season pests: **European red mite, spotted tentiform leafminer**, and **rosy apple aphid**, along with **pear psylla** and **oriental fruit moth**, were all denied favorable conditions for gaining an early season foothold that often preceeds a bad year, so most of these problems were sidestepped this spring, and in some cases for the rest of the year. On the other hand, we had another extended **plum curculio** oviposition period because of the cool temperatures, so growers who failed to keep the fruitl protected until about 2nd cover ended up with some damage that could have been prevented.

As it does most years, **obliquebanded leafroller** appeared pretty much on schedule, but generally responded well to treatment in orchards with reliably heavy populations. Larvae seemed to be about as evident in early July as in most typical seasons, but fruit damage turned out to be relatively lower than normal by most accounts. The internal worm (**codling moth and oriental fruit moth**) infestations of the last few years were puzzling by their scarcity. Certainly, most growers who had previously experienced problems were much more attentive to their mid- and late summer spray programs this year, but there's probably also a weather-related factor working in this "down" portion of the cycle, so there were much fewer complaints in this area by the time loads started reaching the packinghouse. Our research plots did end up showing somewhat of a late season increase in infestation levels, but most problem orchards were nowhere nearly as bad as in 2002.

Apple maggot was well represented in many of the usual high population sites where we trapped for it — high numbers were not uncommon, and some marginal infestations were found; however, there was not much evidence that the summer management programs weren't up to the task of dealing with them. One late season pest that we're still failing to protect against is **woolly apple aphid**. Colonies were troubling for much of the last half of the summer, and we don't really have many effective tactics to try against them. **Comstock mealybug, mirid bugs, stink bugs,** and **San Jose scale** were generally much lower than in the past.

Diseases were much more of a problem than arthropods, in general. **Apple scab** was extremely difficult to control, as the constant rainfall made adequate coverage and prevention a real challenge. Most growers ended up with some fruit scab in every block, although severity was highly variable.

Call of the States: New Jersey
2003 - CSFWC

Horticulture. The 2003 season began wet and cold with bloom thinning sprays timed for 80% full bloom at the center occurred on April 16th (Normal bloom timing). Thinning was not assisted by frost this year. However, the full crop sized well due to ample water supplied from the spring rains. Early season fruit were reduced in sugar content from both the cloudy weather and dilution of sugars by rain. Fruit varieties were delayed 7 to 14 days throughout the season. Gluts in the wholesale peach market made fruit movement sluggish and prices were low.

Cherries were light and cracked badly and then the brown rot came. Apple crop was good but rough finish and poor wholesale market was only fair except for Gala and nice Fuji. Lots of ugly, poor colored Fujis were observed. Juice and processor prices were the same as 1978 if you can find a market. Most that had retail markets did OK but some had a decline in fruit sales. *R. Belding* and *J. Frecon*

Entomology. NJ had an Experimental Use Permit (EUP) for Avaunt to control plum curculio in Peter Shearer's non-OP peach blocks. It worked quite well. Catfacing insects were not really a problem this year probably because the weeds stayed green from all the rain thus tarnished plant bugs and stink bugs stayed on the weeds and did not move to fruit. Green peach aphids were not a problem this year in nectarines/peaches. Despite the rain, most insects were not a problem in most orchards. European red mite resistance to pyramite was documented in a NJ apple block. The brown marmorated stink bug will become a serious pest as it spreads. It has been found in a couple new NJ locations. *P. Shearer*

Plant Pathology. Wet, humid weather throughout most of the growing season contributed greately to peach disease development. Although blossom blight in NJ never contributes to yield loss, higher levels of blight incidence this year resulted in greater numbers of cankers. These cankers, in conjunction with wet weather, increased the disease pressure for brown rot development during the final fruit ripening period. Nonsprayed trees had 100% crop loss at harvest. Nevertheless, application of DMI and QoI fungicides during bloom and prior to harvest provided good to excellent control.

The continually wet environment also resulted in the atypical preharvest appearance of Rhizopus rot and anthracnose. In some commercial peach blocks, greater than 90% of fruit exhibited anthracnose fruit rot. In contrast, the wet weather was not conducive to development of peach rusty spot. Highly susceptible cultivars that had 80% fruit infection on nonsprayed trees in 2002 suffered less than 10% rusty spot infection in 2003.

High winds from Hurricane Isabel caused lodging of young peach and apple orchards. Root damage from this "wind whipping" may result in Phytophthora root and crown rot development. So far this fall, no evidence of infection has been reported. *N. Lalancette*

WEST VIRGINIA STATE REPORT

Alan Biggs, Henry Hogmire, Steve Miller and Richard Zimmerman

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

Biofix of moth pests was later than in 2002 by 2 days for codling moth, and 6 days for both oriental fruit moth and tufted apple bud moth. Compared with last year, development of these pests as a function of degree days was about 8-10 days later through early July and 10-14 days later for the remainder of the season.

Rosy apple aphid was the most troublesome insect of the 2003 season, causing significant fruit injury in quite a few apple orchards. There are numerous factors that probably contributed to the increased incidence of this pest. The abundance of cool and rainy weather experienced this spring kept foliage very succulent for an extended time period, which is very favorable for aphids. These same conditions are less favorable for natural enemies, which can provide some biological control of aphid populations. Cool weather also delayed aphid development, thus prolonging their time period on apple trees before migration to their summer host, narrowleaf plantain. Frequent rains during the prebloom and early postbloom period made it difficult to complete spray applications in a timely fashion and spray washoff undoubtedly occurred in quite a few situations. Finally, there is also the possibility of increased tolerance to pyrethroid (Asana) and organophosphate (Lorsban) insecticides, which are commonly used during the delayed dormant period.

Populations of oriental fruit moth and codling moth were generally lower overall this year, as well as levels of fruit injury. The weather most likely was an important factor with these pests as well, as cool, rainy conditions probably reduced moth activity (mating and egg-laying).

Populations of tufted apple bud moth and levels of fruit injury continue to decline in quite a few orchards, reflecting excellent control with newer, highly effective compounds (Intrepid and SpinTor).

Although some orchards required treatment for European red mites, populations were generally low to moderate in most situations. Predator numbers were quite low overall, even in orchards with higher mite populations.

Late season fruit injury was observed this year initially on peach and then on apple that resembled insect feeding, consisting of shallow excavations through the fruit surface. Injured fruit were on low-hanging branches, usually in the proximity of weeds. Examination revealed that the injury was caused by slugs that fed primarily at night, spending the day in the groundcover.

Once again the weather had a definitive impact on tree fruit and small fruit production in the region. The cold wet winter followed by cool spring temperatures, above average rainfall and little frost damage, provided for relatively good bloom conditions overall; return bloom was spotty in some areas however. The weather did create marginal conditions for optimal pollination. Fruit set in peaches was above average and the crop was forecast to be very good. Peaches developed good size but flavor was off in some varieties, a result of cloudy days and excessive rainfall. The apple crop was above normal but also affected by the weather, particularly with high levels of scab infections. Sugar content in apples was also generally down and never reached optimum levels in most varieties. The generally heavy fruit set in both apples and peaches created challenges for growers relative to thinning practices. There were increased labor costs for hand thinning peaches, and timing and rate decisions for chemical thinning of apples. Apple fruit size was generally good to excellent but storage may become a problem in some varieties because of high water content. Because of the excessive moisture the past year and a half, growers are urged to re-evaluate their orchard nutrition program, particularly for nitrogen. The acres of small fruit plantings, particularly red raspberries, blackberries and strawberries is slowly increasing as tree fruit growers begin to diversify their operations. Production is being marketed fresh through farm markets. Chemical pest control measures in small fruit are generally limited and this presents challenges to producers. The wet weather in the early fall was also hard on small fruit as Botrytis (gray mold) became a severe problem in primocane red raspberries.

Entomology

PROGRESS IN MANAGEMENT OF INTERNAL LEPIDOPTERAN PESTS OF APPLE USING REDUCED RISK PESTICIDES AND PHEROMONE DISRUPTION - 2003

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Research continued for the second year on a project designed to test the effectiveness of a seasonal program to control insect and mite pests of apples using selective (non-OP, carbamate or pyrethroid) reduced risk insecticides plus pheromone disruption. This work was conducted in the original sites set up in 2002 in all major apple growing areas of New York: **Western NY** (Russell, Appleton; Lamont, Oak Orchard; Oakes, Lyndonville; Brown, Waterport; Furber, Burnap & Datthyn, Sodus; Trammel, Phelps); **Central NY** region (Apple Acres and Beak & Skiff, Lafayette); **Hudson Valley** (Crist, Milton; Biltonen, Stone Ridge; Wright, Gardiner); **Capital District** (Knight, Burnt Hills; Hicks, Granville); and **Champlain Valley** (Green, Chazy; Forrence, Valcour).

Materials & Methods

Each research site was a "split-plot design" in which the entire block received a program of reduced risk (RR) insecticides, and a 5-A portion of the block was additionally treated with pheromones for mating disruption of the second and third generations of codling moth (CM), oriental fruit moth (OFM), and lesser appleworm (LAW). A comparison block, which had the same varieties and tree training, was also monitored at each site. These blocks all contained at least one fresh fruit variety such as 'Empire' that might be selected for marketing in Europe or some other market outlet that may eventually demand IPM protocols for market access.

Private crop consultants (J. Misiti, R. Paddock, J. Eve, P. Babcock) played a leading role in the interactions with growers within a region, being responsible for general communication with cooperating growers, and in ensuring that recommended insecticide sprays were applied to the plots. In growing areas where there were insufficient numbers of private crop consultants, the leading role for appropriate seasonal interactions was taken by Cornell PI's or field extension personnel (K. Iungerman). Materials used in the blocks receiving a RR pesticide program included: Apollo or dormant oil plus Pyramite (as needed in summer) for mites, Actara for early season pests (including spotted tentiform leafminer, plum curculio and tarnished plant bug), Avaunt for post-petal fall pests such as plum curculio, internal Lepidoptera and apple maggot, plus Confirm and SpinTor for leafrollers. All sprays were applied by the grower.

From April 22–May 2, Trécé Pherocon IIB pheromone traps were hung in all three plots at each commercial orchard site as follows: one CM, OFM, and LAW trap group was placed at head height and arranged around the canopy of each of three trees in a middle row (one at each end and one in the center) of the RR Pesticides, Pheromone+RR Pesticides, and Comparison blocks at each site. All traps were checked and cleaned weekly until late August; CM lures were changed every 4 weeks, and OFM and LAW lures were changed during the middle two weeks of July. From June 16–July 1, polyethylene pheromone tie dispensers were hung in the Pheromone+RR Pesticides plots at each site, using different products to disrupt two separate moth species: Isomate C+ at 400 ties/A (in dwarf trees) or Isomate CTT at 200 ties/A (in taller trees) for codling moth, and Isomate M-100 at 100 ties/A for oriental fruit moth and lesser appleworm. All OFM ties were hung at head height by hand; CM ties were hung in the upper

1/3 of the tree canopy by hand for dwarf trees, and using a pole+hoop applicator for trees taller than 7 ft. Average time requirements for deploying the pheromone ties were as follows:
Hand-applied: 1.27 hr/A/person (or 0.79 A/hr/person); 236 ties/hr/person
Pole+hoop: 1.24 hr/A/person (or 0..81 A/hr/person); 242 ties/hr/person
On the dates the pheromone ties were applied, four additional CM pheromone traps were hung in the pheromone-disrupted plots. These were Trécé Pherocon IIB pheromone traps baited with a single 10X Trécé CM lure, hung in the upper canopy of trees located 2–3 rows (or trees) inside each corner of the plot. As recommended standard procedure by researchers familiar with CM mating disruption, these were meant to serve as back-up indicators of the pheromones' effectiveness in disrupting CM chemical communication. Moth catches in these 10X traps were also checked weekly, and lures were changed every 4 weeks during the season.

From July 21–31, fruit was examined for internal larval feeding damage in each plot by inspecting 20 random fruits on each of 30 trees along the edges and near hedgerows where pressure from immigrating moths was expected to be most severe. Shortly before the respective harvest date in each orchard, 20 fruits were picked from each of 35 trees in each plot: 6 trees grouped in the center of the plot, 12 trees from the mid-interior region (a few rows in from each of the four edges) and 12 trees from the outside edges + 5 extra along one edge designated as being at high risk for apple maggot injury (700 fruits total per plot). In cases where the RR Pesticides plot was separate from the Pheromones+RR Pesticides plot, a total of 16 trees along the "apple maggot edge" was sampled in each plot (860 fruits total per plot). All fruits were inspected for damage caused by diseases and insects, including the three internal Lepidoptera species.

Results

Pheromone trap catches from around the state revealed population patterns similar to those seen in 2002 for the different species. Catches from some representative orchards are shown in Figs. 1 and 2. As seen in the numbers from all four orchards presented here, codling moth levels were fairly low to moderate throughout the season in all the blocks, with catches rarely exceeding 10 moths per trap per week, and in many cases considerably fewer than 5 per trap. Abundance of the remaining two species was again highly variable, depending on location. In the most western sites (e.g., Fig. 1), lesser appleworm levels tended to be modest, but oriental fruit moth pressure was sometimes severe, with numbers exceeding 125 per trap per week in one instance. In the eastern orchards (e.g., Fig. 2), the opposite trend was seen, with OFM scarcely present, particularly during the latter half of the season, and LAW at reasonably high levels in most of these blocks, particularly towards the end of the season and beyond harvest. In all cases, the pheromone ties suppressed trap catches of not only the two target species (CM and OFM), but also LAW, at levels at or near zero. Interestingly, these low or zero-catch patterns were also seen in the pheromone-disrupted plots even during the first flight of these species; i.e., before the application of this season's pheromone tie dispensers. Because a normal number of moths were being caught in the adjacent non-disrupted plots, it must be assumed that sufficient pheromone was still being released from the previous year's ties to effect continued trap shutdown into the spring of this season. The suppression of LAW is presumed to have occurred because of the similarity of its pheromone blend (98:2 of Z:E-8 12-OAc) to that of OFM (92:8 of Z:E-8 12-OAc).

Fruit damage at harvest caused by internal Lepidoptera was uniformly low across all blocks and treatments (Table 1), with no statistically significant differences between the RR pesticide blocks, with or without pheromones, and the grower standards, similar to the 2002 results. Overall damage was somewhat reduced from last year, however, with only six farms exhibiting any internal worm damage, compared with eight farms in 2002. Some distinct differences did occur among the stratified samples taken within respective blocks, so that for instance, localized damage of up to 13–16% was noted along a specific orchard edge in one case. Subsequent analyses will be conducted on these data to establish any correlations between location of damage incidence and the treatment regimens. The orchards used in this trial were assumed to be relatively clean at the initiation of this multi-year project. If the selective pesticide program tested here does exhibit any shortcomings in the control of CM, OFM, or LAW, we would expect to see evidence of this over time as local populations are given the chance to increase beyond levels that are economically acceptable.

Acknowledgments: We wish to acknowledge the cooperation of all the growers, consultants, and fruit agents participating in this trial, without whom this study could not have taken place. We also thank our Technical Field Assistants, Milo Bonacci, Emily Fitzgibbons, Scott Lakso, Rachel Mussack, Josh Burden, Jason Sheehe, Judy Staton, Peter Jentsch and the Hudson Valley crew. We are grateful for support and material received from CBC America Corp., Dow AgroSciences, Dupont, Makhteshim Agan, and Syngenta. This work was supported by a grant from the USDA Risk Avoidance and Mitigation Program.

Fig. 1. Pheromone trap catches of internal lepidopteran moth pests in Western N.Y. apple orchards receiving a program of pheromones plus RR pesticides, RR pesticides only, or under the grower's standard management program. 2003

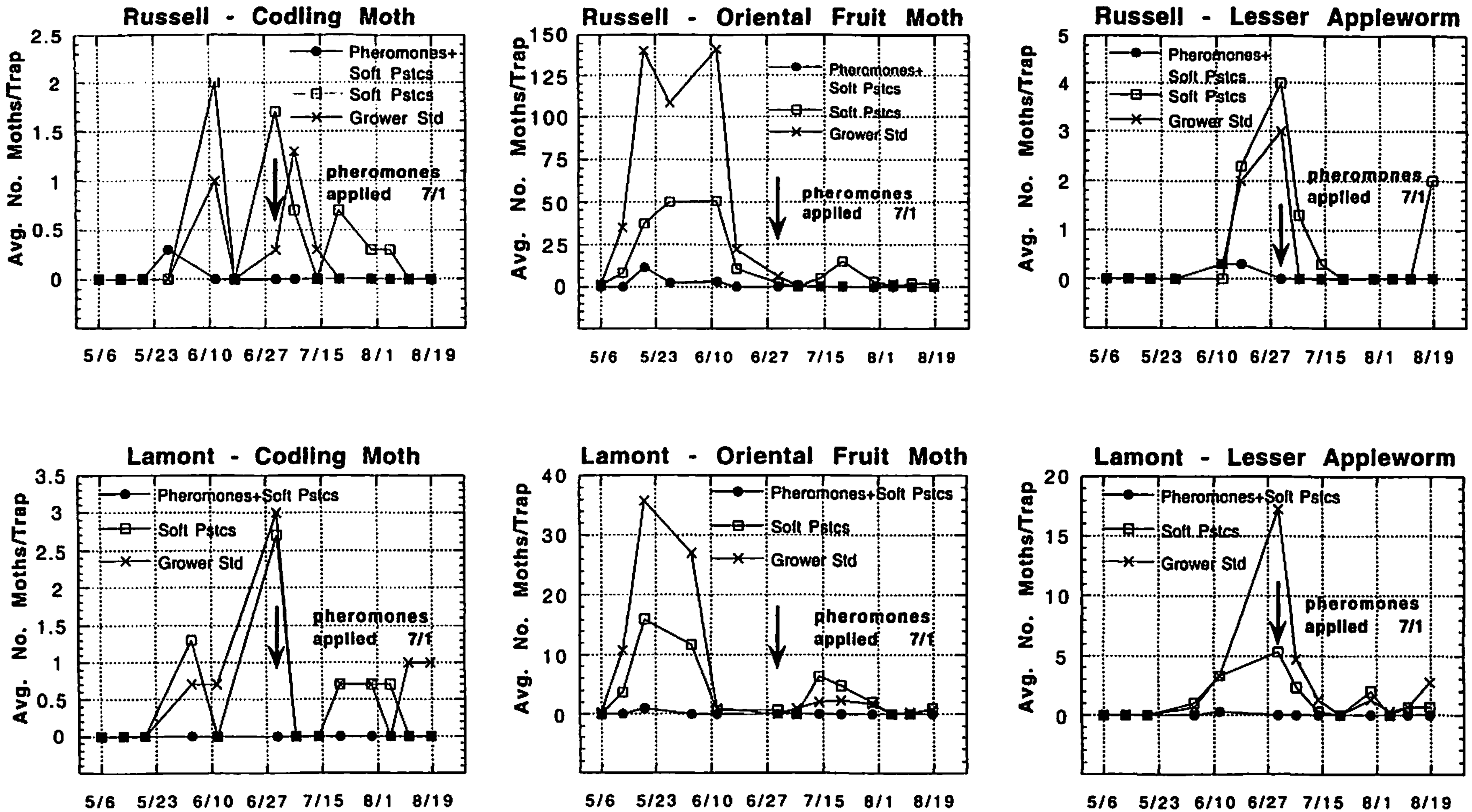

Fig. 2. Pheromone trap catches of internal lepidopteran moth pests in Eastern N.Y. apple orchards receiving a program of pheromones plus RR pesticides, RR pesticides only, or under the grower's standard management program. 2003

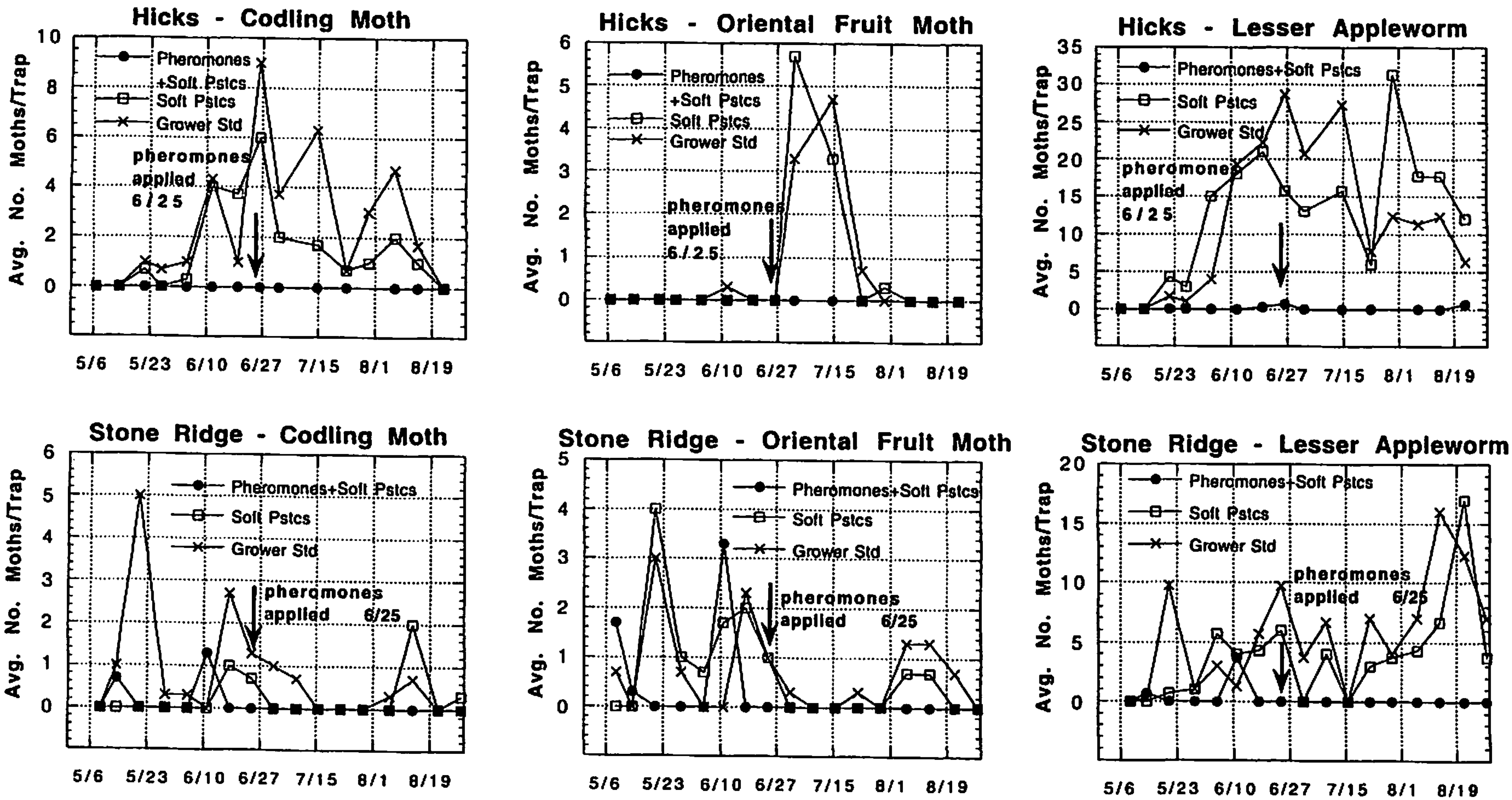

Table 1. RAMP plots 2003, summary of Internal Lepidoptera Fruit Damage

Orchard	Treatment	Mean % fruit damage: Internal Leps, July 21-31	Mean % fruit damage: Internal Leps, Harvest
Apple Acres	Pheromones+ RR Pesticides	0.3	0.00
	RR Pesticides	-	0.00
	Grower Standard	0.0	0.00
Beak & Skiff	Pheromones+ RR Pesticides	0.2	0.00
	RR Pesticides	-	0.19
	Grower Standard	0.0	0.22
Brown	Pheromones+ RR Pesticides	0.0	0.00
	RR Pesticides	-	0.00
	Grower Standard	0.2	0.00
Burnap	Pheromones+ RR Pesticides	0.2	0.00
	RR Pesticides	0.0	0.00
	Grower Standard	0.2	0.00
Chazy	Pheromones+ RR Pesticides	0.2	0.00
	RR Pesticides	-	0.00
	Grower Standard	0.0	0.00
Crist	Pheromones+ RR Pesticides	0.0	0.00
	RR Pesticides	0.0	0.00
	Grower Standard	0.0	0.00
Datthyn	Pheromones+ RR Pesticides	0.0	0.00
	RR Pesticides	-	0.00
	Grower Standard	0.0	0.00
Forrence	Pheromones+ RR Pesticides	0.0	0.00
	RR Pesticides	-	0.00
	Grower Standard	0.0	0.00
Furber	Pheromones+ RR Pesticides	0.5	0.00
	RR Pesticides	-	0.00
	Grower Standard	0.2	0.00
Hicks	Pheromones+ RR Pesticides	0.0	2.06
	RR Pesticides	0.0	0.00
	Grower Standard	0.0	0.00
Knight	Pheromones+ RR Pesticides	0.0	0.00
	RR Pesticides	-	0.00
	Grower Standard	0.0	0.00
Lamont	Pheromones+ RR Pesticides	0.3	0.14
	RR Pesticides	-	0.00
	Grower Standard	0.0	0.00
Oakes	Pheromones+ RR Pesticides	0.3	0.00
	RR Pesticides	-	0.19
	Grower Standard	0.2	0.41
Russell	Pheromones+ RR Pesticides	0.0	0.44
	RR Pesticides	-	0.56
	Grower Standard	0.0	0.56
Stone Ridge	Pheromones+ RR Pesticides	0.0	0.00
	RR Pesticides	0.0	0.00
	Grower Standard	0.0	0.00
Trammel	Pheromones+ RR Pesticides	0.0	0.83
	RR Pesticides	-	5.95
	Grower Standard	0.0	0.65
Wright	Pheromones+ RR Pesticides	0.5	0.00
	RR Pesticides	0.0	0.00
	Grower Standard	0.0	0.00
Means	**Pheromones+ RR Pesticides**	**0.15 a**	**0.20 a**
	RR Pesticides		**0.41 a**
	Grower Standard	**0.05 a**	**0.11 a**

Means followed by the same letter not signifcantly different ($P = 0.05$, Fisher's Protected LSD test).

Values transformed by arcsine-square root before analysis.

STINK BUG PREFERENCE FOR APPLE CULTIVARS AND PRELIMINARY EVIDENCE OF TRAP CROPPING AS A CONTROL

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Stink bugs have recently been shown to have the potential to cause injury to late season apples (Brown 2001, 2003). Before effective management of this pest can be implemented there are many aspects of stink bug biology and interactions between apple and stink bugs that must be investigated. One of these areas is to determine what are the important factors determining variability in stink bug injury to apples within and among orchards. This study was conducted to give a preliminary indication of cultivar preferences by stink bugs and to reveal potential factors that govern variability in apple injury. A second study was conducted to evaluate the possibility of using trap crops as a control for stink bug injury.

Materials and Methods

Cultivar Preference. This study was conducted in a 4 ha variety trial orchard at the Appalachian Fruit Research Station. The orchard was managed according to standard practices, including 10 insecticide applications (Table 1). The trees harvested for this study were all planted in 1995. Each cultivar was planted at two random locations within the orchard with up to five trees at each location and, except for a few cultivars, all fruit per cultivar were pooled for evaluation. About 150 fruit (range 88 to 287) were harvested near peak commercial maturity. Stink bug injury was identified based on both surface and cross-section characteristics and in the case of questionable identity the presence of a feeding puncture was used as the final decision criterion. In the case of 'Honeycrisp' and 'Stayman', fruit from each of the two locations were evaluated separately to obtain an estimate of within orchard variability. Several cultivars of particular interest were also sampled from one other orchard similarly managed and two orchards managed without insecticides.

Trap Crop. Two orchards of peach and apple ('Empire' and 'Granny Smith') were used to test if trap crops affected the amount of injury from stink bugs. In the middle of each orchard a 7m strip of buckwheat, dill, and marigold (in adjacent strips the length of the orchard) were planted with a diverse planting on one side and monoculture plantings of apple and peach on the other side. These orchards received regular fungicide applications and horticultural management but no insecticides. A total of 1038 'Empire' and 990 'Granny

Smith' fruit were harvested and evaluated for stink bug injury as above. For each cultivar, there were 4 replications with data on fruit injury extending linearly from the trap crop in both directions in each orchard. These data were analyzed by regressing percent fruit injury with distance from the trap crop.

Results and Discussion

Cultivar Preference. A range of 1 to 28% fruit injury was found among cultivars (Fig. 1). Some of the early cultivars such as 'Williams 'Pride', 'Pristine', and 'Sunrise' (from another orchard) had little or no injury and may have been harvested before stink bugs began feeding in apple. However, some cultivars such as 'Imperial Gala' (1%), 'Rome' (2%), York (2%), and 'Nittany' (1%, from an unsprayed orchard), all late season cultivars, showed very little injury. At the other extreme 'Braeburn' (28%), 'Imperial Red Delicious' (15%), 'Royal Empire' (14%), and 'Golden Supreme' (14%) showed high incidence of injury.

These results must be considered as preliminary estimates of relative preference by stink bugs because of many sources of variability in injury occurrence. Variation in damage within an orchard can be high. The 'Stayman' apples had an average of 12% injury, but the fruit from one portion of the orchard had 6.5% injury while in another portion of the orchard 16.5% injury. Also the surrounding habitat can influence damage. 'Honeycrisp' had an overall injury rate of 7%, but the injury was 3% from trees next to an open field and the injury was 11% from trees next to a weedy rock outcrop. There can also be a large degree of variation of injury to the same cultivar among orchards. 'Braeburn' had 24% injury in the experimental orchard, but in a similarly managed orchard within 100m it had only 10% injury. Likewise, 'Granny Smith' in the experimental orchard had 4% injury but in an unsprayed orchard 250m away had 11% injury. The lack of insecticide use in this orchard may not be the only difference because 'Empire' fruit from the same two orchards had identical levels of stink bug injury, 14%.

Trap Crop. Both 'Empire' and 'Granny Smith' had a significant reduction in stink bug injury in trees in close proximity to the trap crop (Fig. 2, 3). There was a lot of variation within the data, in part to factors discussed above, but the effect of the trap crop appears real. From a visual examination of the figures, the extent of the trap crop effect was from 6 to 10 rows distant from the trap crop.

References

Brown, M. W. 2001. Is it stink bug or cork spot? Proc. 77th Cumberland-Shenandoah Fruit Workers Conference.

Brown, M. W. 2003. Bitter pit, calcium deficiency or stink bug damage. PA Fruit News 83(5): 17-21.

Table 1. Insecticide application schedule for experimental cultivar evaluation orchard, Appalachian Fruit Res. Sta., Kearneysville, 2003.

Date	Insecticide
April 3	Dormant oil
April 14	Pounce
May 14	Imidan
May 30	Lannate
June 19	Imidan
July 2	Sevin
July 18	Imidan
July 31	Sevin
August 15	Imidan
August 29	Sevin

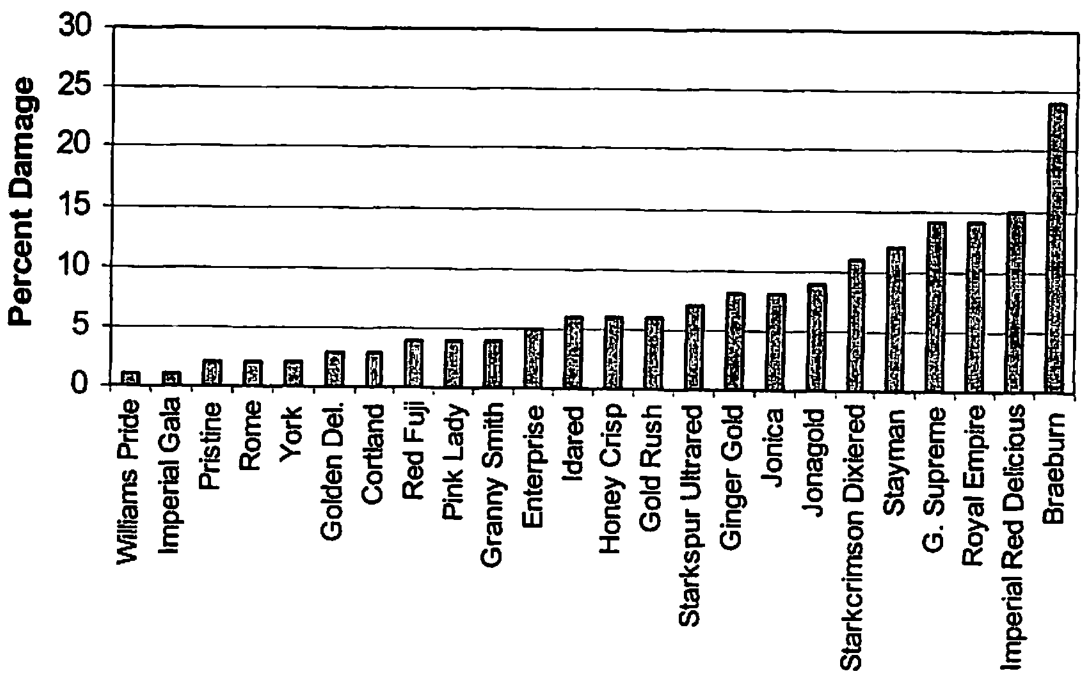

Figure 1. Percent stink bug damage on selected cultivars from experimental cultivar evaluation orchard, estimates based on from 88 to 287 fruit per cultivar.

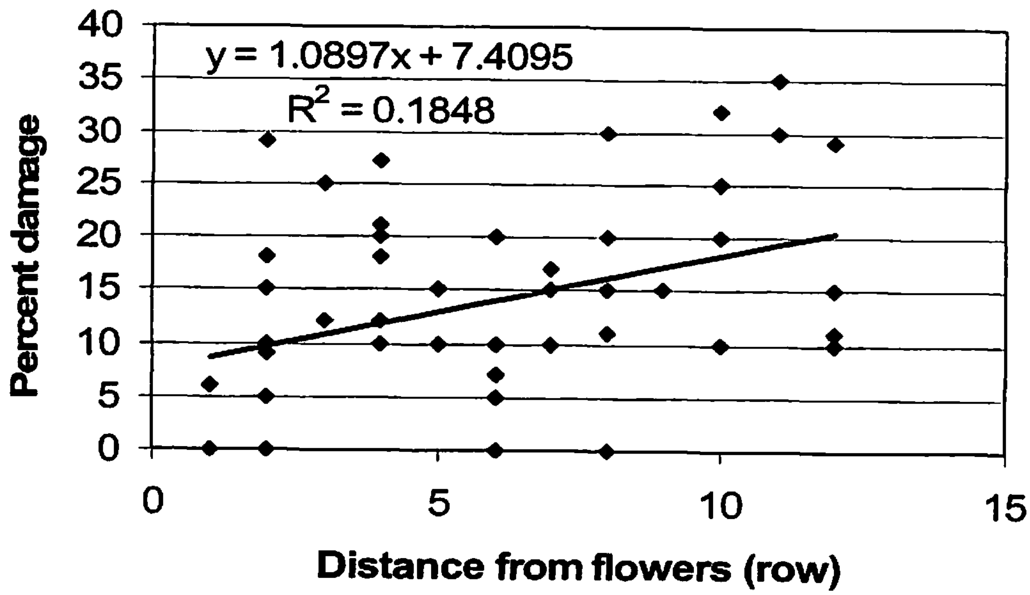

Figure 2. Regression between stink bug damage and distance from trap crop (flowers) for 'Empire' fruit, 1038 fruit examined at harvest.

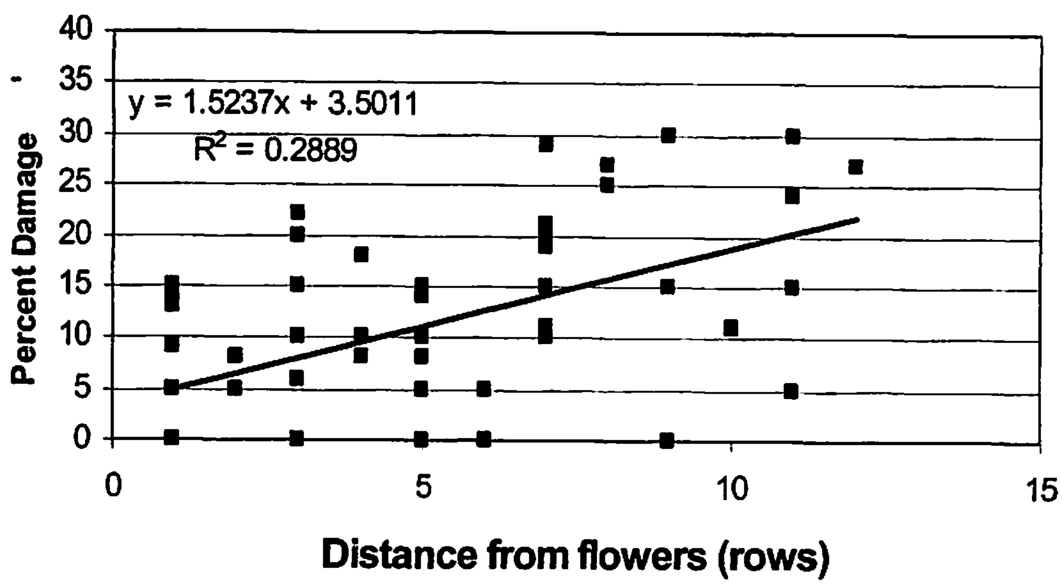

Figure 3. Regression between stink bug damage and distance from trap crop (flowers) for 'Granny Smith' fruit, 990 fruit examined at harvest.

STINK BUG RESPONSE TO FIVE TRAP TYPES IN APPLE AND PEACH ORCHARDS

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Introduction

Management of stink bugs in orchards is hindered by the lack of effective monitoring tools for threshold-based decision making. Monitoring is especially challenging because of the polyphagous nature and high mobility of stink bugs, and has consisted primarily of tree beating, weed sweeping and fruit injury assessments (Hogmire 1995).

The ability to monitor *Euschistus* spp. stink bugs was enhanced significantly by the discovery of an aggregation pheromone, methyl 2,4-decadienoate (Aldrich et al. 1991). Tube-traps consisting of wire mesh cone funnels at either end and baited with methyl 2,4-decadienoate failed to capture *E. conspersus* Uhler in a Washington state study (Krupke et al. 2001), but are recommended as a monitoring tool for this same species in California (Ohlendorf 1999). Pyramid (modified Tedders) traps baited with methyl 2,4-decadienoate have been the most common tool evaluated for monitoring stink bugs in pecans (Mizell and Tedders 1995, Mizell et al. 1996, Yonce and Mizell 1997) and peaches (Johnson et al. 2002) in the southern United States. Mizell and Tedders (1995) found that more stink bugs were captured by pyramid traps coated with 'industrial safety yellow' exterior latex gloss enamel paint than by pyramid traps coated with light and dark green, black, or covered with aluminum foil. A yellow pyramid trap/pheromone combination provided reliable information regarding seasonal occurrence and canopy distribution of brown and dusky stink bugs in pecan orchards (Cottrell et al. 2000). In 2002, we found that a similar yellow pyramid trap/pheromone combination constructed of plywood captured significantly and/or numerically more stink bugs than a plastic jar trap/pheromone combination in apple and peach orchards in West Virginia (Hogmire et al. 2003). Baited pyramid traps placed between fruit trees captured 2.5 times as many stink bugs as baited jar traps hung in the canopy, followed closely by unbaited yellow pyramid traps.

Our objectives in 2003 were to: 1) evaluate additional trap types, and 2) understand stink bug response to traps and pheromone.

Materials and Methods

Trap evaluation. Four study sites were used to evaluate stink bug response to traps in 2003. Two commercial orchards were located in Hampshire Co., WV and consisted of 1.2 ha Rome apples on M7 rootstock planted in 1989 and 3.2 ha Newhaven peaches on Lovell rootstock planted in 1988. Two abandoned orchards consisted of 3.6 ha Empire and Gala apples on M.26 rootstock planted in 1994 in Berkeley Co., WV, and 0.17 ha Loring peaches on Lovell rootstock planted in 1989 in Jefferson Co., WV. Both commercial orchards received applications of crop protection chemicals for pest management.

Five different traps were evaluated. Three types of pyramid traps were constructed of two or four triangular-shaped panels of varying thickness, depending upon material. The material (thickness) was either plywood (13 mm), plastic (6 mm, AIN Plastics, Virginia Beach, VA), or masonite (3 mm) (Fig. 1A, 1B, 1C). Two coats of exterior latex gloss enamel paint, color-matched to professional industrial safety yellow, were applied to each panel. For plywood and plastic traps, each of the two panels measured 1.22 m high, 52 cm wide at the base and 7 cm wide at the top. A slit extending from the base of one panel and from the top of another was cut 61 cm long x 1.5 cm wide, which permitted the panels to interlock perpendicularly to form the pyramid. A 5 mm hole was bored into each corner of the panel with the slit at the top, to which was attached a piece of wire and 25 cm long galvanized nail for anchoring the traps to the ground. Holes in plastic panels were reinforced with metal grommets. Masonite traps, which were developed by Russ Mizell (University of Florida), consisted of four panels (1.22 m high, 26 cm wide at the base, 3 cm wide at the top) which were joined together with cable ties threaded through six holes along the inner margin of each panel. Masonite traps were anchored with a 6 mm diameter, 19 cm long metal rod that was driven into the ground in the center of the pyramid. A 1.9-liter clear plastic Rubbermaid® jar with screw-cap lid was prepared for placement on the top of each plywood and plastic pyramid base. The base of each jar was cut away and a PVC gasket (7 mm thick, 11 mm wide, and outside diameter of 11.4 cm) was cut from 10.2 cm diameter PVC pipe and secured around the perimeter with hot glue. A wire screen funnel was inserted into the base of the jar and attached at the wide end to the jar with hot glue. The jar was vented around the perimeter with four equidistant vertical rows of four 2.5 cm diameter openings, which were covered with pieces of plastic pet screening (New York Wire Co., Mt. Wolf, PA) attached with hot glue. The jar was placed on top of the pyramid so that the support braces of the funnel were positioned against the inserted top baffles of the pyramid base. The jar was secured to the panels of the pyramid base with spring clips attached to wires extending from four holes in the base of the jar. For the masonite pyramid, the collection device consisted of a two-layer cone-shaped aluminum screen cage which was attached with spring clips to the top of the pyramid base.

Two types of jar traps were constructed from 3.8-liter clear plastic Rubbermaid® jars with screw-cap lids (Fig. 1D, 1E). Two off-setting 10 cm diameter holes were cut in opposite sides of the jars, and a PVC gasket (2 mm thick, 7 mm wide, and outside diameter of 11.4 cm) was cut from 10.2 cm diameter PVC pipe and attached around the perimeter of each hole with four bolts and nuts. Plastic pet screening was formed into a cone and fastened with hot glue, with each cone positioned flush with the hole opening and attached with hot glue to the PVC gasket. Cones projected to the center of the jar trap with an internal opening of 15 x 30 cm. Half of the jars were coated on the inside with 'industrial safety yellow' paint (Fig. 1E).

Three replications of five baited and unbaited treatments were set up at each orchard. Baited traps were provisioned with lures containing 200+ mg of *Euschistus* spp. aggregation pheromone, methyl 2,4-decadienoate (IPM Technologies, Inc., Portland, OR). Lures were suspended from the screw-cap lids of plywood and plastic pyramid trap jar tops and jar traps, and from the top of masonite trap screen cages. All traps contained ¼ piece of an Atroban® Extra insecticide ear tag (Schering-Plough Animal Health Corporation, Union, NJ) (Cottrell 2001) impregnated with 10% permethrin and 13% piperonyl butoxide that was attached with wire above the lure. Traps were installed in a border row of the two apple orchards and the commercial peach orchard, adjacent to woods, and throughout the abandoned peach orchard on 28 March (abandoned orchards) and 3 April (commercial orchards). Pyramid traps were located between the trees and jar traps were suspended at head height within the tree canopy. Traps were inspected weekly through the end of August or mid-October in peach and apple orchards, respectively, with lures and ear tags replaced every 6 weeks. Stink bugs were collected in labeled vials of 70% ethanol and identified with taxonomic keys found in McPherson and McPherson (2000). Data were accumulated across weeks and subjected to ANOVA with mean separation by Tukey's HSD Test at $P = 0.05$ level (SAS Institute 2001).

Trap color and lure comparison. Plastic pyramid traps painted 'industrial safety yellow', as described above, were compared with pyramid traps identically constructed from 3 mm thick plastic available from the same manufacturer in 'school bus yellow'. Both pyramid trap colors were baited with IPM Tech lures. An additional treatment consisted of 'industrial safety yellow' pyramid traps baited with Suterra wax puck lures containing 100 mg of *Euschistus* spp. aggregation pheromone, methyl 2,4-decadienoate (Suterra, Bend, OR). Three replications of the three treatments ('industrial safety yellow' pyramid trap/IPM Tech lure; 'school bus yellow' pyramid trap/IPM Tech lure; 'industrial safety yellow' pyramid trap/Suterra lure) were provisioned with ¼ piece of ear tag and installed between trees in the border row, adjacent to a woods, of a 1.2 ha Cresthaven peach orchard from 12 June to 28 August, and a 1.2 ha Rome apple orchard from 28 August to 15 October in Hampshire Co., WV. Stink bugs were collected weekly, as described above, with lures and ear tags replaced when traps were moved from peach to apple. Data were accumulated across weeks and analyzed using ANOVA with mean separation by two-sample t-tests at $P = 0.05$ level (SAS Institute 2001).

Stink bug escape and kill. This study was conducted at the WVU Kearneysville Tree Fruit Research and Education Center. Ten pyramid trap jar tops were provisioned with an IPM Tech lure and ¼ piece of insecticide ear tag, and a sleeve of insect netting was installed over the bottom jar opening. Half of the jar tops (5) received six female brown stink bugs and half received six males. Jar tops were alternated by sex and suspended from a high tensile wire between trees in a border row of Rome apples. Jar tops were installed on 8 September and inspected daily through 15 September to determine escape and kill of stink bugs. Escaped and dead stink bugs were removed upon inspection. The above experiment was repeated, using fresh lures and ear tags, with 10 clear jar traps enclosed in insect netting from 23-30 September. Data were analyzed using ANOVA with mean separation by two-sample t-tests at $P = 0.05$ level (SAS Institute 2001).

Stink bug arrestment. This study was conducted at the USDA-ARS, Appalachian Fruit Research Station from 10 July to 5 August, 2003. For each trial, a single brown stink bug was placed in a small glass vial and chilled for 20 min. The vial was then positioned horizontally at the base of a plywood pyramid trap coated with "industrial safety yellow" paint, with the mouth of the jar facing the trap itself. The trap was either baited with methyl 2,4-decadienoate or left unbaited. Each stink bug was then observed continuously for 30 min. to determine how far it walked up the surface of either a baited or unbaited trap. For baited and unbaited traps, a total of 26 and 21 stink bugs were observed respectively. The number of bugs reaching particular incremental distances (6, 12, 24, and 36 inches), and those reaching the trap top were compared for baited and unbaited traps using a Chi-Square Test of Homogeneity ($P<0.05$).

Results

Overall trap captures. In the commercial apple orchard, baited pyramid traps captured significantly more stink bugs than baited jar traps (Fig. 2A). There was no significant difference in stink bug captures among unbaited traps. A similar pattern of stink bug capture was observed in the abandoned apple orchard, however there was no significant difference among baited plastic pyramid, baited clear jar and unbaited masonite pyramid traps (Fig. 2A). The pattern of captures in the commercial peach orchard was very similar to the commercial apple orchard (Fig. 2B). In the abandoned peach orchard, baited pyramid traps were numerically superior to baited jars and unbaited traps, but only the baited masonite pyramid was significantly different from the other trap types (Fig. 2B). A total of 1,475 stink bugs were captured in all locations by all trap types, with 73% of captures in apples and 27% in peaches. Baited traps accounted for 92% of total capture.

'Industrial safety yellow' pyramid traps captured four times as many stink bugs when baited with IPM Tech lures than with Suterra lures in both apple and peach (Table 1). Captures with the IPM Tech lure were higher than with the Suterra lure throughout the sampling period with the exception of 11 September and 2 October (Fig. 3). Differences in capture were minimal between 'industrial safety yellow' and 'school bus yellow' pyramid traps in both apple and peach (Table 1).

Species responses to traps. In the commercial and abandoned apple orchards, brown stink bug was the most abundant species captured overall by baited traps (Table 2). Captures were significantly higher in pyramid than in jar traps, but not different among versions of each trap type. Captures of dusky stink bugs were lower in both apple orchards and not significantly different among trap types. However, numerically higher captures occurred with all pyramid traps in the commercial orchard and with the masonite pyramid in the abandoned orchard. Captures of green stink bug were very low in the abandoned apple orchard, with no significant difference among trap types. Green stink bugs were more abundant in the commercial apple orchard, with higher captures in pyramid than in jar traps. However, only captures in the masonite pyramid differed significantly from captures in jar traps (Table 2). The higher, but not significantly different capture of green stink bugs in the masonite versus the plywood and plastic pyramid traps was likely due to a location effect. Whereas green stink bug captures in two replications of the masonite pyramid trap were similar to plywood and plastic pyramid trap captures, a total of 101 were captured in the third replication. In the commercial peach orchard, brown stink bug was the most abundant species captured, followed by dusky and green stink bugs (Table 2). Captures of brown and dusky stink bugs were significantly higher in pyramid than in jar traps, with no difference among trap types in captures of green stink bugs. In the abandoned peach orchard, brown stink bug was the predominant species captured, with generally very low captures of dusky and green stink bugs (Table 2). Although higher captures of brown stink bugs occurred with pyramid than with jar traps, only captures in the masonite pyramid were significantly greater than captures in the yellow jar. A significantly higher capture of dusky stink bugs occurred with the masonite pyramid than with other traps, with no significant difference among traps in capture of green stink bugs. When all sites were combined, brown, dusky and green stink bugs represented 63, 22 and 15 percent of capture, respectively.

Based on capture in pyramid traps, stink bugs were detected at similar levels in apples from April through early August, followed by an increase from mid-August through September (Fig. 4A). Brown stink bug was the most abundant species captured throughout most of the season, except for higher captures of green stink bugs beginning in early September. In peaches, peaks in capture occurred in April and from early July through August. Brown stink bug was the most abundant species captured throughout the season, followed by dusky and green stink bugs (Fig. 4B).

Stink bug escape and kill. More brown stink bugs escaped than were killed in pyramid trap jar tops throughout the seven day test period (Fig. 5A). Although not significantly different, escape and kill was higher for males than females. Escape occurred quickly, with 40% of males and 13% of females exiting the trap on the first day. After seven days, escape and kill averaged 63% and 24%, respectively. In jar traps, escape was higher than kill for males but less for females (Fig. 5B). On the first day, escape of males and females was similar to that observed with pyramid trap jar tops. All males had either escaped (67%) or were killed (33%) by day three, whereas escape (43%) or kill (57%) of all females did not occur until day five. Escape was higher for males than females but kill was higher for females, with a significant difference between the sexes in both escape and kill on day three.

Stink bug arrestment. There was no significant difference between the number of stink bugs walking to heights of 6 and 12 inches above the base of baited and unbaited pyramid traps. However, significantly more stink bugs reached 24 and 36 inches on unbaited than baited traps. Similarly, significantly more stink bugs reached the trap top on unbaited than on baited pyramid traps.

Discussion

Pyramid traps painted 'industrial safety yellow' and baited with *Euschistus* spp. aggregation pheromone, methyl 2,4-decadienoate, captured more stink bugs than all other traps in both apple and peach orchards (Fig. 2). Unbaited pyramids and baited and unbaited jar traps had significantly fewer, but similar captures of stink bugs. Overall captures were similar among the three versions of pyramid traps (plywood, plastic, masonite). Pyramid traps constructed of plywood have numerous disadvantages as they are more costly, heavier, subject to chewing damage from squirrels and ground hogs and discoloration from sooty mold, and prone to warp.

Captures of stink bugs in baited traps may be due to response to both visual and olfactory cues. Mizell and Tedders (1995) found that pyramid traps captured more stink bugs when coated with 'industrial safety yellow' than with light and dark green or black paint, or when covered with aluminum foil. Numerous phytophagous insects are known to respond positively to yellow, which is considered to be a super-normal foliage-type stimulus for foraging insects (Prokopy and Owens 1983). In our study, variation in the shade of yellow did not adversely effect trap captures, which were similar between 'industrial safety yellow' and 'school bus yellow' pyramid traps in both apple and peach (Table 1). The visual stimulus of a yellow color was of no benefit with jar traps however, as captures were not significantly different from unpainted (clear) jar traps.

Response of stink bugs to the olfactory stimulus provided by the aggregation pheromone, methyl 2,4-decadienoate, was the primary factor responsible for trap captures. Pyramid and jar traps baited with pheromone accounted for an average of 92 and 97 percent, respectively of the total capture when compared with unbaited traps. Captures of stink bugs in baited pyramid traps were four fold greater with lures from IPM Tech than from Suterra in both apple and peach (Table 1). Because these lures contained a different amount of pheromone (200+ mg for IPM Tech vs. 100 mg for Suterra), one would expect similar captures initially, followed by increased differences as the Suterra lure becomes depleted. The IPM Tech lure resulted in higher captures than the Suterra lure throughout the sampling periods (Fig. 3), indicating that the release rate of pheromone from the dispenser may be an important factor accounting for differences in capture. A strong odor was detectable from the IPM Tech, but not from the Suterra lure.

Brown stink bug represented an average of 63% of all stink bug captures when all sites were combined, with dusky and green stink bugs representing 22 and 15%, respectively. The majority (93%) of stink bugs were captured in traps baited with *Euschistus* spp. aggregation pheromone, methyl 2,4-decadienoate. In the eastern

United States, brown stink bug is typically captured more frequently than other species in pheromone baited yellow pyramid traps deployed on the ground (Yonce and Mizell 1997, Johnson et al. 2002). In our study, baited yellow pyramid traps captured significantly more brown stink bugs than baited clear or yellow jar traps. Differences among trap types were fewer for dusky and green stink bugs, most likely due primarily to lower overall abundance of these species. Significant captures of green stink bugs occurred in the commercial apple site, primarily in baited pyramid traps (Table 2). Although response of green stink bug to the *Euschistus* spp. pheromone would not be expected, baited pyramids accounted for 95% of the total capture when compared with unbaited pyramid traps, with 54% of the capture occurring in a single baited masonite pyramid. High captures of green stink bugs occurred in September (Fig. 4A). At this late time of the season, a decline in attractiveness of a favored weed or tree host could have resulted in the increased response to the plant-derived pheromone, methyl 2,4-decadienoate.

Trap captures of all stink bug species increased in apples beginning in mid-August (Fig. 4A). This response could be due to a decline in attractiveness of various weed or other tree hosts and/or an increase in attractiveness of the maturing fruit. In caged studies to characterize stink bug injury on apple, Brown (2003) found that most fruit injury occurred after mid season. In peach, stink bug captures peaked in April and during July and August (Fig. 4B). Stink bugs are attracted to various weed and tree hosts based on succession of flowering (McPherson and McPherson 2000). Peach trees typically bloom in mid-April, prior to flowering of other plant species, and therefore provide a favorable host for overwintered adults. Other plant species, primarily weeds, are more suitable hosts for feeding and reproduction during the late spring and early summer months. Movement back to peach in late summer could be triggered by senescence of weed hosts, especially during drought conditions, and increased attractiveness of maturing fruits. Continued high captures after mid-August are especially noteworthy, since all fruit was harvested at this time, and indicates response to pheromone in the absence of competition from fruit.

The successful use of a monitoring tool for pest management decision-making depends upon its ability to accurately represent changes in pest population densities. Detection of pest populations with a monitoring tool involves both attraction and capture. Brown stink bugs were attracted in substantial numbers and responded quickly (often within 15 minutes) to IPM Tech lures containing methyl 2,4-decadienoate. It was common to observe more brown stink bugs on or in the vicinity of baited pyramid traps than in traps. *E. conspersus* responded similarly to tube traps baited with methyl 2,4-decadienoate in a Washington state study (Krupke et al. 2001). We found that a significantly greater proportion of individuals reached the top of unbaited pyramid traps compared to baited pyramid traps (Fig. 6), indicating that brown stink bugs were being arrested prior to capture in baited pyramid traps and thus, captures in our monitoring studies were not necessarily reflective of true population densities.

Once attracted to traps, capture depends upon ease of entry and escape, with escape minimized either by trap design or immobilization of stink bugs after entry. High rates of escape and poor kill of stink bugs with insecticide ear tags (Fig. 5) undoubtedly resulted in reduced captures in traps used in our study. Future studies will need to address these trap/pheromone limitations in order to develop a more effective monitoring tool for stink bugs.

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Table 1. Cumulative mean number of stink bugs captured in baited pyramid traps with two pheromone lures and two trap colors in an apple and peach orchard in 2003[a].

	Apple (7 weeks)	Peach (11 weeks)
Lure comparison		
IPM Tech	9.7	20.0
Suterra	2.3	5.0
Trap color comparison		
Industrial Safety Yellow	9.7	20.0
School Bus Yellow	11.3	13.7

[a]No significant difference between lures and trap colors based on two-sample t-tests at $P = 0.05$.

Table 2. Cumulative mean number of brown, dusky and green stink bugs captured in each baited trap type in apple and peach orchards in 2003.

	Commercial Apple			Abandoned Apple		
Trap type	Brown	Dusky	Green	Brown	Dusky	Green
Plywood pyramid	27.7 a	9.7 a	6.3 ab	33.3 a	4.7 a	0.3 a
Plastic pyramid	25.0 a	8.7 a	12.7 ab	29.7 a	4.3 a	0.3 a
Masonite pyramid	24.7 a	10.7 a	40.0 a	27.0 a	12.7 a	0 a
Clear jar	2.0 b	1.3 a	1.0 b	4.0 b	4.3 a	0.3 a
Yellow jar	2.0 b	3.3 a	2.0 b	2.0 b	1.3 a	0 a

	Commercial Peach			Abandoned Peach		
Trap type	Brown	Dusky	Green	Brown	Dusky	Green
Plywood pyramid	13.0 a	4.3 ab	1.0 a	8.3 ab	0 b	0.3 a
Plastic pyramid	22.3 a	7.0 a	1.0 a	10.7 ab	0 b	0.3 a
Masonite pyramid	14.0 a	8.0 a	0.3 a	15.3 a	5.0 a	0.3 a
Clear jar	1.0 b	0.7 b	0.3 a	3.0 ab	0.7 b	0 a
Yellow jar	0 b	0.3 b	0 a	1.0 b	0.3 b	0 a

Means within a column for each fruit type followed by the same letter are not significantly different ($P = 0.05$; Tukey's HSD Range Test).

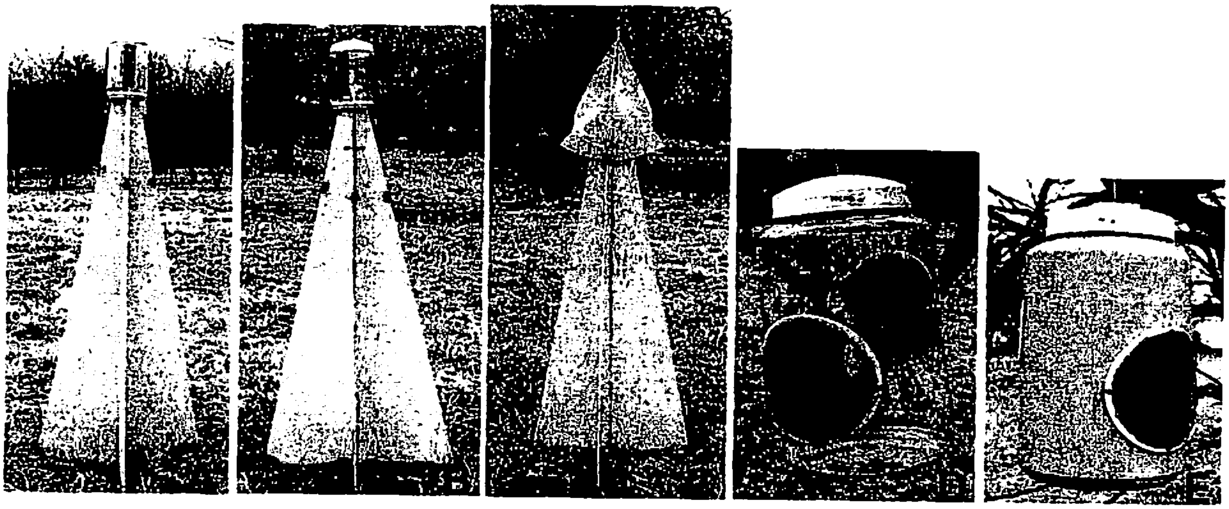
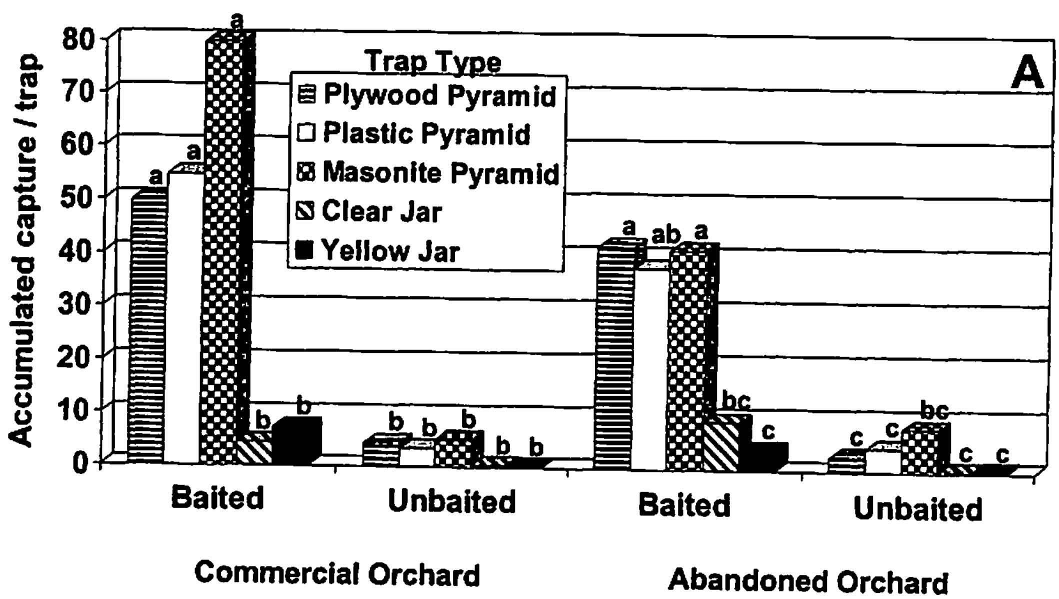


Figure 1. Yellow plywood (A), plastic (B) and masonite (C) pyramid traps, and clear (D) and yellow (E) jar traps used for stink bug monitoring.



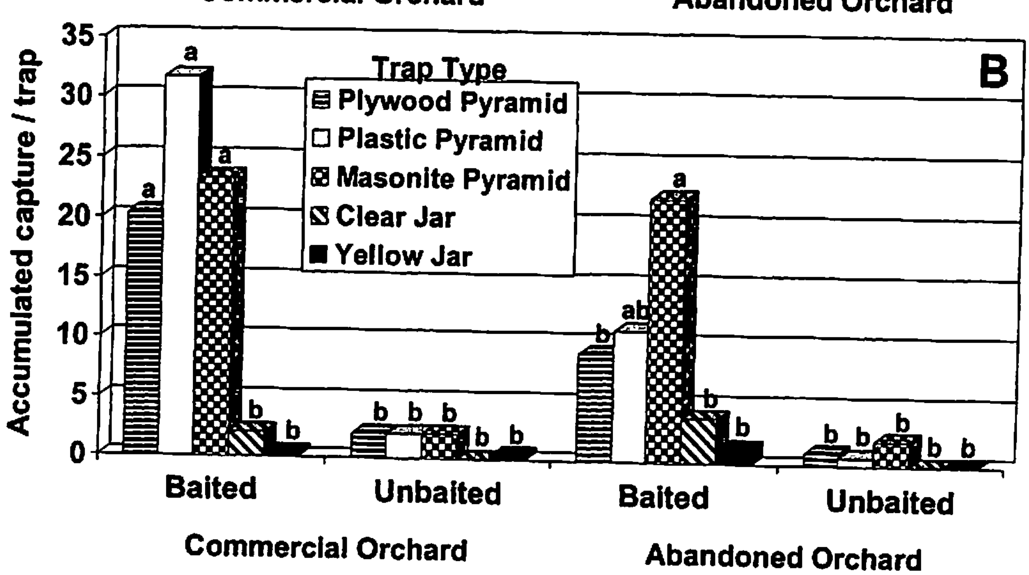


Figure 2. Stink bugs captured in various trap types in apple (A) and peach (B) orchards in 2003.

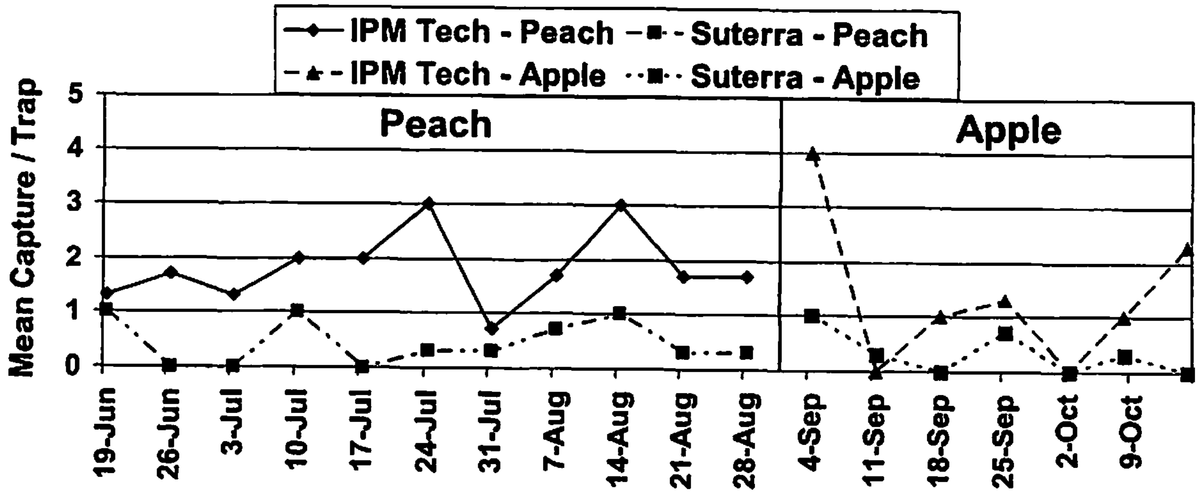


Figure 3. Weekly captures of stink bugs in plastic pyramid traps baited with IPM Tech and Suterra lures in apple and peach in 2003.

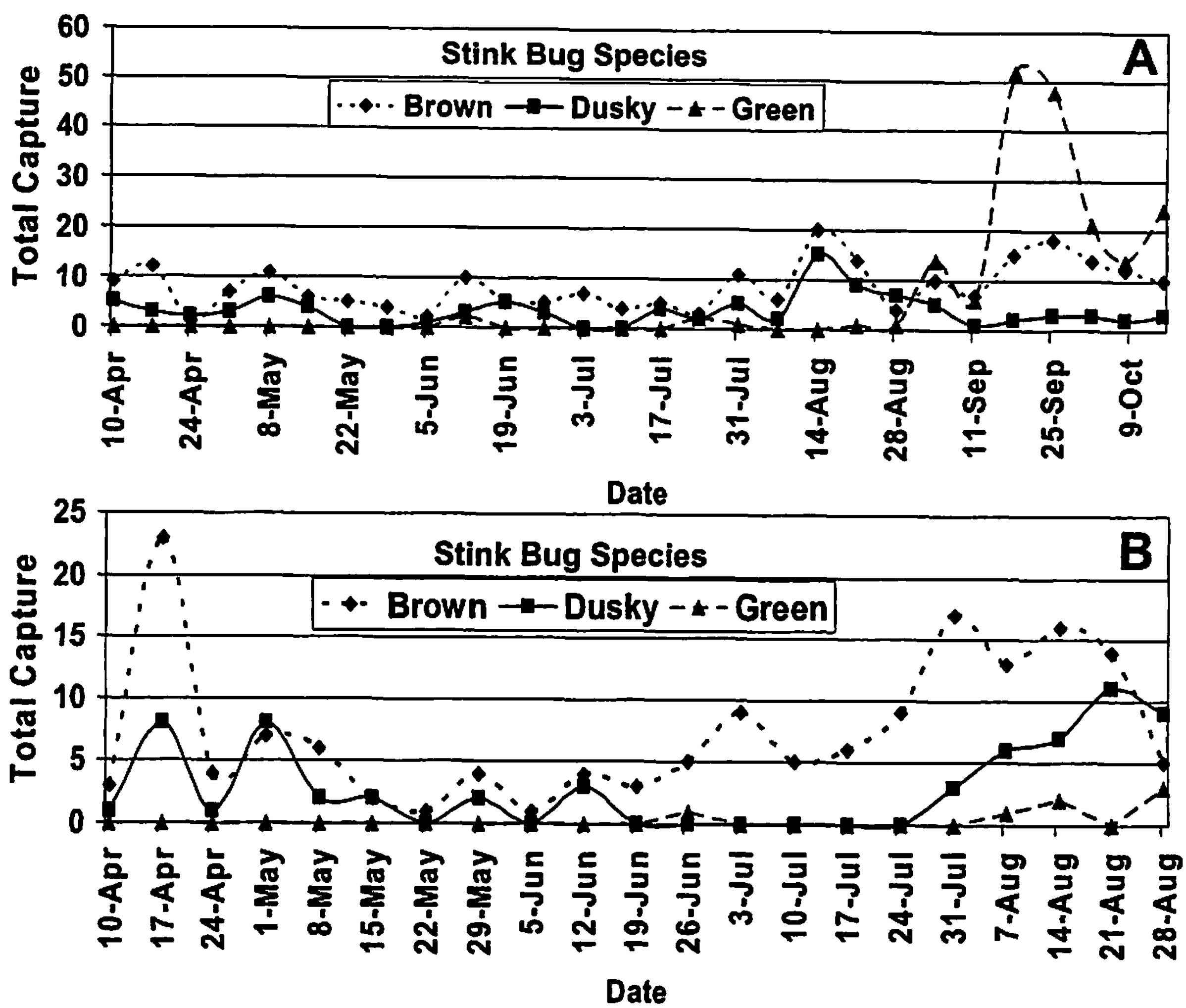
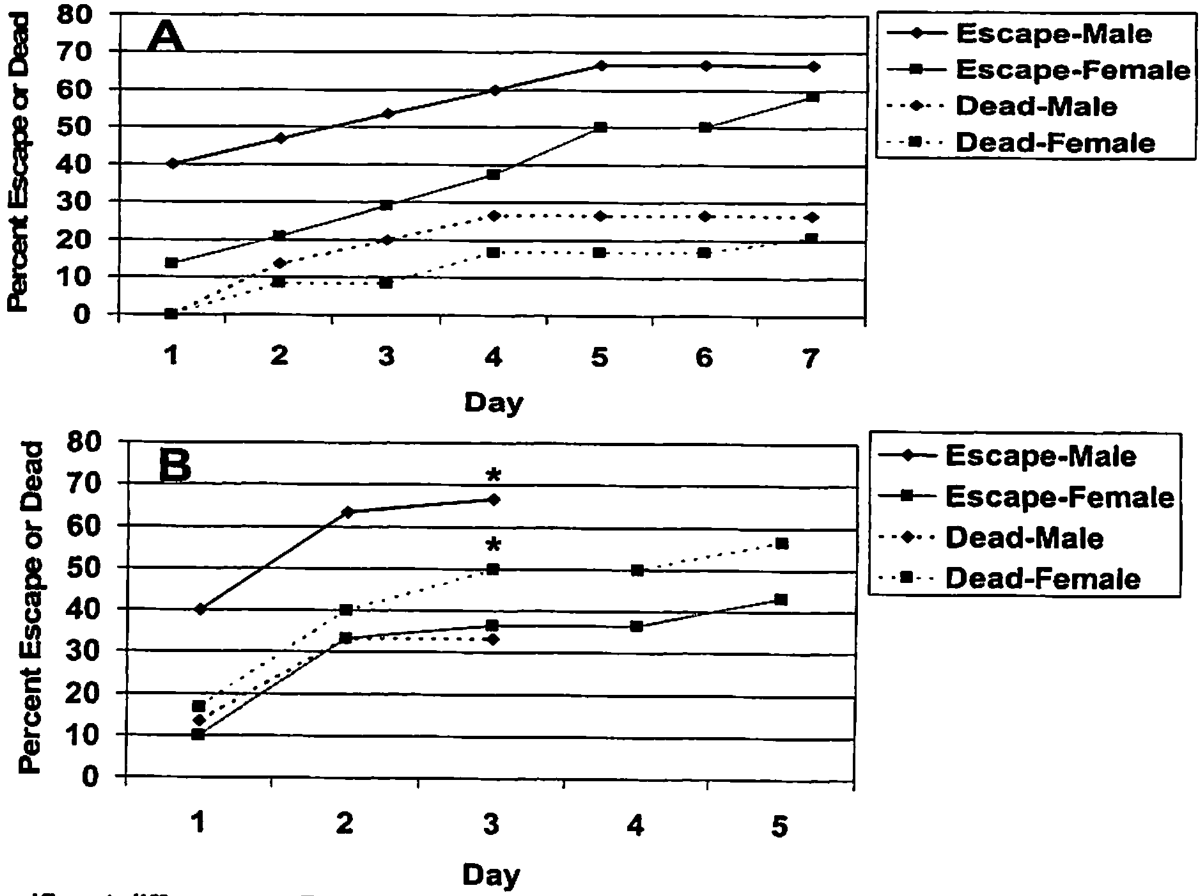
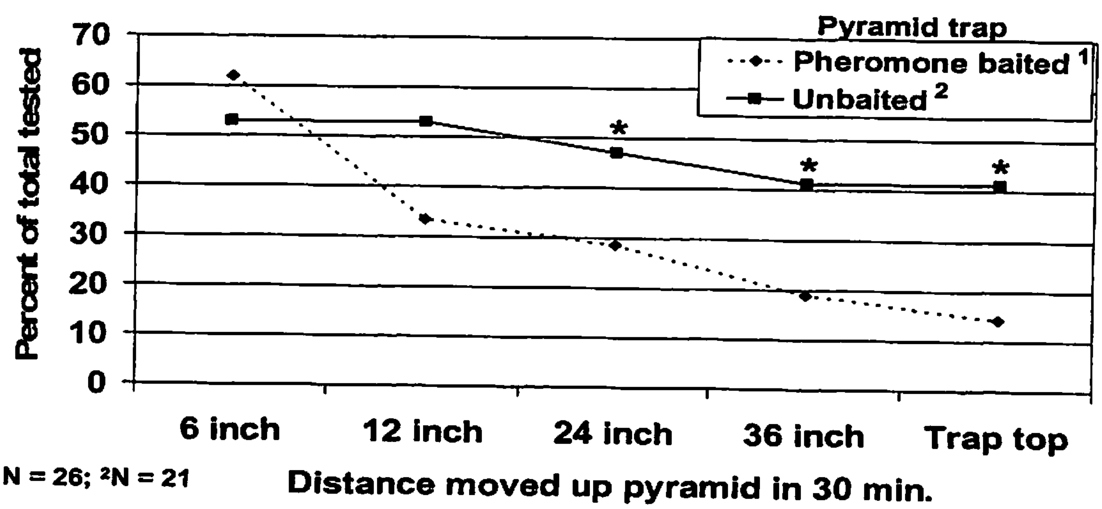


Figure 4. Seasonal occurrence of brown, dusky and green stink bugs as determined with pyramid traps in a commercial apple (A) and peach (B) orchard in 2003.



*Significant difference at P = 0.05

Figure 5. Escape and kill of brown stink bugs in pyramid trap jar tops (A) and clear jar traps (B).



[1]N = 26; [2]N = 21

*Significant difference at P = 0.05

Figure 6. Percentage of released brown stink bugs that walk to a given height on baited and unbaited pyramid traps.

Potato Leafhoppers, Fire Blight and Apogee: A look at their interaction under field conditions

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Following up on studies showing that Apogee affects fire blight and potato leafhopper incidence, and that potato leafhoppers may be associated with fire blight, we designed a field trial looking at all three factors. A three-way factorial experiment, with +/- Apogee, +/- potato leafhoppers, and +/- *Erwinia amylovora* bacteria, was performed. A block of 15-year-old Gala trees on M.26 rootstock at the Horticultural Research Center at Belchertown, Massachusetts was used for the factorial field trial.

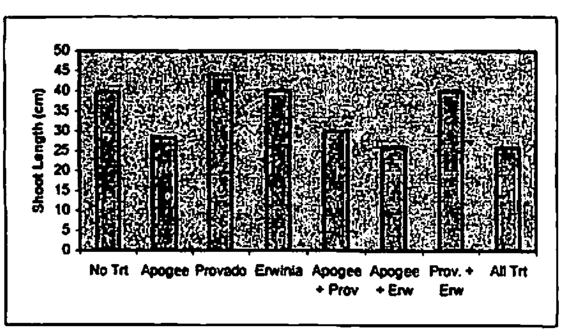
Apogee was applied in accordance with accepted horticultural recommendations used in Massachusetts, at 8-10 cm shoot growth (24 May); two additional treatments were required to achieve the desired growth suppression(7 June and 1 July). The effect of the Apogee treatment was measured by taking weekly measurements of shoot growth on 10 shoots per tree.

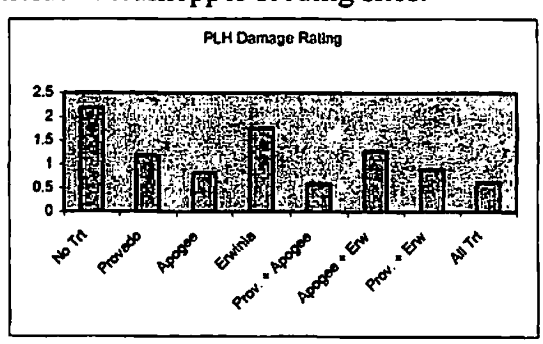
Potato leafhoppers were excluded using insecticide; we used the low-rate, frequent application schedule recommended by Straub and Jentsch at Cornell, of 0.5 oz imidacloprid (Provado) per 100 gallons tree row volume, beginning when leafhoppers arrived in late June and continuing at roughly 10-day intervals – 24 June and 8, 19 and 29 July. Potato leafhopper injury was assessed using a visual damage scale (0 = no damage to 5 = severe damage) on ten shoots per tree weekly; in addition, a spectrophotometer was used to quantify reduction in chlorophyll.

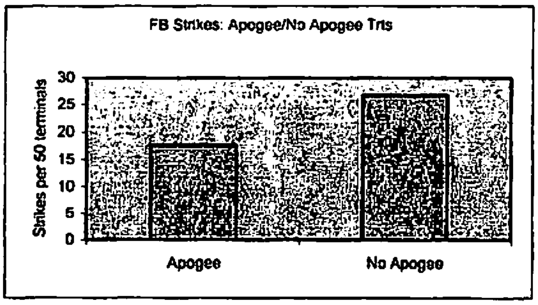
E. amylovora was introduced by spraying a colony suspension of 1 x 10^8 *E. amylovora* per ml on to tree foliage after potato leafhoppers had arrived and built up to appreciable levels (28 June). Fire blight will be assessed by determining the incidence (number of infected shoots) and severity (proportion of shoot length necrosis) of infection.

All materials were applied with a handgun to the point of drip.

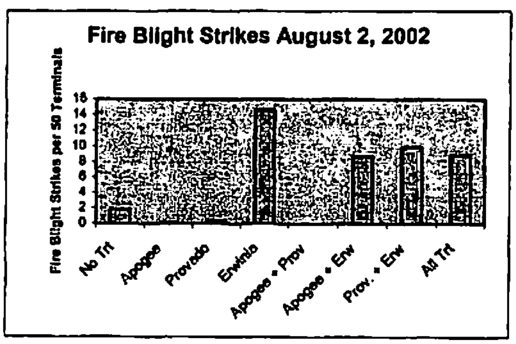
As has been seen in other research trials, Apogee significantly reduced shoot growth, fire blight incidence and severity, as well as leafhopper feeding injury. As expected, Provado significantly reduced leafhopper feeding injury, and Apogee + Provado caused a further significant reduction. We have seen this effect or combining the two materials before, and attribute it to increased retention of the insecticide at leafhopper feeding sites.

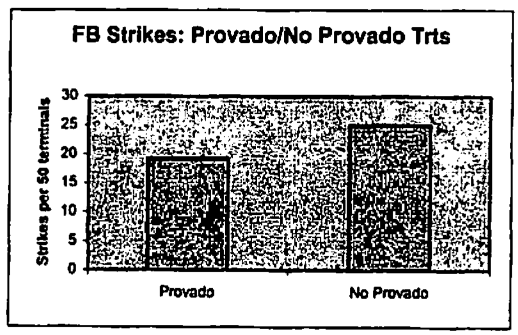




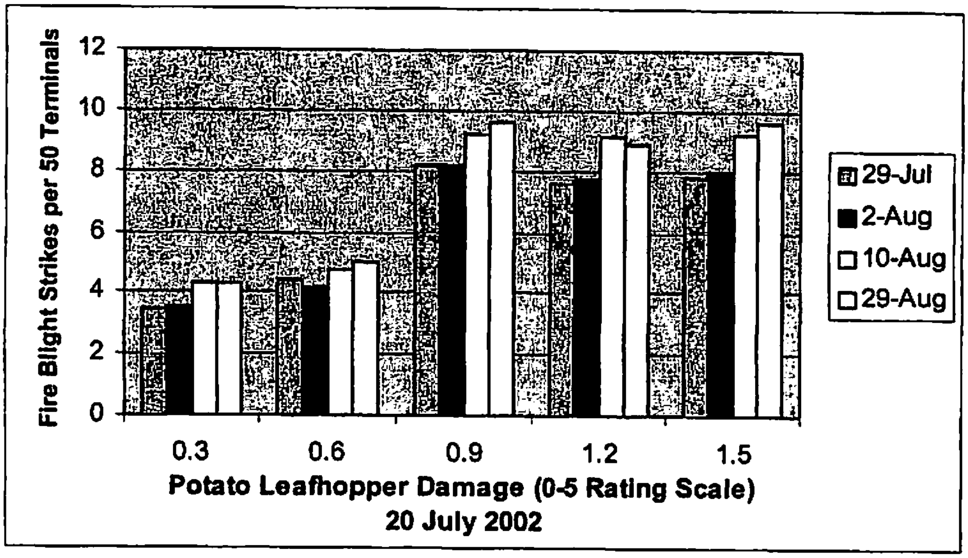


Treatment with Provado also significantly reduced fire blight incidence; control was numerically but not statistically less with Provado than with Apogee. Fire blight incidence was consistently lower in the Provado + Apogee treatments but the difference was generally not significant. The reduced incidence of fire blight suggests that insects played an important role in transmitting or facilitating fire blight. While potato leafhoppers were by far the most abundant terminal-feeding insects present throughout the study, it is possible that other insects may have been involved.





Looking at fire blight incidence and potato leafhopper injury together, we found a significant correlation at the 1% level; in particular, potato leafhopper injury on one date, 20 July, is highly significantly correlated with all subsequent observations of fire blight incidence. Thus it appears that either accumulated feeding injury up to that date, or feeding injury occurring right around that date, had a strong effect on fire blight. Since this was almost a month after the inoculation with *E. amylovora* was done, it is not immediately clear why this particular date seemed so critical. One possible explanation is that a day-long rain/humidity event occurred on July 19, the first day since the end of May where over an inch of rainfall occurred and humidity remained at >90% for about 24 hours. This may have caused resurgence in the epiphytic *E. amylovora* population, while potato leafhopper feeding may have facilitated the entry of the bacteria into the leaves.



Much work remains to be done. Caged studies with all insects excluded except potato leafhopper need to be done, and vectoring studies, to ascertain whether the leafhoppers are able to transfer bacteria from tree to tree, would also be useful. But the work to date is suggestive that potato leafhoppers do play a role in fire blight transmission, and that control of this insect when other infection conditions are met may play a role in controlling the disease.

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ASSESSING INDIVIDUAL COMPONENTS OF A MONITORING SYSTEM FOR PLUM CURCULIO

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Introduction

The plum curculio (PC), *Conotrachelus nenuphar* is a major pest of both apples and peaches in the mid-Atlantic region (Hogmire 1995). Currently, the organophosphate insecticides (OPs) azinphosmethyl and phosmet, and to a lesser degree the synthetic pyrethroids (SPs) permethrin and esfenvalerate, are the only labeled materials that provide a commercially acceptable level of PC control, although several new materials, notably thiamethoxam and indoxacarb (on apples) and kaolin clay (on apples and peaches) have recently been labeled for use against PC. In the mid-Atlantic region, plum curculio is generally managed by OP or SP sprays directed at the lepidopteran pest complex on apple or the lepidopteran/hemipteran complex on peach. However, it is likely that secondary pests such as PC in the mid-Atlantic will emerge as an increasing threat as management regimes progress toward narrow-spectrum, reduced-spray environments due to restrictions placed on broad-spectrum materials. Thus, it is imperative that treatments for PC be triggered by detection of increases in PC abundance or activity. Aside from inspecting fruit for evidence of fresh oviposition scars, which is particularly difficult on peaches, there exists no effective means for monitoring levels of PC activity in orchards.

Development of monitoring systems for PC has been based on the behavioral understanding that most adults overwinter outside of commercial orchards and immigrate into orchards at or near petal fall. Several trap types have been tested including (1) the pyramid trap, believed to provide an attractive visual stimulus by mimicking a tree trunk (Tedders and Wood 1994, Mulder et al. 1997) and has been reported to capture more crawling than flying individuals (Prokopy and Wright 1998); (2) the Plexiglas panel trap covered with Tangletrap and attached to wooden posts, designed to capture flying adult plum curculios (Prokopy et al 2000); (3) the Circle/screen trap, made of folded screen, wrapped around an orchard tree and designed to intercept crawling individuals on the tree trunk (Mulder et al. 1997); and (4) the black cylinder trap, constructed of ABS pipe, providing the visual stimulus of an upright vertical tree branch, and designed to capture crawling adults in the orchard tree canopy (Leskey and Prokopy 2002). Furthermore, in terms of baits, the combination of the aggregation pheromone, grandisoic acid (Eller and Bartelt 1996) with a synthetic fruit volatile increased captures over either bait alone (Piñero et al. 2001). In studies in which these traps and baits have been evaluated for their ability to be used as monitoring tools in West Virginia and Massachusetts, amount or timing of trap captures have failed to reflect amount or timing of oviposition injury observed in fruit trees

(Prokopy et al. 2002, Prokopy et al. 2003, Leskey and Wright in press) and have thus far failed to serve as a reliable tool to determine need for and timing of insecticide application. However, aside from the fact that PC captures decrease significantly after petal fall (Prokopy et al. 2002, Leskey and Wright in press) and olfactory cues seem to be outcompeted by natural host stimuli (Leskey 2002), little is known regarding strengths and weaknesses of particular trapping systems.

Therefore, in order to identify these strengths and weaknesses, each component of the trapping system must be evaluated independently of the others. These components include: (1) synthetic baits deployed in association with monitoring traps; (2) visual cues provided by particular traps; (3) capture mechanism of particular trap styles; and (4) deployment strategy, i.e., where and when the trap is installed. In 2003, we designed experiments to evaluate the following components: (1) known and novel olfactory cues or baits, (2) visual stimuli associated with pyramid and cylinder traps, and (3) capture mechanisms of eight different trap styles.

Materials and Methods

Olfactory Cues. On-tree volatiles were collected from a Stanley plum tree on a polymer absorbent by using a portable aeration system similar to those used by Zhang et al. (1999b) consisting of a large polyethylene bag 48.26 x 58.42 cm (Reynolds Oven Bags, Richmond VA) used as a source containment device placed over select branches (including foliage and branches) and sealed with plastic ties. A second volatile collection of plum fruit removed from plum trees was conducted with fruit placed inside a flask for 24h. For both collections, incoming air was filtered with a cylindrical borosilicate glass cartridge packed with activated charcoal (5-10 mesh), plugged with glass wool, and held in place with a plastic tie. A volatile collection cartridge was packed with 50mg SuperQ (80/100 mesh) and plugged with glass wool, connected by tubing to a vacuum pump and inserted into a bag or volatile flask. Volatiles were collected on cartridges for 24h. Trapped volatiles will be eluted by dripping 2ml dichloromethane through each cartridge. Samples were analyzed on a Hewlett Packard 6890 gas chromatograph equipped with a nonpolar capillary column in splitless mode.

Synthetic volatile baits based on natural ratios of a 6-component on-tree sample, a 7-component plum fruit-only sample, as well as the 2 major components from each were formulated into rubber septa for field deployment. Benzaldehyde alone also was formulated into rubber septa. Benzaldehyde alone or in combination with 10% 1, 2, 4-trichlorobenzene (TCB), which slows oxidation of benzaldehyde (M. Herzog, unpublished data) also was formulated into 1 ml white, UV- resistant low density polyethylene vials (Wheaton Scientific Products, Millville, NJ). For benzaldehyde formulated in UV-resistant vials without TCB, two treatments were evaluated; (1) based on weekly replacement of dispensers, and (2) based on no replacement throughout the entire study. All volatile baits formulated into rubber septa as well as the treatment evaluating benzaldehyde dispensers replaced weekly were deployed alone or in combination with grandisoic acid (ChemTica International, S.A., San Jose, Costa Rica). Dispensers of benzaldehyde in combination with TCB as well as dispensers of benzaldehyde alone that were not replaced throughout the entire experiment were deployed in combination with grandisoic acid only.

All baits were deployed in association with standard black masonite pyramid traps deployed between large apple trees within an unmanaged apple orchard. Four replicates of each bait were deployed. Within each replicate, bait location was randomly assigned. Baited traps were deployed on 4 April and checked weekly through 15 May, 2003. The number of PCs captured in each baited trap was recorded. Bait locations were re-randomized within each replicate every 7-14 d. Data were analyzed using the GLM procedure (SAS Institute 2001) to construct analysis of variance (ANOVA) tables for cumulative trap captures recorded over the entire trapping period. The model included the following class variables: bait combination and replicate. When the GLM indicated significant differences, multiple comparisons were calculated using Fishers LSD ($P<0.05$) were calculated.

Visual Cues. Standard-sized pyramid traps were constructed of black coroplast, black coroplast trimmed in white duct tape along peripheral margins, white coroplast painted with flat latex exterior green paint, and of Plexiglas to represent the following stimuli: standard black trunk-mimic, enhanced trunk-mimic (by use of increasing contrast between black and white), neutral (foliage-mimic), or no stimulus (clear Plexiglas), respectively. These same stimuli were applied to cylinder traps as well. Cylinder traps were constructed of ABS pipe (with the exception of the no stimulus trap of clear acrylic pipe) and painted with green or black flat latex exterior paint. The black cylinder trap representing an enhanced stimulus was fitted with a white coroplast trim to increase contrast. Three replicates of each trap type were deployed in a mixed fruit orchard. Pyramid traps were deployed on the ground between tree trunks and cylinder traps were deployed in the canopy on horizontal branches of plum trees, respectively. Traps were deployed on 17 April and baited with a combination of benzaldehyde and grandisoic acid. On 5 May, all baits were removed and traps remained unbaited for the remainder of the experiment ending on 3 July, 2003. Traps were checked weekly and the number of PCs captured counted. Data were analyzed using the GLM procedure (SAS Institute 2001) to construct analysis of variance (ANOVA) tables for cumulative trap captures recorded over the entire season. The model included the following class variables: trap color and replicate. When the GLM indicated significant differences, multiple comparisons were calculated using Fishers LSD ($P<0.05$).

Trapping Mechanism. Traps were deployed within a block of an unmanaged peach orchard. Four replicates of each trap type were deployed. Within each replicate, trap position was randomly assigned. All traps were baited with a combination of benzaldehyde with an average daily release of ~10 mg/day and grandisoic acid (IPM Technologies) with a reported release rate of ~0.6 mg/day. Benzaldehyde dispensers were replaced weekly. Trap types included (1) "Circle" or screen traps consisting of folded vinyl screen attached at the base of tree trunks, (2) standard black branch-mimicking cylinder traps topped by boll weevil funnel trap tops and attached to horizontal limbs within tree canopies, (3) black cylinder traps of equal dimension, but with the boll weevil collection device attached to the bottom of the cylinder rather than the top (to exploit the visual stimulus, but decrease the distance traveled for capture), attached to horizontal limbs within tree canopies, (4) standard black pyramid traps constructed of masonite, and placed between trees, (5) black pyramid traps constructed of coroplast, with a boll weevil trap top located at the top of the trap and a second boll weevil collection device inserted 30 cm from the base (IPM Technologies), (6) Lindgren funnel traps hung from metal frames placed between trees, (7) Vernon beetle traps deployed on the ground between trees, and (8) black, white and clear "snap traps" constructed of ABS pipe, fitted with inverted screen funnels at either end and attached around horizontal limbs containing fruiting clusters. Traps were deployed on 17 April and checked weekly until 19 June. The number of PCs captured in each trap was recorded. Data were analyzed using the GLM procedure (SAS Institute 2001) to construct analysis of variance (ANOVA) tables for cumulative trap captures recorded over the entire season. The model included the following class variables: trap style and replicate. When the GLM indicated significant differences, multiple comparisons were calculated using Fishers LSD ($P<0.05$).

Results and Discussion

For odor baits tested, the effect of bait ($P=0.05$) and replicate ($P<0.01$) were significant. Greatest numbers of PCs were captured in traps baited with a 6-component whole tree blend in combination with grandisoic acid, and with benzaldehyde dispensers that included the additive (TCB) in combination with grandisoic acid. Other treatments that were also very attractive included the 7-component plum blend, benzaldehyde dispensers (replaced weekly), and the 2-component plum blend, each in combination with grandisoic acid. These results confirm that grandisoic acid enhances response to synthetic fruit volatiles (Piñero et al. 2001, Prokopy et al. 2002, Leskey and Wright in press). Furthermore, these results provide new avenues for research regarding host plant volatiles as the 6-component whole tree blend identified from branches and foliage only (no plum fruit volatiles present) in combination with grandisoic acid was one of the most attractive baits deployed. Thus, by including plum fruit in whole-tree samples, we anticipate an even more attractive bait can be formulated. Furthermore, addition of TCB to benzaldehyde had no adverse effects and eliminated the need for weekly replacement of benzaldehyde dispensers. In terms of the replicate effect, results indicate that PC populations were not distributed uniformly, but instead were higher in certain regions of the orchard.

When pyramid and cylinder traps were baited, there were no significant differences among them; captures among traps with different visual stimuli were similar. However, when baits were removed, there was a significant difference among cylinder traps, with significantly fewer captures in clear cylinders compared to black or black enhanced cylinders (Table 2). This trend, though not significant, was evident for unbaited pyramid traps as well. Thus, visual cues only tend to be evident in the absence of olfactory cues. These results point to the primary importance of olfactory cues and demonstrate that they override effects of any sort of visual stimulus. Therefore, once in host tree orchards, PCs likely find host fruit primarily utilizing olfactory stimuli. Thus, in terms of developing an effective monitoring system for PC, attractive olfactory cues are absolutely essential.

Among trap types, standard pyramid and Circle/screen traps were significantly better than any other trap type (Table 3). These results likely reflect the fact that these traps exploit major points of entry of PCs in or near host fruit trees prior to entering the canopy. It appears that once PCs are in the canopy, trap captures drop off significantly based on fewer captures in standard and enhanced cylinders as well as no captures in any of the snap traps. An interesting result was observed with regard to the standard and enhanced pyramids. In this case, over 2 times as many PCs were captured in the standard compared to the enhanced. This is likely due to the difference in materials used as standard and enhanced pyramid traps are constructed of masonite and coroplast, respectively. Based on our results, it appears that PCs do not find coroplast an acceptable surface for crawling likely because it is very smooth and difficult to grip. Thus, painting the surface could improve performance. Also interesting with regard to the enhanced pyramid trap were the numbers captured in two collection devices. In the upper and lower collection devices, a total of 203 and 30 PCs, respectively, were captured indicating that more PCs were flying to traps. This finding is different than previously described in which PCs were thought to enter traps by crawling rather than flying (Prokopy and Wright 1998). Lindgren funnel, used primarily for Scolytidae, and Vernon beetle, for tropical Curculionidae, failed to provide effective capture mechanisms for PCs.

In conclusion, better baits can be developed based on whole-tree volatile collections that include plum fruit, leaves and branches. Visual cues associated with traps likely are not very important as olfactory cues appear to override any sort of visual response. Tactile or surface features of traps, however, appear to be important. Finally, both standard pyramid and Circle/screen traps appear to provide the best mechanisms of capture in terms of total PC numbers.

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Table 1. Mean ± SE PCs captured in pyramid traps baited with different synthetic odor treatments in an unmanaged apple orchard.

Bait	Mean ± SE[1]
6-Whole Tree +GA	19.0 ± 4.7a
Benz +TCB + GA	18.8 ± 4.3a
7-Plum + GA	15.5 ± 7.5ab
Benz + GA	15.0 ± 6.5abc
2-Plum + GA	14.5 ± 3.9abc
Benz(s)[2]	14.0 ± 6.0abcd
Benz(nr)[3]+GA	12.0 ± 3.0abcd
Benz	11.3 ± 3.5abcd
Unbaited	9.0 ± 2.6bcd
7-Plum	8.8 ± 4.5bcd
2-Whole Tree	8.3 ± 4.1bcd
GA	7.8 ± 1.9bcd
Benz(s) + GA	7.5 ± 2.9bcd
6-Whole Tree	6.3 ± 2.3bcd
2-Whole Tree + GA	6.0 ± 2.0cd
2-Plum	4.8 ± 1.3d

[1] Means in the same column followed by a different letter are significantly different according to one-way ANOVA followed by Fisher's LSD (P<0.05).
[2] Indicates that benzaldehyde is formulated into a rubber septum.
[3] Indicates that benzaldehyde was not replaced throughout the course of the study

Table 2. Mean ± SE PCs captured in baited and in unbaited pyramid and cylinder traps in a mixed fruit orchard.

Visual Cue	Bait Present	Pyramid Traps Mean ± SE[1]	Cylinder Traps Mean ± SE
Black	Yes	7.0 ± 1.1a	4.0 ± 1.0a
Black Enhanced	Yes	11.0 ± 2.0a	3.3 ± 0.9a
Neutral (Green)	Yes	18.0 ± 11.0a	3.0 ± 1.5a
None (Clear)	Yes	9.0 ± 3.6	2.7 ± 1.8a
Black	No	24.3 ± 10.3a	13.3 ± 1.8a
Black Enhanced	No	21.7 ± 7.9a	12.0 ± 2.0a
Neutral (Green)	No	23.6 ± 10.7a	8.7 ± 2.2ab
None (Clear)	No	5.7 ± 2.6a	4.7 ± 0.7b

[1] Means in the same column followed by a different letter are significantly different according to one-way ANOVA followed by Fisher's LSD (P<0.05).

Table 3. Mean ± SE PCs captured in traps in an unmanaged peach orchard.

Trap Type	Mean ± SE[1]
Standard Pyramid	115.0 ± 36.1a
En. Pyramid (base collection device)	58.3 ± 11.8b
Standard Cylinder	21.8 ± 9.2bc
En. Cylinder (base collection device)	11.8 ± 3.1c
Standard Circle/Screen	113.8 ± 11.9a
Lindgren Funnel	5.3 ± 1.6c
Vernon Beetle (ramp)	0.0 ± 0.0c
Black Snap	0.0 ± 0.0c
White Snap	0.0 ± 0.0c
Clear Snap	0.0 ± 0.0c

[1] Means in the same column followed by a different letter are significantly different according to one-way ANOVA followed by Fisher's LSD ($P<0.05$).

Climbing Cutworms Control in Grape - 2003

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Climbing cutworms are a sporadic but occasionally severe problem in Virginia vineyards, with few effective control alternatives. Injury is inflicted by larvae consuming primary buds at the time of bud swell. This trial used two newly-registered insecticides, Intrepid 2F (methoxyfenozide) and SpinTor 2C (spinosad), that are effective against many other Lepidoptera. In addition to the insecticides, Tanglefoot (a sticky material used in insect traps) was used as a physical barrier to prevent larvae from moving from their daytime habitat in the ground cover up the trunks onto the cordons. The block consisted of 'Seyval' vines in a vineyard in Fauquier County. Treatments were applied on 16 April, at bud swell. Insecticides were applied using a hand-held pressurized sprayer. Intrepid was applied at the rate of 114 ml/100L (16 fl oz/100 gal), SpinTor at the rate of 57 ml/100L (8 fl oz/100 gal), and Tanglefoot was applied in a band around the trunk, about 10 cm wide, starting about 20 cm above the soil surface. There were four replicates per treatment, each consisting of a panel of 3 vines, giving a total of 12 vines per treatment.

Injury assessment was made on 6 May. Shoots arising from primary buds were assessed. If a shoots was growing normally and arising from a primary bud, it was rated as healthy. If the bud was destroyed and/or replaced by a shoot from a secondary bud, it was rated as injured. Data for percent injured buds were subjected to analysis of variance, and mean separation using Tukey's HSD test.

SpinTor and Intrepid- treated vines had significantly fewer injured buds than control vines. Tanglefoot was intermediate in effect, being different from neither the insecticides nor the control. No treatment provided a uniformly high degree of control.

Table 1. Percent buds injured by climbing cutworms in a 'Seyval' vineyard block

Insecticide, formulated product/100 gal	% Injured Buds
Intrepid 2F, 16 fl. oz	10.2a
SpinTor 2C, 8 fl oz	8.4a
Tanglefoot	16.9ab
Control	26.8b

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

Evaluation of the efficacy of three non-organophosphate insecticides toward grape berry moth - 2003

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

A spray trial was performed in a vineyard in Ladd, Augusta County, using Concord vines. This vineyard has a history of consistently high populations of GBM. The following materials were tested: Intrepid 2F (methoxyfenozide) 16 fl oz/100 gal, SpinTor 2C (spinosad) 8 fl oz 100 gal, Dipel 4L (*Bacillus thuringiensis*) 32 fl oz/100 gal, and Dipel 4L 64 fl oz/100 gal. An untreated control was included. Spray dates were applied Jul 8, 25, Aug 12, 27, Sep 10. Intrepid was not applied on the last two spray dates because of the long preharvest interval conflicting with the anticipated harvest date. Treatments were applied using a backpack sprayer. There were four replications per treatment, each consisting of a panel of 3-4 vines. Two reps were in the edge row, and two in the next vineyard row. A randomized block design used vineyard row as the blocking factor. Intrepid and SpinTor were both registered for grape last year. Two rates of Dipel were used because of increased grower interest and frequent questions on efficacy toward GBM.

Grapes were harvested on Sep 17. Ten clusters of grapes were collected from each panel, for a total of 40 clusters per treatment. Clusters were retrieved to Blacksburg, where berries were removed from the rachis and inspected individually for GBM injury.

Intrepid provided the most complete control of GBM injury. SpinTor also provided control, damage in those vines being intermediate between Intrepid and the control. The high rate of Dipel while not statistically different from SpinTor, was also not different from the untreated control vines. The low rate of Dipel was not different from the control. The extremely wet season in 2003 provided challenging conditions for all the materials, but may have affected Dipel more than the other insecticides. Control may have improved somewhat with shorter spray intervals. Numbers of live larvae still in the clusters were too low to provide significant results, though apparently numbers reflected approximately the same pattern as injured berries.

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

Treatment, rate/100 gal	% injured berries	Mean live larvae/cluster
Intrepid 2F, 16 fl oz	1.3a	0.02a
SpinTor 2C, 8 fl oz	2.8ab	0.05a
Dipel 4L, 64 fl oz	8.5bc	0.18a
Dipel 4L, 32 fl oz	13.6c	0.45a
Control	14.5c	0.30a

Means in a column followed by the same letter are not significantly different, α=0.05 (Tukey's HSD test)

Comparing Release Technologies for Pheromone-Based Mating Disruption of Codling Moth and Oriental Fruit Moth in Virginia - 2003

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

A major impediment to the adoption of CM/OFM mating disruption has been the cost. Recently, alternative pheromone dispensing systems have become available. It is desirable to compare the competing technologies in order to better incorporate mating disruption into management programs. The main technologies to be incorporated are Isomate rope-style dispensers (CM/OFM-TT, a combination product for both species), IPM Tech LastCall attract and kill, and 3M Canada sprayable pheromones.

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

- **Botetourt** – 2003 was second year of MD; light population of CM, moderate-high pressure of OFM
- **Albemarle** – by 2003, had been in MD program for several years; light population of CM, moderate-high pressure of OFM
- **Rappahannock** – 2003 was the second year of MD; severe problems with internal feeders (for past two years have worked with timing, pesticide chemistry, and calibration issues; have improved situation, but insufficient progress). This year, we attempted to combine mating disruption with a normal insecticide program in an effort to control this intractable population.

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, 400 fruit per plot were collected for final damage evaluation (100/plot in Rappahannock).

Botetourt County: In a 'Rome' and 'Jonathan' orchard block in Troutville, Botetourt County, three pheromone treatment programs were established in separate 5-acre blocks. Trees were about 15' tall, in a 15'x25' spacing (120 trees/A). Combination rope pheromone dispensers (CM/OFM-TT) were place on 2 May. Last Call CM was applied on 7 May and 25 June; Last Call OFM was applied on 9 May and 25 June. 3M Sprayable Pheromone was to be applied for OFM (1.7 fl oz/A) and CM (8 fl oz/A). In pheromone-treated blocks, a conventional insecticide program was followed through first cover. Three pheromone traps each for CM, OFM, VLR, TBM, and RBL were placed in each block and monitored weekly. Harvest injury was assessed on 30 September. At that time, 200 fruit from the edge and center of each block were picked and returned to Blacksburg for examination, for a total of 400 fruit per pheromone treatment.

Albemarle County: Sections of an apple orchard composed primarily of 'Delicious' trees at Miller School, Albemarle County, were treated with several types of pheromone dispensers for CM and OFM. Trees were 2.4-3.0 m tall (8-10 ft), in a 10'x15' spacing (290 trees/A). In section A, a rope-style dispenser (CM/OFM-TT) was used (500/ha (200/A) on 30 April) (ca 10 A (4 ha)). In section B, 3M Sprayable Pheromone was applied for OFM (1.7 fl oz/A) and CM (8 fl oz/A). In section C, 3M Sprayable Pheromone was applied for late season OFM activity, starting in late July (1.7 fl oz/A; 12 g ai/A) and CM (8 fl oz/A; 18 g ai/A). Section D was a conventionally treated control. Azinphosmethyl was applied at first cover (5/24) (diazinon in the 3M sprayable block). The control block received Agri-Mek plus azinphosmethyl or diazinon (6/2), Intrepid (6/12), methoxyfenozide and azinphosmethyl 7/1, azinphosmethyl (7/9 and 7/18), azinphosmethyl/methomyl (8/13), phosmet (8/27), and azinphosmethyl/methomyl (9/5). The CM/OFM-TT block received methoxyfenozide (6/18), azinphosmethyl/methomyl (8/13). The main 3M sprayable received CM MEC (6/13, 7/11, 8/26), OFM MEC (6/19, 7/11, 8/26) and azinphosmethyl/methomyl (8/13). The late 3M block was treated once for both species on 8/30.

Fruit were examined on the tree periodically during the season; 10 fruit were examined on each of 20 trees. Harvest injury was assessed on 16 September. At that time, 200 fruit from the edge and center of each block were picked and returned to Blacksburg for examination, for a total of 400 fruit per pheromone treatment.

Rappahannock County: A mixed block ('Delicious', 'Golden Delicious', 'York') in Washington, Rappahannock County, was selected for the mating disruption trial as part of a multi-pronged attempt to control intense internal feeder injury. Trees were about 20-22 feet tall, with thick canopies. The ShinEtsu CM/OFM-TT combination ropes were was the only disruption treatment.

III. Results and Discussion:

Flight data: Moth flights differed markedly among the orchards for both moth species. Flight data for CM and OFM in Botetourt County are given in Fig. 1. Catches of both species were almost totally disrupted (a single CM was collected in the LastCall block on 30 Jul, and 3 OFM were collected in the Isomate block on 25 Jun. Catches of OFM started to rise in the LastCall block at the end of the season because the last application of these products was omitted. Both species were commonly collected in the sprayable block because the product was not applied in a timely manner, partly as a result of the extremely rainy season.

Flight data for Albemarle County are given for CM and OFM in Fig. 2. No CM were trapped in any of the CM traps in this orchard. Catches of OFM did exceed the treatment threshold several times during the season in the control. OFM catches were reduced by 91.3% in the Isomate block, and by 79.7% in the full season sprayable block. Catches were not reduced in the late application block.

In the Rappahannock County orchard, there were high trap counts for both species in the control block (Fig. 3). Nevertheless, there was almost total trap shutdown in the mating disruption block for both CM and OFM. Levels of shutdown were more pronounced than in the previous year in this orchard (a fairly high degree of trap shutdown was also seen in 2002) (Pfeiffer et al. 2002).

Damage data: Botetourt County: Both the Isomate and LastCall treatments provided good control of both internal feeders. There was substantial injury from internal feeders in the sprayable block (10-14%). Where the identity of the larva could be established, the distribution was almost equal between CM and OFM.

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

Rappahannock County: On 5 Sep, 100 fruit were collected from 10 trees/block. The data are presented in Table 3.

Summary: The two hand-placed dispensing systems resulted in complete or nearly complete trap shutdown, and provided control of internal feeders, once treatments were initiated. OFM captures in the LastCall treatment increased somewhat at the end of the season with the omission of the last application. The sprayable treatment was at a disadvantage this season because of extremely rainy weather and significant injury occurred in one of the orchards. The use of late season sprays of pheromone shows promise since damage was at very low levels in this treatment; more work is needed here, however, since trap shutdown did not occur in this block.

Table 1. Percent fruit injury in mating disruption plots compared with conventional standard in Botetourt orchard (2003) (four samples of 50 fruit in each plot section; 400 fruit per pheromone treatment)

Treatment		Internal	Platynota	RBL	SJS
Control -	Edge	6.5	2.0	0.5	5.5
	Center	0	0	1.5	0.5
LastCall -	Edge	0.5	0.5	2.0	6.0
	Center	0	1.0	0.5	0.5
Isomate -	Edge	0	3.0	1.0	7.0
	Center	0	1.5	0.5	6.0
3M -	Edge	14.0	1.5	0	6.0
	Center	10.0	3.0	0	2.5

Table 2. Percent fruit injury in mating disruption plots compared with conventional standard in Albemarle orchard (2003) (four samples of 50 fruit in each plot section; 400 fruit per pheromone treatment)

Treatment		Internal	Platynota	RBL	TPB
Control -	Edge	0	0	0	0
	Center	0	0	0	0.5
3M -	Edge	1.0	1.0	0	0
	Center	0	2.5	0	0.5
3M Late -	Edge	0	0	0.7	0
	Center	0	0	2.0	0.5
Isomate -	Edge	0	2.5	0	0
	Center	0	1.0	0.5	0.5

Table 3. Percent fruit injury in mating disruption plots compared with conventional standard in Rappahannock orchard (2003) (100 fruit/treatment)

Treatment	Internal	Live CM	Live OFM	Leafrollers	TPB	GFW	SJS
Isomate	9.2	6.5	0.1	4.2	0.1	0.2	0.2
Control	9.6	6.8	0.0	2.4	0.6	0.1	1.0

IV. References Cited:

Pfeiffer, D. G., W. Kaakeh, J. C. Killian, M. W. Lachance and P. Kirsch. 1993. Mating disruption for control of damage by codling moth in Virginia apple orchards. Entomol. Exp. Applic. 67: 57-64.

Pfeiffer, D. G. and J. C. Killian. 1988. Disruption of olfactory communication in oriental fruit moth and lesser appleworm in a Virginia peach orchard. J. Agric. Entomol. 5: 235-239.

Pfeiffer, D. G., X. Zhang, M. H. Rhoades, J. C. Bergh, J. Engleman, B. Short, K. Love and B. Jarvis. 2002. Comparing Release Technologies for Pheromone-Based Mating Disruption of Codling Moth and Oriental Fruit Moth in Virginia - 2002. Proc. Cumberland-Shenandoah Fruit Workers Conf., Winchester.

Fig. 1. Codling moth captures and oriental fruit moth flight data in a mating disruption block - Botetourt County

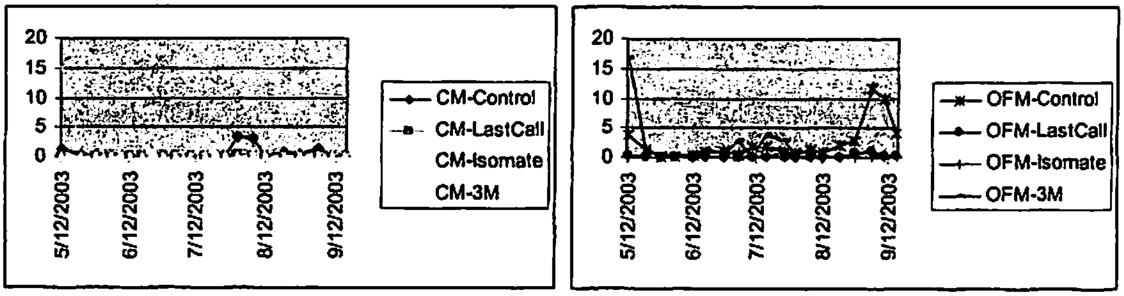


Fig. 2. Codling moth captures and oriental fruit moth flight data in a mating disruption block - Albemarle County

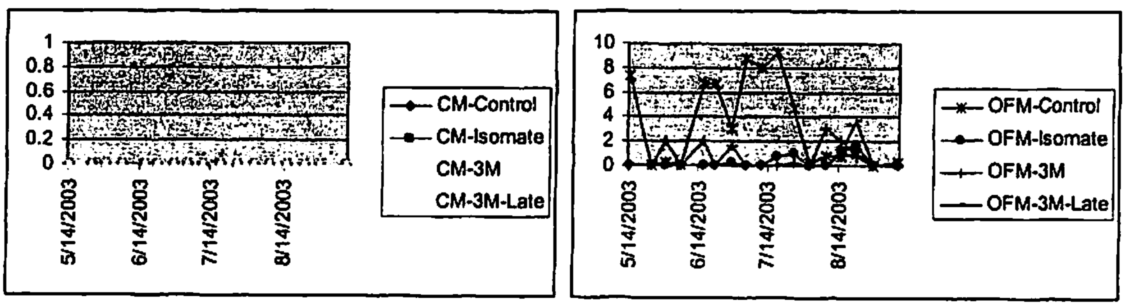
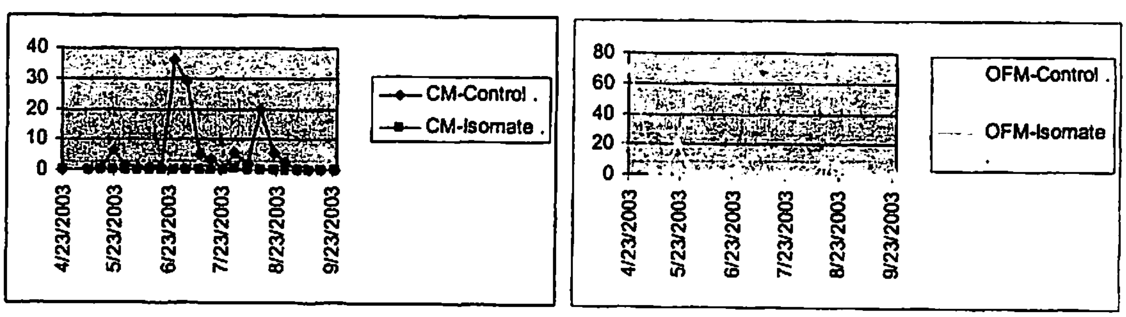


Fig. 3. Codling moth captures and oriental fruit moth flight data in a mating disruption block - Rappahannock County.



Virginia Fruit AdVisor: Using Personal Digital Assistants in Fruit IPM

Douglas G. Pfeiffer, Kenner Love and X. Zhang
Department of Entomology, Virginia Tech, Blacksburg, VA 24061

The Virginia Fruit AdVisor Project: The Fruit AdVisor project endeavors to use PDAs as extension delivery tools, specifically for the dissemination of fruit IPM information and other fruit related issues. Users will have installed in their PDAs information on pest biology, monitoring methods, current population activity, pest control recommendations, and updated regulatory issues. Pest trapping data collected in individual orchards may be uploaded to an IPM specialist's computer, facilitating evaluation of data, and creating of a trapping data network.

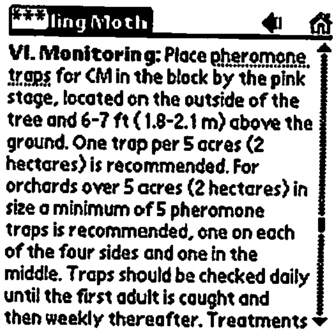
Although the current status is as a pilot program for Virginia fruit producers, the final product will lend itself easily to growers in other states in the Southeast, and can be adapted to other commodities as well, largely by substituting files contained in the PDA. Specific applications that work towards the goals of the project are discussed below:

Personal Digital Assistants: Personal digital assistants (aka PDAs, organizers, handhelds) are small (pocket-sized) computers that have become popular as personal organizers. Many popular models have 8-16 MB of memory; some models possess quite a bit more, but at a higher cost. Basic functions may be adapted for the individual user (address book, date book, expenses, to-do-list, etc.).

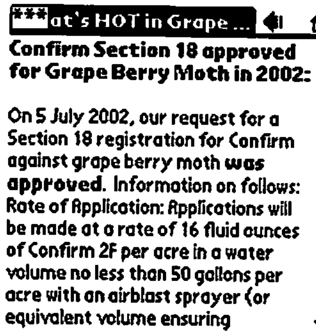
Data files are backed up and updated when the PDA is synchronized with a desktop computer. The user may also use backup modules or cards, available at an extra cost. This extra safeguard may easily pay for itself with added security. Several operating systems are available. PDAs using Palm OS were selected for this project because of cost and flexibility.

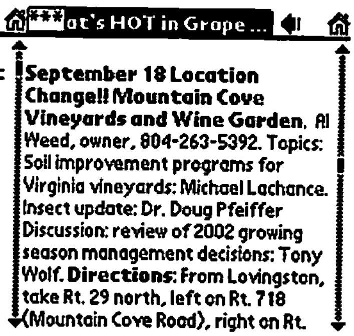
Virginia Fruit Web Site: When the PDA is synchronized with the desktop computer, the current versions of selected web pages are installed on the device using free software (AvantGo). Pages may also be updated using wireless connection. The existing Virginia Fruit Web Site has been modified and streamlined to fit the small format of the PDA, and the crop pages (apple, grape, stone fruit, pear, and small fruit) are available as AvantGo channels. Examples of the information included are:

- Population biology and pest identification and monitoring:

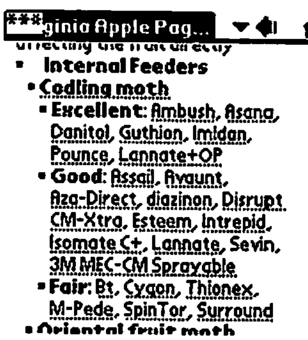


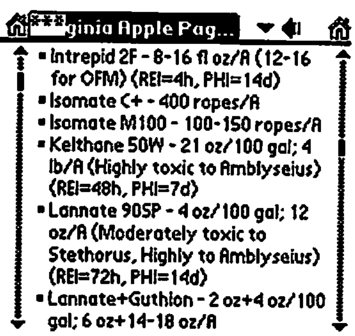
- Updates on pest development and regulatory issues. Regulatory changes can be announced as soon as they are known to the extension specialists, updated in the web page, and installed automatically into the grower's PDA upon the next synchronization. Notice of grower meetings. This feature has been used to announce planned meeting at the beginning of the season, as well as changes in meeting site or date.





- Current fruit pest control recommendations (pest recommendations and pesticide information). Changes in registration status (either new or cancelled uses) can be reflected much more rapidly here than in hard copy publications or the Virginia Cooperative Extension's posted PDF version. When a pesticide of desired efficacy is selected, the user is directed to rates, REI and PHI data.

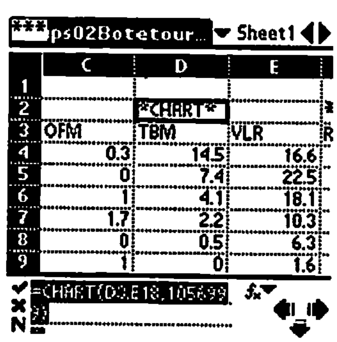




- The following web pages are installed as AvantGo channels for the project (a grower may select crop pages of interest):
  - Virginia Apple AdVisor - (http://www.ento.vt.edu/Fruitfiles/VisorApple.html) (channel size 350k)
  - Virginia Grape AdVisor - (http://www.ento.vt.edu/Fruitfiles/VisorGrape.html) (channel size 180k)
  - Virginia Peach AdVisor - (http://www.ento.vt.edu/Fruitfiles/VisorPeach.html) (channel size 220k)
  - Virginia Pear AdVisor - (http://www.ento.vt.edu/Fruitfiles/VisorPear.html) (channel size 220k)
  - Virginia Small Fruit AdVisor - (http://www.ento.vt.edu/Fruitfiles/VisorSmallFruit.html) (channel size 170k)
    - **For Virginia fruit pages, select channel size indicated, link depth=2, no images**
  - AccuWeather - package channel at AvantGo
  - Fruit Growers News - (http://www.fruitgrowersnews.com) 100k, link depth=1
- Through wireless connectivity, there is also the potential for active web browsing. Several wireless PDA models are available.

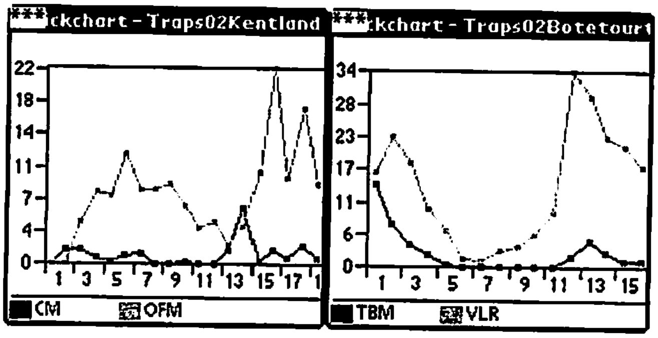
Record-keeping and data collection

- Enter scouting data and instantly generate graphs of population activity while in field. Quicksheet (also available as a part of QuickOffice) may be used to generate spreadsheets that are compatible with Excel. This may be used to generate graphs (see examples directly below). Pendragon Forms may also be used as a stand-alone software to collect trapping data. Growers participating in the Virginia Fruit AdVisor program may enter trapping data into PDA and upload automatically to a specialist's desktop (DGP) using Pendragon Forms/SynchServer (see under Networking below).
- Spreadsheet in Quicksheet is compatible with Excel



	C	D	E
1			
2		*CHART*	
3	OFM	TBM	VLR
4	0.3	14.5	16.6
5	0	7.4	22.5
6	1	4.1	18.1
7	1.7	2.2	10.3
8	0	0.5	6.3
9	1	0	1.6

- Generate line graphs of population activity while still in field:



- Keep mandated spray records while in spray shed, automatically backup on synchronization (either through Quicksheet or Pendragon Forms)

- Digital images may be created using the eyemodule2 Digital camera for Visor. When images are transferred to the desktop, they are in color, even with monochrome PDA models. These images may then be sent by e-mail to extension agents or specialists for aid in evaluation.

Networking

- Networking scouting data with Pendragon SyncServer - A participating grower, agent, or scout may collect field data into the PDA, and upon synchronization, automatically upload trap data, etc., to an IPM specialist. This will facilitate evaluation of population trends, as well as allowing creation of a trapping data network.

- E-mail capability, uploading and downloading upon synchronization
- Power-Point Extension presentations may be made using Presenter-to-Go, for presentations stored in a PDA, connected to a digital projector.

GIS, GPS

- Several GPS receivers on available for PDAs. New - Garmin GPS incorporated into PDA (Garmin iQue 3600).
- Currently can mark locations of individual farms. Potential for farm-level mapping?
- Track movement of new pest distribution though state?

Not for Citation or Publication
Without Consent of the Author

GROWER TRIALS FOR CONTROL OF INTERNAL LEPIDOPTERA IN WESTERN NEW YORK, 2003

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Apples in New York state are attached by a complex of species of internal lepidoptera, the codling moth *Cydia pomonella* (Linnaeus), Oriental fruit moth *Grapholitha molesta* (Busck), and Lesser appleworm *Grapholitha prunivora* (Walsh). Traditionally, NY growers have obtained excellent control of this complex of pests by using organophosphate insecticides that were primarily scheduled to control other direct pests feeding upon fruit such as the plum curculio *Conotrachelus nenuphar* (Herbst) and the apple maggot *Rhagoletis pomonella* (Walsh). During the last several years, damage from internal lepidoptera has gradually increased in the western NY apple production region, and in 2002 more than 80 loads of processing apples were rejected from a group of approximately 42 apple growers in western New York state. Subsequent inspections of samples of larvae collected from infested fruit within this production area showed that most of them were oriental fruit moth. The objective of this study was to compare the effectiveness of different insecticides and treatments of sprayable pheromone with and without sprays of Avaunt (indoxacarb) in controlling oriental fruit moth in commercial apple orchards in NY state that had been heavily infested with larvae at harvest (10-20%) during the previous (2002) growing season.

MATERIALS AND METHODS

The following treatments were compared in 5 commercial orchards: (1) Imidan 70W, 4 lbs/A. (2) Avaunt 30 WDG, 5.0 oz/A. Warrior SCP, 5.0 oz/A. (3) Sprayable formulations of Oriental Fruit Moth pheromone (3M Corporation and SUTERRA) applied at 2.0 oz/A during the first spray and 1.0 oz/A in subsequent, sprays, and (4) Sprayable pheromones applied as in treatment (3), except that Avaunt 5.0 oz/A was also applied as a tank mix in the first two sprays. The original plan of this research was to let growers apply normal control programs for the control of the plum curculio during the early part of the season in the test orchards. Then a phenology model developed at Pennsylvania was going to be used to time an initial insecticide treatment at 1250 DD (base 50°) after the codling moth biofix, followed by a second application at 1600 DD followed by a third spray at a 10-14 day interval if necessary. Another treatment of Imidan was also going to be set up in which the first spray after 1250 DD was going to be applied whenever pheromone trap catches exceede thresholds of 5 codling moths/trap week or 10 oriental fruit moths/trap/week. After the plots had already been set up, we decided to apply Imidan in both plots on the same schedule based on predictions of oriental fruit moth development rather than using trap catch thresholds. Early in the season after petal fall, initial observations indicated that the phenology model for timing oriental fruit moth sprays was not accurately predicting the seasonal activity of this pest during the 2003 growing season.

Therefore, initial sprays of all programs including pheromones were applied about 175-200 DD after initial trap catches increases in the plots suggested that the second flight of OFM had begun. Then, three subsequent sprays were applied in all of the insecticide plots at 10-14 day intervals. The initial spray in all plots was applied ca. on July 16 and the last sprays were applied during the last week in August. The size and relative proximity of the insecticide plots varied among all of the 4 test orchards. The insecticide plots were approximately 5A on the B and DB farms, but much smaller on the D and V farms. Whenever possible the insecticide trials were set out in adjacent plots containing the same size and cultivars. All pheromone plots were applied to 10A split plots. An initial spray of pheromones was applied at the same time the insecticide treatments began. Then the pheromone plots were sprayed three more times at 10-14 day intervals. The entire 10A pheromone plot was always treated with sprayable pheromones, but one-half was also treated with a tank mix of Avaunt (5.0 oz/A) during the first two sprays. No insecticide sprays were ever applied to the pheromone side of the plots on the B farm, but one spray of Avaunt was applied in late August in the Pheromone side of all plots on the D, DB, and V farms because fruit monitoring detected that low levels of internal lepidoptera were present later in the season in August.

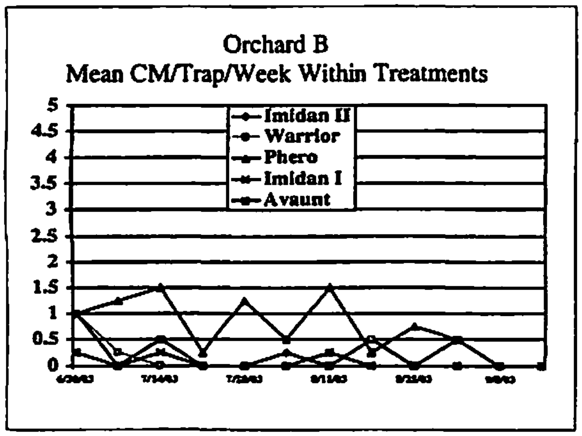
Two Pherocon IIB pheromone traps were set out in the center of each insecticide plot and in the center of each half of the 10A pheromone treatments during the first week in July prior to the beginning of the second flight of oriental fruit moth. These traps were checked twice weekly throughout the season. Fruit was sampled on the trees throughout each block weekly from the last week in June until the last week in August. Each week, a total of 600 fruit was examined for internal lepidoptera (20 fruit on each of 30 trees). At harvest, 600 fruit were harvested from each plot (20 fruit on each of 30 trees), and cut to determine if any infestations of larvae were present. A total of 600 apples was also harvested in each of the two "split plots" in the pheromone treatment, but samples were stratified in different locations. A sample of 100 fruit was collected (20 apples from 5 trees) on each edge of the plots and a similar sample of 100 apples was taken from the center of each plot so that damage could be compared in different locations.

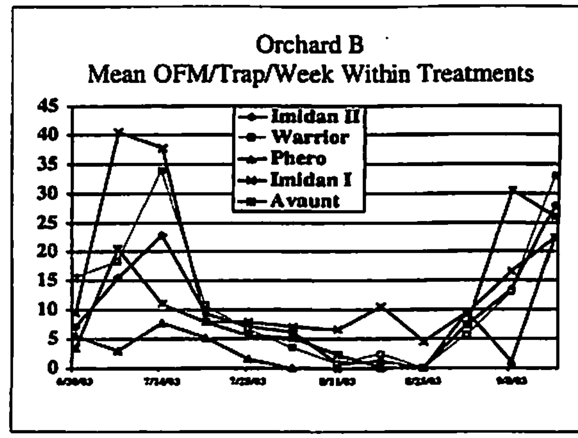
RESULTS AND DISCUSSION

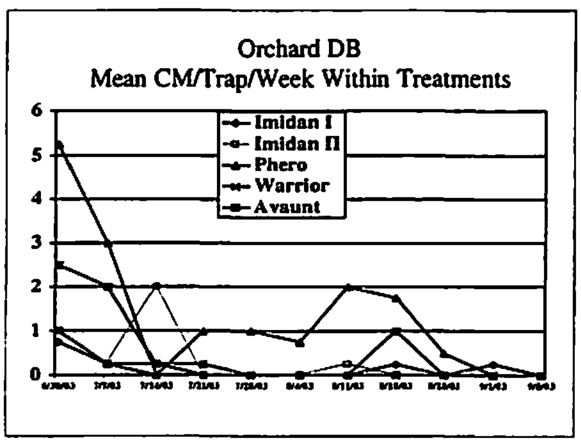
A comparison of the seasonal flight patterns of codling moth and oriental fruit moth is shown for orchard B, which had generally high population pressure from oriental fruit moths, and orchard DB, which had relatively low populations of both species of moths. Codling moth catches were generally low throughout the season in most of the research orchards. In contrast, trap catches of oriental fruit moth were very high early and late in the season in orchard B in all treatments except the pheromone block. Catches of oriental fruit moth were low in all treatments in the DB orchard, and never exceeded the original proposed treatment threshold level of 10 moths/trap/week.

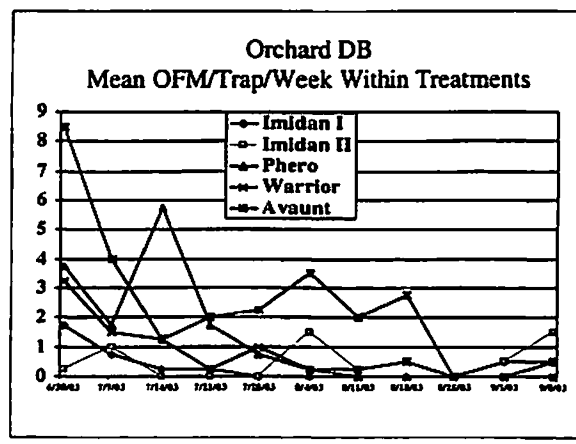
Infestation levels in the weekly fruit samples in all of the treatments in most of the blocks remained very low from the end of July until the last sample was taken in August, and there was no particular pattern of increasing or decreasing damage in any of the treatments. The highest damage observed prior to harvest occurred in the last samples taken on August 24. On that date, the pheromones alone and the Imidan I treatments had the highest levels of damage in the combined samples from all orchards, but the overall average damage in these plots was still less than 1%. Most of the damage observed in the combined Imidan I treatment came from the single plot set up in Orchard B.

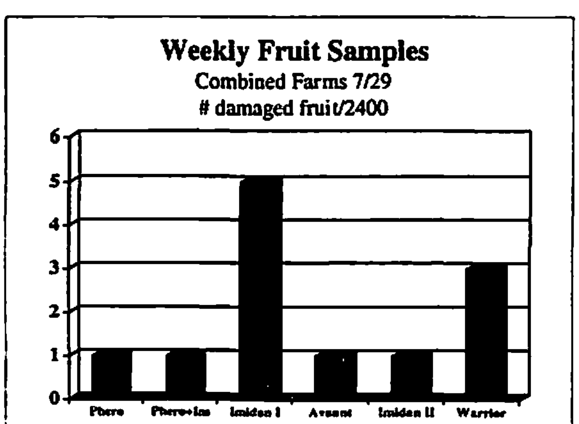
Damage from internal lepidoptera was considerably higher than that observed throughout the season in almost all of the treatments when fruit was evaluated for damage just before harvest. These results suggest that most of this damage occurred after labor day in September and early October, and this late season injury was presumably due to late season activity of the oriental fruit moth. However, even though some infested fruit was observed in most of the treatments, except in the Warrior plots, control was generally commercially acceptable except in one Imidan plot in orchard B, which had almost 16% damage, and in the plots receiving only early sprayable pheromone treatments in the D and DB farms. Warrior, was the most effective insecticide treatment, followed by Avaunt, and Imidan. The integrated program of Avaunt and sprayable pheromones was slightly more effective in protecting fruit than the programs using pheromones alone during the early part of the season.

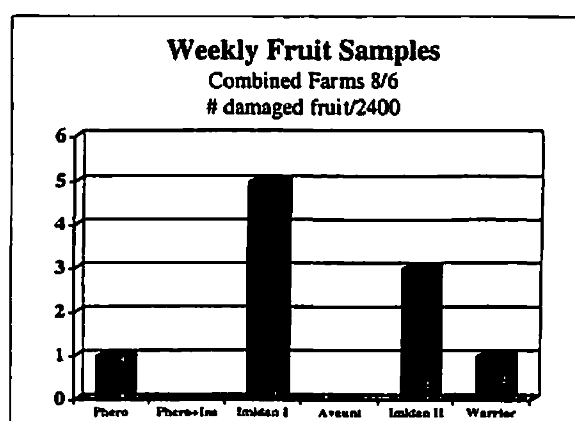

Orchard B
Mean CM/Trap/Week Within Treatments
Imidan II
Warrior
Phero
Imidan I
Avaunt
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0

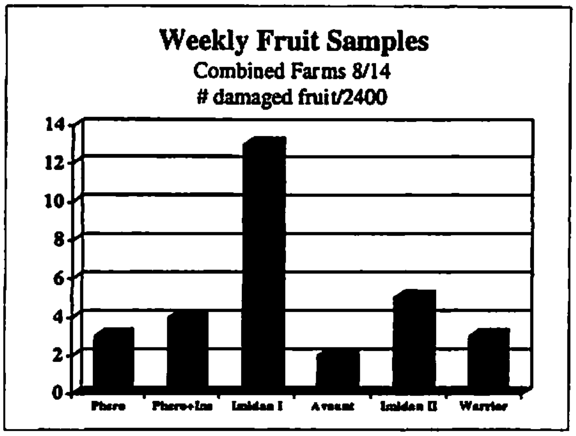

Orchard B
Mean OFM/Trap/Week Within Treatments
Imidan II
Warrior
Phero
Imidan I
Avaunt
45
40
35
30
25
20
15
10
5
0

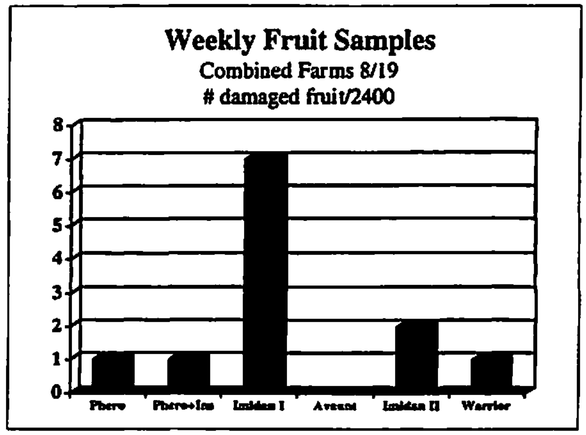

Orchard DB
Mean CM/Trap/Week Within Treatments
Imidan I
Imidan II
Phero
Warrior
Avaunt
6
5
4
3
2
1
0

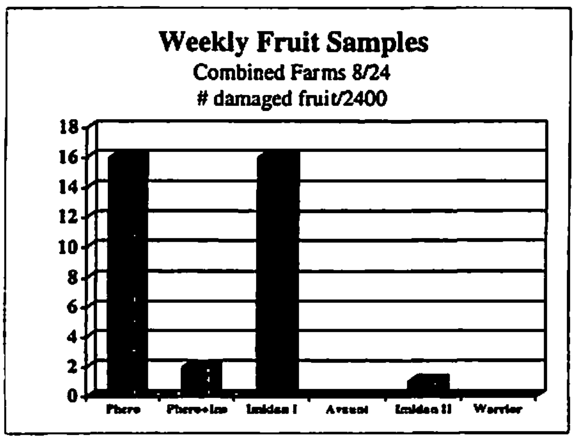

Orchard DB
Mean OFM/Trap/Week Within Treatments
Imidan I
Imidan II
Phero
Warrior
Avaunt
9
8
7
6
5
4
3
2
1
0

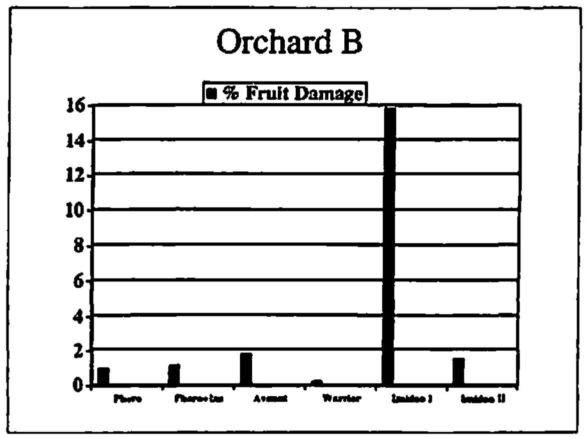

Weekly Fruit Samples
Combined Farms 7/29
damaged fruit/2400
6
5
4
3
2
1
0
Phero
Phero+Ins
Imidan I
Avaunt
Imidan II
Warrior

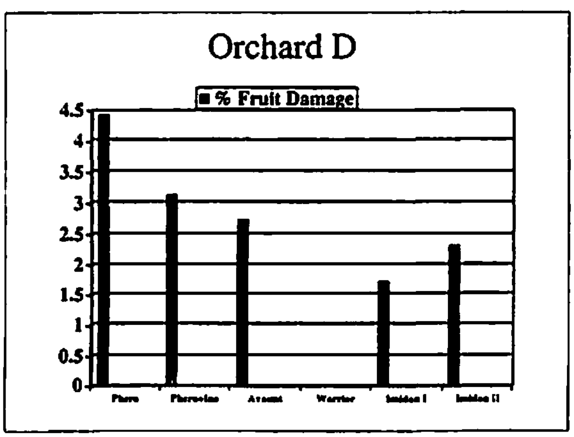

Weekly Fruit Samples
Combined Farms 8/6
damaged fruit/2400
6
5
4
3
2
1
0
Phero
Phero+Ins
Imidan I
Avaunt
Imidan II
Warrior

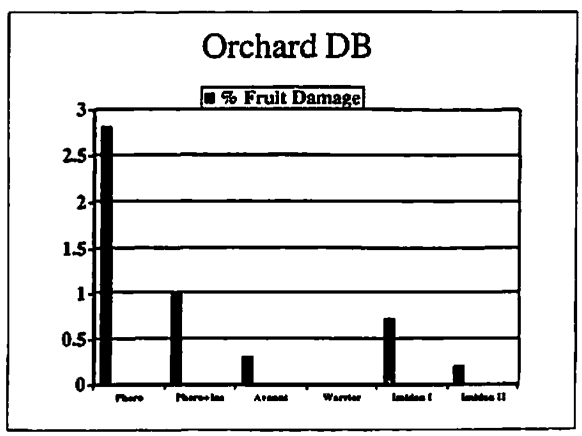

Weekly Fruit Samples
Combined Farms 8/14
damaged fruit/2400
0 2 4 6 8 10 12 14
Phero
Phero+Ins
Imidan I
Avaunt
Imidan II
Warrior

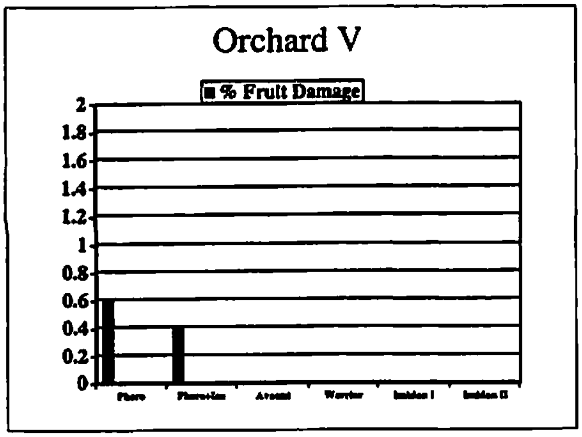

Weekly Fruit Samples
Combined Farms 8/19
damaged fruit/2400
0 1 2 3 4 5 6 7 8
Phero
Phero+Ins
Imidan I
Avaunt
Imidan II
Warrior

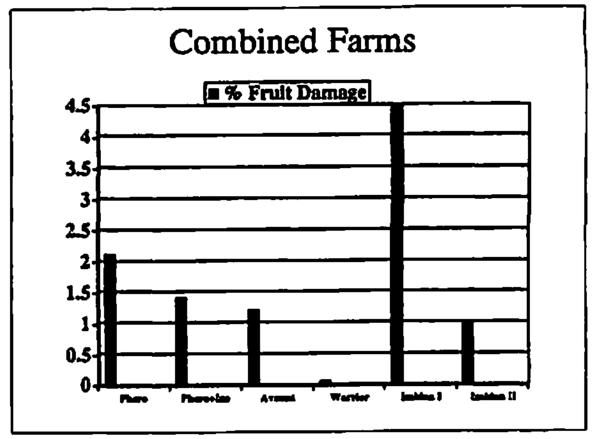

Weekly Fruit Samples
Combined Farms 8/24
damaged fruit/2400
0 2 4 6 8 10 12 14 16 18
Phero
Phero+Ins
Imidan I
Avaunt
Imidan II
Warrior


Orchard B
% Fruit Damage
0 2 4 6 8 10 12 14 16
Phero
Phero+Ins
Avaunt
Warrior
Imidan I
Imidan II


Orchard D
% Fruit Damage
0 0.5 1 1.5 2 2.5 3 3.5 4 4.5
Phero
Phero+Ins
Avaunt
Warrior
Imidan I
Imidan II


Orchard DB
% Fruit Damage
0 0.5 1 1.5 2 2.5 3
Phero
Phero+Ins
Avaunt
Warrior
Imidan I
Imidan II


Orchard V
% Fruit Damage
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0


Combined Farms
% Fruit Damage
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0

A Why What and When Approach to San Jose Scale, 2003

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Dilute to runoff sprays were applied with a handgun sprayer (400-psi) at several timings with various materials through out the 2003 growing season. Applications were made at apple phonology green tip (GT) (18 April), half-inch green (HIG) (24 Apr), and then two sprays for each of the summer broods based on a degree day egg hatch model. Sprays for the first generation of crawlers were timed at 310 DD (24 Jun) after first male catch or 500 DD from 1 March (base 50^0) followed by a second spray 14 days later (8 Jul). Sprays for control of the second generation of crawlers were timed for 400 DD (13 Aug) after first male catch of the second generation or 1451 DD from 1 March (base 50^0) followed by a second spray 14 days later (27 Aug). Treatments received sprays at either GT, HIG, the degree day timings, or a combination of both. See Table 1 for treatments and timings. Typically, SJS is not uniformly distributed among the trees in the research orchard. Therefore, trees were inspected and sampled for the overwintering generation before being chosen for the trial. Treatments were then replicated 3 times and arranged in a RCB design among the selected trees. Each type of treatment that was sprayed at GT (18 Apr) and HIG (24 Apr) was sampled by cutting random twigs and inspecting then in the laboratory on 7 May to determine the efficacy of those materials against overwintering SJS. Approximately, 100 scales were dissected on wood from each treatment to determine if they were alive or dead. Another sample was taken on 20 July to compare the efficacy of treatments against the first generation of SJS crawlers by recording the percentage of fruit damage in a random sample. This was conducted by inspecting 100 apples on each tree in each replication and noting either the presence or absence of SJS crawlers. Harvest samples were taken on 9 Sep following the same protocol for evaluation. Data then was subjected to an AOV with SuperAnova (Abacus concepts). Means were separated with Fisher's Protected LSD Test ($P<0.05$). Data was transformed Arcsin (Sqrt X) prior to analysis.

Natural mortality of overwintering SJS was quite high in the untreated check plots (50.6%), only one of the treatments did not statistically separate from the check for control of the over-wintering generation (Damoil 66.7%). The remainder of the treatments were quite effective in the reduction of the over-wintering black cap stage.

All treatments significantly reduced damage from that found in the check plot for both the first and second generations. However, because of the variability of SJS density among plots there was little statistical separation in first generation damage among the plots that received an application. Data taken at harvest revealed the three treatments that received applications for the summer broods had the best control, however they also exhibited fairly high phytotoxicity levels. The industry standard Lorsban, seemed to be not quite as effective as some of the oil only treatments, or oil in combination with another material. Even when Lorsban was applied with oil, many other treatments fared better outcomes. Treatments that included another material applied with oil at HIG all yielded similar results regardless of what material or oil was used, with the exception of Lorsban. This also held true for the applications that were made only against summer broods. The two treatments that received oil at GT were also applied with Kocide 2000 to determine if any advantages could be gained by using oil with this fungicide. However, due to a miscommunication with maintenance fungicide applications, several diseases were left uncontrolled and will render this evaluation impossible.

TABLE 1. INSECTICIDE EVALUATION FOR CONTROL OF SAN JOSE SCALE, 2003

Treatment	Rate/100	Spray Timing	Black Cap Mortality	1st Gen. Fruit Damage	SJS Damage at Harvest	Phyto Damage at Harvest
Spray Oil 10E Kocide 2000	3.0% 3.0 lb	Green tip Green tip	97.2 bc	1.3 ab	5.3 abc	0.0 a
Purtec 15E Kocide 2000	3.0% 3.0 lb	Green tip Green tip	100.0 c	0.3 ab	4.3 abc	0.0 a
Spray Oil 10E	2.0%	Half-inch Green	96.5 bc	1.0 ab	6.3 abc	0.0 a
Damoil	2.0%	Half-inch Green	66.7 ab	2.3 ab	7.0 abc	0.0 a
Purtec 15E	2.0%	Half-inch Green	97.4 bc	4.7 ab	20.3 c	0.0 a
Lorsban 4EC	16.0 oz	Half-inch Green	98.7 bc	7.7 b	22.3 c	0.0 a
Lorsban 4EC Spray Oil 10E	16.0 oz 2.0%	Half-inch Green Half-inch Green	100.0 c	4.0 ab	16.7 bc	0.0 a
Esteem 35WP Spray Oil 10E	4.0 oz 2.0%	Half-inch Green Half-inch Green	99.3 c	0.3 ab	3.0 abc	0.0 a
Assail 70WP Spray Oil 10E	1.0 oz 2.0%	Half-inch Green Half-inch Green	100.0 c	0.7 ab	4.3 abc	0.0 a
Assail 70WP Purtec 15E	1.0 oz 2.0%	Half-inch Green Half-inch Green	100.0 c	0.7 ab	7.0 abc	0.0 a
Spray Oil 10E Purtec 15E	2.0% 2.0%	Half-inch Green 2 sprays/summer broods	96.5 bc	0.0 a	0.33 a	24.0 b
Esteem 35WP Purtec 15E	4.0 oz 2.0%	2 sprays/summer broods 2 sprays/summer broods	N/A	1.0 ab	0.7 ab	22.3 b
Assail 70WP Purtec 15E	1.0 oz 2.0%	2 sprays/summer broods 2 sprays/summer broods	N/A	2.0 ab	0.7 ab	18.0 b
Untreated Check			50.6 a	36.0 c	50.8 d	0.0 a

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

"What's This Hole In My Apple?"
Insecticide Effectiveness Against the New York Internal Lepidoptera Complex

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During the last several years outbreaks of internal lepidoptera have occurred in commercial apple orchards throughout western New York. Currently it is not known if this recent problem is due to changes in grower's insecticide regimen, improper timing of applications, or the development of resistance by various species of internal lepidoptera. In order to compare the relative susceptibility of the complex (collective term used for Oriental Fruit Moth, Lesser Apple Worm and Codling Moth) to other standard insecticides, as well as newer materials, field trials were set up in 2 orchards where high levels of fruit infestation was observed during the 2002 growing season.

Treatments were applied by a hand gun sprayer at 400 psi on 16 Jul and 29 Jul for the second brood, and again on 14 Aug and 27 Aug for the third brood. These sprays were timed according to degree-day models and aimed towards the early part of the hatch for each generation. The first generation was not sprayed for in this trial due to the fact that most New York growers apply materials against Plum Curcurlio that will control the internal lepidoptera complex. Treatments had 4 replicates at the first location and 3 replicates at the second location on single tree plots and arranged in a RCB design. Cultivars at the first site (Verbridge) were limited to 'Ida Red', while the second site had 'Ida Red' and 'Twenty-Ounce'. Both locations are in the Lake Ontario fruit growing region, Wayne County, New York. Refer to Tables 1A and 1B for treatments and application rates. Harvest samples were conducted by randomly picking 100 apples per treatment in each rep at both locations on 14 Sep and again on 10 Oct. This was to determine if any late season damage had occurred after the residual effects of the pesticides had diminished. Data then was subjected to an AOV with SuperAnova (Abacus concepts). Means were separated with Fisher's Protected LSD Test ($P<0.05$). Data was transformed Arcsin (Sqrt X) prior to analysis.

Damage was assessed as either "deep" (internal trail greater than 1/16") or "sting" (internal trail less than 1/16'). The amount of damage found in the untreated check plots at both sites during the first sample evaluations proved that pressure from internal worms was substantial. The Bartelson site generally had higher damage in all treated plots, but the amount of damage found in the untreated plot was also higher. This may or may not be caused from a different dominant species or a larger population. The organophosphate treatments (Guthion & Imidan) were statistically as effective as Calypso, Assail, Diamond, Warrior, Avaunt and Intrepid, although Avaunt and Intrepid were at the high end of the range. Esteem and Deliver had little effect on the worms and would not be recommended for control. Assail had the best overall results at both locations. Based on the information obtained at harvest, it does not seem as if there is a resistance issue with the organophasphate materials. Airblast application may yield different results because of coverage problems due to the size of the test trees. The second sample indicates that the residual effects of most materials are ineffective against a late season brood. With the exception of two plots at the Bartelson site, the remainder of the treatments increased in severity. The last spray was applied on 27 Aug and although internal damage in treated trees was reduced from the untreated control after 6 weeks unprotected, a late season spray may be required to control the encroachment from this third brood.

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Table 1A – Verbridge Site

Material	Rate/100	% w/ Deep Tunnel (< 1/16") (9/14/03)	% w/ Deep Tunnel (< 1/16") (10/10/03)	% Difference from 1st to 2nd Sample	% w/ Sting (>1/16") (9/14/03)	% w/ Sting (>1/16") (10/10/03)	Combined Sites % w/ Deep Tunnel (< 1/16") (9/14/03)	Combined Sites % w/ Deep Tunnel (< 1/16") (10/10/03)
Diamond	8.8 oz/100	3.0 abc	9.8 b	+6.8	2.5abc	2.0 a	9.4 ab	12.3 bc
Calypso	1.0 oz/100	4.0 bc	8.8 b	+4.8	4.5 cde	3.0 abc	11.6 ab	17.3 bc
Avaunt 30WG	1.75 oz/100	5.3 cd	14.3 c	+9.0	4.0 cde	5.5 bcd	16.1 bc	22.6 cde
Esteem 35WP	1.5 oz/100	20.3 e	30.8 c	+10.5	5.8 de	4.8 abcd	31.8 d	44.4 fg
Intrepid 2F	5.3 oz/100	8.5 d	23.8 c	+15.3	8.0 e	9.8 d	15.7 bc	29.7 de
Warrior 1CS	1.0 oz/100	2.0 ab	2.8 a	+0.8	0.5 a	1.5 a	8.7 ab	10.6 ab
Assail 25WP	1.1 oz/100	1.8 ab	2.0 a	+0.2	1.3 ab	3.0 ab	4.0 a	3.5 a
Guthion 50W	8.0 oz/100	1.0 a	11.5 b	+10.5	1.5 ab	3.3 abc	6.1 a	16.3 bcd
Imidan 70W	1.4 lbs/100	5.5 cd	9.3 b	+3.8	2.8 bcd	3.5 abc	8.9 ab	15.7 bc
Deliver	5.5 oz/100	16.0 e	27.3 c	+11.3	7.3 e	6.8 cd	24.0 cd	35.0 ef
Untreated Control		40.8 f	55.5 d	+14.7	7.0 e	9.3 d	49.7 e	59.4 g

Means within a column followed by the same letter are not significantly different (Fisher's Protected LSD Test, $P<0.05$). Data transformed Arcsin (Sqrt X) prior to analysis.

"What's This Hole In My Apple?"
Insecticide Effectiveness against the New York Internal Lepidoptera Complex

Table 1B - Bartelson Site

Material	Rate/100	% w/ Deep Tunnel (< 1/16") (9/14/03)	% w/ Deep Tunnel (< 1/16") (10/10/03)	% Difference from 1st to 2nd Sample	% w/ Sting (>1/16") (9/14/03)	% w/ Sting (>1/16") (10/10/03)	Combined Sites % w/ Deep Tunnel (< 1/16") (9/14/03)	Combined Sites % w/ Deep Tunnel (< 1/16") (10/10/03)
Diamond	8.8 oz/100	18.0 abc	15.7 ab	-2.3	2.0 abcd	6.0 ab	9.4 ab	12.3 bc
Calypso	1.0 oz/100	21.7 abc	28.7 bc	+7.0	1.7 ab	6.3 ab	11.6 ab	17.3 bc
Avaunt 30WG	1.75 oz/100	30.7 cd	33.7 bc	+3.0	2.7 abcd	7.0 b	16.1 bc	22.6 cde
Esteem 35WP	1.5 oz/100	46.7 de	62.7 d	+16.0	3.7 bcd	3.0 a	31.8 d	44.4 fg
Intrepid 2F	5.3 oz/100	25.3 bc	37.7 bc	+12.4	6.0 cd	6.0 ab	15.7 bc	29.7 de
Warrior 1CS	1.0 oz/100	17.7 abc	21.0 ab	+3.3	0.3 a	4.3 ab	8.7 ab	10.6 ab
Assail 25WP	1.1 oz/100	8.5 a	6.5 a	+2.0	1.0 ab	2.5 a	4.0 a	3.5 a
Guthion 50W	8.0 oz/100	13.0 ab	22.7 abc	+9.7	1.3 ab	7.3 ab	6.1 a	16.3 bcd
Imidan 70W	1.4 lbs/100	13.3 ab	24.3 abc	+11.0	2.0 abc	4.0 ab	8.9 ab	15.7 bc
Deliver	5.5 oz/100	34.7 cd	45.3 cd	+10.6	8.3 d	7.7 b	24.0 cd	35.0 ef
Untreated Control		61.7 e	64.7 d	+3.0	3.0 abcd	4.7 ab	49.7 e	59.4 g

Means within a column followed by the same letter are not significantly different (Fisher's Protected LSD Test, $P<0.05$). Data transformed Arcsin (Sqrt X) prior to analysis.

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MONITORING SUSCEPTIBILITY TO AZINPHOSMETHYL OF POPULATIONS OF OFM IN APPLE ORCHARDS IN WESTERN NY, 2003

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During the last several years, damage from internal lepidoptera has gradually increased in the western NY apple production region, and in 2002 more than 80 loads of processing apples were rejected from a group of approximately 42 apple growers in western New York state. Subsequent inspections of samples of larvae collected from infested fruit within this production area showed that most of them were oriental fruit moth. Currently, the factors causing these recent outbreaks of oriental fruit moths in western NY apple orchards are not known. Possible contributing factors may include: (1) Late season reductions of applications of broad-spectrum insecticides such as organophosphates and substitution of more selective new insecticides such as *Bacillus thuringiensis* and Spinosad during July and August for control of the obliquebanded leafroller. (2) Termination of insecticide sprays in August prior to the final flight of oriental fruit moths. (3) Changes in the biology of oriental fruit moths, resulting in increased late season activity. (4) Development of organophosphate-resistance in field populations of oriental fruit moths. The objective of this study was to conduct laboratory bioassays to compare the susceptibility to azinphosmethyl of populations of oriental fruit moths captured in commercial orchards in western NY that had high levels of fruit injury in 2002. Moths captured in a research orchard on the grounds of the NYSAES that had not been regularly treated with insecticides were used s susceptible reference population.

MATERIALS AND METHODS

The susceptibility of oriental fruit moths were compared from 4 commercial orchards in western NY in Wayne County. Fruit infestation levels in all of these orchards exceeded 10% at harvest in all of these blocks and examinations of larvae collected from infested apples prior to harvest suggested that most of the injury was caused by oriental fruit moth larvae. The susceptibility of adult males from each population was compared using bioassays of moths captured in pheromone traps with techniques described by Riedel et al. 1985. Moths collected during the first flight were incubated at 23°C after treatment, but moths bioassayed from subsequent flights were kept at 25°C. Mortality was assessed at 24 hours post-treatment. Pherocon VI traps with liners were deployed in all of the orchards to capture moths as soon as the initial flight of oriental fruit began. Liners were scraped with a spatula to remove excess sticky material to insure that trapped moths were not excessively coated with stickum. Moths from each population were exposed to 4-6 concentrations of technical azinphosmethyl with dosages separated by one-fourth log increments. Bioassays were conducted in the field throughout the season to compare the susceptibility of all three generations of moths. The susceptible population of moths was collected from a research orchard on the Denton Farm on the grounds of the NYSAES.

This orchard has not been regularly sprayed with insecticides in the past, and no insecticides were applied in this orchard during the 2003 growing season. Dosage-mortality regressions were analyzed by probit analysis. Resistance ratios were estimated by dividing the LC_{50} and LC_{90} values of populations from the commercial orchards by the LC_{50} and LC_{90} values, respectively, from the susceptible population. Eventually, these resistance ratios will be tested for significance by calculating 95% confidence limits, and if the confidence limits do not bracket 1.0, then the LC_{50}s will be classified as significantly different (Robertson and Preisler 1992).

RESULTS AND DISCUSSION

The original goal of this research was to treated 40-60 moths/dosage/flight in each orchard, but catches were too low during some times of the year in some of the research blocks. Also, during the preliminary analysis of data, some data did not fit a probit model. Therefore, data is presented only for those locations in which sufficient moths were captured to allow adequate replication and the response fit the probit model.

Table 1. Comparison of LC_{50} Values for Populations of Oriental Fruit Moths Bioassayed From Problem Commercial Orchards in Western NY in 2003.

	(LC_{50} (µg ai/ml)		
Orchard	1st Flight (23°C)	2nd Flight (25°C)	3d Flight (25°C)
Bartleson	25.6	21.6	19.8
Datthyn	16.6	27.5	26.5
Verbridge	43.8	25.4	-.-
Check (Orchard 12	32.4	10.6	11.4

Table 2. Comparison of LC_{90} Values for Populations of Oriental Fruit Moths Bioassayed From Problem Commercial Orchards in Western NY in 2003.

	(LC_{90} (µg ai/ml)		
Orchard	1st Flight (23°C)	2nd Flight (25°C)	3d Flight (25°C)
Bartleson	63.4	72.5	58.8
Datthyn	113.4	58.6	53.4
Verbridge	123.9	71.9	-.-
Check (Orchard 12	94.2	28.4	42.7

Table 3. Comparison of Resistance Ratios for LC_{50}'s of Populations of Oriental Fruit Moths Bioassayed From Problem Commercial Orchards in Western NY in 2003.

	(RR=LC_{50} WNY/LC_{50} Standard		
Orchard	1st Flight (23°C)	2nd Flight (25°C)	3d Flight (25°C)
Bartleson	-.-	2.0	1.7
Datthyn	-.-	2.6	2.3
Verbridge	1.4	2.4	-.-

Table 4. Comparison of Resistance Ratios for LC_{90}'s of Populations of Oriental Fruit Moths Bioassayed From Problem Commercial Orchards in Western NY in 2003.

	(RR=LC_{90} WNY/LC_{90} Standard		
Orchard	1st Flight (23°C)	2nd Flight (25°C)	3d Flight (25°C)
Bartleson	-.-	2.6	1.4
Datthyn	1.2	2.1	1.3
Verbridge	1.3	2.5	-.-

During the first flight of oriental fruit moths, only the Verbridge orchard had a higher LC $_{50}$ value than the susceptible standard, Orchard 12 and the LC $_{90}$ values of moths from this orchard and from the Datthyn blocks were only slightly larger than that of the standard. In contrast, resistance ratios for the LC_{50}'s of the second flight of adults ranged from 2.0 in the Bartleson orchard to 2.6X at Datthyn's. Resistance ratio's for LC $_{90}$'s of the second flight among the various orchards were also similar, ranging from 2.1 to 2.6X. Resistance ratio's for the third flights were lower and ranged from 1.7 to 2.3 for the LC $_{50}$'s and 1.3 to 1.4X for the LC $_{90}$'s. The LC $_{50}$ and LC $_{90}$ values remained fairly constant during the different flights of moths from the commercial orchards, but values were much lower for the later flights of moths from the susceptible standard orchard. The reasons for this variation in response among generations of moths in the standard research orchard are not known.

In conclusion, it appears that field populations of oriental fruit moths in commercial apple orchards in western NY in which severe injury has been noted during the last several seasons may have developed relatively low levels of resistance (Ca. 2-2.5X) to organophosphates. The results of testing late summer control programs in these orchards during the 2003 growing season indicate that synthetic pyrethroids such as Warrior are slightly more effective in protecting fruit than organophosphates. Although an unacceptable level of damage (ca. 16%) occurred in one plot treated with multiple applications of a high rate of Phosmet during July and August, the Phosmet program provided adequate control in all of the rest of the plots. Additional resistance monitoring and tests of insecticides should be conducted to optimize management programs for this pest in problem orchards in western NY in the future.

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Management of Leafhopper and Aphids Pests on Apple Using Reduced Rates of Imidacloprid

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INTRODUCTION

Two leafhopper species, the white apple leafhopper (WALH), *Typhlocyba pomaria* McAtee and the potato leafhopper (PLH) *Empoasca fabae* (Harris), comprise a complex that annually damages apple foliage in New York State. In the Hudson Valley region moreover, the rose leafhopper (RLH), *Edwardsiana rosae* (L.) is an annual pest – due in large to the widespread occurrence of it's alternate host, multiflora rose. Damage to apple foliage by the mesophyll-feeding hoppers (WALH and RLH) appears as stippling or leaf chlorosis. The migratory PLH is a terminal-feeder that injects a salivary toxin while feeding, producing symptoms ranging from chlorosis to the typical 'hopper burn', resulting in reduced growth rate of terminals. Accumulated excrement from the leafhopper complex reduces the marketability of fresh market fruit, while moderate to high adult presence at harvest causes considerable annoyance to harvesters.

Although three species of terminal-feeding aphids attack New York apple, the green apple aphid (GAA), *Aphis pomi* De Geer, is generally considered as the pest of greatest significance. Feeding on new growth by GAA nymphs causes stunted and misshapen leaves. Because aphids produce honeydew, high populations feeding in proximity to fruit clusters can cause cosmetic damage due to development of the sooty mold fungus on this sugary exudate. In more uncommon instances, they cause blemishes by feeding directly on developing fruit.

Populations of GAA will often be dramatically affected by a duo of natural enemies (larvae of Cecidomyiidae and Coccinellidae) if detrimental insecticides are withheld. Nonetheless, if populations remain excessive for an extended time period, many growers will apply pesticidal control measures.

Imidacloprid (Provado 1.6F®) is generally recognized for it's high degree of efficacy against sucking insects, particularly leafhoppers and aphids. Because this insecticide is costly relative to older standards however, we performed field trials using applications of reduced rates and various application timings to examine efficacy against leafhoppers and aphids, and to assess the effects of reduced rates on aphid natural enemies.

METHODS AND RESULTS

Treatments were applied to single-tree plots (buffered by two guard trees) replicated four to five times in a RCB design. Treatments were applied from one to three times, depending upon individual protocols. Applications were made dilute to runoff using a high-pressure handgun sprayer operate4d at 300 psi, delivering ca. 2.0 gal/tree.

2000 Trial, Leafhopper Nymphs and Adults – 'Liberty' on M.26 rootstock were used for experimentation. During September, single-application treatments comprising full (8.0 oz/acre) and one-quarter (2.0 oz/acre) label rates of Provado were compared to full (48.0 oz/acre) and one-quarter (12.0 oz/acre) label rates of Sevin XLR. Efficacy against WALH and RLH nymphs (number/leaf) and adults (numbers/3 min. collected by a vacuum sampler) was determined at 2d post treatment, and at 4d and 10d post treatment, respectively. Means were compared by using Fisher's Protected LSD (P=0.05).

Results showed very good efficacy against nymphs from reduced rates of both insecticides (Table 1). At 4d post treatment, significant reductions in adult numbers were obtained by one-quarter label rates of both insecticides; at 10d post treatment however, all Provado treatments were superior to Sevin XLR. The enhanced persistence of Provado is logical, given that the neonicotinoid penetrates and is stored in the leaf (translaminar), whereas XLR has no similar properties. Prior to the registration of Provado, various formulations of Sevin were used extensively in NY to manage leafhoppers. The results show that reduced rates of Provado are effective against both motile stages of leafhoppers – significantly more so than the older standard.

2001 Trial, Leafhopper Nymphs – Having demonstrated that greatly reduced rates were effective, we sought to examine the cost effectiveness of various programs. Treatments were applied to plots containing one tree each of 'Delicious' and 'Golden Delicious', replicated four times in a randomized complete block design. Trees on the M.7 rootstock were 3 yr-old, and had not yet filled their space. Treatment scenarios (Table 2.) using full, one-quarter and a combination of full and one-quarter label rates of Provado were compared during mid-season (3rd to 5th cover). During this period, indigenous WALH and RLH, and migratory PLH are usually present in Hudson Valley apple orchards. In general, 3rd cover applications impact immigrating adult PLH, 4th cover applications coincide with nymphal emergence of all three species, while 5th cover applications affect early instar nymphs of all species. Efficacy was assessed, one day after the final application, by [a] counting the number of nymphs per 5 leaf sample, [b] assessment of adult leafhopper numbers by sweeping the tree perimeter for 4 min. with a vacuum sampling machine, and [c].estimatiion of percent leaves damaged or curled by PLH by sampling 10 distal leaves on 10 terminals. The cost of each spray program was estimated (dosage x no. applications x cost), based a local distributor quote ($4.00 per oz. of formulation).

All rates and application timings provided very good control of WALH and RLH (Table 2). Against high populations of PLH nymphs, multiple applications generally provided superior control, regardless of rate – PLH continually reinfest new leaves not exposed to residues from precious applications. Assessment of foliar damage (chlorosis and curled leaves) by PLH revealed that multiple applications of reduced rates were generally effective in the reduction of both symptoms, particularly curled leaves. By comparisons of each program's economics, it is apparent that effective management of leafhoppers can be achievable at significantly reduced costs. Because established apple trees can tolerate a good deal of damage from the indirect feeding of leafhoppers, multiple applications of Provado at one-quarter label rate is a logical program.

2002 Trial, Green Apple Aphid and Predators – Because Provado is often used during early season to manage GAA infestations, an experiment was designed examine the effects of reduced rates against this pest and two of it's most important natural enemies. Experimental trees were M.7/'Golden Delicious , approximately 20 yr-old and 25 ft high. Single applications of Provado were applied to single-tree plots (buffered by two nearest neighbor trees) replicated five times. Similar to prior leafhopper studies, full, one-half, one-quarter, and one-eighth label rates of Provado were applied once during mid-summer. Thirty aphid-infested terminals/replicate were tagged for pre treatment counts and subsequent evaluation. Post treatment aphid counts were made at 3d, 7d and 23d. Aphid numbers per terminal were estimated by a rating where: 0 = no aphids; 1 = 1-10 aphids/t leaf; 2 = 11-100 aphids/leaf; and 3 = >100 aphids/leaf. Treatment effects on predators were assessed 7d post treatment by counting the number of larvae/5 apical terminal leaves. Means were compared by Fisher's protected LSD (P=0.05).

At the 3d and 7d assessment dates, GAA reductions followed a dose-response relationship (i.e, full rate > one-half rate, etc.) (Table 3). At 7d, all treatment rates reduced GAA numbers by at least 70 percent. Aphid numbers in all treatments, including untreated, decreased >90 percent 27d after application – as July wanes, aphid populations naturally decline due to lack of succulent tissue as terminal buds set, and and/or because of natural enemies. The results indicate that decreasing rates of Provado provide decreasing efficacy against GAA – however, all but the one-eighth label rate provided considerable, and probably acceptable, efficacy.

A single application of Provado was generally detrimental to larvae of Coccinellidae and Cecidomyiidae (Table 4). All treatments between full and one-quarter label rates significantly reduced numbers of both predators. The one-eighth label rate however, allowed both predator species to increase dramatically at 7d after application – such increases may have contributed to the 70 percent reduction in GAA populations provided by this treatment (previous Table). The results suggest that the one-eighth label rate provides adequate suppression of aphids, while preserving predators.

Producers would have to decide the degree of control desired for a particular situation. If management or suppression below some marginal level of damage is desired, reduced rates of Provado could provide a cost effective program against these two foliar-feeding pest complexes. Expenditures could be reduced to an even greater degree if reduced rates of Provado were tank mixed with other pest control treatments applied during regular cover spray periods, thereby minimizing application costs.

Table 1. Efficacy of reduced rates of Provado® and Sevin XLR® against leafhopper nymphs and adults[1], 2000.

Treatment	Amt./ acre	No. nymphs/25 leaves *2d post treat.*	No. adults/3 min. (percent reduction)[2] *4d post treat.*	*10d post treat.*
Provado 1.6F	8.0 oz	0.0 a	6.1 ab(93.7)	2.9 a (97.5)
Provado 1.6F	4.0 oz	0.0 a	7.3 ab (95.0)	2.9 a (97.6)
Sevin XLR plus	48.0 oz	0.6 a	3.8 a (96.1)	12.5 b (87.1)
Sevin XLR plus	12.0 oz	0.8 a	9.9 b (87.8)	23.5 bc (71.2)
Untreated	-	28.6 b	78.6 c (4.3)	77.2 c (6.1)

Means followed by the same letter are not significantly different (*P*=0.05; Fisher's protected LSD).
[1]White apple and rose leafhopper (>95 percent rose leafhopper).
[2]Adults collected by vacuum sampler. Reduction based on precounts taken 17 Sept.

Table 2. Efficacy and approximate costs of reduced rates of Provado® against leafhopper nymphs and damage, 2001.

Treatment	Amt./ acre	Timing[1] (no. apps.)	No./leaf WALH, RLH[2]	No./leaf PLH[2]	Percentage shoot lvs. chlorosis by PLH[2]	Percentage shoot lvs. curled by PLH[2]	Cost/ acre[3]
Provado 1.6F	8.0 oz	3C (1)	<0.1	13.0	66.0	43.0	$32.00
Provado 1.6F	8.0 oz	3, 4C (2)	0.0	1.6	19.0	4.0	$64.00
Provado 1.6F Provado 1.6F	8.0 oz 2.0 oz	3C (1) 4,5C (2)	0.0	0.2	56.0	1.0	$48.00
Provado 1.6F	2.0 oz	3-5C (3)	0.0	0.7	37.0	6.0	$24.00
Untreated	-	-	5.1	11.0	97.0	77.5	-

[1]Third cover, fourth cover, etc.
[2]White apple leafhopper(WALH), rose leafhopper(RLH) and potato leafhopper(PLH).
[3]Based on estimated cost of $4.00 per ounce of formulation and 400 gal/acre.

Table 3. Efficacy of reduced rates of Provado® against green apple aphid, 2002.

Treat.	Amt./ acre	*3d post treat.* 27 June Aphid rating[1]	Percent redn.[2]	*7d post treat.* 1 July Aphid rating	Percent redn.	*23d post treat.* 17 July Aphid rating	Percent redn.
Provado 1.6F	8.0 oz	0.70 a	76.7	0.14 a	95.3	0.06 a	97.9
Provado 1.6F	4.0 oz	1.05 b	65.0	0.37 b	87.7	0.05 a	98.4
Provado 1.6F	2.0 oz	1.38 c	54.0	0.53 b	82.3	0.20 a	93.3
Provado 1.6F	1.0 oz	1.49 c	50.3	0.89 c	70.3	0.08 a	97.5
Untreated	-	2.85 c	5.0	2.71 d	9.7	0.15 a	95.0

Means followed by the same letter are not significantly different (P=0.05; Fisher's protected LSD).
[1]Rating (0 – 3) of aphid numbers/terminal; see text for details.
[2]Based on precounts taken 24 June.

Table 4. Efficacy of reduced rates of Provado® against two key aphid predators, 2002.

Treatment	Amt/ acre	7d post treat. (1 July)[1] Cocc.[3] larvae	Cecid.[3] larvae	Percent reduction[2] Cocc. larvae	Cecid. larvae
Provado	8.0 oz	0.01 a	0.03 a	95.7	87.8
Provado	4.0 oz	0.02 a	0.04 a	84.3	93.8
Provado	2.0 oz	0.07 ab	0.04 a	87.8	93.2
Provado	1.0 oz	0.20 b	0.19 b	⇑ 329.2	⇑ 53.6
Untreated	-	1.19 c	0.21 b	⇑ 487.2	⇑ 22.0

Means followed by the same letter are not significantly different (P=0.05; Fisher's protected LSD).
[1]Average number of larvae/aphid infested terminal.
[2]Based on precounts taken 24 June.
[3]Cocc. = Coccinellidae (Coleoptera); Cecid. = Cecidomyiidae(Diptera); ⇑ = population increase.

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Effects of Reduce-Risk Insecticides on Mortality, Survival, and Oviposition of European red mite (*Panonychus ulmi*)

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A number of reasons have been proposed for pesticide-induced increases of phytophagous mites in agricultural cropping systems, including; reductions of natural enemies, behavioral changes that affect population dynamics, and hormoligosis, the latter the result of a pesticide affecting mite physiology that may lead to increased fecundity or shorten development rates. Among the insecticides, pyrethroids have been most closely associated with causing flare-ups of mites. In recent years, new groups of reduced-risk (RR) insecticides have been introduced in a diversity of agricultural crops, and some of these insecticides have been associated with flare-ups of mite populations, (Usmani and Shearer 2000, James and Price 2002, Carter 2003). In apple orchards of western North Carolina, the European red mite (ERM), *Panonychus ulmi* Koch (Acari: Tetranychidae), is the most important phytophagous mite. The objective of this study was to identify and evaluate effects of a selected group of reduced-risk insecticides on the survival, mortality and oviposition of ERM in the laboratory.

Materials and Methods

'Golden Delicious' apple leaves with and without ERM were collected from the field from a pesticide free orchard and a commercial orchard respectively and brought to the laboratory from mid-July to mid-August. The mite-free leaves were washed and disks (1.5 cm diameter) were removed. The RR insecticides tested included Assail® 70 WP (acetamiprid, Dupont) at 115 ppm a.i., Actara® 25 WP (thiamethoxam, Syngenta) at 37 ppm a.i., Provado® 1.6F (imidacloprid, Bayer Co.) at 60 ppm a.i., Calypso® 4F (thiacloprid, Bayer) at 75 ppm a.i., Intrepid® 2F (methoxyfenozide, Dow AgroSciences) at 187 ppm a.i., Esteem® 35WP (pyriproxyfen, Valent) at 105 ppm a.i., Avaunt® 30WDS (indoxacarb, Dupont) at 112 ppm a.i., SpinTor® 2SC (spinosad, Dow AgroSciences) at 75 ppm a.i. Additional treatments included the commonly used "conventional" insecticides Guthion® 50WP l (azinphosmethy, Bayer) at 600 ppm a.i., Danitol® 2.4EC (fenpropathrin, Valent) at 239 ppm a.i., Asana® 0.66EC (esfenvalerate, Dupont) at 62 ppm a.i., and a water treated control. Insecticide rates tested were equivalent to the lower field label rates and were prepared in 1 liter solutions. All insecticide solutions and the water control received 0.1 ml of the surfactant Triton®-X 100 to improve leaf coverage. Each disk was dipped into the respective insecticide solution, air dried for 2 hr, and then five ERM females were carefully transferred from ERM infested apple leaves to each disk with a 5/0 sable brush. A total of 10 disks were prepared for each insecticide solution and the bioassay was replicated 4 times. All bioassays were conducted in an environmental chamber at 25° C, 60 ± 5 % RH and 14:10 (L:D) daylength. Survival, and mortality of female ERM and the number of eggs laid were counted at 24, 48, and 72 h. Data were transformed using $\sqrt{X+0.5}$, and then subjected to a two-way ANOVA and means were compared using Fisher's LSD test (P < 0.05) (Statistica™, StatSoft Inc., Tulsa, OK).

Results

The number of live and dead ERM were significantly different ($P < 0.05$) among treatments at 24, 48, and 72 h (Fig. 1). At 24 h (Fig. 1a) ERM mortality on the two pyrethroids Danitol and Asana averaged >4.8 mites per disk (>95%), and Provado had the highest mortality (38 %) among the RR insecticides, while mortality on the Assail, Avaunt, Spintor and Guthion treated disks were low (~15%) and not significantly different ($P > 0.05$) from the control treatment (Fig 1a). At 48 h all ERM on the pyrethroid treatments were dead (Fig. 1b), but mortality in all treatments increased. At 72 h, mortality was close to 50% in the control treatment, and ~60% in Assail, which was the lowest mortality among RR insecticides. The highest mortality was in Provado >95% (Fig. 1c). Female ERM laid no eggs in the Asana treatment and only 0.07 ± 0.05 (mean ±SEM) in the Danitol treatment, while fewer numbers of eggs were laid in Provado and Calypso than the other RR insecticides ($P < 0.05$) (Fig. 2). The Esteem, Avaunt and SpinTor treatments laid the highest numbers of eggs and did not differ from the control ($P > 0.05$) (Fig. 2).

Discussion

The pyrethroids Asana and Danitol controlled ERM females and reduced their oviposition under these bioassay conditions. It should be noted that this bioassay system did not allow mites to disperse from leaf disks to non-treated areas, which as been shown to be factor in mite flare-ups with certain pyrethroids (Penman et al. 1986, Hall and Thacker 1993). In this study ERM mortality and survival were high and significant differences ($P < 0.05$) were found among treatments (Figs. 1 and 2). However, several authors have reported the opposite effect with several nicotinoids: Actara (VanBuskirk and Hilton 2000), Provado and Calypso (Alston 2002), and Assail and Admire (Carter 2003). These authors found that repeated applications of these insecticides increased spider mite densities in apples, cherries and pears. In addition James and Price (2002) reported that *Tetranychus. urticae* fecundity increased when this species was topically exposed to Provado, also the latter authors found that mites that fed on bean leaves treated with Provado exhibited enhanced longevity compared with mites on control leaves. Information on the effects of the remaining RR insecticides on spider mites is scarce or inexistent. Villanueva and Walgenbach (unpublished) reported that Spintor could be toxic against mites, although mortality on SpinTor-treated leaves did not differ from the control at 48 or 72 h, and was not different ($P > 0.05$) from most of the other RR insecticides (Fig 1).

A direct effect of the ERM mortality is a reduction in observed in fecundity. The accumulated number of eggs laid by ERM after 72 h in the control and Provado treatments were <30 and ~10 per 5 females, which represents only about 30% and 10% of the expected number (100 eggs) based on a female tetranychid laying an average of 5 eggs per day (Sabelis 1985). Hence we cannot assume that the high mortality and low fecundity in this study were the direct result of insecticides, with exception of the pyrethroids that was explained above. In addition to the insecticides themselves, we hypothesize that a combination of several experimental factors were contributed to mite mortality, including injury of mites during the transfer process, environmental conditions, and variability of age of adult mites used in the study. Maximum egg production by spider mites has been reported at low (25-30%) compared with high humidity (85-90%) (Huffaker et al. 1969). Relative humidity was maintained at ~60% in this study, which may have partially affected the outcome of the bioassay. The age of field collected ERM females also may have contributed to higher than expected mortality. Dean (1969) reported that natural mortality usually occurs in midsummer when undisturbed populations decreased sharply, and mites for these tests were collected from mid-July to mid-August. Further research will be completed next year to clarify these results.

Acknowledgement

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Figure 1. Mean numbers of ERM (±SEM) found alive and dead on leaf disks treated with insectides at 24, 48 and 72 h. Different letter among treatments indicate significance ($P < 0.05$, LSD, ANOVA)

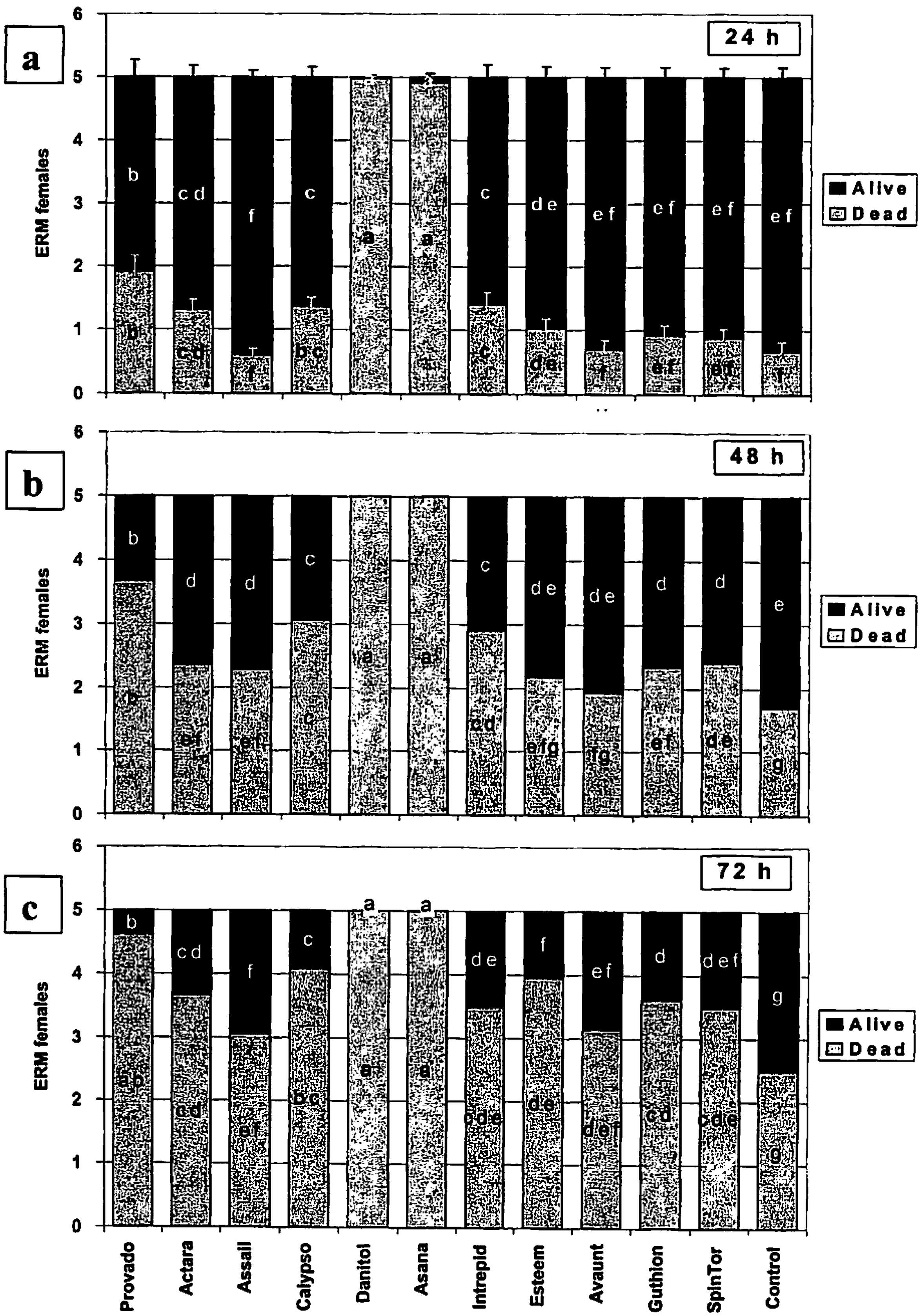
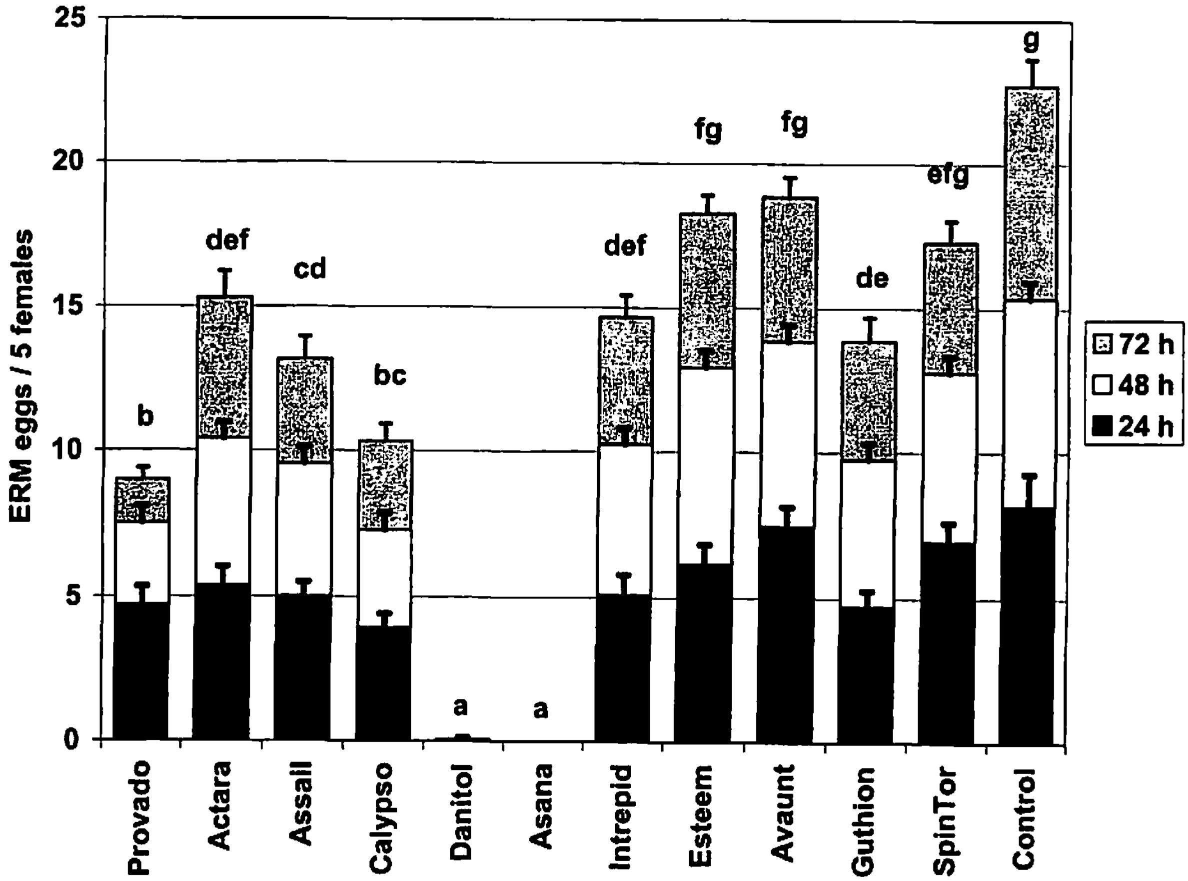


Figure 2. Daily and acumulated mean numbers (±SEM) of *Panonychus ulmi* eggs oviposited by 5 *P. ulmi*. Different letter among treatments indicate significance ($P < 0.05$, LSD, ANOVA) at 72 h.



Horticulture and Small Fruits

The Canker in the Bud: How *Colletotrichum Acutatum* Survives in Dormant Flower Buds of Highbush Blueberry

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Colletotrichum acutatum is the causal agent of anthracnose fruit rot of highbush blueberry (*Vaccinium corymbosum* L.), a postharvest disease that poses a serious threat to the marketability and shelf life of fruit grown for the fresh market. Infected fruit may rot and become covered with sticky orange spore masses in storage, and infection can spread quickly through containers in the presence of moisture. Latent infections occur on green fruit in the field, though symptoms do not appear until ripening (Daykin and Milholland, 1984). Growers typically control anthracnose by weekly applications of fungicides from bloom to harvest.

The distribution and amount of overwintering inoculum in dormant blueberry bushes is the major determinant of the incidence and severity of infection in the following season. *C. acutatum* has been reported to overwinter in blighted wood on the blueberry bush, particularly in fruit spurs (Stretch, 1967; Hartung, 1981). The authors recently found that the pathogen can overwinter in living buds as well as dead wood. Indeed, flower buds appear to be the major source of overwintering inoculum, contributing more than twice as many infections as blighted wood in dormant samples taken from susceptible and resistant cultivars (DeMarsay and Oudemans, 2002). Our current objective is to elucidate the histopathology and timing of flower bud infection by answering the following questions:

- Does *C. acutatum* overwinter on dormant flower buds or within them?
- If within them, how far into the bud does the pathogen penetrate?
- In what form or forms does the pathogen overwinter (mycelium, conidia, appressoria)?
- When do developing flower buds become infected?

Dormant blueberry "flower buds" are actually inflorescence buds containing multiple flower bud primordia encased in layers of bud scales (modified leaves). Vegetative buds form in the axils of leaves during the previous spring and summer, and several buds per shoot typically differentiate into inflorescence buds. Floral initiation appears to be a local phenomenon, beginning in a shoot when it has finished elongation (Coville, 1911). As the bush approaches dormancy, vegetative and floral buds stop developing. The exposed areas of the outer bud scales turn brown and seal, protecting the interior tissues from freezing and desiccation during dormancy.

Experiment 1: Is the pathogen on the bud—or in it?

Materials and methods. To determine whether *C. acutatum* was loosely or firmly attached to the surface of flower buds, or within them, we collected 18 dormant 'Bluecrop' twigs about 10 cm long, bearing a total of 149 flower buds, in late January 2003. The twigs were taken from a sampling plot in a commercial field in Atlantic County, NJ, that had not been treated with fungicides in more than five years. The twigs were taken from low branches inside the bushes, where the incidence of infection might be expected to be highest. Twigs were cut into short segments containing at least one bud each, then sonicated and washed on a rotary shaker in sterile distilled water. Aliquots of the tissue wash were plated on a semiselective medium (20% V-8 plus streptomycin sulfate and copper hydroxide) at dilutions of 10^0

to 10^{-2} and incubated for four days at 18° C and one day at 27° C (Agostini and Timmer, 1992). Samples of the tissue wash were examined under the microscope at 400X for propagules. Half of the twig segments were plated directly onto water agar; the other half were surface-sterilized in 0.525% sodium hypochlorite for 60 to 90 seconds and rinsed in sterile distilled water before plating. Twig plates were incubated at 25° C in the dark and periodically examined for *C. acutatum* spore masses. Infections were confirmed by microscopic examination of conidia at 200x.

Results and discussion. No propagules of *C. acutatum* were found in the tissue wash, either on the plates or in samples examined under the microscope at 400x. There was no significant difference in the number of surface-sterilized vs. unsterilized flower buds on which spore masses appeared after incubation. Of the 41 buds infected, 19 were on twig segments that had been surface-sterilized and 22 on segments that had not been. While this population study was intended as preliminary work for a larger study, the results were so conclusive that we did not continue.

Experiment 2: How far into the flower bud does the pathogen penetrate?

Materials and methods. To find out how far overwintering *C. acutatum* infections penetrated into an inflorescence bud, we dissected 105 'Bluecrop' buds taken from low branches inside bushes in the same sampling plot in late March 2003. The bud scales and flower bud primordia were placed in order, from outer to inner, on 100 water agar plates. Five double buds were plated together. Plates were incubated at ambient temperature and observed for emerging *C. acutatum* spore masses. Infections were confirmed by microscopic examination of conidia at 200x. Each plate was read only once to avoid counting infections due to colonization, which occurred rapidly.

Results and discussion. As shown in Table 1, the majority of infections were confined to the outer scales of the inflorescence bud. Of the 52 buds infected on 51 plates, 96 percent (50) had infections in the outer scales, 23 percent (12) had infections that reached the first four flower bud primordia, and only one bud had infections that penetrated two bud layers. In one double bud pair, only the central bud primordia in each were infected.

	Number of inflorescence buds		
	Total	***Infected***	***Uninfected***
Depth of infections:			
Outer scales	105	50	55
Outer bud layer (up to 4 buds)	102	12	90
Middle bud layer (up to 4 buds)	99	1	98
Inner bud layer (up to 4 buds)	60	0	60
Central buds (1 or 2 buds)	105	2	103

Table 1. Penetration of *Colletotrichum acutatum* infections into dissected dormant 'Bluecrop' flower buds on water agar, 2003.

The concentration of infections in the outer layers of the inflorescence bud suggests that buds are infected early in their development during the previous summer, as the outer bud scales form before the flower bud primordia (Bell, 1950). Variations in the depth of penetration might be due to the timing of infection or to other factors such as the growth of the fungus before cold weather sets in, relative host susceptibility to *C. acutatum*, or differences in virulence among strains. At the time of dissection, a number of buds were found to have flower bud primordia that had died at various stages of development. There was no apparent correlation between the deaths of these primordia and infection by *C. acutatum*.

Experiment 3: In what form does the pathogen overwinter in flower buds?

Materials and methods. In early March 2003, 100 dormant 'Bluecrop' flower buds were collected from low branches inside bushes in the same sampling plot and split lengthwise. The bud scales from one-half of each bud were dissected into 96-well PCR racks in order, from outer to inner, preserved in formalin-acetic acid solution (FAA), and stored in 70% ethanol. The bud scales were individually stained in 0.01% lacto-trypan blue, mounted on slides, and examined microscopically at 200x and 400x for the presence of conidia, appressoria, or mycelium of *C. acutatum*.

Results and discussion. Scales from 30 buds have been mounted and examined. No fungal structures were evident. Based on previous experience, we would expect 30 to 50 percent of the buds in the sample to have at least one infected bud scale. We plan to examine scales from the remaining buds using a scanning electron microscope (SEM) in hopes of locating the overwintering structures.

Experiment 4: When do flower buds become infected?

Materials and methods. In summer 2003, potted 'Bluecrop' bushes grown in a cold frame were spray-inoculated with a suspension of *C. acutatum* spores (concentration: 1×10^5 spores/ml), using a pump sprayer. The bushes were held in a mist chamber for 48 hours and returned to the cold frame. Control plants received a water spray at the same time and were also kept in the mist chamber for 48 hours. Five single-bush replicates and two control plants were treated at weekly intervals from July 2 through July 23, then twice a month from August 15 through the end of September, for a total of eight treatments. Five check plants remained in the cold frame throughout the season. Berries were removed from bushes as they ripened. In early November, five twig tips with flower buds were taken from each of the inoculated, control, and check plants. Twigs are being incubated in moist chambers and *C. acutatum* infections tallied as spore masses appear to determine when infection is occurring. Infections are being confirmed by microscopic examination of conidia at 200x.

After each set of inoculated and control plants was returned to the cold frame, three twigs were harvested and the buds at nodes 2, 3, and 4 dissected to determine the stage of bud development. Three additional twigs were taken from inoculated plants, preserved in FAA, and stored in 70% ethanol for later examination of the infection process by SEM.

To observe the timing of infection in the field, samples of 20 twig tips bearing five buds were taken from low branches inside bushes in the 'Bluecrop' sampling plot every two weeks from July 11 through October 20. The stage of bud development—vegetative, transitional, or floral—and the number of growth flushes on the shoot were recorded. The shoots, with leaves removed, were incubated on water agar plates and observed once a week for the emergence of *C. acutatum* spore masses on the buds.

Results and discussion. The incubation of buds from inoculated plants is still underway. Initiation of floral bud development was first observed in the meristems of dissected buds on July 13. By August

20, six of the nine buds dissected had floral or transitional meristems. On August 29, we found the first fully differentiated inflorescence bud, with layers of flower bud primordial wrapped in bud scales beneath its outer scales.

In the July 11 field sample of 20 shoots, 13 of 100 buds were already infected. The numbers rose in succeeding samples to 34 infections in the July 25 sample and 28 infections in the August 6 sample. On these dates, most buds from the potted plants were still vegetative or differentiating internally. Infections declined sharply in later samples; the last sample, taken October 20, had only 10 of 100 buds infected. Buds may become more resistant as they mature or develop into flower buds, or *C. acutatum* infections may be dying even before dormancy.

Summary of Findings

- *Colletotrichum acutatum* overwinters within living buds, not on their outer surfaces.
- At the end of dormancy, the outer bud scales of an infected inflorescence bud typically harbor the fungus. Less commonly, the pathogen has penetrated to the flower bud primordia and inner layers of scales enclosing them.
- The survival structure (or structures) of *C. acutatum* within the inflorescence bud has not yet been identified.
- Buds probably are infected early in their development, while they are still in a vegetative or transitional state.

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

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The effect of Apogee (prohexadione-calcium) on vegetative shoot growth in apple (Byers and Yoder, 1999; Greene, 1999; Miller, 2002; Schupp et al., 2003; Unrath, 1999), sweet cherry (Elfving et al., 2003a), and pear (Costa et al., 2001; Elfving et al., 2003b) has been well documented. Apogee has also been shown to suppress the shoot blight stage of fire blight in apple (Yoder et al., 1999; Adlwinckle et al., 2000) and pear (Costa et al., 2001) and increase fruit set in apple (Greene, 1999; Unrath, 1999).

Most of the studies on vegetative shoot growth control have reported the effects of single or multiple sprays applied during a single growing season. Few studies have reported the effects of annual applications made to the same trees extending over two or more seasons. Miller (2002) and Unrath (1999) reported no appreciable carryover effect or no additive effect on shoot growth when mature apple trees were treated in two successive growing seasons.

A secondary effect associated with Apogee is an increase in fruit set. Greene (1999) reported a linear rate effect on fruit set for 'McIntosh' apple trees treated at doses between 0 and 325 $mg \cdot L^{-1}$. Return bloom declined quadratically with increasing rate of Apogee and appeared to be inversely related to fruit set the previous year. Unrath (1999) found that time of application affected the fruit set response to Apogee with applications (250 $mg \cdot L^{-1}$) made between 0 and 14 days after petal fall increasing fruit set.

Another secondary effect from Apogee sprays is its ability to limit the development and spread of the shoot blight stage of fire blight caused by *Erwinia amylovora* (Aldwinckle et al., 2000; Yoder et al., 1999). Because vigorous growth is highly susceptible to infection by fire blight (van der Zwet and Beer, 1995), suppressing vegetative growth with Apogee presents a unique approach to controlling this disease. Treating newly planted or young trees with Apogee to reduce growth, however, does not fit the horticultural goals of maximizing bearing canopy and filling the allotted orchard space quickly. Few, if any studies of Apogee treatment have been directed at young trees growing under field conditions. Norelli and Miller (2001) have presented preliminary data on the use of low-dose (63 $mg \cdot L^{-1}$) Apogee sprays on young apple trees to suppress fire blight without sacrificing tree growth. In the initial trials low-dose sprays effectively reduced blight, but only when shoot growth was controlled during the blight infection period.

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

The objective of this study was to evaluate the long-term effect of annual Apogee sprays on apple trees using a combination of rates employed by Norelli and Miller (2001). The study is designed to begin application when trees are young and just beginning to bear fruit. Of particular interest will be the yearly and cumulative effects on yield, fruit size, shoot growth, tree size and the economic impact following repeat treatment. This paper reports the results following the first year of Apogee treatment.

Materials and Methods

The trees selected for the study were 'Nittany' on Malling 9 (M.9) rootstock planted in May 2000. Trees were spaced 2.4 m apart in a row that was maintained in a herbicide strip. All trees were trained to the central leader form and supported by a single conduit pole tied to a trellis wire. Trees were of uniform size at the time of the initial spray treatment, and were maintained using local cultural and pesticide recommendations. An initial foliar spray of Apogee 27.5DF (BASF Corp., Research Triangle Park, NC) was applied to 10 single tree replications at petal fall (7 May) using a backpack hand wand sprayer. An equal number of trees were selected to serve as controls. Sprays were applied dilute to wet all the foliage on the tree to the point of drip. A second Apogee spray was applied 2-weeks after petal fall (WAPF) (20 May) followed by a third application 4 WAPF (2 June). The initial Apogee spray was applied at 125 $mg \cdot L^{-1}$ in a volume of 566 $L \cdot ha^{-1}$ [about 60 gal. per acre (gpa)]. The calculated tree-row volume (TRV) for the 'Nittany' trees was 800 $L \cdot ha^{-1}$ (85.5 gpa). The second and third Apogee sprays were applied at 63 $mg \cdot L^{-1}$ each. Ammonium sulfate (AMS) (spray grade) was added as a water conditioner to all spray solutions on an equal weight basis with Apogee. A non-ionic adjuvant, Regulaid (Kalo, Inc., Overland park, KS), was included in all treatment sprays at 0.125% (v/v). The final spray solution was adjusted to a pH of about 6.2 with distilled white vinegar (National Fruit Product Co., Inc., Winchester, VA). Trees were hand thinned in early June, before "June drop", to space fruit about 15 to 20 cm apart. A follow-up hand thinning was applied in mid-July to achieve desirable final fruit spacing.

High winds from a passing hurricane resulted in abnormal fruit drop on 19 Sept. about 14 d before predicted harvest maturity. All fruit detached by high winds were harvested, counted and weighed on 23 Sept. All trees were harvested between 3 and 6 Oct. when 'Nittany' was considered to be commercially acceptable for harvest. The total number of fruit harvested from each tree was counted and weighed and mean fruit weight calculated. Mean fruit diameter was determined by measuring the diameter of all fruit harvested from a tree. A representative sub-sample of 10 fruit was selected for fruit quality measurements. Flesh firmness was determined on opposite pared sides of each fruit with a McCormick Model FT-327 penetrometer fitted with an 11.4-mm tip and mounted in a drill-press stand. Firmness was recorded to the nearest tenth of a pound. Soluble solids concentration (SSC) to the nearest 0.1% was determined with a digital refractometer (Atago, PR100; NSG Precision Cells, Inc., Farmingdale, NY) from a composite juice sample from the 10-apple sample. Starch-iodine index (SI) was visually rated using the technique and 1 to 8 scale as described by Blanpied and Silsby (1992). At the end of the growing season trunk diameter was recorded 30 cm above the graft union and trunk cross-sectional area calculated. At the same time tree height was recorded and canopy spread was determined by measuring the canopy at the widest point within the row and across the row and averaging the two measurements. Mean shoot growth was determined from 10 terminal shoots selected at random around the periphery of the tree. Analysis of variance and Student's *t*-test were used to analyze treatment effects.

Results and Discussion

A visible reduction in shoot growth is expected within 10 to 14 days of an Apogee application (Greene, 1999; Schupp et al., 2001). In this study no growth response was evident on 20 May, 13 days after the initial application. Light rainfall occurred about 3 HR after the initial Apogee spray; a total of 5.1 mm rainfall was recorded over the next 12 HR period. Between 8 May and 12 May an additional 26.7 mm of rainfall was recorded. This precipitation combined with extensive cloud cover for 3 days after the initial treatment may have reduced activity. Growth response was visible on 30 May, 23 days after the first Apogee spray and 10 days after the second Apogee treatment. On 11 June pronounced growth suppression was evident on the Apogee treated trees. A rosy apple aphid (RAA) [*Dysaphis plantaginea* (Passerini)] infestation affected some fruits and shoot growth, but a timely spray of imidacloprid at recommended rates reduced further damage. Fruits affected by RAA were removed when possible during the thinning operation. A single fire blight strike was observed in a control tree in early-June. The strike was about 15 cm in length when noted and was pruned back to a healthy lateral shoot about 20 cm beyond the visible infection. No additional blight sysmtoms were observed during the season. In late August several fruits were noted with a bitter rot (*Colletotrichum acutatum*) infection. A fungicide spray of Captan at (8.9 kg•ha^{-1}) was applied to reduce further damage. Over a 3 wk period about 30 fruits were observed with bitter rot infection. These fruits were removed from the orchard and not included in the yield.

On 19 Sept. all trees were subjected to sustained winds of about 35 mph (30 knots) with gusts to 50 mph (43 knots). An average of 3.6 kg fruit per tree was lost. There was no difference in the weight of fruit lost between Apogee treated trees and controls (data not shown).

The effect of the Apogee sprays on tree growth is presented in Table 1. Apogee had no effect on the TCSA of fourth leaf 'Nittany'/M.9 in the first year of treatment. There was a slight but non-significant reduction in canopy spread on Apogee treated trees. Apogee reduced tree height and terminal shoot growth. Shoot growth was reduced about 56% by Apogee compared to the control which is similar or slightly better than the growth suppression reported by others for apple (Aldwinckle et al., 2000; Byers and Yoder, 1999; Greene, 1999; Miller 2002; Unrath, 1999).

Apogee treated trees had a lower yield (harvested fruit weight and harvested weight plus weight of drops) than control trees in this study (Table 2). The reason for the lower crop load on Apogee treated trees is not readily apparent. Most previous studies (Byers and Yoder, 1999; Miller, 2002; Schupp et al., 2003) have reported no effect on yield; however, a few have reported an increase in yield as a result of increased fruit set (Greene, 1999; Unrath, 1999). The trees in this study were judged to have a uniform moderate to somewhat heavier bloom. Thinning was based on fruit spacing, not number of fruits. While Apogee treated trees had about 66% of the bitter rot affected fruit (which were removed before harvest and not included in the total weight per tree), adding these fruits into the weight would not have affected the results (data not shown). In addition to fewer number of fruit and a lower harvested fruit weight, Apogee treated fruit had a smaller mean fruit diameter and lower mean fruit weight than control fruit (Table 2).

Reports on the effect of Apogee on apple fruit size have been conflicting. In multiple studies between 1994 and 1998 involving Delicious', 'Gala', 'Golden Delicious', 'Rome', and 'Stayman' apple trees Byers and Yoder (1999) and Miller (2002) found no effect on fruit size with Apogee applied at rates up to 500 $mg \cdot L^{-1}$. Greene (1999) however, found a significant reduction in fruit size when fruit set was increased. Recently Schupp et al. (2003) reported a size reduction on 'Empire' treated at 63 $mg \cdot L^{-1}$ in tests in New Jersey or at 250 $mg \cdot L^{-1}$ in tests in Geneva, New York. I observed a size reduction in 2001 on several apple cultivars treated with Apogee at recommended rates when crop load was not a factor (unpublished data). Several commercial orchards also noted reduced fruit size in the same year (Greg Butler, B&G Orchards and Dave Cosby, National Fruit Product Co., personal communication) on Apogee treated trees carrying a light to moderate crop load. Warrington et al. (1999) reported that fruit size was reduced on several apple cultivars when temperatures during the immediate postbloom period (0 to 40 days) were low (daily mean high 9 °C; mean low 3 °C) compared to higher (daily mean high 25 °C; mean low 15 °C) postbloom temperatures. Postbloom temperatures in 2003 averaged 2.4 °C below normal; postbloom temperatures in 2001 were also below normal. This suggests that low postbloom temperatures in combination with Apogee treatment may have a negative effect on fruit growth and fruit size at harvest. Elfving et al. (2003b) reported that high rates of Apogee reduced the size of 'Bartlett' pears when sprays were applied during the cell-division phase of fruit development.

In this study 'Nittany' apples treated with Apogee were significantly firmer at harvest than non-treated 'Nittany'(Table 3). Byers and Yoder (1999) reported an increase in flesh firmness of 'Starkrimson Delicious' apples treated at rates between 125 and 500 $mg \cdot L^{-1}$, and Greene (1999) reported a linear increase in flesh firmness on 'McIntosh' treated at 125 - 375 $mg \cdot L^{-1}$. In contrast Greene (1999) found no effect of Apogee on firmness of 'Macoun' apples treated at rates between 30 and 270 $mg \cdot L^{-1}$. Most previous studies (Byers and Yoder, 1999; Miller, 2002) have reported no effect on fruit firmness. The SSC of Apogee treated fruit was not different from control fruit. Fruit harvested from Apogee treated trees had a higher SI rating indicating fruit were lower in starch and more mature than control fruit (Table 3). Greene (1999) reported that Apogee lowered SSC and increased SI rating on 'McIntosh'. Byers and Yoder (1999) found no effect of Apogee on SSC or starch in 'Stayman' apples treated at 125 - 375 $mg \cdot L^{-1}$.

Conclusions and Future Studies

1. Three dilute foliar sprays of Apogee at an effective cumulative dose of 250 $mg \cdot L^{-1}$ reduced vegetative shoot growth and tree height of 3-year-old (fourth leaf) 'Nittany'/M.9 apple trees, but had no effect on canopy spread or TCSA.
2. Multiple spray treatments at rates of 63 to125 $mg \cdot L^{-1}$ resulted in reduced fruit size of 'Nittany' even in the absence of an increased crop load.
3. Apogee sprays to suppress shoot growth in young bearing 'Nittany' apple trees increased fruit firmness and lowered starch levels at harvest.

The purpose of this study is to evaluate repeat annual applications of Apogee applied over a four to five year period to young apple trees. Of interest are the effects on annual shoot growth, canopy size, return bloom, fruit set, yield, fruit size, fruit quality, natural fire blight infection and tree survival. The ultimate objective will be an economic analysis to examine the cost of Apogee application and the farm gate value generated by Apogee treated trees vs. control trees.

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Table 1. Effect of Apogee sprays on the growth of fourth leaf 'Nittany' apple trees on Malling.9 rootstock. [z]

Variable	Treatments		
	Apogee	Control	*P* – value
Trunk cross-sectional area (cm^2)	17.1	17.2	0.974
Canopy spread (m)	1.86	2.08	0.088
Tree height (m)	2.63 b[y]	2.92 a	0.003
Terminal shoot growth (cm)	16.7 b	38.2 a	<0.001

[z] Three sprays applied dilute: 125 mg/L at petal fall, 63 mg/L 2-weeks after petal fall(WAPF), and 63 mg/L 4-WAPF.

[y] Mean separation between treatments by Student's *t*-test.

Table 2. Effect of Apogee sprays on the yield and fruit size of fourth leaf 'Nittany' apple trees on Malling.9 rootstock. [z]

Variable	Treatments		
	Apogee	Control	P – value
Number fruit harvested per tree	30 b[y]	47 a	0.034
Weight harvested fruit (kg/tree)	6.05 b	10.90 a	0.007
Mean fruit weight (g)	216 b	238 a	0.040
Mean fruit diameter (cm)	7.57 b	7.95 a	0.004
Total weight of drops plus harvested fruit (kg/tree)	10.9 b	15.7 a	0.016

[z] Three sprays applied dilute: 125 mg/L at petal fall, 63 mg/L 2-weeks after petal fall(WAPF), and 63 mg/L 4-WAPF.
[y] Mean separation between treatments by Student's *t*-test.

Table 3. Effect of Apogee sprays on the fruit quality of apples harvested from fourth leaf 'Nittany' apple trees on Malling.9 rootstock. [z]

Variable	Treatments		
	Apogee	Control	P – value
Flesh firmness (lbs.)	18.9 a[y]	18.2 b	0.046
Soluble solids concentration (%)	14.7 a	14.2 a	0.189
Starch index rating[x]	3.7 a	2.9 b	0.022

[z] Three sprays applied dilute: 125 mg/L at petal fall, 63 mg/L 2-weeks after petal fall(WAPF), and 63 mg/L 4-WAPF.
[y] Mean separation between treatments by Student's *t*-test.
[x] Rating scale of 1 to 8 where 1 = least mature and 8 = most mature

Interpretive Summary:

Apple growers would like to use the growth regulator Apogee on younger fruit trees, but they have concerns about excessive growth control and the use of annual sprays on these trees. A study was initiated on 3-year-old apple trees using a lower dose multiple spray treatment of Apogee. Sprays will be repeated on the same trees each season over the next four to five growing seasons. This report provides information on the effects after the first year of treatment. Apogee reduced tree height and terminal shoot growth, but also reduced fruit size, increased fruit firmness, and lowered fruit starch levels at harvest. This information will benefit apple growers and extension fruit specialist who provide recommendations to the fruit industry.

Technical Summary:

Three-year-old 'Nittany'/M.9 apple trees were treated with three individual sprays of the growth regulator Apogee. The initial spray was applied at petal fall at 125 $mg{\cdot}L^{-1}$. At 2-wks and again at 4-wks after petal fall a second and third spray was applied each at 63 $mg{\cdot}L^{-1}$. Trees were hand thinned after "June-drop" to space fruit about 15 cm apart and to distribute crop load over the canopy. Fruit was harvested at the time of commercial harvest for the cultivar in the area and using flesh starch indexing ratings as a guide. Apogee treated trees had fewer fruit numbers and total fruit weight than control trees. Apogee treated fruit was also smaller, both in diameter and weight, than fruit from control trees. However, fruit from Apogee treated trees was firmer and had a higher starch index rating (meaning fruit was more mature) than control fruit. Growth measurements showed that Apogee decreased terminal shoot growth, and reduced tree height, but had no effect on canopy spread or trunk cross-sectional area after the first year of treatment. Sprays will be applied each season during the next four years to determine long-term effects of repeated application of Apogee to apple trees.

Peach Tree Production and Culture as Affected by Growth Habit, Tree Spacing, and Pruning [1]

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In the United States, peach production per hectare (National Peach Council, 2003) is significantly below that for apple (Belrose, 2003). Apple production is higher and has increased significantly in the past several decades mostly through the use of dwarfing rootstocks, spur growth habit trees, and adaptable high-density planting systems (Ferree, 1980; Robinson and Hoying, 2002). Acceptable dwarfing rootstocks for commercial peach production have not been identified, although a recent research report provides optimism for the future (Weibel, 2003). To accommodate higher-density peach plantings, research has developed a number of training and production systems (Chalmers et al., 1978; DeJong et al., 1994; Erez, 1982; Miles et al., 1999; Taylor, 2003) that are based on the use of standard growth habit trees. In practice these standard (or "normal") trees do not readily adapt to high-density plantings as crowding increases shading, which lowers production and fruit quality (Marini et al., 1991; Taylor, 1988). In addition, the management of shoot vigor becomes a problem (DeJong et al., 1994);vigorous growth dominates the upper canopy and forces the bearing mantle toward the top of the tree (Theodore DeJong, personal communication).

An alternative approach to training and pruning systems that rely on standard growth habit trees is the development of growth habits suited to high-density systems (Scorza, 1984). Scorza identified two growth habits with the potential for high density planting, the pillar and upright form trees (Scorza, 1988). Because of their vigorous growth and compact type canopies (Miller and Scorza, 2002; Scorza, 1988), these trees may require specialized training and management systems for efficient production.

A report detailing the initial training and pruning requirements, growth, and yield of pillar and upright habit trees at various planting densities using two pruning systems has been published (Miller and Scorza, 2002). This paper provides additional data on tree size, time required for dormant and summer pruning, yield, and fruit size during the second through the fifth leaf of the planting.

Materials and Methods

Details concerning the planting, training, early pruning, and cultural management of the trees in this study have been presented (Miller and Scorza, 2002). Briefly the experiment had a factorial arrangement of treatments with tree growth habit, training system and summer pruning (SP) in a split-split-split plot design. The whole plot was tree density (spacing). The growth habits were: pillar (P) ('Crimson Rocket'), upright

[1] The authors gratefully acknowledge the technical contributions of V. Larry Crim, USDA-ARS, Appalachian Fruit Research Station, Kearneysville, WV, in this work.

(UP) ('Sweet-N-UP'), and standard (S) ('Harrow Beauty'). Four planting densities [135 trees/ha (6.0 x 6.0 m), 418 trees/ha (4.0 x 6.0 m), 833 trees/ha (2.0 x 6.0 m), and 1112 trees/ha (1.5 x 6.0 m)] with three replications of eight trees each for each of three tree growth habits were planted in a randomized complete block. Border trees were used to separate blocks between and within rows. Two training systems [central leader (CL) or multiple leader (ML)] were assigned randomly to four adjacent trees within each 8–tree plot. The ML training system produced a tree form similar to that of a traditional open center or open-vase system as described by Marini et al. (1995) for S growth habit trees. Trees were dormant pruned each year in late March and early April before full bloom. Designated trees were summer pruned each season about seven weeks before the first fruit were harvested. Summer pruning consisted primarily (about 95%) of thinning cuts to remove new shoot and sucker growth to open the canopy for better light penetration and to help maintain the desired tree form (CL or ML). Where heading cuts were used, shoots were pruned back to 2 to 4 nodes from the point of origin.

Each tree was subjected to two harvest dates. The initial harvest date for a given growth habit (cultivar) was chosen when a few overly mature fruit were seen to have abscised and dropped to the ground. On the first harvest date fruit were harvested at commercial maturity with background color changing from green to yellow (fruit size was not considered as a harvest criteria). About 5 to 7 days later all remaining fruits were harvested. Total yield per tree and average fruit weight and size was recorded. Weight of harvested fruit and the diameter of fruit were recorded for individual trees. A commercially recommended spray schedule was followed for pest control. Trees were maintained in a weed-free strip with the use of herbicides according to local recommendations. In 1999, 10N-4.4P-8.3K at 0.68 kg/tree was applied to all trees on 14 Apr. and again on 3 June. Only S trees were fertilized in 2001 (30 May, 0.91kg/tree calcium nitrate) and 2003 (12 may, 0.91 kg/tree 10N-4.4P-8.3K). No fertilizer was applied in the 2002 growing season.

To minimize variability due to individual pruning biases, the senior author performed all pruning. Data were analyzed by ANOVA as a factorial and means separated by Duncan's new multiple range test at $P = 0.05$.

Results

The effect of main treatment factors on shoot growth and tree size at the end of the third growing season (2001) are presented in Table 1. The UP form trees had the largest trunk circumference (27.2 cm) among the three growth habits, and trees planted at the lowest density (widest in-row spacing) had the largest trunk size. These results agree with other reports that show peach tree trunk size is reduced when trees are planted at higher densities (Marini and Sowers, 2000; Miles et al., 1999; Taylor, 2003). P trees had the greatest tree height (4.1 m) and longest terminal shoot growth (110.3 cm) while S trees had the largest canopy width. Tree height was limited each season by dormant pruning to about 3.3 m ± 0.2 m. When in-row spacing increased from 1.5 to 6.0 m, tree size and terminal growth of all growth habits increased and trees planted at the widest spacing (6.0 m) were the largest. Training system had little or no influence on trunk size or shoot growth (Table 1), but CL trained trees were taller than ML trained trees, as might be expected. Summer pruning reduced tree size, although differences were small. Terminal growth in the third leaf was unaffected by SP (Table 1).

The time required (sec/tree) to dormant prune trees represented by the three growth habits and the effect of spacing, training system, and summer pruning on the dormant pruning time in the fourth leaf is presented in Fig. 1. S habit trees required more time (mean of 364 sec/tree) to dormant prune than P (237 sec/tree) or UP trees (318 sec/tree), but differences were not significant between S and UP trees. When the in-row spacing between trees was increased, the time required to dormant prune trees also increased. Marini (1986) reported a dormant pruning time of 13 min/tree (780 seconds) for 6-year-old 'Redhaven' peach trees planted at 6.1 m spacing. While dormant pruning times in this study were below those reported by Marini (1986), his trees were slightly older and likely had a larger canopy. In contrast, Taylor (2003) reported dormant pruning times equal to or greater than ours for standard peach trees grown as traditional open center low-density (331 trees /ha) or in two high-density (665 and 996 trees/ha) systems in the third leaf, but considerably less dormant pruning times for the same trees in the fourth leaf than we report. Training system had no effect on dormant pruning time in the fourth leaf. Summer pruning reduced the time required to dormant prune trees by about 50%. There was a significant SP x growth habit interaction. The interaction means (data not shown) showed that summer pruning UP trees reduced dormant pruning time by about 58% compared to non-SP trees. In P trees, SP reduced dormant pruning time by about 47% while in S trees, SP reduced dormant pruning time by only about 42% compared to non-SP trees. Dormant pruning times for main treatment effects and differences between treatments in the third leaf (data not shown) were very similar to those reported for the fourth leaf (Fig. 1).

The time required to summer prune trees among the three growth habits at four spacings and for the two training systems in the third through the fifth leaf is given in Table 2. UP trees consistently required more SP time than P or S trees. Trees planted at an in-row spacing of 4.0 m required more SP time than trees at 1.5 and 2.0 m, and trees spaced 6.0 m apart required more time to SP than trees at all other spacings. The effect was consistent over all three years. Trees trained to the CL system required more SP time in the third and fourth leaf years than ML trained trees, but there was no difference between training systems in the fifth leaf. It is interesting to note that in the fourth leaf, a light crop year, more time was required to SP trees than in the heavier cropping third and fifth leaf years. Few studies have focused on the time required to SP peach trees. Marini and Rossi (1985) indicated that 20 hr/ha were required to summer prune mature 'Sunqueen' peach trees planted at 143 trees/ha. In our study S trees in their fifth leaf planted at 274 trees/ha (6.0 x 6.1 m) required ≈58 hr/ha to SP. In comparison UP trees planted at 455 trees/ha (4.0 x 6.1 m) required ≈81 hr/ha and P trees planted at 1366 trees/ha (1.5 x 6.1 m) required ≈116 hr/ha to SP. The SP performed in our study was comprehensive and likely more detailed than would be accepted in a commercial orchard.

While SP significantly reduced the time needed to dormant prune trees (Fig. 1), the total pruning time (dormant plus SP) required for trees that had been SP was significantly greater than for the non-SP trees (Table 3). A similar response in total pruning time was demonstrated for UP and S trees and for trees at all spacings (data not shown).

Annual yield (kg/tree) in the second through the fifth leaf and the cumulative yield for the planting are given in Table 4. Frost severely reduced the crop in the fourth leaf. UP trees initially (2^{nd} and 3^{rd} leaf) had higher yields per tree than P or S trees, but in the fourth and fifth leaf, yield of S trees was not different from UP trees. Annual yield per tree was consistently lower for P trees compared to UP and S trees. UP trees showed the highest cumulative yield over the first four cropping seasons, but was not different from the cumulative yield for S trees (Table 4). Increasing the in-row tree spacing generally increased yields per tree, although there was no difference for trees at the 1.5 and 2.0 m spacing, however, there was a significant yield difference among all spacings for cumulative yield. The effect of training system on yield was inconsistent, but ML trees often had a slightly higher yield than CL trained trees. The effect of SP was also variable with yield of SP trees sometimes lower than that for non-SP trees. There was a significant interaction of many of the main treatment factors with growth habit in most years. The interaction of spacing and growth habit for the third and fifth leaf yield per tree is presented in Table 5 and Table 6, respectively. In the third leaf increasing the in-row spacing had no effect on the yield of P trees, but there was a significant increase in the yield of UP and S trees as spacing increased (Table 5). P trees have a narrow, upright canopy which normally does not grow to fill a wide spacing, as occurs with UP and S form trees. In the fifth leaf, P trees grown at the widest spacing (6.0 m) had filled more of this available space, as reflected by the higher yield per tree (Table 6).

While yields are an important aspect when evaluating the performance of orchard systems, other factors, such as fruit size at harvest and fruit overcolor, must also be considered. Main treatment effects on peach fruit diameter in the third through fifth growing seasons are presented in Table 7. UP trees consistently produced the largest sized fruit. In the third and fifth leaf harvests (the heavy cropping years), P trees produced larger fruit than S trees. In the fourth leaf, when frost reduced the crop load, S and P trees produced similar size fruit at harvest. Peaches harvested from trees at the widest in-row spacing (6.0 m) were larger than fruit from the closest spacing (1.5 m) in all three seasons. Marini and Sowers (2000) reported that individual fruit weight was lower in high-density plantings (740 trees/ha) compared to low-density (370 trees/ha) plantings. In our study, the effect of training system was inconsistent and minimal, but some studies have seen an effect of training system on yield (Marini et al., 1995). The effect of SP on peach fruit size has been inconsistent (Miller, 1988). Fruit from SP trees in the present trial was often smaller, although only slightly, than fruit from non-SP trees. A comprhensive statistical analysis of fruit red color (overcolor) has not been completed, however, preliminary data indicate that red color averaged between 76% and 82% of fruit surface for both P and UP trees that were SP or not SP (data not shown).

Table 8 presents projected peach yields in MT per ha and in bushels per acre for the three growth habits at the current in-row spacing using actual yields per tree in the fifth leaf at proposed between row tree spacing. Based on these inputs, UP trees would produce the largest yields (48 MT/ha) among the three growth habits at the closest in-row spacing (1.5 m). A recent study in Georgia using 'Redglobe'/'Lovell' trained as a "Quad-V" and planted at 665 trees/ha showed yields of only 16 MT/ha in the fourth leaf (Taylor, 2003). This training system would closely resemble UP trees trained to a ML form and planted at 3.0 x 5.5 m. Based on data in Table 8 this planting could be expected to yield about 39 MT/ha, considerably more than the standard form trees planted at a higher density in the Georgia study. As the data in Table 8 illustrate, higher planting densities, regardless of growth habit, may be expected to result in greater yields, however, this may not be the most profitable system, as suggested by Marini and Sowers (2000) and DeJong et al. (1999). It should also be noted that at very high densities, yields may decline, as shown by Giulivo et al. (1984) for peach and nectarine trees. Based on our observations, ideal in-row spacing for the three growth habits planted in this study and on this site would be 1.5 m for P trees, between 2.0 and 4.0 m for UP trees, and 6.0 m for S trees. At these suggested in-row spacing and the proposed between row spacing

(Table 8), yields per ha for P and UP trees might be comparable (about 39 MT/ha). However, to achieve this high yield with P trees would require 1366 trees/ha compared to only about 610 trees/ha (3.0 x 5.5 m spacing) for UP trees. In addition, as our data shows, fruit sizes are likely to be significantly larger for UP trees compared to P trees. The lowest projected yield of 14.1 MT/ha (6.0 x 4.9 m spacing) for P trees is slightly above the average US yield per ha for peaches of 13.6 MT/ha (National Peach Council, 2003).

Conclusions

1. Growth habit and spacing have a significant effect on peach tree management and performance.
2. Summer pruning increases total pruning time per tree for all growth habits compared to non-SP trees and has no apparent advantage in yield or fruit quality except to reduce dormant pruning time per tree.
3. CL or ML training systems provided no distinct advantage in pruning time or yield for the three growth habits and four in-row tree spacings used in this study.
4. Freestanding, high-density peach plantings are feasible with P and UP growth habit trees. These growth habits offer distinct yield advantages over traditional low-density planting systems.
5. UP growth habit trees provide a good "transition" for peach growers who desire to move from traditional low-density planting systems to a higher density system.

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Table 1. The effect of peach tree growth habit, tree spacing, training system and summer pruning on tree size and terminal growth in the third leaf in the orchard (2001).

Main Effects	Trunk circum. (cm)	Tree height (m)	Canopy width in-row (cm)	Canopy width across row (cm)	Terminal growth (cm)
Growth habit					
Pillar	23.7 a[z]	4.1 c	162 a	167 a	110.3 b
Upright	27.2 b	3.9 b	250 b	276 b	83.0 a
Standard	24.7 a	3.4 a	291 c	350 c	85.3 a
Spacing (m)			*[y]		
1.5	22.6 a	3.8 a	165 a	256 a	90.9 b
2.0	23.3 a	3.7 a	200 b	255 a	81.3 a
4.0	26.2 b	3.7 a	274 c	267 ab	95.4 bc
6.0	28.8 c	4.0 b	299 d	278 b	103.8 c
Training system		*			* †[x]
CL[w]	25.1 a	4.0 b	236 a	263 a	90.0 a
ML	25.4 a	3.6 a	232 a	265 a	95.7 b
Summer pruned				†	
Yes	24.9 a	3.7 a	231 a	259 a	92.7 a
No	25.6 b	3.8 b	238 b	270 b	93.0 a

[z] Mean separation within main treatment effects by Duncan's new multiple range test, P=0.05.
[y] Significant interaction with growth habit.
[x] Significant interaction with spacing.
[w] Central leader (CL) or multiple leader (ML) training system.

Figure 1. Dormant pruning time in fourth leaf peach trees as affected by growth habit, spacing, training system, and summer pruning. Letters indicate significance within main treatment effects by Duncan's new multiple range test, $P = 0.05$.

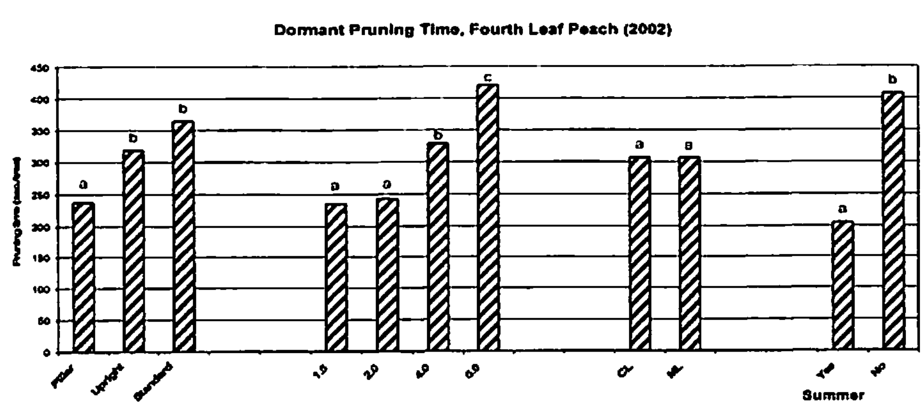

Table 2. The effect of peach tree growth habit, tree spacing, and training system on time required for summer pruning trees in the third through the fifth leaf in the orchard.

	Summer pruning time		
	3rd Leaf	4th Leaf	5th Leaf
Main effect		(sec/tree)	
Growth habit			
Pillar	436 a[z]	571 a	500 a
Upright	559 b	756 b	626 b
Standard	377 a	645 a	486 a
Spacing (m)			
1.5	379 a	477 a	369 a
2.0	400 a	534 a	404 a
4.0	483 b	679 b	567 b
6.0	566 c	941 c	817 c
Training system			
CL[y]	489 b	682 b	562 a
ML	425 a	633 a	512 a

[z] Mean separation within main treatment effects by Duncan's new multiple range test, P=0.05.
[y] Central leader (CL) or multiple leader (ML) training system.

Table 3. Dormant, summer, and total pruning time for pillar (P) trees that were summer pruned (SP) or not summer pruned (NSP) in the fourth leaf (2002) at a 1.5 m and 6.0 m in-the-row spacing in the orchard.

	Mean pruning time (sec/tree) at two in-row tree spacings					
	Dormant		Summer		Total	
Pruning	1.5	6.0	1.5	6.0	1.5	6.0
SP	122	217	454	773	576	990
NSP	250	390	0	0	250	390
P – value	0.001	0.001			0.001	0.001

Mean separation between treatments by Student's t-test.

Table 4. The effect of peach tree growth habit, tree spacing, training system and summer pruning on yield per tree in the second through the fifth leaf and cumulative yield.

	Yield (kg/tree)				
Main Effect	2nd Leaf 2000	3rd Leaf 2001	4th Leaf 2002	5th Leaf 2003	Cumulative
Growth habit					
Pillar	0.56 a[z]	13.9 a	6.7 a	33.8 a	55 a
Upright	1.80 c	33.4 c	10.8 b	68.3 b	114 b
Standard	1.15 b	27.3 b	10.2 b	63.7 b	102 b
Spacing (m)		*[y]	*	*	*
1.5	---	19.3 a	4.9 a	36.5 a	62 a
2.0	---	22.6 a	7.9 ab	42.4 a	74 b
4.0	---	28.2 b	10.5 bc	57.9 b	98 c
6.0	---	29.4 b	13.8 c	84.3 c	129 d
Training system		*	*	*	
CL[x]	1.06 a	24.4 a	8.6 a	52.7 a	87 a
ML	1.28 b	25.3 a	9.9 a	57.6 b	94 b
Summer pruned	*			*	*
Yes	1.08 a	24.3 a	8.4 a	53.8 a	87 a
No	1.26 a	25.5 a	10.1 b	56.5 b	93 b

[z] Mean separation within main treatment effects by Duncan's new multiple range test, P=0.05.
[y] Significant interaction with growth habit.
[x] Central leader (CL) or multiple leader (ML) training system.

Table 5. The effect of spacing and peach tree growth habit on yield per tree during the third leaf in the orchard (2001).

	Yield (kg/tree) for growth habit:		
Spacing (m)	Pillar (P)	Upright (UP)	Standard (S)
1.5	13.9 a[z]	23.7 a	20.3 a
2.0	14.8 a	27.4 a	25.5 ab
4.0	13.8 a	38.1 b	32.6 b
6.0	13.1 a	44.3 b	30.9 b
P – value	0.846	0.006	0.088
Growth habit mean	13.9 A[y]	33.4 C	27.3 B

[z] Mean separation within growth habit by Duncan's new multiple range test, P=0.05.
[y] Mean separation across growth habits by Duncan's new multiple range test, P=0.05.

Table 6. The effect of spacing and peach tree growth habit on yield per tree during the fifth leaf in the orchard (2003).

	Yield (kg/tree) for growth habit:		
Spacing (m)	Pillar (P)	Upright (UP)	Standard (S)
1.5	28.5 a[z]	39.9 a	41.1 a
2.0	30.2 ab	48.1 a	48.8 ab
4.0	35.0 ab	73.3 b	66.8 b
6.0	41.6 b	112.3 c	99.5 c
P – value	0.134	0.001	0.004
Growth habit mean	33.8 A[y]	68.3 B	63.7 B

[z] Mean separation within growth habit by Duncan's new multiple range test, P=0.05.
[y] Mean separation across growth habits by Duncan's new multiple range test, P=0.05.

Table 7. Effect of peach tree growth habit, in-row spacing, training system, and summer pruning on diameter of fruit harvested in the third though the fifth leaf in the orchard.

	Fruit diameter (cm)			
	3rd Leaf[z]	4th Leaf	5th leaf – 2003	
Main Effect	2001	2002	1st Pick	2nd Pick
Growth habit				
Pillar	6.33 b[y]	6.89 a	6.87 b	6.92 b
Upright	6.93 c	7.59 b	7.25 c	7.40 c
Standard	5.96 a	6.94 a	6.03 a	6.17 a
Spacing (m)				
1.5	6.25 a	6.92 a	6.49 a	6.61 a
2.0	6.27 a	7.08 b	6.70 b	6.77 b
4.0	6.49 ab	7.26 c	6.80 b	6.96 c
6.0	6.61 b	7.29 c	6.87 b	7.02 c
Training system	*[x]			
CL[w]	6.44 b	7.14 a	6.76 b	6.84 a
ML	6.38 a	7.14 a	6.67 a	6.84 a
Summer pruned	*	*		†[v]
Yes	6.36 a	7.10 a	6.67 a	6.82 a
No	6.45 b	7.17 b	6.75 b	6.84 a

[z] First and second picks combined.
[y] Mean separation within main treatment effects by Duncan's new multiple range test, P=0.05.
[x] Significant interaction with growth habit.
[w] Central leader (CL) or multiple leader (ML) training system.
[v] Significant interaction with spacing.

Table 8. Projected peach yields per hectare (and per acre) in the fifth leaf using actual yields for three peach tree growth habits at four in-row tree spacings and proposed between row spacing.

Growth Habit[z]	Actual in-row spacing (m)	Actual in-row spacing (ft)	Proposed between row spacing (m)	Proposed between row spacing (ft)	Trees per (ha)	Trees per (acre)	Mean yield per tree (actual) 5th leaf (2003) (kg)	Mean yield per tree (actual) 5th leaf (2003) (lbs.)	Projected yield[y] MT/ha	Projected yield[y] bu./ac[x]
P	1.5	(4.9)	4.9	(16)	1366	553	28.6	63	39.0	725
	2.0	(6.5)	4.9	(16)	1025	415	30.4	67	31.2	579
	4.0	(13.1)	4.9	(16)	514	208	34.9	77	17.9	334
	6.0	(19.7)	4.9	(16)	341	138	41.8	92	14.1	264
UP	1.5	(4.9)	5.5	(18)	1216	492	39.9	88	48.4	902
	2.0	(6.5)	5.5	(18)	912	369	48.1	106	43.9	815
	4.0	(13.1)	5.5	(18)	455	184	73.5	162	33.4	621
	6.0	(19.7)	5.5	(18)	304	123	112.6	248	34.1	636
S	1.5	(4.9)	6.1	(20)	1095	443	41.3	91	45.3	840
	2.0	(6.5)	6.1	(20)	820	332	49.0	108	40.1	747
	4.0	(13.1)	6.1	(20)	410	166	66.7	147	27.4	508
	6.0	(19.7)	6.1	(20)	274	111	99.4	219	27.1	506

[z] P = pillar, UP = upright, and S = standard habit tree.
[y] Based on actual in-row spacings and fifth leaf yields per tree and proposed between row spacing.
[x] 48 lb. boxes

STRAWBERRY TRIALS 2001-2003

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Experiment 1. To evaluate the effects of using a 2.1 ounce floating row cover (FRC) on harvest yields.
Experiment 2. To evaluate Spring harvest yields from Spring planted material.
Experiment 3. To evaluate two plant types and 3 mulch colors and there effects on Fall fruiting of Sweet Charlie

CULTURE:

For all trials, late-Summer pre-bedding operations consisted of a pre-plant fertilizer, 400 lb/a of 16-8-8. In August, black plastic was applied on raised beds 8 inch high x 29 inch wide at the bed shoulder. A single drip line (0.45gpm) was installed in the center of the bed. Transplanting was accomplished with a tractor-mounted water-wheel with an application of soluble 20-20-20 fertilizer at 2 lbs/100gallon water. Planting configuration was a double staggered row, 12 inch x 12 inch spacing between and within rows. All plots received multiple, post-planting overhead irrigation to help establish the plants. Spring fertilizer application of 30 lb nitrogen plus 0.75 lbs boron/acre through the drip system with one-half applied in March and one-half applied in April. No pre-plant fumigation was used and no small fruits had ever been planted at this site. Fungicides and insecticides were applied as needed per local commercial recommendations. Irrigation frequency was determined with tensiometers at 6 and 12 inches within the planted row.

Spring flower bud frost protection was accomplished by using FRC's or overhead irrigation. There was a high degree of certainty that exposed flowers or flower buds were not damaged during the Spring. Winter damage to flower buds is still unclear.

Standard cultural recommendations (STD) for the milder mid-Atlantic areas for the annual strawberry plasticulture system are to plant during the first two weeks in September and to apply a FRC for over-Wintering the planting in early December.

Experiment 1.

OBJECTIVE:

To determine if harvest yields are different when a 2.1 FRC is deployed on two dates.

METHODS:

In 2001, three week old plug plants of Chandler(CH), Sweet Charlie(SC), Camarosa(CA) and Allstar(AS) were planted on September 3. The 2.1 ounce FRC was deployed on October 25(EC) and December 12(LC). In 2002, three-week old plug plants of Sweet Charlie were planted September 4 and Chandler plug plants were planted on September 12. The FRC was deployed on October 24 (EC) and November 27 (LC).

In 2001 plots consisted of ten plants replicated four times, and in 2002 plots were twenty plants replicated three times. Actual plot area covered by the FRC treatments was 900sqft. The FRC used was a 2.1 ounce Amoco 4801 needle punch polypropylene product. This same cover was left on throughout the winter. For both years it was removed in March.

RESULTS:

The 2002/03 seasons was considerably colder than the 2001/02 seasons and first Spring harvest dates were later in 2003. Soil and air temperature measurements show increases under the FRC (Figures 1 and 2). Data on light measurements are pending at this time. 2002 total harvest yields and average fruit size had no significant differences between FRC deployment dates (LC or EC) for all varieties (Table 1). In 2003 Sweet Charlie total yields and fruit size were depressed by the early FRC treatment (EC) (Table 2). First harvest date for each variety between FRC treatments was the same. However total harvest yields for the first three harvests was advanced in both years for all varieties for the EC treatment.

Table1. 2002 Harvest Data

Cultivar	CH	CH	SC	SC	CA	CA	AS	AS
Treatment	EC	LC	EC	LC	EC	LC	EC	LC
Total plant yield (g)	786	800	351	325	442	423	460	473
Avg. berry size (g)	14.1	14.5	12.4	12.8	13.0	13.3	12.9	13.4
1-3 harvest as % of standard	38	Std	26	Std	16	Std	19	Std

Table 2. 2003 Harvest Data

Cultivar	FRC treatment	Yield per plant (g)	Average fruit size(g)	Harvest 1-3 as % of Std
Chandler	EC	436	23.2	31
Chandler	LC	445	20.4	Std
Sweet Charlie	EC	279	15.2	16
Sweet Charlie	LC	333	18.5	Std

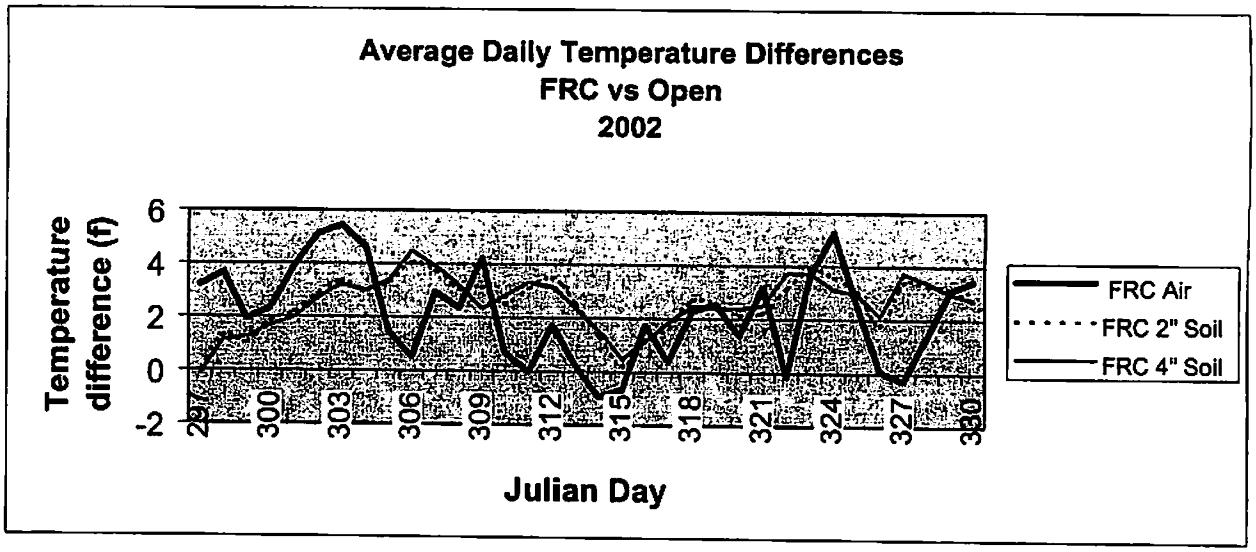


Figure 1.

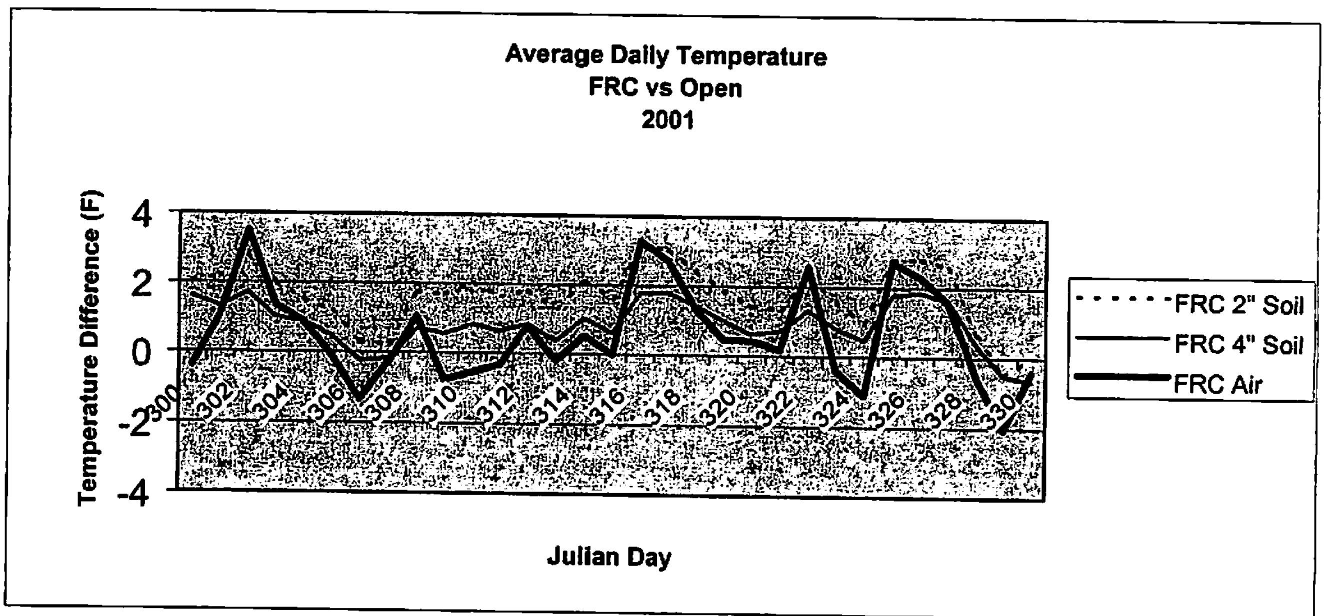


Figure 2.

Experiment 2.

OBJECTIVE:

To determine the feasibility of using greenhouse grown mother plants used for Fall runner-tip production in an outdoor Spring planted plasticulture system.

METHODS:

Strawberry mother plants of Chandler(CH), Camarosa(CA), Sweet Charlie(SC) and Honeye(HO) were obtained from a local greenhouse strawberry runner-tip production supplier in March 2003. These plants were carried-over in an unheated greenhouse after runner tips were harvested the previous Fall. The plants were minimally maintained in an unheated greenhouse for sale in the Spring. These plants were set out on March 15 2003 on beds made the previous Fall. Plots consisted of 20 plants, replicated three times.

A root pruning treatment consisting of un-pruned compared to removing one-third of the roots was evaluated.

RESULTS:

First harvest for Sweet Charlie, Honeye, Chandler and Camarosa were April 30, May 5, May 9 and May 12 respectively. Final harvest for all cultivars was June 30. Total yields and average berry size were about one-half of Fall planted systems (Table 3).

It is believed that under different growing conditions such as in greenhouses or high- tunnels that these plants would have been more productive. First harvest dates for this system were five to ten days earlier than the Fall planted systems, but first fruits were considerably smaller as well. Root pruning did not influence yields.

Table 3.

Cultivar	Root Pruned	Spring Planted Per Plant Yield (g)	Average Berry Size (Spring) (g)	Fall Planted Plug Plant Yield For Comparison (g)	Average Berry Size (g) (Fall plug planted)
Camarosa	Yes	202.7	17.4	--	--
Camarosa	No	210.4	16.3	--	--
Chandler	No	255.9	12.5	445	20.4
Chandler	Yes	227.1	12.7	--	--
Honeye	No	140.0	12.3	--	--
Honeye	Yes	168.9	12.4	--	--
Sweet Charlie	No	135.6	13.4	351	18.5
Sweet Charlie	Yes	148.8	13.2	--	--

-- Not planted

Experiment 3.

OBJECTIVE:

To evaluate the use of black, silver and black plastic covered with straw and its effects on Fall planted plug or Fall dug Sweet Charlie plants on Fall strawberry production

METHODS:

Local grown Sweet Charlie plugs 50/tray or fresh dug plants (one year old) from Spring- fruited plots held-over in the field until dug on September 4. These crowns were split if multiple crowns were present. Both plant types(dug and plug) were planted on September 4. Three mulch types, black (BLK), silver (FOIL), and black covered with straw (BSTR) were evaluated. The Foil and BSTR treatments were used to provide cooler soil temperatures during plant establishment.

Low tunnel hoops with clear plastic were installed, similar to those used in vegetable production on October 22. A heavy nursery-type foam was applied on November 1 through November 8. Clear plastic only from November 8 through November 18. Heavy Nursery foam from November 8 through November 26. Decisions for these covering treatments and venting were based on projected night-time temperatures and daily high temperatures. On December18, the nursery foam was removed from the tunnels and an over-wintering FRC 2.1 ounce/sqyd was deployed until March 12, 2003.

Harvest began on May 10 and last pick was June 5. Plant counts, total field run fruit weights and 25 berry sub-samples to determine average fruit size were measured. Treatment plots consisted of 20 plants, replicated 3 times.

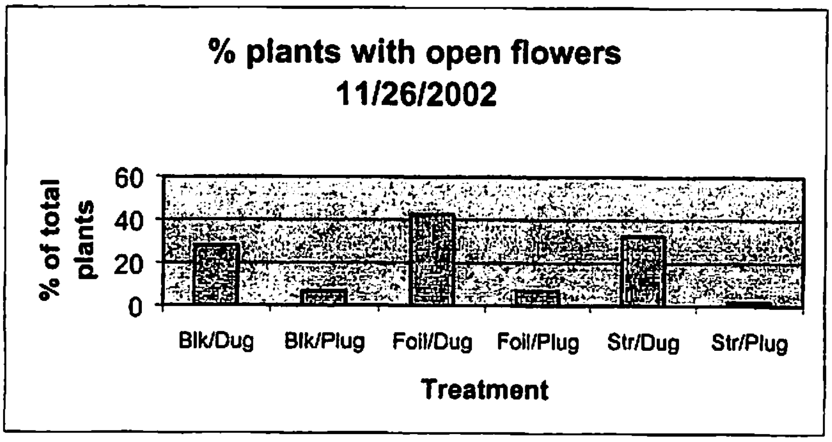
Results:

Fall temperatures were below average and temperatures in the mid-teens in early December prevented fruit from full development. Flower counts in November (figure 3) show that the dug plants had higher flower production compared to the plug plants. Table 4 are the Spring yields. Fall flower production probably reduced Spring yields for the dug plants. Yields for plug plants were greater than other Sweet Charlie plug plants planted under different management systems (Table 2).

Table 4.

Treatment	Total Plot Weight (g)	Plot Plant Count	Yield per Plant (g)	Average Berry size (g)
BLK/dug	3791.3	14.7	257.7	14.0
BSTR/dug	4181.7	16.7	252.1	13.9
FOIL/dug	4013.0	14.3	288.1	13.8
BLK/Plug	7786.3	20.0	389.3	17.2
BSTR/Plug	7515.7	18.7	402.3	17.8
FOIL/Plug	8386.7	19.3	432.6	16.7

Figure 3.



Plant Pathology

Influence of Fludioxonil Rate and Application Volume on Postharvest Development of Peach Brown Rot in a Commercial Setting

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The postharvest application of fungicide is an important component of the overall peach disease control program. Disease control at this time prevents infection during the subsequent packing and shipping process, as well as on the grocery shelf, thereby protecting fruit up to the point of sale. In years in which much disease has occurred in the field, a postharvest application can be absolutely critical. Maintenance of high fruit quality is essential to the consumers overall perception of peach as a "fruit of choice".

Fludioxonil (Scholar 50WP) is a new, reduced-risk fungicide recently labeled for postharvest application to stone fruit. Proper application of this fungicide is important for maximum postharvest control of brown rot, the most important disease in the eastern peach-growing region. This study attempts to examine the efficacy of different rates and application volumes of Scholar fungicide in a commercial setting. Furthermore, these experimental treatments were compared to the current commercial rate and volume, as well as a dip treatment.

MATERIALS AND METHODS

Fruit History. The experiment was conducted during the late summer and early fall of the 2003 growing season. Fruit for postharvest treatment were obtained from four 8-year-old 'Autumnglo' peach trees that were part of a season-long fungicide efficacy test. These trees received the following fungicides and rates/A: Orbit 3.6EC (4 fl oz) at pink and bloom; Abound 2.08SC (15.4 fl oz) at PF and SS; Nova 40W (5 oz) + Captan 50WP (6 lb) at first cover; Abound 2.08SC (15.4 fl oz) at second cover; Captan 50WP (6 lb) at third through sixth cover; and Orbit (4 fl oz) at 32, 23, 14, and 4 days preharvest. An extended ripening period resulted in the unusual four preharvest Orbit applications in lieu of the typical three applications. Brown rot control was excellent for this treatment, attaining 96.4% control at harvest (3.2% infected fruit vs. 88.7% for the non-treated control treatment).

Fruit Harvest and Storage. A total of 240 firm, ripe healthy fruit were harvested from each of the four replicate trees on 16 September 2003. Fruit containers were tagged so that fruit from each tree acted as a replicate in the postharvest study. Immediately following picking, fruit were brought to a local grower / packer (Larchmont Farms) where they were hydrocooled.

Water used for hydrocooling was treated with HTH (68% calcium hypochlorite) at the rate of 6 lb HTH / 8,000 gallons of water. Following hydrocooling, the fruit were brought back to the Rutgers Agricultural Research and Extension Center (RAREC) and placed in cold storage (mean temp = 31.75 °F).

Postharvest Treatments. After sixteen days storage, all fruit were brought to a commercial packing house for treatment on 2 October 2003. Typically, commercial fruit will proceed immediately from the hydrocooler to the packing line, or at most be stored for a few days prior to packing. However, we needed to wait until the packing facility was finished with all growers' fruit in order to conduct the experiment. Nevertheless, fruit quality was excellent after this storage period.

All treatments on the packing line consisted of (1) placing fruit on rollers; (2) movement of fruit through a water washer (spray jets); (3) application of Scholar 50WP using a controlled droplet applicator; and (4) removal of fruit on the subsequent packing line. Fruit were advanced through both the water wash and fungicide application stages by rolling on top of cylindrical brushes.

The first treatment consisted of the current commercial Scholar concentration and volume employed by the facility, which was labeled as a "1X" rate of application. The Scholar concentration employed was 48 oz Scholar 50WP / 55 gallons wax emulsion; the fungicide applicator pump was set at "25" (an arbitrary scale that influences frequency of droplets and therefore volume dispensed). Subsequent experimental treatment rates were calculated relative to these commercial settings.

The second treatment involved doubling the amount of Scholar in the wax emulsion (conc = 2X) but keeping the pump frequency constant (vol = 1X), for a combined relative application rate of 2X. The third treatment involved doubling the concentration (2X) and increasing the pump setting to 50 (vol = 2X), which resulted in a final relative application rate of 4X. A third experimental treatment consisted of dipping fruit in a Scholar suspension at the labeled application rate of 8 oz / 100 gallons. Fruit remained submersed for a total of 20 to 30 seconds, then removed and allowed to air dry. Unlike the packing line treatments, this dip treatment did not include wax.

Fruit reserved for the non-sprayed control treatments were not run through the packing line due to the likihood of being contaminated by fungicide residue on the rollers and brushes. However, these fruit were nevertheless brought to the packing facility so that they would experience the same shipment conditions and temperatures.

Following fungicide treatment, all fruit were returned to cold storage for 4 days. This post-treatment storage period mimicked commercial storage durations following packing. Typically, commercial fruit are stored for one to seven days following packing before shipment to distributors.

Inoculation. All four fungicide treatments and a non-treated control were inoculated with *Monilinia fructicola* spores, causal agent of peach brown rot. Inoculations were performed by dipping each replicate set of fruit in a spore suspension set at 170,000 viable conidia / ml. The order of inoculations was non-sprayed control, 1X rate (commercial standard), 2X rate, 4X rate, and fungicide dip. Immediately following inoculation, replicate containers were placed in plastic bags and allowed to incubate overnight for 12 hours duration. Mean temperature during this period was 59.1 °F, and relative humidity was assumed to be close to 100% (fruit were moist upon opening).

Disease Assessment. Following the inoculation period, fruit were placed on benches to dry in a shaded greenhouse maintained at an average air temperature of 66.8 °F. After 3.5 and 7 days incubation from the time of inoculation, the total number of fruit observed with brown rot was counted for each treatment replicate. Disease incidence was expressed as the percentage of fruit rotted.

Estimation of Actual Rate. With the exception of the dip treatment, fungicide application rates for experimental treatments were determined relative to the commercial standard. However, measurements were taken to determine the absolute rate of Scholar being applied for the commercial setting as well as the treatments.

Volume of fungicide application was determined by placing a household aluminum gutter below the droplet nozzles to catch all dispensed fungicide / wax suspension. Measurements were taken for 3 minutes at pump settings of 25 and 50. The captured suspension was transferred to a graduated cylinder for volume determination.

The amount of fruit treated per unit time was determined by sending and timing the movement individual peaches through the washer / brusher / fungicide applicator. This estimated time, along with a measurement of the bed width (60"), an assumed average peach diameter of 2.5", and a mean weight of 2.5" diameter peaches (150.4 g) allowed calculation of the number of pounds of peaches being sprayed per unit time.

The concentration of Scholar in the suspension, the volume dispensed / unit time, and the weight of peaches sprayed / unit time allowed calculation of the absolute rate of Scholar application. Per the current Scholar label, results were expressed in ounces of fungicide formulation / 200,000 lbs of fruit.

RESULTS AND DISCUSSION

Brown Rot. At 3.5 days after inoculation, only 9.7% of the non-inoculated non-treated control fruit were observed to have brown rot symptoms (Table 1). In contrast, 31.2% of the inoculated control fruit were infected at this time. This significant 21.5 % increase in disease can most likely be attributed to the inoculation.

Although fungicide treated fruit were also inoculated, every treatment was observed to have significantly less disease than the inoculated non-treated control (Table 1). Furthermore, the experimental 2X rate (2X conc, 1X vol) had significantly less disease than the commercial standard. Percent disease control at 3.5 days ranged from 95.5% for the 2X rate to 78.8% for the commercial 1X rate (Table 2).

Brown rot incidence increased considerably during the next 3.5 days of incubation from the time of the first assessment. At 7 days post-inoculation, the inoculated control, with 83.4% incidence, had approximately twice as much brown rot as the non-inoculated control (Table 1). The standard commercial treatment was no longer significantly different from the inoculated control. Although fruit receiving the 4X rate of Scholar had significantly less disease than both the inoculated control and commercial 1X treatment, this "best" treatment still only yielded 51.3% disease control (Table 2).

Fludioxonil appeared to have influenced the ability of *M. fructicola* to sporulate. At 7 dpi, non-treated fruit were observed to be sporulating profusely. Infected fruit for the 1X treatment had small amounts of sporulation. However, infected fruit for the 2X, 4X, and dip treatments, although thoroughly rotted, did not exhibit any sporulation.

Estimation of Actual Rates. Application volumes and rates estimated for the commercial settings (1X rate) were considerably lower than listed on the Scholar label (Table 3). The volume of 2.4 gal fungicide-wax emulsion / 200,000 lbs fruit was only one-third of the lowest labeled volume of 7 gal. Similarly, the estimated rate of 2.09 oz Scholar 50WP/200,000 lbs fruit was only approximately one-fourth the labeled 8 oz rate.

As a matter of design, the experimental packing line treatment rates were higher than the commercial standard. The 2X rate was approximately half the labeled rate, while the 4X rate of 8.25 oz / 200,000 lbs fruit was slightly more than the lowest labeled rate. None of the volumes, however, were as high as recommended on the label. The highest volume applied (4X trt) was only two-thirds the lowest volume listed on the label.

CONCLUSIONS

- Based on the 3.5 day assessment, Scholar 50WP effectively controlled brown rot development in both experimental packing line treatments, providing 91 to 95% disease control. However, under the high inoculum conditions of the study, none of the treatments provided acceptable control after 7 days incubation.

- The commercial application rate for Scholar was much too low for effective disease control, particularly in the presence of additional inoculum. A significant increase in control (at 3.5 dpi) was observed when doubling the rate.

- The commercial volume for Scholar application was too low. A higher volume should help improve coverage and control. A significant increase in control (at 7 dpi) was observed when both the rate and volume were doubled (4X treatment).

- The fungicide dip treatment performed as well as the two experimental packing line treatments.

- Scholar appeared to influence the ability of *M. fructicola* to sporulate. Such activity would help prevent spread of disease during the packing / shipping process.

CAVEAT

- The non-inoculated non-treated control fruit received hydrocooling (with chlorine disinfectant) but no packing line exposure. Thus, exposure to inoculum was minimal after harvest. Yet, 41.5% of these fruit rotted by 7 days post-inoculation. This may indicate that the harvested, apparently healthy fruit contained latent infections. Scholar would not be expected to control such infections. However, it is entirely possible that these fruit became infected during the incubation period, especially since the inoculated control fruit exhibited profuse sporulation during this period.

TABLE 1. Brown Rot Post-harvest Incidence							
	Scholar 50WP Application Method	Relative				% Fruit Infected [1]	
Treatment		Conc.	Volume	Rate	Inoculation	3.5-dpi	7-dpi
Non-treated	-----	-----	-----	-----	No	9.7 [2]	41.5 [2]
Non-treated	-----	-----	-----	-----	Yes	31.2 a	83.4 a
Standard [3]	Control Droplet	1X	1X	1X	Yes	6.6 b	69.0 ab
Experimental	Control Droplet	2X	1X	2X	Yes	1.4 c	48.9 bc
Experimental	Control Droplet	2X	2X	4X	Yes	2.8 bc	40.6 c
Experimental	Fungicide Dip	Label	-----	Label	Yes	3.5 bc	50.1 bc

[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); dpi = days post-inoculation.
[2] Analyses performed only on inoculated treatments (uninoculated NTC not included);
[3] Standard treatment = current packing house settings for concentration and volume

TABLE 2. Percent Brown Rot Control							
	Scholar 50WP Application Method	Relative				% Disease Control [1]	
Treatment		Conc.	Volume	Rate	Inoculation	3.5-dpi	7-dpi
Standard [2]	Control Droplet	1X	1X	1X	Yes	78.8	17.3
Experimental	Control Droplet	2X	1X	2X	Yes	95.5	41.4
Experimental	Control Droplet	2X	2X	4X	Yes	91.0	51.3
Experimental	Fungicide Dip	Label	-----	Label	Yes	88.8	40.0

[1] Percent control for each fungicide treatment calculated relative to the inoculated non-treated control treatment; dpi = days post-inoculation.
[3] Standard treatment = current packing house settings for concentration and volume

TABLE 3. Relative and Actual Rates of Scholar 50WP for Postharvest Application						
	Scholar 50WP Application Method	Relative			Actual / 200,000 lbs [1]	
Treatment		Conc.	Volume	Rate	Volume	Rate
Standard [2]	Control Droplet	1X	1X	1X	2.4 gal	2.09 oz
Experimental	Control Droplet	2X	1X	2X	2.4 gal	4.18 oz
Experimental	Control Droplet	2X	2X	4X	4.7 gal	8.25 oz
Experimental	Fungicide Dip	Label	-----	Label	100 gal	8.00 oz
Scholar Label: High Volume		-----	-----	-----	25-100 gal	8-16 oz
Scholar Label: Low Volume		-----	-----	-----	7-25 gal	8-16 oz

[1] Estimated rates assume average fruit size of 2.5" diameter
[2] Standard treatment = current packing house settings for concentration and volume

Management of Peach Diseases Using Mixtures and Combinations of DMI and QoI Fungicides

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Fungicides of different chemistry were examined in various combinations for their efficacy against one or more important peach diseases. Particular emphasis was placed on integrating DMI and QoI fungicides. These combinations were compared to each other and to treatments having timings consisting of a single fungicide active against a particular disease (Scala; Elite; Orbit). In addition, peach scab sprays were initiated one growth stage earlier, at petal fall, in an attempt to improve control in a block having extremely high inoculum pressure.

MATERIALS AND METHODS

Treatments. The experiment was conducted during the spring and summer of the 2003 growing season. The test block consisted of mixed-cultivar orchard of 8-year-old 'Autumnglo' peach, 'Suncrest' peach, and 'Redgold' nectarine. Trees of each cultivar alternated within the rows and were planted at 20 ft x 25 ft spacing. Only 'Autumnglo' trees were used in the experiment.

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

Fungicide applications were made on the following dates and tree growth stages: 14 Apr (P, pink); 21 Apr (B, bloom); 30 Apr (PF, petal fall); 9 May and 11 ((SS, shuck split) a second SS application was made due to rain during the first); and 19 May, 3, 17, Jun, 1, 15, 29 Jul (1C-6C, first-sixth cover). Typically three pre-harvest (PH) sprays for fruit rot control are applied; however, a delay in ripening resulted in four applications on 11, 20, 29 Aug and 8 Sep (32, 23, 14, and 4 days PH). Nevertheless, one treatment (Orbit) received only 3 pre-harvest applications on 15, 25, Aug and 5 Sep (28, 18, and 7 days PH). Insecticides and miticides were applied as needed to the entire block using a commercial airblast sprayer.

Environment. The wet weather conditions this year were favorable for blossom blight, scab, and the harvest and post harvest rots (Figure 1). Between PF and 2C, the period the fruit is susceptible to rusty spot, the weather was wet and cooler than normal; this most likely explains the very low incidence of rusty spot in 2003. A total of 37 days with rain >0.10 in occurred from bloom on 14 Apr to 15 Aug (28 days PH); there were 18 days of rain with < 0.10 in accumulation. The number of rain days with over >0.10 in following each spray during this time were: P, 1;B, 2; PF, 1; SS, 2; 1C, 6; 2C, 5; 3C, 4;

4C, 6; 5C, 2; and 6C, 8. Conditions were favorable for brown rot on cultivars during their pre-harvest period due to inoculum in the block from earlier cultivars and wet weather near the time of harvest. Six rain periods >0.10 in and occurred during the 32 days prior to harvest, with most of them concentrated just over a week before harvest. For the treatment receiving four preharvest sprays, the number of rain days following each spray during this time was: 32 PH, 2; 23 PH, 0; 14 PH, 4 and 4 PH, 0. For the treatment receiving three postharvest sprays, the number of rain days follow each spray time was: 28 PH, 2; 18 PH, 4; and 7 PH, 0.

Assessment. Blossom blight (*M. fructicola*) was evaluated on 14 July by examining 25 fruiting shoots. Rusty spot (*Podosphaera leucotricha?*) was evaluated on 23 Jun by examining 50 fruit per tree. Scab (*Cladosporium carpophilum*) was evaluated on 28 Aug by examining 50 fruit per tree. Brown rot (*M. fructicola*) was evaluated at harvest on 12 Sep by examining all fruit on two or more branches per replicate tree; a minimum of 100 fruit / tree was examined. For post-harvest evaluations, 40-50 healthy fruit were harvested from each tree and placed on benches in a shaded greenhouse (ave. air temp. = 76ºF). Brown, Rhizopus, and Anthracnose rot were assessed at 3 and 6 days postharvest (dph).

RESULTS AND DISCUSSION

Blossom Blight. Unlike previous years, sufficient infection of blooms occurred in 2003, resulting in the development of blossom blight cankers; the non-sprayed trees had an 11% incidence. The wet weather and inoculum from mummies that overwintered on the ground and in trees are likely responsible for the higher disease levels. All the treatments had a significantly lower level of blossom blight cankers than the non-sprayed control (Table 1). The low rate of USF2010 had a significantly higher disease incidence (2%) than most other treatments.

Rusty Spot. As also observed in commercial orchards, there was a very low incidence and severity of rusty spot in the test block. Non-sprayed control trees had 9% infected fruit and averaged less than 1 lesion per 10 fruit. In contrast, control trees in this same block in 2002 sustained 90% fruit infection and 3.5 lesions per fruit. All treatments, with the exception of Scala, significantly reduced disease levels when applied at the critical period for susceptibility for rusty spot between petal fall and second cover (Table 2). These treatments did not differ significantly from one another in controlling rusty spot at this low level of disease pressure.

Scab. A combination of high inoculum (twig lesions) and 33 rainy periods (> 0.10 in) from SS to 40 days before harvest resulted in extremely high disease pressure for scab. Control trees had 100% of their fruit with >10 lesions; many fruit were covered by large areas of coalescing lesions. Relative to the non-sprayed control, all fungicide treatments with the exception of Scala, had significantly less disease incidence and severity (Table 3). Application of fungicide increased the proportion of fruit in the 1-10 lesion category, while reducing the number of fruit with >10 lesions. Nevertheless, none of the treatments provided commercially acceptable control under the severe conditions of the study.

The high rate of USF2010 had the lowest fruit disease incidence and severity (Table 3). Although this treatment had significantly less infected fruit then all other treatments, it still only provided 51.5% disease control. Scala was the least effective treatment and did not show any reduction in disease incidence and severity.

Brown Rot. At harvest, the non-sprayed trees in the test block had an 88.7% incidence of brown rot (Table 4). The wet weather throughout the growing season and a large amount of inoculum due to brown rot on earlier cultivars in the test block contributed to the high disease level. All fungicide treatments, except Scala, provided excellent disease control (> 92%). Although Scala had significantly less brown rot at harvest then the non-treated control, it nevertheless only provided 16.8% disease control. No significant differences were observed among the other fungicides.

For the postharvest study, healthy fruit with yellow backround color were selected over less ripe fruit. However, fruit from the non-sprayed and the less effective treatments were less ripe than those from the other treatments. Most of the riper fruit in the less effective treatments were showing symptoms of rot at harvest.

Post-harvest brown rot development was severe, attaining 49% and 74% rotted fruit after 3 and 6-days incubation, respectively, for the non-treated control. After three days post-harvest, all treatments had significantly less rot than the control (Table 4). At this time, disease control ranged from 44% for the Scala to 99% for Elite. For both post-harvest assessments, Scala was the least effective treatment and provided significantly less control than all other treatments. The treatment having three pre-harvest Orbit sprays was the next least effective; it exhibited significantly more post-harvest brown rot than the treatment which four pre-harvest Orbit sprays.

After 6 days incubation, disease levels increased several fold (Table 4). BAS 516 had the least amount of disease and was significantly different from all other treatments except the two Elite+Flint treatments.

Rhizopus Rot. None of the treatments had symptoms of Rhizopus at harvest with the exception of Scala, which had a 2% incidence (Table 5). After 3 and 6 days post-harvest, Scala-treated fruit had the highest amount of Rhizopus rot at 5.8% and 10.9% incidence respectively; disease levels for this treatment were not statistically different from the non-sprayed. Although most treatments had less Rhizopus rot at 3 and 6 days than the non-sprayed, none of them were significantly different from the control.

Anthracnose Rot. In grower orchards and in the test block, more anthracnose was seen this year than in prior years. At harvest, very little anthracnose was seen on the fruit; the Scala treatment had the highest incidence at 2.1% infected fruit. At three and six days post-harvest, the non-sprayed had the highest incidence with 5.8% and 11.5% infected fruit respectively. All treatments had significantly lower levels of the disease than the control, but there was no statistical difference between the treatments. At 6 days post-harvest, disease control ranged from 63.5% for Elite (6.0 oz rate) to 100% for Elite+Flint (high rate).

CONCLUSIONS

- No single treatment was highly effective against all diseases. Scala was the least effective fungicide. For each disease examined, Scala either did not differ significantly from the non-sprayed control or did not provide an acceptable level of control.

- All fungicide treatments (except Scala) provided acceptable control of rusty spot. However, since disease incidence and severity was at an all-time low in 2003, no differences in efficacy between treatments were discernable.

- Peach scab disease pressure was very high due to favorable weather, a large amount of overwintering inoculum, and the presence of non-sprayed buffer trees. Under these conditions, the high rate of USF2010 was the most effective treatment. Fruit receiving this treatment had the lowest scab incidence, which was significantly less than all other treatments.

- Although brown rot disease pressure was intense, all treatments (except Scala) provided excellent control. There was no statistical difference in the amount of brown rot between most of the treatments at harvest. After 6 days post-harvest, BAS 516 followed by both Elite+Flint treatments were most effective in controlling brown rot.

- In general, mixtures of DMI and QoI fungicides (Elite+Flint, USF2010, BAS 516) performed as well as DMI fungicides alone (Elite, Orbit) in controlling brown rot at harvest and post-harvest.

- There was no significant difference between USF2010 and Elite+Flint in controlling rusty spot, Rhizopus rot, and anthracnose rot. Trees treated with the lower rate of USF2010 had a significantly higher incidence of blossom blight than those treated with the lower rate of Elite+Flint.

- There was no significant difference in the amount of brown rot at harvest between the fruit treated with Elite+Flint and the fruit treated with USF 2010. However, at 3- and 6-days post-harvest, fruit treated with the lower rate of USF2010 had significantly more brown rot than the fruit which received the comparable amount of Elite+Flint.

- At harvest, there was no significant difference in brown rot between treatments having the three and four pre-harvest Orbit sprays. However, after 3- and 6-days post-harvest, fruit receiving one less pre-harvest spray of Orbit had a significantly higher level of brown rot than fruit which received four pre-harvest Orbit sprays. This difference in control may also be due to differences in application timing between the two treatments.

TABLE 1. Blossom Blight Canker Incidence[1]			
Treatment	**Rate/ A**	**Timing**	**% Shoots w/Canker**[2]
Nontreated Control	----------------	----------------	11.0 a
BAS 516 38 WG (Pristine)	**14.7 oz**	**P, B** PF, SS, 1C-6C 32, 23, 14, 4 DPH	0.0 c
Scala 60SC	**18.0 fl oz**	**P, B** PF, SS, 1C-6C 32, 23, 14, 4 DPH	1.0 bc
Elite 45DF + Flint 50WG	**2.9 oz + 2.56 oz**	**P, B** PF, SS, 1C-6C 32, 23, 14, 4 DPH	0.0 c
Elite 45DF + Flint 50WG	**3.46 oz + 3.1 oz**	**P, B** PF, SS, 1C-6C 32, 23, 14, 4 DPH	0.0 c
USF2010 500 SC	**5.00 fl oz**	**P, B** PF, SS, 1C-6C 32, 23, 14, 4 DPH	2.0 b
USF2010 500 SC	**5.97 fl oz**	**P, B** PF, SS, 1C-6C 32, 23, 14, 4 DPH	0.0 c
Elite 45DF **Flint 50WG** Nova 40W + Captan 50WP Captan 50WP Elite 45DF	**6.0 oz** **3.0 oz** 5.0 oz + 6.0 lb 6.0 lb 6.0 oz	**P, B** PF, SS, 2C 1C 3C-6C 32, 23, 14, 4 DPH	1.0 bc
Orbit 3.6EC **Quintec 2.08SC + Captan 50WP** Captan 50WP Orbit 3.6EC	**4.0 oz** **8.0 fl oz + 6.0 lb** 6.0 lb 4.0 fl oz	**P, B** PF, SS, 1C, 2C 3C-6C 28, 18, 7 DPH	0.0 c
Orbit 3.6EC **Abound 2.08SC** Nova 40W + Captan 50WP Captan 50WP Orbit 3.6EC	**4.0 fl oz** **15.4 fl oz** 5.0 oz + 6.0 lb 6.0 lb 4.0 fl oz	**P, B** PF, SS, 2C 1C 3C-6C 32, 23, 14, 4 DPH	0.0 c

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

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

Treatment	Rate / A	Timing	% Inf. Fruit[2]	# Lesions/Fruit[2]
Nontreated Control	----------------	----------------	9.0 a	0.09 b
BAS 516 38 WG (Pristine)	**14.7 oz**	P, B **PF, SS, 1C, 2C,** 3C-6C 32, 23, 14, 4 DPH	3.5 b	0.04 c
Scala 60SC	**18.0 fl oz**	P, B **PF, SS, 1C, 2C,** 3C-6C 32, 23, 14, 4 DPH	11.0 a	0.12 a
Elite 45DF + Flint 50WG	**2.9 oz + 2.56 oz**	P, B **PF, SS, 1C, 2C,** 3C-6C 32, 23, 14, 4 DPH	4.0 b	0.04 c
Elite 45DF + Flint 50WG	**3.46 oz + 3.1 oz**	P, B **PF, SS, 1C, 2C,** 3C-6C 32, 23, 14, 4 DPH	2.0 b	0.02 c
USF2010 500 SC	**5.00 fl oz**	P, B **PF, SS, 1C, 2C,** 3C-6C 32, 23, 14, 4 DPH	2.0 b	0.02 c
USF2010 500 SC	**5.97 fl oz**	P, B **PF, SS, 1C, 2C,** 3C-6C 32, 23, 14, 4 DPH	2.0 b	0.02 c
Elite 45DF **Flint 50WG** **Nova 40W + Captan 50WP** Captan 50WP Elite 45DF	6.0 oz **3.0 oz** **5.0 oz + 6.0 lb** 6.0 lb 6.0 oz	P, B **PF, SS, 2C** **1C** 3C-6C 32, 23, 14, 4 DPH	2.0 b	0.02 c
Orbit 3.6EC **Quintec 2.08SC + Captan 50WP** Captan 50WP Orbit 3.6EC	4.0 oz **8.0 fl oz + 6.0 lb** 6.0 lb 4.0 fl oz	P, B **PF, SS, 1C, 2C** 3C-6C 28, 18, 7 DPH	2.0 b	0.02 c
Orbit 3.6EC **Abound 2.08SC** **Nova 40W + Captan 50WP** Captan 50WP Orbit 3.6EC	4.0 fl oz **15.4 fl oz** **5.0 oz + 6.0 lb** 6.0 lb 4.0 fl oz	P, B **PF, SS, 2C** **1C** 3C-6C 32, 23, 14, 4 DPH	2.0 b	0.02 c

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

TABLE 3. Scab Incidence and Severity [1]			% Fruit [2]		
Treatment	**Rate / A**	**Timing**	**Infected**	**1-10 lesions**	**>10 lesions**
Nontreated Control	-----------------	-----------------	100.0 a	0.0 d	100.0 a
BAS 516 38 WG (Pristine)	**14.7 oz**	P, B **PF, SS, 1C-6C** 32, 23, 14, 4 DPH	85.5 b	43.5 abc	42.0 b
Scala 60SC	**18.0 fl oz**	P, B **PF, SS, 1C-6C** 32, 23, 14, 4 DPH	100.0 a	0.0 d	100.0 a
Elite 45DF + Flint 50WG	**2.9 oz + 2.56 oz**	P, B **PF, SS, 1C-6C** 32, 23, 14, 4 DPH	76.5 b	37.0 bc	39.5 b
Elite 45DF + Flint 50WG	**3.46 oz + 3.1 oz**	P, B **PF, SS, 1C-6C** 32, 23, 14, 4 DPH	76.5 b	52.5 a	24.0 bc
USF2010 500 SC	**5.00 fl oz**	P, B **PF, SS, 1C-6C** 32, 23, 14, 4 DPH	83.5 b	44.5 abc	39.0 b
USF2010 500 SC	**5.97 fl oz**	P, B **PF, SS, 1C-6C** 32, 23, 14, 4 DPH	48.5 c	31.5 c	17.0 c
Elite 45DF **Flint 50WG** **Nova 40W + Captan 50WP** **Captan 50WP** Elite 45DF	6.0 oz **3.0 oz** **5.0 oz + 6.0 lb** **6.0 lb** 6.0 oz	P, B **PF, SS, 2C** **1C** **3C-6C** 32, 23, 14, 4 DPH	84.0 b	50.0 ab	34.0 bc
Orbit 3.6EC **Quintec 2.08SC + Captan 50WP** **Captan 50WP** Orbit 3.6EC	4.0 oz **8.0 fl oz + 6.0 lb** **6.0 lb** 4.0 fl oz	P, B **PF, SS, 1C, 2C** **3C-6C** 28, 18, 7 DPH	73.5 b	37.5 bc	36.0 bc
Orbit 3.6EC **Abound 2.08SC** **Nova 40W + Captan 50WP** **Captan 50WP** Orbit 3.6EC	4.0 fl oz **15.4 fl oz** **5.0 oz + 6.0 lb** **6.0 lb** 4.0 fl oz	P, B **PF, SS, 2C** **1C** **3C-6C** 32, 23, 14, 4 DPH	83.5 b	43.5 abc	40.0 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 4. Brown Rot Harvest and Post-harvest Incidence [1]			% Fruit Infected [2]		
Treatment	Rate / A	Timing	Harvest	3-dph	6-dph
Nontreated Control	----------------	----------------	88.7 a	48.8 a	73.6 a
BAS 516 38 WG (Pristine)	**14.7 oz**	P, B PF, SS, 1C-6C **32, 23, 14, 4, DPH**	1.4 c	1.7 de	13.0 f
Scala 60SC	**18.0 fl oz**	P, B PF, SS, 1C-6C **32, 23, 14, 4 DPH**	73.8 b	27.2 b	58.9 b
Elite 45DF + Flint 50WG	**2.9 oz + 2.56 oz**	P, B PF, SS, 1C-6C **32, 23, 14, 4 DPH**	1.6 c	1.2 e	18.2 ef
Elite 45DF + Flint 50WG	**3.46 oz + 3.1 oz**	P, B PF, SS, 1C-6C **32, 23, 14, 4 DPH**	2.7 c	1.2 e	20.2 ef
USF2010 500 SC	**5.00 fl oz**	P, B PF, SS, 1C-6C **32, 23, 14, 4 DPH**	3.3 c	5.3 cd	32.2 cd
USF2010 500 SC	**5.97 fl oz**	P, B PF, SS, 1C-6C **32, 23, 14, 4 DPH**	1.8 c	1.7 e	25.4 de
Elite 45DF Flint 50WG Nova 40W + Captan 50WP Captan 50WP **Elite 45DF**	6.0 oz 3.0 oz 5.0 oz + 6.0 lb 6.0 lb **6.0 oz**	P, B PF, SS, 2C 1C 3C-6C **32, 23, 14, 4 DPH**	2.2 c	0.6 e	23.9 de
Orbit 3.6EC Quintec 2.08SC + Captan 50WP Captan 50WP **Orbit 3.6EC**	4.0 oz 8.0 fl oz + 6.0 lb 6.0 lb **4.0 fl oz**	P, B PF, SS, 1C, 2C 3C-6C **28, 18, 7 DPH**	6.3 c	6.4 c	36.3 c
Orbit 3.6EC Abound 2.08SC Nova 40W + Captan 50WP Captan 50WP **Orbit 3.6EC**	4.0 fl oz 15.4 fl oz 5.0 oz + 6.0 lb 6.0 lb **4.0 fl oz**	P, B PF, SS, 2C 1C 3C-6C **32, 23, 14, 4 DPH**	3.2 c	2.3 de	21.5 e

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

TABLE 5. Rhizopus Harvest and Post-harvest Incidence[1]			% Fruit Infected[2]		
Treatment	**Rate / A**	**Timing**	**Harvest**	**3-dph**	**6-dph**
Nontreated Control	----------------	----------------	0.0 b	1.2 ab	5.8 ab
BAS 516 38 WG (Pristine)	**14.7 oz**	P, B PF, SS, 1C-6C **32, 23, 14, 4 DPH**	0.0 b	0.0 b	0.5 b
Scala 60SC	**18.0 fl oz**	P, B PF, SS, 1C-6C **32, 23, 14, 4 DPH**	2.1 a	5.8 a	10.9 a
Elite 45DF + Flint 50WG	**2.9 oz + 2.56 oz**	P, B PF, SS, 1C-6C **32, 23, 14, 4 DPH**	0.0 b	1.2 ab	2.9 b
Elite 45DF + Flint 50WG	**3.46 oz + 3.1 oz**	P, B PF, SS, 1C-6C **32, 23, 14, 4 DPH**	0.0 b	0.6 ab	1.8 b
USF2010 500 SC	**5.00 fl oz**	P, B PF, SS, 1C-6C **32, 23, 14, 4 DPH**	0.0 b	0.6 ab	1.8 b
USF2010 500 SC	**5.97 fl oz**	P, B PF, SS, 1C-6C **32, 23, 14, 4 DPH**	0.0 b	0.0 b	0.6 b
Elite 45DF Flint 50WG Nova 40W + Captan 50WP Captan 50WP **Elite 45DF**	6.0 oz 3.0 oz 5.0 oz + 6.0 lb 6.0 lb **6.0 oz**	P, B PF, SS, 2C 1C 3C-6C **32, 23, 14, 4 DPH**	0.0 b	1.2 ab	2.9 b
Orbit 3.6EC Quintec 2.08SC + Captan 50WP Captan 50WP **Orbit 3.6EC**	4.0 oz 8.0 fl oz + 6.0 lb 6.0 lb **4.0 fl oz**	P, B PF, SS, 1C, 2C 3C-6C **28, 18, 7 DPH**	0.0 b	0.0 b	0.6 b
Orbit 3.6EC Abound 2.08SC Nova 40W + Captan 50WP Captan 50WP **Orbit 3.6EC**	4.0 fl oz 15.4 fl oz 5.0 oz + 6.0 lb 6.0 lb **4.0 fl oz**	P, B PF, SS, 2C 1C 3C-6C **32, 23, 14, 4 DPH**	0.0 b	3.1 ab	5.2 ab

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

TABLE 6. Anthracnose Harvest and Post-harvest Incidence[1]			% Fruit Infected[2]		
Treatment	**Rate / A**	**Timing**	**Harvest**	**3-dph**	**6-dph**
Nontreated Control	----------------	----------------	0.0 c	5.8 a	11.5 a
BAS 516 38 WG (Pristine)	**14.7 oz**	**P, B PF, SS, 1C-6C 32, 23, 14, 4 DPH**	0.0 c	0.0 b	0.6 b
Scala 60SC	**18.0 fl oz**	**P, B PF, SS, 1C-6C 32, 23, 14, 4 DPH**	2.1 a	0.0 b	3.0 b
Elite 45DF + Flint 50WG	**2.9 oz + 2.56 oz**	**P, B PF, SS, 1C-6C 32, 23, 14, 4 DPH**	0.0 c	0.6 b	0.6 b
Elite 45DF + Flint 50WG	**3.46 oz + 3.1 oz**	**P, B PF, SS, 1C-6C 32, 23, 14, 4 DPH**	0.0 c	0.0 b	0.0 b
USF2010 500 SC	**5.00 fl oz**	**P, B PF, SS, 1C-6C 32, 23, 14, 4 DPH**	0.0 c	0.0 b	0.6 b
USF2010 500 SC	**5.97 fl oz**	**P, B PF, SS, 1C-6C 32, 23, 14, 4 DPH**	0.0 c	0.0 b	0.6 b
Elite 45DF Flint 50WG Nova 40W + Captan 50WP **Captan 50WP** **Elite 45DF**	6.0 oz 3.0 oz 5.0 oz + 6.0 lb **6.0 lb** **6.0 oz**	P, B PF, SS, 2C 1C **3C-6C** **32, 23, 14, 4 DPH**	1.0 ab	0.6 b	4.2 b
Orbit 3.6EC Quintec 2.08SC + Captan 50WP **Captan 50WP** **Orbit 3.6EC**	4.0 oz 8.0 fl oz + 6.0 lb **6.0 lb** **4.0 fl oz**	P, B PF, SS, 1C, 2C **3C-6C** **28, 18, 7 DPH**	0.2 bc	1.2 b	2.9 b
Orbit 3.6EC Abound 2.08SC Nova 40W + Captan 50WP **Captan 50WP** **Orbit 3.6EC**	4.0 fl oz 15.4 fl oz 5.0 oz + 6.0 lb 6.0 lb **4.0 fl oz**	P, B PF, SS, 2C 1C **3C-6C** **32, 23, 14, 4 DPH**	0.0 c	0.8 b	3.5 b

[1]Antracnose rot treatments, rates, and application timings in boldface; optimum timing is late cover sprays through harvest.
[2]Means in the same column with the same letter do not differ significantly according to the Waller-Duncan K-ratio t-test ($P \leq 0.05$, K=100).

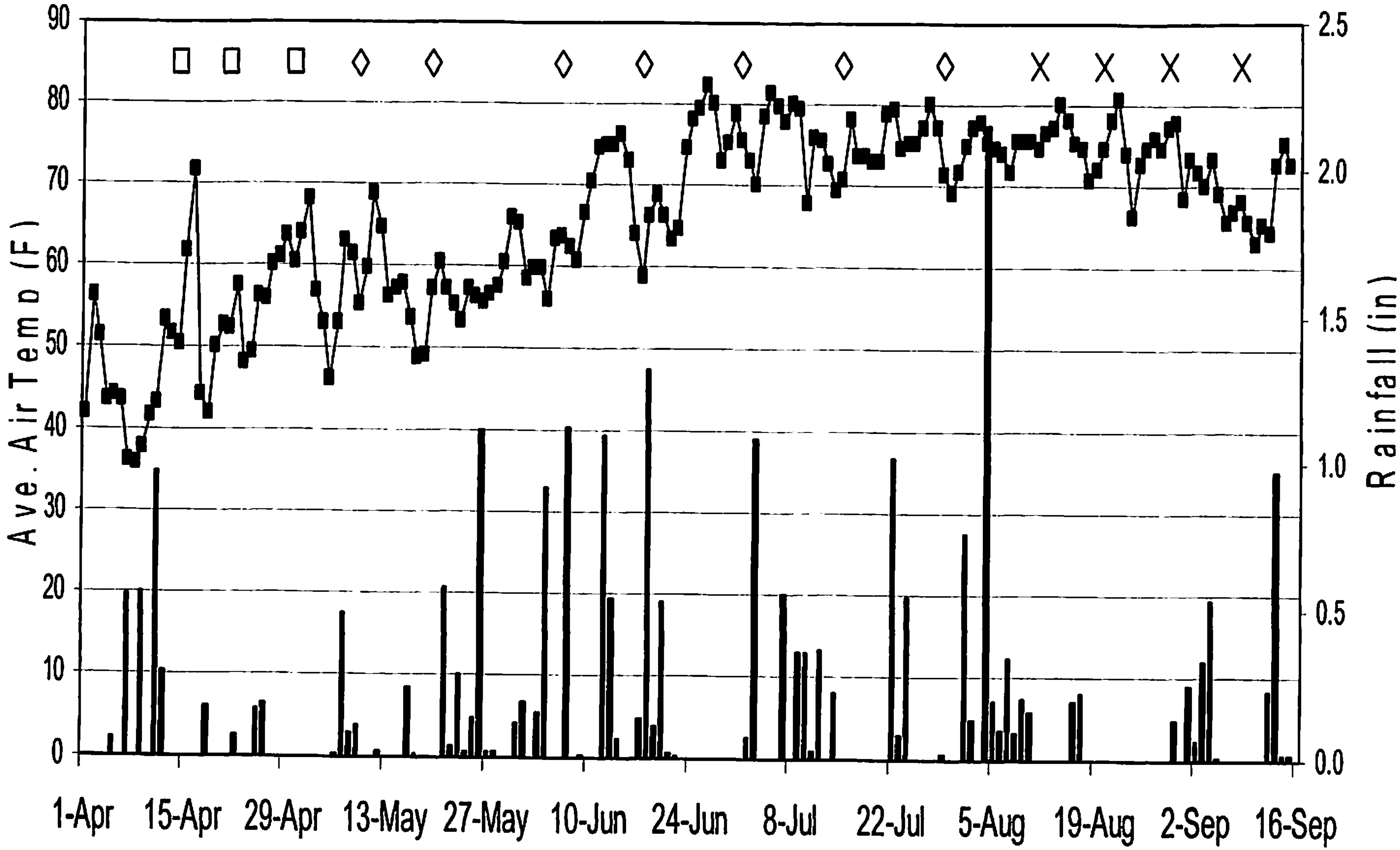

Figure 1. Rainfall, air temperature, and fungicide application timing on 'Autumnglo' peach during the 2003 growing season, Rutgers Agricultural Research and Extension Center, Bridgeton, NJ. Box, diamond, and X symbols represent application timing for bloom (P, B, PF), shuck-split through cover (SS-6C), and pre-harvest (PH) fungicide sprays.

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Date	Jerseymac growth stage	Scab ascospore counts: % mature spores	Scab ascospore counts: cumm. % dis-charged	Wetting periods: date	start time	dura-tion (hr)	avg. temp (°F)	rain-fall (in.)	Mill's rating 1°	2°
4 Apr		14.3								
10 Apr	green tip									
11 Apr		33.3	3.5	11 Apr	0745	25.5	43.1	0.36	L	
				22 Apr	0145	11.5	50.1	0.19	-	
	3/4-in green			22 Apr	1700	5.25	54.7	0.02	-	
		***Combined wetting 22 Apr**				**16.75**	**51.6**	**0.21**	**L**	**-**
	tight cluster			26 Apr	0200	24.0	51.9	0.27	M	
	pink			30 Apr	0815	1.0	50.6	0.01	-	
				1 May	*0900*	*3.5*	*54.5*	*0.03*	-	
				1 May	*2330*	*9.5*	*63.1*	*0.22*	*L*	
				2 May	*1530*	*5.0*	*52.3*	*0.26*	-	
		Combined wetting 1 - 2 May				**18.0**	**59.7**	**0.51**	**M**	
	king-bloom			*5 May*	*1845*	*15.50*	*44.9*	*0.06*	*?*	
				7 May	*0045*	*6.75*	*50.7*	*Fog*	-	
	full bloom			*7 May*	*2245*	*19.75*	*56.2*	*0.20*	*M*	
				9 May	*0045*	*7.25*	*55.0*	*0.01*	-	
		Combined wetting 5 - 9 May				**49.25**	**51.7**	**0.27**	**H**	
	25% petal fall			11 May	1545	19.0	55.9	0.28	M	
13 May	**Scab lesions found in unsprayed trees: begin secondary scab infections**									
				13 May	1045	3.25	53.8	0.03	-	-
	petal fall			18 May	0300	4.0	40.8	Fog	-	-
				21 May	0330	11.50	58.6	0.21	L	+
				22 May	*1715*	*3.0*	*53.9*	*0.01*	-	-
				23 May	*0400*	*9.25*	*52.9*	*0.03*	-	+
				23 May	*1945*	*23.0*	*55.4*	*0.15*	*H*	+
		Combined wetting 22 – 23 May				**35.25**	**54.6**	**0.19**	**H**	**+**
				26 May	*0130*	*32.75*	*55.9*	*1.53*	*H*	+
				27 May	*2015*	*14.25*	*59.1*	*0.39*	*M*	+
				28 May	*1430*	*17.5*	*57.6*	*0.30*	*M*	+
				29 May	*2345*	*8.0*	*60.2*	*0.02*	*L*	+
				30 May	*1430*	*3.0*	*71.5*	*0.05*	-	-
				31 May	*1345*	*24.25*	*61.7*	*1.53*	*H*	+
		Combined wetting 26 – 31 May				**99.75**	**59.0**	**3.85**	**H**	**+**
				4 Jun	*0000*	*13.0*	*56.0*	*0.21*		+
				4 Jun	*2145*	*14.25*	*59.9*	*0.19*		+
		Combined wetting 4 Jun			**27.25**	**58.1**	**0.40**		**+**	
				7 Jun	0845	23.25	61.6	0.44		+
				12 Jun	*0330*	*3.75*	*69.3*	*<0.01*		-
				12 Jun	*1845*	*23.5*	*65.7*	*0.77*		+
				14 Jun	*0430*	*2.25*	*61.8*	*0.01*		-
		Combined wetting 12 – 14 Jun				**29.5**	**65.9**	**0.78**		**+**
				18 Jun	0315	9.25	59.8	0.17		+

* The method for calculating split wettings was modified this year. We adopted the convention proposed by Bill MacHardy for combining successive wetting periods: "two successive wetting periods, the first started by rain, should be considered a single, uninterrupted wet period if the intervening dry period is less than 24 hr, regardless of weather conditions (sunshine, temperature, and RH) during the intervening dry period." The issue of split wettings was discussed by Turechek and Carroll in *Scaffolds Fruit Journal* 12(7):3-4 [2003] (available at http://www.nysaes.cornell.edu/ent/scaffolds/2003/4.28.html#d1). Temperatures for split wetting periods were calculated using only hours when foliage was actually wet. In this table, individual wetting events that contributed to longer split wetting periods are shown in italics and the split wetting periods themselves are shown in bold print

		Wetting periods				
	start	dura-tion	avg. temp	rain-fall	Mill's rating	
date	time	(hr)	(°F)	(in.)	1°	2°
19 Jun	*0015*	*6.75*	*63.2*	*<0.01*		-
19 Ju	*2030*	*84.5*	*62.3*	*1.87*		+
Combined wetting 19 - 23 Jun		**91.25**	**62.4**	**1.87**		**+**
24 Jun	0430	2.25	62.3	Dew		-
29 Jun	1945	0.5	74.3	<0.01		-
30 Jun	0345	3.0	65.9	Dew		-
2 Jul	0445	1.5	58.4	Dew		-
3 Jul	0500	1.25	60.9	Dew		-
3 Jul	2345	7.5	67.0	<0.01		+
4 Jul	1825	14.0	71.8	0.32		+
7 Jul	1715	13.25	70.9	1.41		+
9 Jul	*0830*	*6.0*	*65.0*	*0.37*		+
9 Jul	*2215*	*6.25*	*60.6*	*Dew*		+
Combined wetting 9 Jul		**12.25**	**62.8**	**0.37**		**+**
11 Jul	*0315*	*7.5*	*63.5*	*0.17*		+
11 Jul	*1830*	*0.5*	*72.0*	*0.03*		-
11 Jul	*2200*	*9.0*	*63.7*	*Dew*		+
Combined wetting 11 Jul	**17.0**	**64.1**	**0.20**		**+**	
14 Jul	0000	8.25	60.4	Dew		+
15 Jul	0000	8.0	61.9	Dew		+
16 Jul	*0515*	*1.75*	*67.7*	*0.02*		-
17 Jul	*0300*	*4.25*	*61.0*	*Dew*		-
Combined wetting 16 – 17 Jul		**6.0**	**62.9**	**0.02**		**+**
18 Jul	1000	5.0	69.9	0.13		-
21 Jul	*2030*	*8.75*	*68.5*	*1.36*		+
22 Jul	*2115*	*9.75*	*71.6*	*0.18*		+
23 Jul	*1745*	*4.0*	*75.0*	*0.08*		-
24 Jul	*0300*	*2.5*	*70.3*	*0.05*		-
24 Jul	*0945*	*1.0*	*75.1*	*0.02*		-
Combined wetting 21 – 24 Jul		**26.0**	**71.1**	**1.69**		**+**
25 Jul	0345	3.25	63.2	Dew		-
26 Jul	1445	2.0	60.5	Dew		-
27 Jul	0515	1.5	69.1	0.02		-
30 Jul	0245	4.5	62.6	Dew		
31 Jul	0100	7.25	60.7	Dew		
1 Aug	*0230*	*23.5*	*67.6*	*0.38*		+
2 Aug	*2345*	*7.5*	*73.2*	*Dew*		
3 Aug	*1515*	*15.25*	*73.7*	*2.12*		+
4 Aug	*1100*	*20.5*	*75.6*	*0.10*		+
5 Aug	*1445*	*20.5*	*72.4*	*0.74*		+
6 Aug	*1545*	*1.5*	*79.1*	*0.03*		-
6 Aug	*2215*	*10.0*	*69.5*	*Fog*		+
Combined wetting 1 – 6 Aug		**98.75**	**72.1**	**3.37**		**+**
7 Aug	2100	11.0	72.1	0.07		+
9 Aug	0400	3.0	73.0	Fog		+
9 Aug	*1700*	*21.5*	*75.4*	*1.10*		+
10 Aug	*1930*	*41.75*	*74.2*	*3.18*		+
12 Aug	*2315*	*8.75*	*72.7*	*0.01*		+
13 Aug	*1430*	*0.5*	*82.5*	*0.01*		-

date	start time	Wetting periods: duration (hr)	Wetting periods: avg. temp (°F)	Wetting periods: rainfall (in.)	Mill's rating 1°	Mill's rating 2°
14 Aug	*0015*	*8.0*	*71.5*	*0.01*		+
Combined wetting 9 – 14 Aug		**80.5**	**74.2**	**4.31**		**+**
15 Aug	0415	3.25	64.0	Dew		
16 Aug	0430	1.75	69.2	Dew		
16 Aug	1730	15.25	69.8	0.03		+
18 Aug	2330	8.25	63.9	Fog		
20 Aug	0330	4.0	64.2	Dew		
21 Aug	0345	3.5	65.2	Dew		
22 Aug	0430	3.0	71.6	Dew		
22 Aug	1615	2.5	84.1	0.03		
26 Aug	0300	4.5	63.8	Dew		
27 Aug	0130	2.0	68.8	Dew		
29 Aug	0245	5.0	54.9	Dew		
29 Aug	2300	12.75	72.4	0.24		+
1 Sep	*0515*	*33.5*	*60.4*	*3.47*		+
2 Sep	*2330*	*36.5*	*63.8*	*0.77*		+
Combined wetting 1 – 2 Sep		**70.0**	**62.2**	**4.24**		**+**

Development of flyspeck during September

On 30September 2003, I noted three calls in one day from different growers who were concerned that flyspeck was "popping out" on apples that had not been sprayed since late August. A consultant also noted that flyspeck appeared rather suddenly during the last few days of September.

Heavy rain on 1& 2 September presumably removed all fungicide residues present in August. Therefore, the sudden appearance of flyspeck in late September provided an ideal test of the Sutton model which states that approximately 270 hr of wetting are between after infection and development of visible symptoms.

As noted in the table on the right, the grower calls in late September coincided nicely with the model prediction that symptoms should appear 270 hr after infection! In the table at the left, we did not eliminate wetting periods shorter than 3 hr as Sutton did in developing his model.

Rain and accumulated wetting during September:

Date	Daily rain	Accum rain	Daily wetting	Accum Wetting
1-Sep-03	1.34	1.34	18.8	19
2-Sep-03	2.13	3.47	15.3	34
3-Sep-03	0.38	3.85	24.0	58
4-Sep-03	0.31	4.16	12.0	70
5-Sep-03	0	4.16	0.0	70
6-Sep-03	0	4.16	5.0	75
7-Sep-03	0	4.16	8.3	83
8-Sep-03	0	4.16	0.0	83
9-Sep-03	0	4.16	0.0	83
10-Sep-03	0	4.16	7.3	91
11-Sep-03	0	4.16	5.3	96
12-Sep-03	0	4.16	8.8	105
13-Sep-03	0.15	4.31	13.8	118
14-Sep-03	0.06	4.37	16.5	135
15-Sep-03	0.17	4.54	9.8	145
16-Sep-03	0.22	4.76	9.5	154
17-Sep-03	0	4.76	8.0	162
18-Sep-03	0	4.76	1.5	164
19-Sep-03	0.43	5.19	11.5	175
20-Sep-03	0	5.19	0.0	175
21-Sep-03	0	5.19	1.5	177
22-Sep-03	0	5.19	6.8	183
23-Sep-03	2.09	7.28	12.0	195
24-Sep-03	0	7.28	2.3	198
25-Sep-03	0.07	7.35	14.0	212
26-Sep-03	0.16	7.51	13.5	225
27-Sep-03	0.2	7.71	10.8	236
28-Sep-03	1.29	9	24.0	260
29-Sep-03	0.13	9.13	14.8	275
30-Sep-03	0	9.13	2.8	277

2003 MAXIMUM AND MINIMUM TEMPERATURES AND PRECIPITATION
Hudson Valley Laboratory, Highland, NY

All readings were taken at 0800 EST on the dates indicated

	MARCH			APRIL			MAY			JUNE			JULY			AUGUST			SEPTEMBER		
Date	Max	Min	Precip	Max	Min	Precip	Max	Min	Precip	Max	Min	Precip	Max	Min	Precip	Max	Min	Precip	Max	Min	Precip
1	39	23		40	21	0.06	69	49	0.01	67	59	1.49	83	55		82	64	0.12	72	56	0.19
2	41	32		37	31		73	52	0.25	61	44	0.04	83	57		75	66	0.26	64	60	3.24
3	43	8	0.63	52	37	0.12	76	45	0.26	72	48	0.01	87	61		86	72		61	58	0.26
4	19	2		41	35	0.01	60	41		71	54	0.21	83	65		85	71	2.12	66	62	0.47
5	37	12		38	32	0.03	66	36		61	56	0.19	93	69	0.32	83	73	0.10	75	58	
6	47	28	0.24	38	27	0.16	64	41	0.06	71	53		92	72		85	67	0.74	75	52	
7	28	-3	0.50	43	26		64	46		77	55	0.01	91	65		83	68	0.03	74	51	
8	32	15		34	29		79	54	0.13	63	60	0.43	87	67	1.41	82	70	0.07	80	60	
9	44	31		39	32	0.24	61	53	0.08	68	58		89	68		82	71		75	55	
10	47	9		42	36	0.04	68	45		74	56		71	58	0.37	83	73	0.56	73	50	
11	27	6		54	37	0.04	72	54		80	60		76	62	0.16	82	69	2.56	75	53	
12	39	22		48	36	0.32	66	50	0.28	75	68		74	59	0.04	80	71	1.14	80	53	
13	50	33		67	38		66	51		71	65	0.67	81	59		84	72	0.03	73	58	
14	34	13	0.51	57	29		61	45	0.03	68	61	0.11	78	58		87	67	0.01	71	62	0.19
15	34	21		63	42		63	45		84	56		80	60		89	62	0.01	84	70	0.02
16	52	30		84	55		72	52		82	54		85	66	0.02	89	68		78	62	0.39
17	67	38		86	33		62	44		73	51		85	59		88	68	0.03	77	51	
18	68	44		47	34		67	38		72	58	0.17	84	64		81	63		76	57	
19	56	28		50	35		74	39		68	60		74	57	0.13	81	62		75	60	0.41
20	49	30	0.01	68	38		80	42		77	62	0.17	81	54		85	62		81	65	0.02
21	51	32	1.18	71	38		81	55	0.20	64	60	0.21	83	64		87	63		80	49	
22	65	43	0.04	68	48	0.19	64	51	0.01	66	57	0.79	84	67	1.36	90	70		73	51	
23	64	37		61	43	0.02	55	51	0.04	66	59	0.70	81	70	0.18	91	59	0.03	70	59	1.23
24	55	28		45	37		56	53	0.11	87	61		82	69	0.13	81	53		72	50	0.86
25	59	35		59	35		60	54	0.04	92	60		83	62	0.02	78	60		73	51	
26	65	37		67	50	0.11	64	55	0.96	93	68		85	59		84	61		76	56	0.23
27	60	34	0.11	56	49	0.16	60	53	0.57	93	69		87	68	0.02	81	68		68	57	0.01
28	62	35		68	40		68	57	0.39	92	60		87	67		86	55		78	67	1.15
29	65	48		81	53		69	53	0.30	83	59		83	58		78	53		70	51	0.33
30	72	38		75	43		74	58	0.02	82	65		83	60		80	66	0.24	65	43	0.13
31	38	26					75	56	0.05				86	58		77	52				
Avg/ Total	48.7	26.3	4.03	56.0	37.3	1.50	67.4	49.0	3.79	75.1	58.5	5.20	83.3	62.5	4.16	83.4	65.1	8.05	73.7	56.2	9.13

APPLE (*Malus* x *domestica* 'Golden Delicious', 'Jerseymac', 'Redcort')
Apple scab; *Venturia inaequalis*
Cedar apple rust; *Gymnosporangium juniperi-virginianae*
Quince rust; *Gymnosporangium clavipes*
Powdery mildew; *Podosphaera leucotricha*
Summer rots; *Botryosphaeria* species
Flyspeck; *Zygophiala jamaicensis*
Sooty blotch; species complex

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Apple Disease Control with Tanos, Pristine, and Older Fungicides, 2003

Treatments were compared using three-tree plots containing one tree of each cultivar on M.9 rootstocks. Treatments were replicated four times with two replications on 18-yr-old trees and two replications on adjacent 8-yr-old trees. Unsprayed buffer rows were maintained between sprayed rows. Plots within rows were separated by cedar trees that provided inoculum for apple rust diseases and minimized drift between plots. Populations of *V. inaequalis* in the test orchard were still near baseline for sensitivity to dodine. DMI fungicides and strobilurin fungicides when tested by Dr. Wolfram Koeller in 2003. Fungicide treatments were sprayed to drip using a handgun at 200 psi. Details of treatment spray timings are shown in Table 1.

Few if any primary scab infections developed from the first potential infection period on 11 Apr (26 hr wetting, 43 °F) when trees were at green tip. A moderate infection period on 26 Apr (24 hr wetting, 52 °F) when trees were at tight cluster resulted in infections that became visible on May 13 (late bloom). Additional primary infection periods occurred 1-2 May (18 hr, 60 °F), 5-9 May (49 hr, 52 °F), 11-12 May (19 hr, 56 °F), 21 May (12 hr, 59 °F), 22-23 May (35 hr, 55 °F), and 26-32 May (100 hr, 59 °F, 3.85 in. rain). Infection periods were calculated by combining wetting periods separated by less than 24 hr of drying, but mean temperatures for split wetting periods were calculated using only hr when foliage was actually wet. A total of 147 hr wetting occurred between 19 May (petal fall) and 31 May. June weather included 5 secondary scab infection periods, 102 hr of wetting, and 5.2 in. of rain. July had 6 scab infection periods, 139 hr wetting, 4.2 in. rain; August had 5 infection periods, 259 hr wetting, 8.1 in. rain; and September had 277 hr wetting and 9.13 in. rain. Measurable precipitation occurred on 16 consecutive days beginning 21 May and provided for extensive secondary spread of scab and heavy infection by rust fungi. A maintenance spray of Asana XL 10 fl oz/A, Agrimek 10 fl oz/A, and Damoil 1 gal/A was applied on 27 May when foliage was extremely succulent and may have contributed to slower disease development than would have been expected given the extended wetting periods that occurred between 21 May and 24 Jun. Control trees were heavily scabbed, but scab did not cause significant defoliation during summer and cedar apple rust infections on terminal leaves were less extensive than in several previous years.

Treatments involving SI or strobilurin fungicides provided good control of mildew and scab. Pristine controlled rust diseases as well as the SI fungicides, but Sovran applied alone throughout the season did not. The combination of Dithane + Captan provided better control of early-season scab on Jerseymac than did Dithane applied alone. Tanos applied alone did not provide adequate control of early-season diseases. Treatments where Tanos was applied in combination with contact fungicides (treatments 9-11) were never better than the comparable contact fungicide applied alone (treatment 2).

The wet summer provided ideal conditions for development of sooty blotch and flyspeck. A total of 4.16 inches of rain 1-4 Sep removed any fungicide residues remaining from the last application in Aug. Thus, the incidence of flyspeck and sooty blotch on Redcort (harvested 11 Sep) provides a better indication of fungicide efficacy than does the data from Golden Delicious that were harvested on 24 Sep. By 24 Sep, fungicide residues had been displaced long enough to allow significant development of sooty blotch on the fruit, something that does not occur very often under NY conditions when the last spray is applied in mid-Aug.

In treatments 4 & 5, alternating rates of Captan were applied as a comparison for treatments 9, 10, and 11 where Tanos was sprayed in combination with the low rate of Captan on 3 July and 11 Aug. Tanos treatments 10 & 11 provided better control of flyspeck on Redcort than was achieved with treatments 4&5. All three Tanos treatments provided better control of both sooty blotch and flyspeck on Golden Delicious than was achieved with treatment 5. We could not determine why treatments 4 and 5 resulted in significantly different levels of summer disease control despite the fact that they received the same fungicide sprays during summer. Treatments involving Tanos were never better than the standard summer program that utilized Topsin M in the last two applications (Treatments 2 & 3). Treatments 6, 7, and 8 included a strobilurin fungicide in the last two sprays of the season and provided the best control of flyspeck on Redcort.

Very few fruit developed summer decays (black rot, white rot, bitter rot), and there were no significant differences among the fungicide treatments for either Redcort (Table 5) or Golden Delicious (data not shown). For Golden Delicious, none of the treatments had more than 2.5% of the fruit showing summer decays at harvest.

Weather conditions immediately after bloom favored development of severe russetting on Golden Delicious. Although we found significant treatment effects on russetting, it was difficult to discern any pattern when treatments involving similar chemistries and spray timings were compared.

NOTE: Tanos (DPX-KP481) is 25% Famoxate (famoxodone) + 25% Curzate (cymoxanil)
Pristine (BAS 516) = 12.8% pyraclostrobin + 25.2% boscalid

Table 1.

Material and rate of formulated product per 100 gal	Spray application dates									% JM terminal lvs with mildew (8 youngest)
	21 Apr	30 Apr	09 May	19 May	30 May	12 Jun	03 Jul	26 Jul	11 Aug	10 Jun [1]
1. Control										35.6 c[2]
2. Dithane RSNT 75DF 1 lb	x	x	x	x	x					
Captan 50W 1 lb						x	x			
Captan 1 lb + Topsin M 70W 3 oz								x	x	30.9 bc
3. Dithane RSNT 75DF 8 oz + Captan 50W 8 oz	x	x	x	x	x					
Captan 50W 1 lb						x	x			
Captan 1 lb + Topsin M 70W 3 oz								x	x	21.4 b
4. Dithane 75 RSNT 75DF 1 lb + Rubigan 1EC 3 floz	x	x	x	x	x					
Captan 50W 2 lb						x		x		
Captan 50W 1 lb							x		x	0.8 a
5. Dithane RSNT 75DF 1 lb + Nova 40W 1.5 oz	x	x	x	x	x					
Captan 50W 2 lb						x		x		
Captan 50W 1 lb							x		x	0.2 a
6. Pristine (BAS 516) 38WG 4.8 oz	x	x	x	x	x	x	x	x	x	0.5 a
7. Sovran 50WG 1.33 oz	x	x	x	x	x	x	x	x	x	0.9 a
8. Polyram 80DF 1 lb + Sovran 50WG 1.33 oz	x	x								
Polyram 1 lb + Rubigan 1 EC 3 floz			x	x	x					
Captan 50W 1 lb						x	x			
Captan 1 lb + Sovran 50WG 1.1 oz								x	x	1.4 a
9. Tanos (KP 481) 50WP 2.67 oz + Dithane RSNT 75DF 10.67 oz	x		x		x					
Dithane RSNT 75DF 1 lb		x		x						
Captan 50W 2 lb						x		x		
Tanos (KP 481) 50WP 2.67 oz + Captan 50W 1 lb							x		x	36.7 c
10. Tanos (KP 481) 50WP 3.3 oz + Dithane RSNT 75DF 10.67 oz	x		x		x					
Dithane RSNT 75DF 1 lb		x		x						
Captan 50W 2 lb						x		x		
Tanos (KP 481) 50WP 2.67 oz + Captan 50W 1 lb							x		x	34.7 bc
11. Tanos (KP 481) 50WP 2.67 oz + Dithane RSNT 75DF 1 lb	x		x		x					
Dithane RSNT 75DF 1 lb		x		x						
Captan 50W 2 lb						x		x		
Tanos (KP 481) 50WP 2.67 oz + Captan 50W 1 lb							x		x	29.8 bc
12. Tanos (KP 481) 50WP 3.3 oz	x	x	x	x	x					
Tanos (KP 481) 50WP 2.67 oz						x	x	x	x	35.3 bc

[1] Data from 20 terminals per tree.

[2] Numbers within columns followed by the same letter do not differ significantly (Fisher's Protected LSD, $P \leq 0.05$). The arcsine transformation was used for statistical analyses, but arithmetic means are shown.

Table 2.

Application dates	Interval from green tip or from the last spray: number of days	rain (inches)	hours of wetting	Mill's scab infection periods	Start time of interveneing infection periods counted as days after the last spray was applied
(10 Apr – green tip)					
	4	0.36	26	L ?	1
14 Apr (COCS)					
	7	0	0		
21 Apr					
	9	0.49	42	<u>M</u>	1, 5
30 Apr					
	9	0.78	67	L, <u>M</u>	1, 7
9 May					
	10	0.31	26	M,+ [1]	2
19 May					
	11	2.64	119	L, H, H, M, M, L,+	2, 4, 7, 8 //[2] 9, 10
30 May					
	13	2.42	82	4[3]	1,4, 5 // 8
12 Jun					
	21	0.95	50	3	0, 6, 7
3 Jul					
	23	4.14	121	9	0, 1, 4, 6 // 8, 11, 12, 18, 19
26 Jul					
	16	6.60	162	9	6, 8, 9 // 10, 11, 12, 14, 15
11 Aug					
	24	1.49	112.5	4	1, 3, 5, 18
(31 Aug)					

[1] A "+" indicates secondary infection periods occurring after primary inoculum was exhausted.
[2] Double slashes indicate point at which more than 2 inches of rain had accumulated since the last spray.
[3] Numbers indicate the number of secondary infection periods during the interval. excluding those infection periods attributable only to dew periods.

Table 3.

Material and rate of formulated product per 100 gal [1]	% scab infection on Jerseymac[6]: cluster lvs 10 Jun	fruitlets 16 Jun	terminal leaves 30 Jun	terminal leaves 26 Aug	fruit 6 Aug
1. Control	41.7 d[7]	98.4 e	80.1 f	97.8 f	98.6 e
2. Dithane RSNT 75DF 1 lb [2]	0.6 ab	3.7 bc	7.6 de	12.4 cd	11.8 d
3. Dithane 8 oz + Captan 50W 8 oz [2]...............	0.7 ab	0.0 a	2.7 bc	6.2 bc	3.0 abc
4. Dithane 1 lb + Rubigan 1EC 3 floz [3]	1.5 ab	0.7 ab	0.7 ab	2.6 ab	5.8 bcd
5. Dithane 1 lb + Nova 40W 1.5 oz [3]...............	1.7 ab	0.3 a	0.3 a	2.0 ab	0.0 a
6. Pristine (BAS 516) 38WG 4.8 oz	0.5 ab	0.0 a	0.2 a	1.2 a	1.6 ab
7. Sovran 50WG 1.33 oz	0.3 a	0.5 ab	0.2 a	1.2 a	0.0 a
8. Polyram 80DF 1 lb + Sovran 1.33 oz Polyram 1 lb + Rubigan 1 EC 3 floz Captan 50W 1 lb (+ Sovran 1.1 oz)..........	0.2 a	0.3 a	0.6 ab	3.0 ab	0.7 ab
9. Tanos (KP 481) 50WP 2.67 oz + Dithane RSNT 75DF 10.67 oz [4]. Tanos 2.67 oz + Captan 50W 1 lb [5]	2.1 b	6.8 c	13.6 e	18.4 d	8.6 cd
10. Tanos 3.3 oz + Dithane 10.67 oz [4] Tanos 2.67 oz + Captan 50W 1 lb [5]	1.8 ab	2.1 abc	5.7 cd	11.2 cd	10.1 cd
11. Tanos 2.67 oz + Dithane 1 lb [4] Tanos 2.67 oz + Captan 50W 1 lb [5]	1.4 ab	1.0 ab	7.4 d	11.2 cd	3.9 bc
12. Tanos (KP 481) 50WP 3.3 oz Tanos (KP 481) 50WP 2.67 oz................	24.8 c	78.5 d	75.7 f	92.0 e	97.2 e

[1] See Table 1 for treatment timings; Dithane = Dithane RSNT 75DF, Captan = Captan 50W, Tanos = Tanos 50W.
[2] Summer sprays were Captan 50W 1 lb, with Topsin M 70W 3 oz added in the last two sprays 26 Jul and 11 Aug.
[3] Summer sprays were Captan 50W 1 lb alternating with Captan 50W 2 lb as a control for treatments 9-11.
[4] Alternating sprays with Dithane 1 lb [5] Alternating sprays with Captan 50W 2 lb
[6] Data from all leaves on 20 clusters/tree (10 Jun,), all fruitlets on 20 clusters (16 Jun), all leaves on 20 terminals/tree on 30 Jun or 15 terminals/tree on 26 Aug, and an average of 101 fruit/tree on 6 Aug (range of 51 to 110 fruit/tree).
[7] Numbers within columns followed by the same letter do not differ significantly (Fisher's Protected LSD, $P \leq 0.05$). The arcsine transformation was used for statistical analyses, but arithmetic means are shown.

Table 4.

Material and rate of formulated product per 100 gal [1]	% Golden Del. term lvs with rust 30 Jun	% fruit with quince rust: Jerseymac[6] 16 Jun	Jerseymac[6] 6 Aug	Golden Del. 24 Sep
1. Control	32.1 e[7]	11.0 e	3.1 c	15.7 c
2. Dithane RSNT 75DF 1 lb [2]	3.2 bc	0.4 ab	1.2 bc	6.5 b
3. Dithane 8 oz + Captan 50W 8 oz [2]	2.8 bc	0.5 ab	1.2 abc	3.0 b
4. Dithane 1 lb + Rubigan 1EC 3 floz [3]	0.7 ab	0.0 a	0.0 a	0.0 a
5. Dithane 1 lb + Nova 40W 1.5 oz [3]	0.0 a	0.0 a	0.0 a	0.5 ab
6. Pristine (BAS 516) 38WG 4.8 oz	1.0 ab	0.8 ab	0.0 a	1.5 ab
7. Sovran 50WG 1.33 oz	6.4 cd	4.5 de	1.6 bc	3.5 b
8. Polyram 80DF 1 lb + Sovran 1.33 oz Polyram 1 lb + Rubigan 1 EC 3 floz Captan 50W 1 lb (+ Sovran 1.1 oz)	3.3 bcd	0.0 a	0.0 a	0.5 ab
9. Tanos (KP 481) 50WP 2.67 oz + Dithane RSNT 75DF 10.67 oz [4] Tanos 2.67 oz + Captan 50W 1 lb [5]	1.7 bc	1.0 abc	0.5 ab	3.0 ab
10. Tanos 3.3 oz + Dithane 10.67 oz [4] Tanos 2.67 oz + Captan 50W 1 lb [5]	2.9 bcd	0.4 ab	0.5 ab	3.5 ab
11. Tanos 2.67 oz + Dithane 1 lb [4] Tanos 2.67 oz + Captan 50W 1 lb [5]	1.0 abc	2.5 bcd	1.1 ab	1.5 ab
12. Tanos (KP 481) 50WP 3.3 oz Tanos (KP 481) 50WP 2.67 oz	11.0 d	4.6 cd	3.7 c	20.0 c

[1] See bottom of page for footnotes.

Table 5.

Material and rate of formulated product per 100 gal [1]	% fruit with flyspeck[6]: Redcort 11 Sep	Golden Del. 24 Sep	% fruit with sooty blotch[6]: Redcort 11 Sep	Golden Del. 24 Sep	% black rot on Redcort[6]
1. Control	85.8 e[7]	99.5 e	20.7 b	99.5 d	0.0 a
2. Dithane RSNT 75DF 1 lb [2]	41.6 b	34.0 abc	0.0 a	29.0 ab	2.0 a
3. Dithane 8 oz + Captan 50W 8 oz [2]	50.2 b	51.3 c	0.0 a	43.4 b	2.6 a
4. Dithane 1 lb + Rubigan 1EC 3 floz [3]	70.5 cd	39.1 bc	0.3 a	29.9 ab	0.3 a
5. Dithane 1 lb + Nova 40W 1.5 oz [3]	69.2 cd	74.6 d	0.0 a	73.2 c	4.0 a
6. Pristine (BAS 516) 38WG 4.8 oz	17.7 a	17.0 a	0.0 a	16.0 a	0.0 a
7. Sovran 50WG 1.33 oz	16.4 a	17.5 a	0.0 a	17.5 a	0.7 a
8. Polyram 80DF 1 lb + Sovran 1.33 oz Polyram 1 lb + Rubigan 1 EC 3 floz Captan 50W 1 lb (+ Sovran 1.1 oz)	15.0 a	27.9 ab	0.0 a	26.0 ab	1.0 a
9. Tanos (KP 481) 50WP 2.67 oz + Dithane RSNT 75DF 10.67 oz [4] Tanos 2.67 oz + Captan 50W 1 lb [5]	56.5 bc	32.0 abc	0.9 a	26.0 ab	0.3 a
10. Tanos 3.3 oz + Dithane 10.67 oz [4] Tanos 2.67 oz + Captan 50W 1 lb [5]	51.0 b	38.4 bc	0.0 a	28.4 ab	0.3 a
11. Tanos 2.67 oz + Dithane 1 lb [4] Tanos 2.67 oz + Captan 50W 1 lb [5]	41.9 b	22.0 ab	0.0 a	18.0 a	1.3 a
12. Tanos (KP 481) 50WP 3.3 oz Tanos (KP 481) 50WP 2.67 oz	79.1 de	98.0 e	1.8 a	97.5 d	2.5 a

[1] See Table 1 for treatment timings; Dithane = Dithane RSNT 75DF, Captan = Captan 50W, Tanos = Tanos 50W.
[2-5] See Table 3 for details of treatment combinations and alternations.
[6] Data from 75 Redcort fruit/tree and from 50 Golden Delicious fruit/tree
[7] Numbers within columns followed by the same letter do not differ significantly (Fisher's Protected LSD, $P \leq 0.05$). The arcsine transformation was used for statistical analyses, but arithmetic means are shown.

Table 6.

Material and rate of formulated product per 100 gal [1]	% fruit with scab[6] Redcort 11 Sep	Golden Del. 24 Sep	Russetting on Golden Delicious[6] Russet rating (1-5 scale)[7]	% fruit with russet rating ≥ 3
1. Control	89.1 d[8]	55.7 c	3.29 cde	93.5 e
2. Dithane RSNT 75DF 1 lb [2]	4.0 ab	2.0 a	2.91 abc	74.5 bc
3. Dithane 8 oz + Captan 50W 8 oz [2]	2.9 ab	2.0 a	2.79 ab	64.2 ab
4. Dithane 1 lb + Rubigan 1EC 3 floz [3]	0.0 a	0.0 a	3.07 bcd	78.3 bcd
5. Dithane 1 lb + Nova 40W 1.5 oz [3]	0.9 a	0.0 a	3.22 cd	87.8 cde
6. Pristine (BAS 516) 38WG 4.8 oz	0.0 a	1.0 a	2.75 ab	63.5 ab
7. Sovran 50WG 1.33 oz	0.0 a	0.0 a	3.68 e	93.5 e
8. Polyram 80DF 1 lb + Sovran 1.33 oz Polyram 1 lb + Rubigan 1 EC 3 floz Captan 50W 1 lb (+ Sovran 1.1 oz)	0.3 a	0.0 a	2.81 ab	68.7 ab
9. Tanos (KP 481) 50WP 2.67 oz + Dithane RSNT 75DF 10.67 oz [4] Tanos 2.67 oz + Captan 50W 1 lb [5]	16.7 b	0.0 a	3.00 bcd	71.0 ab
10. Tanos 3.3 oz + Dithane 10.67 oz [4] Tanos 2.67 oz + Captan 50W 1 lb [5]	2.0 ab	0.5 a	2.76 ab	67.6 ab
11. Tanos 2.67 oz + Dithane 1 lb [4] Tanos 2.67 oz + Captan 50W 1 lb [5]	1.8 ab	0.0 a	2.56 a	55.0 a
12. Tanos (KP 481) 50WP 3.3 oz Tanos (KP 481) 50WP 2.67 oz	66.3 c	32.0 b	3.33 de	91.5 de

[1] See Table 1 for treatment timings; Dithane = Dithane RSNT 75DF, Captan = Captan 50W, Tanos = Tanos 50W.

[2-5] See Table 3 for details of treatment combinations and alternations.

[6] Data from 75 Redcort fruit/tree and from 50 Golden Delicious fruit/tree

[7] Fruit russetting was rated on a scale of 1-5 wherein 1 = smooth fruit, 2= roughened lenticels, 3 = slight russetting extending from lenticels, 4 = patches of russetting skin evident on fruit, 5 = very severe russetting.

[8] Numbers within columns followed by the same letter do not differ significantly (Fisher's Protected LSD, $P \leq 0.05$). The arcsine transformation was used for statistical analyses, but arithmetic means are shown.

APPLE (*Malus* x *domestica* 'Jerseymac', 'Ginger Gold')
Apple scab; *Venturia inaequalis*
Cedar apple rust; *Gymnosporangium juniperi-virginianae*
Quince rust; *Gymnosporangium clavipes*
Powdery mildew; *Podosphaera leucotricha*
Summer rots; *Botryosphaeria & Colletotrichum* species
Flyspeck; *Zygophiala jamaicensis*
Sooty blotch; species complex

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Effectiveness of OxiDate and Flint-Elite Combinations for Controlling Apple Diseases, 2003.

Treatments were applied to 17-yr-old trees on M.9 rootstock. Treatments were replicated four times in two-tree plots that contained one tree of each cultivar. Plots within rows were separated by buffer trees. Fungicide treatments were sprayed to runoff using a handgun at 200 psi. Jerseymac trees were at green-tip on 10 April. All treatments were applied 21 Apr (half-inch green), 30 Apr (pink), 9 May (full bloom), 19 (petal fall), 30 May. In addition, OxiDate and Microthiol Disperss were also applied on 25 Apr; 7, 15, 24 May for a total of nine applications of these products. The entire block, including control plots, was sprayed with Flint 2 oz/A on 10 June. No other fungicides were applied for the remainder of the season.

Few if any primary scab infections developed from the first potential infection period on 11 Apr (26 hr wetting, 43 °F) when trees were at green tip. A moderate infection period on 26 Apr (24 hr wetting, 52 °F) when trees were at tight cluster resulted in infections that became visible on May 13 (late bloom). Additional primary infection periods occurred 1-2 May (18 hr, 60 °F), 5-9 May (49 hr, 52 °F), 11-12 May (19 hr, 56 °F), 21 May (12 hr, 59 °F), 22-23 May (35 hr, 55 °F), and 26-32 May (100 hr, 59 °F, 3.85 in. rain). Infection periods were calculated by combining wetting periods separated by less than 24 hr of drying, but mean temperatures for split wetting periods were calculated using only hr when foliage was actually wet. A total of 147 hr wetting occurred between 19 May (petal fall) and 31 May. June weather included 5 secondary scab infection periods, 102 hr of wetting, and 5.2 in. of rain. July had 6 scab infection periods, 139 hr wetting, 4.2 in. rain; August had 5 infection periods, 259 hr wetting, 8.1 in. rain; and September had 277 hr wetting and 9.13 in. rain. Measurable precipitation occurred on 16 consecutive days beginning 21 May and provided for extensive secondary spread of scab and heavy infection by rust fungi. A maintenance spray of Asana XL 10 fl oz/A, Agrimek 10 fl oz/A, and Damoil 1 gal/A was applied on 27 May when foliage was extremely succulent and may have contributed to slower disease development than would have been expected given the extended wetting periods that occurred between 21 May and 24 Jun. Control trees were heavily scabbed, but scab did not cause significant defoliation during summer and cedar apple rust infections on terminal leaves were less extensive than in several previous years.

OxiDate was less effective than sulfur (Microthiol Disperss) for controlling quince rust on Jerseymac and for all evaluations of scab and mildew. Periodic casual observations during May suggested that OxiDate was providing reasonable suppression of apple scab, and the first lesions that became visible had a reddish "burnt-out" appearance. However, OxiDate failed to prevent scab during the extended wetting periods in late May. By May 26, a chemical burn was evident on many fruit on trees treated with OxiDate, and fruit from OxiDate plots showed severe russetting at harvest. Because of the short spray intervals and the relatively high rate of Microthiol Disperss that was used for treatment 3, considerable fungicide residue was present on leaves when the Asana/Agrimek/oil spray was applied on 27 May. The sulfur-oil combination caused extensive leaf burn on Microthiol-treated trees and may have contributed to the severe russetting noted,for Ginger Gold in the Microthiol plots. However, Microthiol did not caused russetting on Jerseymac whereas OxiDate did.

All of the treatments involving Flint provided excellent control of mildew and season-long control of apple scab. The latter is especially worth noting because both apple cultivars used in this test are extremely susceptible to apple scab, and no fungicides were applied after 10 June. Treatments involving Flint + Elite combinations did not show any improvement in scab or mildew control compared to the low rate of Flint used alone. However, the Flint + Elite combinations provided excellent control of both cedar apple rust and quince rust whereas Flint applied alone did not provide acceptable control of quince rust on Jerseymac fruit. Thus, a tank-mix combination of Flint and Elite might be useful in regions where rust diseases must be controlled at the same time that sprays are applied for scab and mildew.

Because no fungicides were applied after June 10, flyspeck incidence was high in all of the plots when Ginger Gold fruit were evaluated on 8 Aug. However, Flint applied at 0.67 oz provided flyspeck control equivalent to that provided by Dithane whereas treatments Flint at 0.33 oz had significantly more flyspeck. All of the fungicide treatments except OxiDate provided suppression of summer fruit rots in Jerseymac, and several treatments involving Elite also provided a significant reduction in summer fruit rots in Ginger Gold.

Material and rate of formulated product per 100 gal [1]	% scab infection on Jerseymac: cluster lvs [2] 9 Jun	terminal leaves [2] 23 Jun	terminal leaves [2] 28 Aug	fruit [3] 17 Jun	fruit [3] 25 Jul	% Ginger Gold fruit with scab 8 Aug
1. Control	30.4 e [5]	34.4 d	77.4 c	79.2 c	82.4 c	30.6 b
2. OxiDate 27% 1 gal	21.3 d	14.6 c	76.5 c	43.5 b	75.7 c	17.0 b
3. Microthiol Disperss 80W 5 lb	0.2 ab	0.4 a	16.0 ab	0.3 a	0.0 a	1.0 a
4. Dithane RSNT 75DF 1 lb	1.0 c	3.8 b	18.8 b	3.2 a	1.4 ab	1.7 a
5. Flint 50WG 0.67 oz	0.2 ab	0.1 a	9.8 ab	0.0 a	0.0 a	1.0 a
6. Flint 50WG 0.33 oz	0.2 ab	0.1 a	5.6 a	0.0 a	0.0 a	0.0 a
7. Elite 45DF 0.37 oz + Flint 50WG 0.33 oz	0.0 a	0.8 a	8.2 a	0.0 a	0.0 a	0.3 a
8. Elite 45DF 0.53 oz + Flint 50WG 0.48 oz	0.2 ab	0.0 a	9.7 ab	0.0 a	0.0 a	0.3 a
9. Elite 45DF 0.37 oz	1.0 bc	0.8 a	14.0 ab	2.1 a	6.4 b	1.0 a

[1] Treatments 4-9 were applied 21 & 30 Apr, 9, 19, & 30 May. Treatments 2 & 3 were applied 21, 25, 30 Apr; 7, 9, 15, 19, 24, & 30 May. The entire block, including control plots, was sprayed with Flint 2 oz/A on 10 June. No other fungicides were applied for the remainder of the season.

[2] From evaluation of all leaves on 20 clusters or 15 terminal shoots per tree.

[3] From all fruitlets on 20 clusters/tree (17 Jun) or all available fruit on 25 Jul (mean =79, range =15-128 fruit/tree).

[4] From mean of 73 fruit/tree (range of 33—77 fruit/tree)

[5] Numbers within columns followed by the same letter do not differ significantly (Fisher's Protected LSD, $P \leq 0.05$). The arcsine transformation was used for statistical analyses, but arithmetic means are shown.

Material and rate of formulated product per 100 gal	% of 8 youngest terminal leaves with mildew on 11 Jun [1]: Jerseymac	Ginger Gold	Grand means [5]	% fruit with summer fruit rots [2]: Jerseymac at harvest 25 Jul [3]	Ginger Gold harvested 8 Aug, then incubated 11-14 days @ 100% RH [4]	Grand mean for both cultivars [5]
1. Control	46.3 d [5]	61.9 e	54.1 e	6.3 d	8.7 c	7.5 e
2. OxiDate 27% 1 gal	21.3 c	36.3 d	28.8 d	2.7 cd	5.1 bc	3.9 cde
3. Microthiol Disperss 80W 5 lb	3.4 b	5.6 bc	4.5 c	3.6 bc	9.1 c	6.3 de
4. Dithane RSNT 75DF 1 lb	51.6 d	52.5 e	52.0 e	0.7 abc	6.3 bc	3.5 bcd
5. Flint 50WG 0.67 oz	0.3 a	0.0 a	0.2 a	0.5 abc	4.3 abc	2.4 abc
6. Flint 50WG 0.33 oz	2.2 ab	2.2 ab	2.2 ab	2.1 bc	4.0 abc	3.0 bcd
7. Elite 45DF 0.37 oz + Flint 50WG 0.33 oz	0.0 a	1.3 ab	0.6 ab	0.0 a	2.0 ab	1.0 ab
8. Elite 45DF 0.53 oz + Flint 50WG 0.48 oz	1.3 ab	2.8 abc	2.0 bc	0.2 ab	3.4 abc	1.8 abc
9. Elite 45DF 0.37 oz	3.4 b	7.2 c	5.3 c	0.0 a	1.0 a	0.5 a

[1] From evaluation of the 8 youngest leaves on 10 terminals per tree.

[2] Combination of black rot, white rot, and bitter rot.

[3] From evaluation of all available fruit on 25 Jul (mean =79, range =15-128 fruit/tree).

[4] From evaluation of ca. 73 fruit/tree (range of 33—77 fruit/tree). After harvest, fruit were held at 75° F. and 100% relative humidity for 11-14 days before they were rated to allow development of fruit rots and blemishes.

[5] Numbers within columns followed by the same letter do not differ significantly (Fisher's Protected LSD, $P \leq 0.05$). The arcsine transformation was used for statistical analyses, but arithmetic means are shown. Grand means were derived from split-plot analyses of data from both cultivars.

Material and rate of formulated product per 100 gal	% Ginger Gold terminal lvs with rust 02 Jul[1]	% fruit with quince rust: Jerseymac[2] 17 Jun	% fruit with quince rust: Jerseymac[2] 25 Jul	% fruit with quince rust: Ginger Gold 8 Aug[3]	% Ginger Gold fruit with cedar apple rust 8 Aug[3]
1. Control	44.0 d[4]	76.5 e	56.5 e	44.3 d	7.6 b
2. OxiDate 27% 1 gal	10.0 c	37.9 d	29.9 d	6.9 c	0.7 a
3. Microthiol Disperss 80W 5 lb	5.0 c	4.5 b	9.6 b	3.5 bc	0.0 a
4. Dithane RSNT 75DF 1 lb	2.5 abc	7.9 b	6.5 b	7.6 c	0.7 a
5. Flint 50WG 0.67 oz	5.2 bc	18.3 c	17.7 c	3.6 bc	0.3 a
6. Flint 50WG 0.33 oz	7.4 c	14.9 c	13.3 bc	3.3 abc	0.0 a
7. Elite 45DF 0.37 oz + Flint 50WG 0.33 oz	1.0 ab	0.0 a	0.0 a	0.0 a	0.0 a
8. Elite 45DF 0.53 oz + Flint 50WG 0.48 oz	0.3 a	0.0 a	0.0 a	1.0 ab	0.0 a
9. Elite 45DF 0.37 oz	0.6 a	0.9 a	0.0 a	0.0 a	0.3 a

[1] From all leaves on 20 terminals per tree.
[2] From all fruitlets on 20 clusters/tree (17 Jun) or all available fruit on 25 Jul (mean =79, range =15-128 fruit/tree).
[3] From evaluation of ca. 73 fruit/tree (range of 33—77 fruit/tree).
[4] Numbers within columns followed by the same letter do not differ significantly (Fisher's Protected LSD, $P \leq 0.05$). The arcsine transformation was used for statistical analyses, but arithmetic means are shown.

Material and rate of formulated product per 100 gal[1]	% Ginger Gold fruit on 8 Aug with:[1] Flyspeck	% Ginger Gold fruit on 8 Aug with:[1] Sooty blotch	% fruit with russet rating >2 (using 1-5 scale, where 1=no russet)[2] Jerseymac	% fruit with russet rating >2 Ginger Gold	Mean russet rating (using 1-5 scale, where 1=no russet)[2] Jerseymac	Mean russet rating Ginger Gold
1. Control	90.6 bcd[3]	9.0 a	1.6 abc	83.2 b	1.2 a	3.6 b
2. OxiDate 27% 1 gal	94.8 cd	8.4 a	52.4 d	95.7 c	2.6 b	4.3 c
3. Microthiol Disperss 80W 5 lb	83.0 ab	3.5 a	2.9 c	94.5 bc	1.2 a	3.8 bc
4. Dithane RSNT 75DF 1 lb	81.4 ab	0.7 a	0.2 ab	35.4 a	1.1 a	2.4 a
5. Flint 50WG 0.67 oz	83.6 ab	1.6 a	1.2 abc	44.4 a	1.1 a	2.6 a
6. Flint 50WG 0.33 oz	96.0 d	2.3 a	0.3 ab	55.7 a	1.0 a	2.8 a
7. Elite 45DF 0.37 oz + Flint 50WG 0.33 oz	90.8 bcd	3.0 a	0.3 ab	41.2 a	1.1 a	2.6 a
8. Elite 45DF 0.53 oz + Flint 50WG 0.48 oz	78.0 a	2.0 a	0.0 a	43.6 a	1.1 a	2.5 a
9. Elite 45DF 0.37 oz	82.0 abc	6.3 a	2.6 bc	49.4 a	1.1 a	2.7 a

[1] From evaluation of ca. 73 fruit/tree (range of 33—77 fruit/tree). After harvest, fruit were held at 75° F. and 100% relative humidity for 11-14 days before they were rated to allow development of fruit rots and blemishes.
[2] Rating scale used : 1 = smooth finish, 2 = enlarged lenticels fruit feels rough, 3 = some netting between lenticels, 4 = small patches of russet, 5 = large area of russet. Fruit with a russet rating of 3,4, or 5 would not qualify as USDA Extra Fancy.
[3] Numbers within columns followed by the same letter do not differ significantly (Fisher's Protected LSD, $P \leq 0.05$). The arcsine transformation was used for statistical analyses, but arithmetic means are shown.

Apple Disease Control with Syllit, Scala, Vangard and Two Formulations of Topsin M, 2003.

Treatments were compared using 2-tree plots in a 6-yr-old orchard of trees on MM.111 rootstocks with M.9 inter-stems. Each test plot contained one Golden Delicious tree and one two-part tree in which the lower scaffolds were McIntosh and the upper portion of the tree was grafted to Ginger Gold. Treatments were replicated four times using a randomized block design. Cedar trees were planted between plots within rows to provide inoculum for rust diseases and to minimize drift between plots. Populations of *V. inaequalis* were still near baseline for sensitivity to dodine, DMI fungicides and strobilurin fungicides when tested by Dr. Wolfram Koeller using young scab lesions collected from this orchard on 2 Jun 2003. Treatments were applied to drip using a handgun and a high-pressure sprayer set at 200 psi. Fungicide rates and spray timings are shown in the first data table.

Few if any primary scab infections developed from the first potential infection period on 11 Apr (26 hr wetting, 43 °F) when trees were at green tip. A moderate infection period on 26 Apr (24 hr wetting, 52 °F) when trees were at tight cluster resulted in infections that became visible on May 13 (late bloom). Additional primary infection periods occurred 1-2 May (18 hr, 60 °F), 5-9 May (49 hr, 52 °F), 11-12 May (19 hr, 56 °F), 21 May (12 hr, 59 °F), 22-23 May (35 hr, 55 °F), and 26-32 May (100 hr, 59 °F, 3.85 in. rain). Infection periods were calculated by combining wetting periods separated by less than 24 hr of drying, but mean temperatures for split wetting periods were calculated using only hr when foliage was actually wet. A total of 147 hr wetting occurred between 19 May (petal fall) and 31 May. June weather included 5 secondary scab infection periods, 102 hr of wetting, and 5.2 in. of rain. July had 6 scab infection periods, 139 hr wetting, 4.2 in. rain; August had 5 infection periods, 259 hr wetting, 8.1 in. rain; and September had 277 hr wetting and 9.13 in. rain. Measurable precipitation occurred on 16 consecutive days beginning 21 May and provided for extensive secondary spread of scab and heavy infection by rust fungi. A maintenance spray of Asana XL 10 fl oz/A, Agrimek 10 fl oz/A, and Damoil 1 gal/A was applied on 27 May when foliage was extremely succulent and may have contributed to slower disease development than would have been expected given the extended wetting periods that occurred between 21 May and 24 Jun. Control trees were heavily scabbed, but scab did not cause significant defoliation during summer and cedar apple rust infections on terminal leaves were less extensive than in several previous years.

In treatments 2 & 3, two formulations of Topsin M were compared using applications that began on 27 May. Penncozeb was used to control scab and rust prior to 27 May. There were no significant differences between treatments 2 & 3 for any of the parameters measured. Mildew was relatively well controlled by both formulations of Topsin despite the fact that some mildew infections became established in these plots prior to 27 May when Penncozeb was being applied alone. Because the scab population in this block is resistant to benzimidazoles, there was a high incidence of leaf scab in these plots on 29 Aug.

Syllit (dodine) was evaluated in treatments 5 & 6. Treatment 4 was identical to treatment 5 except that in treatment 4, Dithane was substituted for Syllit. There were no significant differences among treatments 4, 5, and 6 for any of the diseases evaluated, and these treatments provided good control of scab, mildew, and rust diseases.

Weather conditions immediately after bloom favored development of severe russetting on Golden Delicious. Dodine has historically been viewed as a potential contributing factor for fruit russetting on Golden Delicious. In this test, the last Syllit spray in treatment 6 occurred on 18 May when trees were at petal fall. Fruit russetting on Golden Delicious in treatment 6 was significantly worse that in several of the other fungicide treatments. In treatment 5, the last Syllit application was at tight cluster on April 23, and russetting was not significantly different from the treatment with the least russetting. Thus, early-season sprays may be less likely to contribute to russetting on Golden Delicious than sprays that are applied after the pink bud stage. The 7 May fungicide application was intended as a pink-bud spray, but high temperatures in late April caused rapid bud development and rains during the first five days of May caused the pink spray to be delayed.

Scala and Vangard (anilinopyrimidine fungicides) were compared in treatments 8, 9, & 10 where they were applied on 23 April and 7 May. Even though a scab infection period occurred 1-2 May, mid-way through the 14-day spray interval, all of these treatments provided good scab control as judged from evaluations made during June. Flint applied on 18 and 27 May may have temporarily suppressed secondary scab development in plots where Scala and Vangard provided less-than-perfect early-season scab control, but wet summer weather promoted development of secondary scab and magnified small differences in levels of prebloom scab control. The 1 Jul rating of leaf scab on Ginger Gold showed that the higher rate of Scala was more effective than the lower rate. Despite five applications of captan during summer, McIntosh trees sprayed with Scala or Vangard on 23 April and 7 May had roughly five times more leaf scab on 29 Aug than similar trees that received Flint on those dates (treatment 7). Scala and Vangard might have performed better if we had avoided the 14-day spray interval between 23 April and 7 May. Nevertheless, these results clearly show that Scala and Vangard are less effective than Flint or Nova when spray intervals become stretched because of rainy weather.

Heavy rainfall at various points during the summer removed fungicide residues and provided ideal conditions for development of sooty blotch and flyspeck. A total of 1.49 inches of rain that occurred between 11 Aug (the date of the last fungicide application) and 31 Aug. An additional 4.16 inches of rain between 1 and 4 Sep removed any remaining fungicide residue. Thus, the incidence of flyspeck and sooty blotch on McIntosh (harvested 9 Sep) provides a better indication of fungicide efficacy than does the data from Golden Delicious that were harvested on 22 Sep. By 22 Sep, fungicide residues had been displaced long enough to allow significant development of sooty blotch on the fruit.

Application dates	Interval from green tip or from the last spray: number of days	rain (inches)	hours of wetting	Mill's scab infection periods	Start of infection periods counted as days after the last spray was applied
(10 Apr – green tip)					
18 Apr	8	0.36	26	L ?	1
23 Apr	5	0.21	17	0	
7 May	14	0.85	65	M, L	3, 9
18 May	11	0.52	53	M, M	0, 4
27 May	9	1.93	80	L, H, H	3, 6, 8
6 Jun	10	2.69	94	M, M, L, H, +, +[1]	0, 1, 3, 4, //[2] 8, 9
23 Jun	17	0.95	69	3[3]	1, 6, 12
8 Jul	15	1.73	43	2	11, 14
29 Jul	21	2.43	89	3	3, 13, // 14
7 Aug	9	3.37	111	4	3, 5, // 6, 7
(31 Aug)	24	4.68	160	7	0, 2, 3, // 5, 7, 9, 22

[1] A "+" indicates secondary infection periods occurring after primary inoculum was exhausted.
[2] Double slashes indicate point at which more than 2 inches of rain had accumulated since the last spray.
[3] Numbers indicate the number of secondary infection periods during the interval, excluding those infection periods attributable only to dew periods.

Material and rate of formulated product per 100 gal	Spray application dates: 18 Apr	23 Apr	7 May	18 May	27 May	6 Jun	23 Jun	8 Jul	29 Jul	7 Aug	% Ginger Gold terminal leaves with mildew [1]: 16 Jun	10 Sep
1. Control	X	X	X	X	X	X					25.3 c[2]	55.0 c
2. Penncozeb 75 DF 1 lb....................	X	X	X	X								
Penncozeb 75 DF 1 lb + Topsin M 4.5F 5 fl oz					X							
Topsin M 4.5F 5 fl oz						X	X	X	X	X	4.5 b	25.3 b
3. Penncozeb 75DF 1 lb....................	X	X	X	X								
Penncozeb 75 DF 1 lb + Topsin M 70W 4 oz					X							
Topsin M 70W 4 oz						X	X	X	X	X	2.8 b	20.0 b
4. Dithane RSNT 75DF 1 lb....................	X	X										
Dithane RSNT 75DF 1 lb + Nova 40W 1.5 oz........			X	X	X	*[3]	*	*	*	*	0.0 a	17.5 ab
5. Syllit 400F 8 fl oz....................	X	X										
Dithane RSNT 75DF 1 lb + Nova 40W 1.5 oz........			X	X	X	*[3]	*	*	*	*	0.3 a	nr[5]
6. Syllit 400F 8 fl oz + Nova 40W 1.5 oz	†[4]	†[4]	X	X								
Dithane RSNT 75DF 1 lb + Nova 40W 1.5 oz........					X	*[3]	*	*	*	*	0.6 ab	nr[5]
7. Flint 50DF 0.67 oz........................	†[4]	X	X	X	X	*[3]	*	*	*	*	0.0 a	10.0 a
8. Scala 60SC 1.5 fl oz........................	†[4]	X	X									
Flint 50DF 0.67 oz........................				X	X	*[3]	*	*	*	*	0.6 ab	nr[5]
9. Scala 60SC 2.27 fl oz........................	†[4]	X	X									
Flint 50DF 0.67 oz........................				X	X	*[3]	*	*	*	*	1.6 ab	nr[5]
10. Vangard 75WG 1.67 oz........................	†[4]	X	X									
Flint 50DF 0.67 oz........................				X	X	*[3]	*	*	*	*	0.8 ab	nr[5]

[1] Data collected from the 8 youngest leaves on 10 terminal shoots per tree
[2] Numbers within columns followed by the same letter do not differ significantly (Fisher's Protected LSD, $P \leq 0.05$). The arcsine transformation was used for statistical analyses, but arithmetic means are shown.
[3] Captan 50W 1 lb was applied five times during summer (6 Jun to 7 Aug).
[4] Dithane RSNT 75DF 1 lb was applied on dates indicated.
[5] nr = not rated

Material and rate of formulated product per 100 gal	% scab on McIntosh cluster lvs 3 Jun[1]	% terminal lvs with apple scab: McIn-tosh 19 Jun	Ginger Gold 1 Jul	Grand mean: both cultivars	% McIntosh terminal lvs with scab 29 Aug
1. Control	21.9 b[2]	73.6 d	62.4 d	68.0 c	95.8 d
2. Penncozeb 75 DF 1 lb Penncozeb 1 lb + Topsin M 4.5F 5 fl oz Topsin M 4.5F 5 fl oz	1.3 a	10.2 c	11.8 c	11.0 d	55.8 c
3. Penncozeb 75DF 1 lb Penncozeb 1 lb + Topsin M 70W 4 oz Topsin M 70W 4 oz	1.2 a	8.1 c	9.3 c	8.7 d	64.3 c
4. Dithane RSNT 75DF 1 lb Dithane 1 lb + Nova 40W 1.5 oz [4]	0.0 a	0.4 ab	0.2 a	0.3 ab	5.3 a
5. Syllit 400F 8 fl oz Dithane 1 lb + Nova 40W 1.5 oz [4]	0.0 a	0.5 ab	0.2 a	0.4 ab	6.3 a
6. Syllit 400F 8 fl oz + Nova 40W 1.5 oz Dithane 1 lb + Nova 40W 1.5 oz [4]	0.0 a	0.0 a	0.0 a	0.0 a	5.9 a
7. Flint 50DF 0.67 oz [3,4]	0.0 a	0.2 ab	0.2 a	0.2 ab	6.2 a
8. Scala 60SC 1.5 fl oz Flint 50DF 0.67 oz [3,4]	0.4 a	2.4 b	2.7 b	2.6 c	26.3 b
9. Scala 60SC 2.27 fl oz Flint 50DF 0.67 oz [3,4]	0.4 a	1.2 ab	0.6 a	0.9 ab	33.3 b
10. Vangard 75WG 1.67 oz Flint 50DF 0.67 oz [3,4]	0.5 a	0.6 ab	0.9 ab	0.7 bc	34.2 b

[1] Data collected from all leaves on 20 clusters/tree; all fruitlets on 20 clusters/tree; all leaves on 20 teminals/tree on 19 Jun; 10 terminals/tree 1 Jul; 15 terminals/tree on 29 Aug.
[2] Means separations: arcsine transformation, Fisher's Protected LSD ($P \leq 0.05$); arithmetic means are shown.
[3] Dithane RSNT 75DF 1 lb was applied on 18 Apr.
[4] Captan 50W 1 lb was applied five times during summer (6 Jun to 7 Aug).

Material and rate of formulated product per 100 gal	% fruit with scab: McIntosh 19 Jun	McIntosh 9 Sep	Golden Del. 22 Sep	% fruit with flyspeck: McIntosh 9 Sep	Golden D 22 Sep	% Golden Del fruit with sooty blotch 22 Sep
1. Control	95.3 b	100.0 d	51.6 b	66.7 b	100.0 c	100.0 a
2. Penncozeb 75 DF 1 lb Penncozeb 1 lb + Topsin M 4.5F 5 fl oz Topsin M 4.5F 5 fl oz	0.0 a	36.6 c	3.5 a	4.7 a	62.4 a	70.5 a
3. Penncozeb 75DF 1 lb Penncozeb 1 lb + Topsin M 70W 4 oz Topsin M 70W 4 oz	2.1 a	25.8 c	4.0 a	8.6 a	60.2 a	76.7 a
4. Dithane RSNT 75DF 1 lb Dithane 1 lb + Nova 40W 1.5 oz [4]	0.0 a	0.3 a	0.0 a	61.3 b	79.3 b	74.8 a
5. Syllit 400F 8 fl oz Dithane 1 lb + Nova 40W 1.5 oz [4]	0.0 a	0.3 a	0.5 a	61.0 b	89.5 b	83.9 a
6. Syllit 400F 8 fl oz + Nova 40W 1.5 oz Dithane 1 lb + Nova 40W 1.5 oz [4]	0.0 a	0.3 ab	0.0 a	64.0 b	84.5 b	82.0 a
7. Flint 50DF 0.67 oz [3,4]	0.0 a	0.3 a	0.0 a	60.3 b	84.0 b	88.0 a
8. Scala 60SC 1.5 fl oz Flint 50DF 0.67 oz [3,4]	0.0 a	2.2 ab	0.0 a	56.4 b	87.6 b	83.0 a
9. Scala 60SC 2.27 fl oz Flint 50DF 0.67 oz [3,4]	1.2 a	3.9 ab	4.5 a	62.9 b	86.9 b	88.0 a
10. Vangard 75WG 1.67 oz Flint 50DF 0.67 oz [3,4]	0.0 a	3.1 b	2.4 a	59.9 b	94.5 bc	94.7 a

[1] Data collected from all leaves on 20 clusters/tree; all fruitlets on 20 clusters/tree; all leaves on 20 terminals/tree on 19 Jun; 10 terminals/tree 1 Jul; 15 terminals/tree on 29 Aug.
[2] Means separations: arcsine transformation, Fisher's Protected LSD ($P \leq 0.05$); arithmetic means are shown.
[3] Dithane RSNT 75DF 1 lb was applied on 18 Apr.

[4]Captan 50W 1 lb was applied five times during summer (6 Jun to 7 Aug).

Material and rate of formulated product per 100 gal	% Gold Delicious terminal leaves with cedar apple rust on 2 Jul	% fruit with quince rust McIntosh 19 Jun[1]	% fruit with quince rust Golden Del 22 Sep	% Golden Del. fruit Black rot 22 Sep	% Golden Del. fruit Bitter rot 22 Sep	Mean Golden Delicious russet rating[5] 22 Sep
1. Control	41.2 d	11.5 c	13.7 b	4.1 a	6.9 a	4.44 c
2. Penncozeb 75 DF 1 lb Penncozeb 1 lb + Topsin M 4.5F 5 fl oz Topsin M 4.5F 5 fl oz	17.7 bc	1.0 ab	0.0 a	0.0 a	0.0 a	3.44 a
3. Penncozeb 75DF 1 lb Penncozeb 1 lb + Topsin M 70W 4 oz Topsin M 70W 4 oz	9.8 b	0.0 a	0.0 a	0.5 a	0.0 a	3.37 a
4. Dithane RSNT 75DF 1 lb Dithane 1 lb + Nova 40W 1.5 oz[4]	0.7 a	0.0 a	0.0 a	0.0 a	0.0 a	3.47 ab
5. Syllit 400F 8 fl oz Dithane 1 lb + Nova 40W 1.5 oz[4]	0.2 a	1.0 ab	0.5 a	2.0 a	1.0 a	3.67 ab
6. Syllit 400F 8 fl oz + Nova 40W 1.5 oz Dithane 1 lb + Nova 40W 1.5 oz[4]	0.7 a	0.0 a	0.0 a	0.5 a	0.0 a	4.02 bc
7. Flint 50DF 0.67 oz[3,4]	17.9 bc	0.0 a	1.5 a	0.5 a	0.0 a	3.62 ab
8. Scala 60SC 1.5 fl oz Flint 50DF 0.67 oz[3,4]	27.8 cd	8.8 bc	21.8 b	4.9 a	1.0 a	4.04 bc
9. Scala 60SC 2.27 fl oz Flint 50DF 0.67 oz[3,4]	34.0 d	4.2 abc	22.2 b	2.5 a	1.0 a	3.96 abc
10. Vangard 75WG 1.67 oz Flint 50DF 0.67 oz[3,4]	28.9 cd	5.8 abc	26.5 b	3.9 a	3.4 a	3.79 ab

[1]Data collected from all fruitlets on 20 terminals/tree; all leaves on 20 terminals/tree on 2 Jul.
[2]Means separations: arcsine transformation, Fisher's Protected LSD ($P \leq 0.05$); arithmetic means are shown.
[3]Dithane RSNT 75DF 1 lb was applied on 18 Apr.
[4]Captan 50W 1 lb was applied five times during summer (6 Jun to 7 Aug).
[5]Fruit russetting was rated on a scale of 1-5 wherein 1 = smooth fruit, 2= roughened lenticels, 3 = slight russetting extending from lenticels, 4 = patches of russetting skin evident on fruit, 5 = very severe russetting.

Fungicides for Controlling Fabraea Fruit and Leaf Spot on Pears, 2003

Treatments were compared using 4-tree plots in a pear orchard that was planted in 1974 and in which trees were pruned so as to limit tree height to no more than 12-ft. Each test plot contained two Barlett and two Bosc trees. Treatments were replicated four times using a randomized block design. Treatments were applied to drip using a handgun and a high-pressure sprayer set at 200 psi. The entire orchard, including control plots, was sprayed with Dithane RSNT 75 DF at 3 lb/A on 7 May and with Manzate 75 DF at 3 lb/A on 15 and 19 May. Fungicide treatments were initiated on 27 May and were repeated on 3 Jun, 18 Jun, 1 Jul, 25 Jul, 8 Aug, and 21 Aug. For all applications after 27 May, LI700 at 8 oz/100 was included with the fungicides to enhance wetting of the pear foliage.

Because the test orchard did not have any Fabraea leaf spot in previous years, inoculum was introduced placing diseased leaves into plastic mesh onion bags and hanging one bag about 6-ft above ground in the center of each Bosc tree in the orchard. Each bag contained approximately 64 in^3 of loosely-packed leaves. In the first attempt to introduce inoculum over-wintered leaves were collected from beneath trees in a commercial orchard that had been defoliated by Fabraea leaf spot in 2002. Although the leaves were collected early April, the grower had applied a dormant copper spray to manage fire blight. Several days before the leaves were collected. These leaves were placed into test trees on 1 May. Despite extensive wetting periods during early summer, no Fabraea infections were evident in control plots in late June, perhaps because of the copper residues in our inoculum samples. On July 15, severely diseased leaves were stripped from current season shoots in a recently abandoned orchard, were placed into mesh bags as described above, and were used in a second attempt to initiate disease in the test orchard. This second source of inoculum proved effective for initiating disease in our test orchard. Fabraea lesions were evident in control trees by late July.

Because inoculum introduced in May failed to cause infections, the only period of interest in this trial is the period from 15 July through the end of the season. Major rainfall and wetting events during that interval included 16-17 Jul (6 hr wet, 0.02 in rain), 21-24 Jul (26 hr wet, 1.7 in rain), 1-6 Aug (99 hr wet, 3.37 in rain), 9-14 Aug (81 hr wet, 4.31 in rain), 1-2 Sep (70 hr wet, 4.24 in rain), 13-16 Sep (51 hr wetting, 0.6 in rain), and 23-30 Sep (94 hr wetting, 3.9 in rain). The latter two infection periods occurred after or just prior to fruit harvest and therefore did not affect incidence of disease on fruit, but they provided ideal conditions for continued spread of disease on leaves. Rainfall totals between the summer fungicide applications totaled 4.1 inches between 1 and 25 Jul (with 2.1 inches 4-9 Jul before inoculum was introduced and 1.5 inches 20-21 Jul), 3.5 inches between 25 Jul and 8 Aug, with 2.1 inches on 2 Aug), 4.3 inches between 8 and 21 Aug, with 3.2 inches on 10 Aug). The heavy rains in early Sep presumably removed all remaining fungicide residues.

The late introduction of Fabraea into this test orchard may have made disease control easier than it would have been in an orchard containing natural inoculum from the previous season However, several factors favored disease development after inoculum was introduced on 15 Jul and made this a severe test:

1. Fungicide residues from the 1 Jul application had been weathered by more than 2 in of rain before inoculum was introduced.
2. Several wetting periods occurred after inoculum was introduced on 15 Jul and before the next spray was applied on 25 Jul, thereby allowing opportunities for Fabraea to become established before the first fungicide was applied following initial infections.
3. Heavy rainfall during late July, August, and early September removed fungicide residues between applications and provided opportunities for infection of sprayed trees.

Except for Scala, all of the fungicide treatments provided acceptable control of Fabraea on fruit. The incidence of Fabraea on fruit might have been greater if initial infections had occurred earlier in the season. The defoliation ratings showed that all treatments except Scala and Captan provided excellent disease control on foliage through 24 Oct. All of the treatments except Scala provided reasonable control of flyspeck on Bartlett fruit, but only those treatments that included Topsin M provided adequate control of the sooty blotch and sooty mold complex on Bartlett fruit. No resistance-monitoring has been done to determine if Topsin M is still widely effective against Fabraea in commercial orchards. However, both Sovran and Flint proved effective in this trial and could be substituted for Topsin M. The value of including LI700 with the fungicides was not determined in this trial, but it may have contributed to the effectiveness of the fungicides tested.

Material and rate of fromulated product per 100 gal[1]	Defoliation ratings for Bosc[2]				
	8 Sep	17 Sep	10 Oct	24 Oct	Grand means for all dates
Control	2.13 c	2.75 b	4.13 c	5.00 d	3.50 d
Captan 50W 1.5 lb	1.13 a	1.13 a	1.88 b	3.63 c	1.94 b
Scala 60SC 1.5 floz	1.63 b	2.38 b	3.63 c	4.50 d	3.03 c
Sovran 50WDG 1.6 oz	1.00 a	1.00 a	1.00 a	1.88 ab	1.22 a
Flint 50WDG 0.8 oz	1.00 a	1.00 a	1.00 a	1.38 a	1.09 a
Topsin M 70W 4 oz	1.00 a	1.00 a	1.50 ab	2.13 b	1.41 a
Topsin M 70W 4 oz + Ziram 76DF 1.5 lb	1.00 a	1.00 a	1.13 a	1.88 ab	1.25 a
Topsin M 70W 4 oz + Sovran 1.25 oz	1.00 a	1.00 a	1.25 a	1.38 a	1.16 a
Grand mean for date	1.23 A	1.41 B	1.94 C	2.72 D	

[1] All plots were covered with Dithane RSNT 75 DF on 7 May; Manzate 75 DF on 15 and 19 May; Individual treatments were applied 27 May; 3, 18 Jun; 1, 25 Jul; 8 and 21 Aug. LI 700 at 8 oz/100 was included in all sprays starting 3 Jun.

[2] Rating scale for defoliation 1 = <10 % leaf defoliation; 2 = 10 – 25 % leaf defoliation; 3 = 25 – 50 % leaf defoliation; 4 = 50 – 75 % leaf defoliation; 5 = > 75% leaf defoliation.

Material and rate of fromulated product per 100 gal	% fruit with Fabraea lesions at harvest[1]		% Bartlett fruit with	
	Bosc	Bartlett	flyspeck	sooty blotch & sooty molds[2]
Control	52.6 c	23.4 b	87.9 b	90.3 e
Captan 50W 1.5 lb	2.6 ab	0.8 a	22.9 a	20.9 bc
Scala 60SC 1.5 floz	14.3 b	12.0 b	85.3 b	94.3 e
Sovran 50WDG 1.6 oz	0.0 a	1.6 a	17.7 a	36.7 cd
Flint 50WDG 0.8 oz	0.7 a	0.0 a	21.5 a	61.3 d
Topsin M 70W 4 oz	1.0 a	0.0 a	8.3 a	7.5 ab
Topsin M 70W 4 oz + Ziram 76DF 1.5 lb	0.5 a	0.8 a	12.9 a	12.4 ab
Topsin M 70W 4 oz + Sovran 1.25 oz	0.7 a	0.7 a	8.4 a	2.0 a

[1] Bartlett pears were harvested 8 Sep and Bosc pears were harvested 17 Sep.

[2] This rating included both sooty blotch infections and sooty molds growing in pear psylla honeydew that had dripped onto fruit late in the season.

[3] An insecticide spray consisting of 3.5 lb/A of Imidan, 10 oz/A of Agrimek, and Damoil 1 gal/A of was applied 27 May after the fungicide treatments applied on the same day had dried, and this spray caused considerably foliar phytotoxicity, presumably because of the succenlent state of leaves that unfurled during the previous week of cloudy damp weather. Agrimek 10 fl oz/A + Damoil 2.7 qt/A was applied again on 10 June. The timing and cause of phytotoxicity observed on fruit at harvest could not be determined but may have been related to the combination of fungicides and insecticides that were applied on 27 May.

APPLE (*Malus x domestica* 'Honeycrisp')
Blue mold; *Penicillium expansum*
Gray mold; *Botrytis cinerea*
Black rot; *Botryosphaeria obtusa*

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Controlling Postharvest Decays in Stored Honeycrisp Apples, 2002-2003.

Growers storing Honeycrisp apples have reported that this cultivar is highly susceptible to postharvest decays caused by various fungal pathogens. At the Hudson Valley Lab, we have occasionally observed a high incidence of black rot and/or white rot in Honeycrisp guard trees adjacent to our fungicide test plots. The objective of this trial was to determine if postharvest fungicide treatments could reduce the incidence of postharvest decays that develop in Honeycrisp apples. Fruit used for these treatments were from guard trees that had received no fungicides during summer. Honeycrisp fruit were harvested 4 Sep 2002 and held at 35° F until 18 Sep 2002. In the afternoon of 18 Sep, Honeycrisp were moved to ambient temperature and sorted into 24 baskets (6 treatments x 4 replications) and left overnight. On the morning of 19 Sep, apples were dipped for 30 sec in various fungicide treatments. After drying for several hours, apples were placed on spring cushion trays, packed into fiberboard boxes and returned to cold storage at 35° F. Apples were evaluated for decays on 21 May 2003 after 244 days of cold storage. For this experiment, fruit were neither wounded nor artificially inoculated.

Because Honeycrisp apples have an exceptional storage life, fruit in this experiment were still of acceptable eating quality after 244 days of cold storage. Approximately 29% of the apples developed bitter pit (a calcium-related physiological disorder), but incidence of bitter pit was not affected by postharvest treatment. The incidence of postharvest decays that developed in this experiment was relatively low compared to losses observed when fruit were stored in previous seasons. The unusually dry summer 2002 may have prevented the levels of infections and/or infestation of fruit that occurs during summers with more rainfall. Scholar provided good control of blue mold both when used alone and when combined with DPA, but Mertect 340F was only effective when combined with DPA. A similar trend was evident for gray mold, but variability in the incidence of gray mold was so great as to preclude any level of statistical significance. Previous studies have shown that DPA controls many benzimidazole-resistant isolates of *P. expansum* and *B. cinerea*, so the improved performance of Mertect when combined with DPA (as compare to Mertect used alone) is not surprising. None of the treatments provided control of black rot. Black rot infections presumably occurred in the orchard and were present as latent infections on fruit at harvest.

Materials and rate of formulated product per 100 gal of drench solution	% fruit with decay on 21 May 2003 after 244 days storage at 35° F					
	blue mold		gray mold		black rot	
	no DPA	with DPA[1]	no DPA	with DPA[1]	no DPA	with DPA[1]
Control	12.6 b[2]	10.1 b	12.7[3]	15.1[3]	12.7[3]	7.5[3]
Mertect 340F 16 fl oz	8.8 ab	1.3 a	13.8	3.8	12.5	6.3
Scholar 50W 12 oz	2.5 a	1.3 a	8.8	5.0	16.3	17.5

[1] Decco NoScald DPA 40 fl oz/ 100 gal (= 1000 ppm of active ingredient)

[2] Numbers within columns followed by the same letter do not differ significantly (Fisher's Protected LSD, $P \leq 0.05$, applied to simple means from the 2-way analysis of three fungicide treatments with/without DPA,). The arcsine transformation was used for statistical analyses, but arithmetic means are shown.

[3] Means within the column are not significantly different based on Fisher's Protected LSD test, $P \leq 0.05$.

APPLE (*Malus x domestica* 'McIntosh', 'Redcort', 'Delicious')
Blue mold; *Penicillium expansum*

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Effectiveness of Abound and Scholar for Control of Blue Mold on Apples, 2002-2003.

The objectives of this experiment were to determine if postharvest application of Abound can be used to control blue mold in apples and whether Abound is as phytotoxic to mature apple fruit as it is when applied to immature fruit in the field. Fruit were harvested on 5 Sep (Redcort), 25 Sep (McIntosh) and 26 Sep 2002 (Delicious) and were held at 35°F until the experiment was initiated on 2 Oct 2002. Apples were then moved from the cooler and wounded on a single hemisphere using a large cork fitted with three finishing nails spaced about 1 cm apart in a triangular pattern. Wounds were approximately 3 mm deep by 2 mm in diameter and simulated stem punctures, a common entry site for *P. expansum* in apples. Each treatment was replicated four times using 25 fruit per replicate for each of the three varieties tested. On 3 Oct, approximately 18 hr after fruit were wounded, baskets containing the wounded fruit were dipped for 30 sec in tanks containing a 10,000 spores/ml of a benzimidazole-sensitive isolate of *P. expansum* (P-99). Inoculum was prepared by washing conidia from 12-day old cultures growing on potato-dextrose agar plates using sterile water that contained 0.01% Tween 20. Spore concentration of the stock suspension was determined using a hemacytometer, and an appropriate amount of stock suspension was added to the inoculation tanks just prior to inoculation. Approximately one hour after inoculation, apples were immersed for 30 seconds in either water or in one of the fungicide solutions. After 4 hr of drying time, apples were placed on spring cushion trays in wooden boxes and were then moved to cold storage at 35 °F. Apples were evaluated 2 Dec 2002 and again on 2 Jan 2003.

Scholar was more effective than Abound for controlling blue mold. Abound suppressed blue mold more effectively in Delicious than in McIntosh or Redcort. McIntosh treated with the high rate of Abound developed more decay after 91 days of storage than McIntosh treated with the lower rate of Abound. When applied in the field, Abound causes no injury on Delicious, but it is very phytotoxic to McIntosh and Redcort. None of the apples developed visible phytotoxicity (i.e., skin browning) as a result of postharvest treatment, but it is possible that the high rate of Abound caused non-visible damage to the skin of McIntosh and Redcort fruit, thereby providing entry sites for *P. expansum*. Results from this trial show that Abound will not be useful for controlling postharvest decays of apples.

Material and rate of formulated product per 100 gal of drench solution	Grand means for treatment effects	% fruit with blue mold on 2 Dec, 60 days after treatment		
		McIntosh	Redcort	Delicious
Control	24.4 c*	33.0 b	24.1 b	16.1 b
Scholar 50W 12 oz	1.0 a	1.0 a	1.0 a	1.0 a
Abound 2.08F 15.4 fl oz	6.0 b	5.0 a	11.0 b	2.0 ab
Abound 2.08F 30.8 fl oz	10.7 b	17.0 b	13.0 b	2.0 ab
Grand means for cultivar effects**		14.0 B	12.3 B	5.3 A

* Means within columns followed by the same small letter do not differ significantly (Fisher's Protected LSD, $P \leq 0.05$). The angular transformation was used for statistical analysis, but arithmetic means are shown.
** Grand means followed by the same upper-case letter are not significantly different ($P \leq 0.05$) as determined using a 2-way analysis of four treatments across three cultivars. *P*-values for replicate, treatment, cultivar, and treatment*cultivar interaction were 0.324, <0.001, 0.016 and 0.337 respectively.

Material and rate of formulated product per 100 gal of drench solution	Grand means for treatment effects	% fruit with blue mold on 2 Jan, 91 days after treatment		
		McIntosh	Redcort	Delicious
Control	55.2 c*	71.0 d	64.5 c	30.2 c
Scholar 50W 12 oz	2.7 a	2.0 a	4.0 a	2.0 a
Abound 2.08F 15.4 fl oz	19.3 b	16.0 b	33.0 b	9.0 ab
Abound 2.08F 30.8 fl oz	27.7 b	43.0 c	30.0 b	10.0 b
Grand means for cultivar effects**		33.0 B	32.9 B	12.8 A

* Means within columns followed by the same small letter do not differ significantly (Fisher's Protected LSD, $P \leq 0.05$). The angular transformation was used for statistical analysis, but arithmetic means are shown.
** Grand means followed by the same upper-case letter are not significantly different ($P \leq 0.05$) as determined using a 2-way analysis of four treatments across three cultivars. *P*-values for replicate, treatment, cultivar and treatment*cultivar interaction were 0.342, <0.001, <0.001 and 0.022 respectively.

APPLE (*Malus x domestica* 'Golden Delicious')
Gray mold; *Botrytis cinerea*

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Postharvest Control of Gray Mold on Golden Delicious with Scholar and Mertect, 2002-03

Golden Delicious apples were harvested 7 Oct '02 and were held at ambient temperature in an unheated building until the experiment was initiated on 8 Oct. Apples were wounded on a single hemisphere using a large cork fitted with three finishing nails spaced about 1 cm apart in a triangular pattern. Wounds were approximately 3 mm deep by 2 mm in diameter and simulated stem punctures, a potential entry site for *B. cinerea* in apples. Approximately 18 hr after they were wounded, apples were immersed for 30 seconds in a spore suspension. Spores of *B. cinerea* were harvested from 9 day old cultures grown on King's B medium under constant light. The concentration of the stock spore suspension was determined using a hemacytometer and an appropriate amount of stock suspension was added to the inoculation tanks to achieve the final concentration of 10,000 spore per ml. Apples were allowed to dry approximately 30 minutes and were then immersed for 30 seconds in either water or a fungicide treatment. Approximately 3 hours after fungicide treatments were completed, fruit were placed on spring cushion trays, packed into fiberboard boxes and moved to regular cold storage at 35° F. Fruit were evaluated on 7 Jan '03 (90 days after treatment), 12 Mar '03 (154 days after treatment), and again after storage for an additional 20 days at 65° F and 100% relative humidity.

Very little decay developed in any of the treatments during 154 days of cold storage, but considerable decay was evident after 20 days at 65° F. Mertect did not provide adequate control of *B. cinerea* in this trial, and the Mertect + DPA treatment was not significantly different from Mertect used alone. DPA also had no impact on the efficacy of Scholar. Scholar provided control of *B. cinerea* at all of the rates tested, but the control provided by Scholar was significantly better than that provided by Mertect + DPA only when Scholar was applied at rates between 4 and 16 oz per 100 gallons.

Materials and rates of formulated product per 100 gal of drench solution	% fruit with gray mold: 7 Jan '03 90 days @ 35° F	12 Mar '03 154 days @ 35° F	154 days @ 35° F + 20 days at 65° F
Control	3.1 b	4.1 b	40.5 d*
Mertect 340F 16 fl oz	0.0 a	0.0 a	20.0 cd
Mertect 340F 16 fl oz + Decco No Scald DPA 40 fl oz	0.0 a	0.0 a	15.0 bc
Scholar 50W 1 oz	0.0 a	0.0 a	10.0 abc
Scholar 50W 1 oz + Decco No Scald DPA 40 fl oz	0.0 a	0.0 a	11.0 abc
Scholar 50W 2 oz	0.0 a	0.0 a	9.0 acb
Scholar 50W 4 oz	0.0 a	0.0 a	3.0 a
Scholar 50W 8 oz	0.0 a	0.0 a	4.0 ab
Scholar 50W 12 oz	0.0 a	0.0 a	3.0 ab
Scholar 50W 16 oz	0.0 a	0.0 a	2.0 a
Scholar 50W 16 oz + Decco No Scald DPA 40 fl oz	0.0 a	0.0 a	3.0 a

*Numbers within columns followed by the same letter do not differ significantly (Fisher's Protected LSD, $P \leq 0.05$). The arc-sine transformation was used for statistical analyses, but arithmetic means are shown.

APPLE (*Malus x domestica* 'Empire')
Blue mold; *Penicillium expansum*

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Controlling Apple Blue Mold with a Scholar-plus-Hypochlorite Treatment, 2002-2003.

In eastern United States, postharvest fungicides are usually applied to apples in recycling drench solutions that also contain diphenylamine (DPA). DPA is an anti-oxidant that is used to control storage scald, a physiological disorder. In food handling systems, recycling solutions of any kind are a concern because of the small but potentially deadly possibility that the drench solutions could become contaminated with human pathogens that would then be spread to all of the food product treated with that solution. One way to minimize that risk is to include a sanitizer such as sodium hypochlorite in the recycling solution. Hypochlorite is very effective for killing bacteria in water solutions and can prevent the dissemination of pathogens in water. However, including hypochlorite in apple postharvest treatments has not been feasible in the past because hypochlorite is incompatible with DPA. In Europe, apples are now being treated by fogging DPA into apple storage rooms after the rooms have been filled. That process eliminates the need for DPA in postharvest drenches, so it may become feasible in the future to apply postharvest fungicides in a drench solution that also contains hypochlorite. This experiment was conducted to determine if sodium hypochlorite (Agclor 310) would inactivate Scholar when the two products are mixed in a postharvest treatment.

Empire apples were harvested on 23 Sep '02 and were held at 35° F until this experiment was initiated. On 29 Oct, apples were removed from storage and were wounded on a single hemisphere using a large cork fitted with three finishing nails spaced about 1 cm apart in a triangular pattern. Wounds were approximately 3 mm deep by 2 mm in diameter. Wounded apples were held at 60° F until they were used for treatments. Half of the fruit was treated and inoculated on 30 Oct and the other half on 31 Oct. The tanks of treatment solutions used the first day were held and re-used the second day to determine if Agclor would reduce activity of Scholar during a 24 hr holding period at 60° F. An inoculum stock solution was prepared on 29 Oct and held at 38° F until it was used. The stock solution was made by washing spores from 11 day old plates of *P. expansum* growing on potato dextrose agar. The spore concentration of the stock solution was determined using a hemacytometer, and appropriate amounts of stock solution were added to inoculation tanks just before fruit were inoculated on 30 Oct and again on 21 Oct.

On each treatment day, apples were dipped for 30 seconds into fungicide/sanitizer solutions and were then left to dry for approximately 4 hours. Each treatment was replicated four times using 25 apples per replicate. Apples were subsequently inoculated by submersion for 30 seconds in a spore suspension containing 10,000 spores/ml of a benzimidazole-sensitive isolate of *P. expansum* (P-99). Agclor, like all hypochlorite solutions, has no residual activity, so by inoculating fruit after treatments had been applied we hoped to measure the effect of Agclor on Scholar activity without any interference from the activity of Agclor against the pathogen itself. After inoculation apples were placed on spring cushion trays in fiberboard boxes and were moved to storage at 35° F until fruit were evaluated for decay.

As expected Agclor had no effect on development of decay. Scholar controlled blue mold equally well when used alone or when used with Agclor, and there was no Scholar-Agclor interaction. Results of this experiment show that Scholar fungicide is not inactivated by hypochlorite when mixed solutions are held for 24 hr at 60° F. Thus, using a recycling drench of Scholar plus hypochlorite to control postharvest decays should be feasible if DPA is no longer needed in the postharvest drench solution.

	% fruit with blue mold on 5 Mar '03					
	fruit treated/inoculated 30 Oct '02			fruit treated/inoculated 31 Oct '02		
	None	Agclor[1]	Grand means: Scholar effects	None	Agclor[1]	Grand means: Scholar effects
Control	69.6 b[2]	68.0 b	68.8 b	45.0 b	69.0 b	57.0 b
Scholar 50W 12 oz	6.0 a	0.0 a	3.0 a	3.0 a	5.0 a	4.0 a
Grand means: Agclor effects	37.8	34.0		24.0	37.0	

[1] Agclor 310 was used at 100 ppm with pH adjusted to 7.1 using Decco 312 Buffer Concentrate (phosphoric acid).
[2] Means within columns were significantly different ($P \leq 0.05$) for all comparisons in this trial as determined using a three-way analysis involving effects of Agclor, Scholar, and inoculation date. However, the effect of chlorine treatment was not significant ($P=0.627$), nor were there any significant interactions between effects of Scholar and Agclor ($P=0.064$).

APPLE (*Malus x domestica* 'Empire')
Blue mold; *Penicillium expansum*

D. A. Rosenberger, F. W. Meyer and K. L. VanCamp
Cornell's Hudson Valley Laboratory

Postinfection Activity of Mertect 340F and Scholar Against *Penicillium expansum*, 2002-2003.

The objective of this experiment was to compare the effectiveness of two postharvest fungicides applied at various intervals after apple fruit had been inoculated with *P. expansum*. Empire apples were harvested on 23 Sep '02 and held 35° F until the experiment was initiated. On 14 Oct, the apples were moved to a room at 60° F where they were wounded on a single hemisphere using a large cork fitted with three finishing nails spaced about 1 cm apart in a triangular pattern. Wounds were approximately 3 mm deep by 2 mm in diameter. All apples were inoculated the morning of 15 Oct by immersing baskets of fruit for 30 seconds in spore suspensions containing 10,000 spores/ml of a benzimidazole-sensitive isolate of *P. expansum* (P-99). Inoculum came from 6-day-old cultures grown on potato dextrose agar. Fruit were treated with water or fungicides at 6, 12, 24, 48, and 72 hr after inoculation by immersing the fruit in treatment solutions for 30 seconds. Fungicide solutions were mixed prior to the first treatment and were then held at 60° F and re-agitated and re-used for each subsequent treatment timing. Each treatment was replicated four times with 25 fruit per replication. Following treatment, apples were allowed to dry and were then placed on spring-cushion trays and stored in fiberboard boxes. All of the apples were held at 60° F until the last group had been treated and packed on 18 Oct. All of the fruit were then held at 35° F until they were evaluated for decay. Fruit were considered decayed if decay was evident at any one of the three wound sites.

After 120 days, incidence of decay ranged from 83 to 97% in fruit that received no fungicide treatment. All of the fungicide treatments controlled decay when fruit were treated at 6 or 12 hr after inoculation, and all but the highest rate of Scholar were effective at 24 hr after inoculation. Mertect 340F was more effective than any of the Scholar treatments when applied 72 hr after inoculation. Reasons for the inconsistent rate responses noted with Scholar at 24 and 48 hr are not known. Based on results of this trial, we conclude that Schlolar will provide adequate protection against blue mold if applied within 12 hr after inoculation, and perhaps when applied between 12 and 24 hr after inoculation. Although Scholar exhibited slightly less post-infection activity that Mertect 340F, this difference is unlikely to affect control under commercial conditions because most infections are initiated during the harvesting/handling processes and most apples are treated with fungicide and moved to storage within 24 hr of harvest.

Material and rate of formulated product per 100 gal of drench solution	% Empire fruit with blue mold 42 days after inoculation as affected by the number of hours that elapsed between inoculation and treatment				
	6 hr	12 hr	24 hr	48 hr	72 hr
Control	59.0 b*	58.2 b	45.0 b	80.0 b	71.0 c
Mertect 340F 16 fl oz	1.0 a	2.0 a	0.0 a	5.0 a	4.0 a
Scholar 50W 2 oz	0.0 a	0.0 a	1.0 a	19.0 a	30.0 b
Scholar 50W 8 oz	1.0 a	2.0 a	1.0 a	4.0 a	27.0 b
Scholar 50W 16 oz	0.0 a	2.0 a	7.0 a	13.0 a	17.0 ab

* Numbers within columns followed by the same letter do not differ significantly (Fisher's Protected LSD, $P \leq 0.05$). The arcsine transformation was used for statistical analyses, but arithmetic means are shown.

Material and rate of formulated product per 100 gal of drench solution	% Empire fruit with blue mold 120 days after inoculation as affected by the number of hours that elapsed between inoculation and treatment				
	6 hr	12 hr	24 hr	48 hr	72 hr
Water control	87.0 b*	82.7 b	89.0 c	96.0 c	97.0 c
Mertect 340F 16 fl oz	1.0 a	6.0 a	0.0 a	7.0 a	16.0 a
Scholar 50W 2 oz	3.0 a	2.0 a	4.0 a	38.0 b	60.0 b
Scholar 50W 8 oz	4.0 a	4.0 a	1.0 a	14.0 a	69.0 b
Scholar 50W 16 oz	1.0 a	3.0 a	14.0 b	31.0 b	61.0 b

* Numbers within columns followed by the same letter do not differ significantly (Fisher's Protected LSD, $P \leq 0.05$). The arcsine transformation was used for statistical analyses, but arithmetic means are shown.

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Effect of 1-MCP Treatment on Development of Blue Mold Decay in Empire Apples

Background

Several experiments were initiated at harvest in 2002 to determine if treating apples with 1-MCP would have any effect on development of blue mold decay caused by *Penicillium expansum*. Past research has shown that wound-healing in apples can reduce susceptibility of fruit to invasion by *P. expansum* through wounds. Invasion through stems has been observed during long-term controlled atmosphere (CA) storage, but not during air storage. Both wound healing and resistance to invasion through stems probably depend on metabolic activity of the fruit. Treatment of fruit with 1-MCP could conceivably block natural mechanisms that are involved in development of resistance to infection by *P. expansum*. If that occurred, treatment with 1-MCP might result in increased decay during long-term CA storage. Therefore, the effects of 1-MCP on decay development in Empire fruit were evaluated using a variety of inoculation and storage conditions.

Experimental

In Trial #1, effects of 1-MCP-treatment were evaluated using both wound-inoculated and stem-inoculated fruit stored at 36° F and 95% relative humidity in the following atmospheres:

1. Air storage
2. 5% CO_2 —2% O_2
3. 2.5% CO_2 —2% O_2
4. 2% CO_2 —2% O_2
5. 1% CO_2 —2% O_2.

Empire fruit for Trial #1 were harvested from trees at the Hudson Valley Lab in Highland on 23 September 2002 at the beginning of the commercial harvest period for CA Empire. Fruit were transported to Ithaca, then inoculated and treated with 1-MCP on 24 September. Fruit were moved into the CA atmospheres on 25 September and were removed for evaluation on either 12 December (wound-inoculated fruit) or 5 June (stem-inoculated fruit). Empire fruit used for this experiment had a mean starch index of 3.6 and a mean firmness of 17.4 lb when evaluated on 25 September at the time fruit were placed into CA atmospheres.

For wound inoculations, fruit were wounded on a single face using a finishing nail mounted in a cork so as to produce a wound approximately 3 mm deep by 2 mm in diameter. Wounds were inoculated by placing 100 spores of *P. expansum* (10 μl of spore suspension) into each wound with a micropipette. Stem inoculations were made by micropipetting 10 μl containing 500 spores of *P. expansum* onto the end of the stem of each non-wounded apple. Each treatment was replicated four times using 12 fruit per replicate. Ten non-inoculated fruit for post-storage quality assessments were also included in each replicate. Fruit of similar sizes were grouped within replicates to diminish the possibilities that fruit size might contribute to experimental error. Fruit were laid on spring cushion trays and stored in plywood boxes. 1-MCP (1 ppm) was applied using standard methods for small trials.

For Trial #2, Empire fruit were collected from nine different growers in western NY. The following six treatments were replicated four times in Storage A and five times in Storage B by using fruit from different orchards for each replication:

1. Stem-inoculation — no 1-MCP
2. Stem-inoculation + 1-MCP
3. Wound-inoculation — no 1-MCP
4. Wound-inoculation + 1-MCP
5. No inoculation — no 1-MCP
6. No inoculation + 1-MCP

For each orchard source, inoculation treatments were applied to bags containing 25 fruit. Wounded fruit were dipped into inoculum suspensions containing 10,000 conidia/ml of *P. expansum* whereas stem-inoculations were performed by dipping fruit into suspensions containing 50,000 conidia/ml. Inoculations were made on 8 October, and 1-MCP treatments were applied later the same day. All of the inoculated fruit, along with comparable non-inoculated fruit designated for post-storage quality assessments were held in CA storage. The room at Storage A was sealed 9 October, reached 5% O_2 on 12 October, was held at 36° F, 2% O_2 and 0.5% CO_2 until December, and then 1.7-2% O_2 and 1-2% CO_2 until the room was opened on 21 April. The room at Storage B was sealed 8 Oct. and was held at 34° F and 2% O_2. CO_2 reached 1% by 23 October and 2% by 25 November, but CO_2 was not allowed to rise above 2% throughout the remainder of the storage period. Storage B was opened on 10 March and resealed on 13 March, and then re-opened on 1 April. Fruit in storage B were held at 34° F in air from 1 April until they were evaluated. Fruit from both storages were evaluated for decay on 21 April and again after 7 days at room temperature. Fruit firmness was evaluated at the end of the 7-day shelf-life test.

Results

In Trial 31, 1-MCP-treatment did not have any consistent effect on development of decay during storage. For wound-inoculated fruit held in cold air, more decay developed in 1-MCP-treated than in non-treated fruit, but the reverse was true for stem-inoculated fruit (Table 1). The higher incidence of deçay in non-treated fruit held in air until June was probably attributable the soft condition of these fruit (Table 2). 1-MCP-treatment had no effect on decay development in fruit stored under modified atmospheres except that 1-MCP-treated fruit held at 0% CO_2 had more decay three days after removal from CA than non-treated fruit.

For evaluations completed on 9 June, just 3 days after the CA storages were opened, stem-inoculated fruit that were treated with 1-MCP had a higher incidence of decay when stored at 0% or 1% CO_2 than when stored at 2.5% or 5% CO_2 (Table 1). The same trend was evident for the 9 June evaluations of fruit that had not received 1-MCP treatment and for the 1-MCP-treated fruit on 23 June.

The greatest effect of 1-MCP on fruit firmness was evident at the end of the shelf-life test. CO_2 concentration had a significant effect on firmness of untreated fruit when measured on 6 June, but the CO_2 levels had less effect on firmness of fruit that had been treated with 1-MCP (Table 2). Effects of CO_2 on firmness of non-treated fruit had disappeared by the end of the shelf-life test.

In Trial #2, fruit treated with 1-MCP were consistently firmer than non-treated fruit at the end of the experiment (Table 3). Firmness differences between treated and non-treated fruit ranged from a low of 1.2 lb to a high of 3.3 lb for the nine different orchard sources that were evaluated.

At Storage A, wound-inoculated fruit treated with 1-MCP developed significantly more decay than wounded non-treated fruit (96% vs. 64% infection), but 1-MCP treatment had no effect on decay development in wounded fruit at Storage B (94% decay with 1-MCP vs. 95% with no 1-MCP). Some of the decays in stem-inoculated fruit clearly resulted from invasion of *P. expansum* through the stems. However, other fruit had decays that developed from wounds created during harvesting or handling, and some fruit were so completely decayed that the origins of the decay could not be determined. 1-MCP had no effect on development of decay that originated at the stems, nor did it affect the total incidence of decay (Table 4). A low incidence of decay also developed in non-inoculated fruit as a result of inoculum that came either from the orchard or from other sources after harvest. 1-MCP did not have any significant effect on decay development in non-inoculated fruit (Table 4).

Conclusions:

1-MCP treatment resulted in a significant increase in decay in only two of 10 comparisons derived from the experiments conducted following harvest in 2002 (Figure 1). Both cases where 1-MCP-treatment caused significant increases in decay occurred with wound-inoculated fruit, but 1-MCP had no effect on decay in the two other comparisons that involved wound-inoculated fruit. The inconsistent effect of 1-MCP treatment on wound-inoculated fruit may be attributable to differences in time lags between inoculation and 1-MCP treatment or between inoculation and cooling of the fruit. The fact that 1-MCP had no effect on development of decay in 8 of the 10 comparisons suggests that in most cases 1-MCP will neither exacerbate decay problems nor contribute to decay control.

Data from Trial #2 suggest that holding fruit at 0% or 1% CO_2 for the entire duration of CA storage may have two undesirable effects. Fruit from these atmospheres softened faster and were more susceptible to decay than fruit held at 2.5% or 5% CO_2 (Figure 2). Therefore, caution is advised when using lower CO_2 concentrations than recommended for the variety. Other approaches may be needed to reduce the risk of CO_2 injury that may be associated with 1-MCP treatment.

Acknowledgements: The authors thank participating growers for providing the fruit samples used for Trial #2 and Lake Ridge Storage and Dobbins Storage for CA storage space needed for Trial #2. Thanks to Fritz Meyer, Keri VanCamp, and Jackie Nock for technical assistance.

Table 1. Percent fruit with blue mold decay as affected by 1-MCP treatment and storage atmosphere.

Storage atmosphere: 2% O_2 plus—	Wound-inoculated fruit evaluated 12 Dec 2002			Stem-inoculated fruit evaluated after CA+3 days 9 Jun			Stem inoculated fruit after CA+14 day shelf-life test: 23 June[1]		
	1-MCP		untreated	1-MCP		untreated	1-MCP		untreated
Air storage	96 a[2]	*[3]	77 a	0 a	*[3]	8 c	17 ab	*[3]	85 c
5% CO_2	98 a	—	98 b	0 a	—	0 a	8 ab	—	13 ab
2.5% CO_2	96 a	—	92 b	0 a	—	0 a	6 a	—	4 a
1% CO_2	92 a	—	92 b	10 b	—	6 bc	21 b	—	15 ab
0% CO_2	94 a	—	100 b	10 b	*	2 ab	21 ab	—	19 b

[1] After removal from CA storage, fruit were held for three days at 36° F and then for another 14 days at 70° F prior to the final evaluation.

[2] A two-way analysis (1-MCP treatment X 5 storage atmospheres) was used for statistical analysis of data from each observation date. Within columns, simple means followed by the same small letter are not significantly different ($P \le 0.05$). There was a significant interaction between 1-MCP treatment and storage atmosphere on all three observation dates.

[3] Asterisks indicate significant effect ($P \le 0.05$) of 1-MCP treatment for the indicated evaluation date and atmosphere. A dash indicates differences between 1-MCP-treated and non-treated fruit were not significant.

Table 2. Effects of 1-MCP treatment and storage atmosphere on Empire fruit firmness measured in pounds at three intervals after treatment.

Storage atmosphere: 2% O_2 plus—	12 Dec 2002 (mid-CA)			6 June 2003 (CA+1 day)			23 June (CA+ 14 d.@ 70° F)		
	with 1-MCP		un-treated	with 1-MCP		un-treated	with 1-MCP		un-treated
Air storage	17.2 a	*[3]	14.2 a	15.2 a	*[3]	8.3 a	14.5 a	*[3]	5.7 a
5% CO_2	17.8 b	*	17.2 b	16.4 bc	—	15.9 d	15.5 bc	*	13.2 b
2.5% CO_2	17.7 b	—	17.6 b	16.6 c	*	15.7 cd	16.2 c	*	13.4 b
1% CO_2	17.4 ab	—	17.6 b	16.1 b	*	15.3 bc	15.1 ab	*	12.9 b
0% CO_2	17.7 b	*	17.4 b	16.0 b	*	15.0 b	15.3 ab	*	13.0 b

[1] After removal from CA storage, fruit were held for three days at 36° F and then for another 14 days at 70° F prior to the final evaluation.

[2] A two-way analysis (1-MCP treatment X 5 storage atmospheres) was used for statistical analysis of data from each observation date. Within columns, simple means followed by the same small letter are not significantly different ($P \le 0.05$). There was a significant interaction between 1-MCP treatment and storage atmosphere on all three observation dates.

[3] Asterisks indicate significant effect ($P \le 0.05$) of 1-MCP treatment for the indicated evaluation date and atmosphere. A dash indicates differences between 1-MCP-treated and non-treated fruit were not significant.

Table 3. Effects of 1-MCP treatment on Empire fruit firmness measured in pounds on 28 April after the CA-stored fruit had been held at room temperature for 7 days.

Storage and Grower	1-MCP	untreated
Storage A		
Orchard #1	14.9	13.3
Orchard #2	13.6	12.4
Orchard #3	14.1	12.8
Orchard #4	14.9	13.3
1-MCP effect: Storage A	14.4 **[1]	13.0
Storage B		
Orchard #5	12.9	10.0
Orchard #6	12.3	10.4
Orchard #7	13.1	9.8
Orchard #8	12.9	10.2
Orchard #9	11.4	10.1
1-MCP effect: Storage B	12.3**[1]	10.1

[1] Asterisks indicate significant differences ($P \leq 0.05$) between 1-MCP-treated and non--treated fruit at this storage. Mean fruit firmness was higher at Storage A than at Storage B because the 7-day shelf-life test was initiated immediately after the CA room was opened at Storage A whereas the CA room at Storage B was opened on 1 April and fruit were held in cold air storage for 22 days before the shelf-life test was initiated.

Table 4. Effects of 1-MCP treatment on percent Empire fruit with decay on 28 April after the CA-stored fruit had been held at room temperature for 7 days.

	Inoculated fruit				Non-inoculated fruit:	
	Stem-end decay[1]		All decays[2]		all decays	
Storage and Grower	1-MCP	untreated	1-MCP	untreated	1-MCP	untreated
Storage A						
Orchard #1	0	8	24	32	0	0
Orchard #2	0	0	36	36	25	4
Orchard #3	12	20	72	48	4	4
Orchard #4	8	8	44	40	0	4
1-MCP effects: Storage A[3]	5	9	44	39	8	3
Storage B						
Orchard #5	24	12	40	60	0	20
Orchard #6	12	8	52	40	4	8
Orchard #7	4	12.	20	44	8	21
Orchard #8	0	0	16	12	0	3
Orchard #9	16	8	96	60	16	35
1-MCP effects: Storage B[3]	10	8	45	43	6	17

[1] Stem-end decays are decays that were clearly initiated through the stem.

[2] All decays include stem-end decays, decays initiated at wounds, and completely decay fruit for which the infection site could not be determined.

[3] 1-MCP-treatment did not have any significant effect ($P \leq 0.05$) on incidence of decay for any of the comparisons in fruit from this storage.

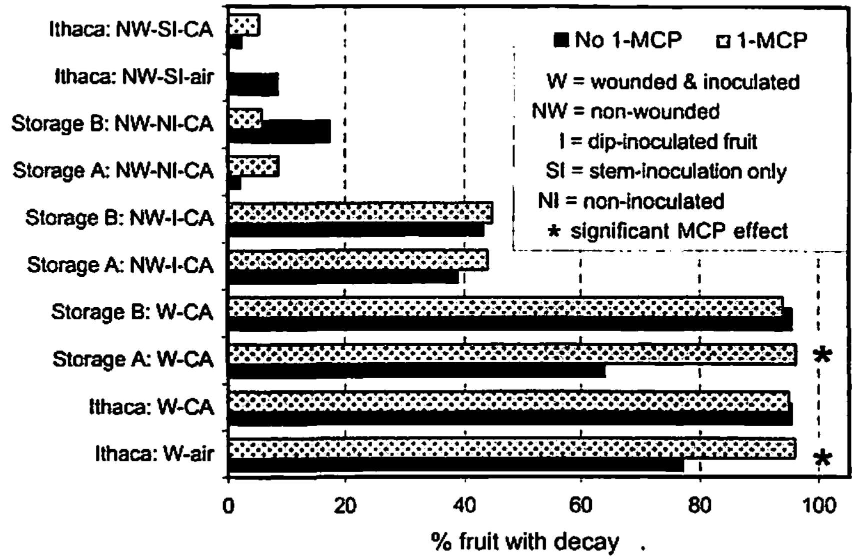

Figure 1. Ten comparisons showing effects of 1-MCP treatment on development of decay caused by *Penicillium expansum* in Empire apples harvested in 2002. Comparisons involved three different storages, wounded versus non-wounded fruit, inoculated versus non-inoculated fruit, and both air and controlled atmosphere (CA) storages. Statistically significant differences (P≤0.05) occurred in only two trials, both involving wound-inoculated fruit.

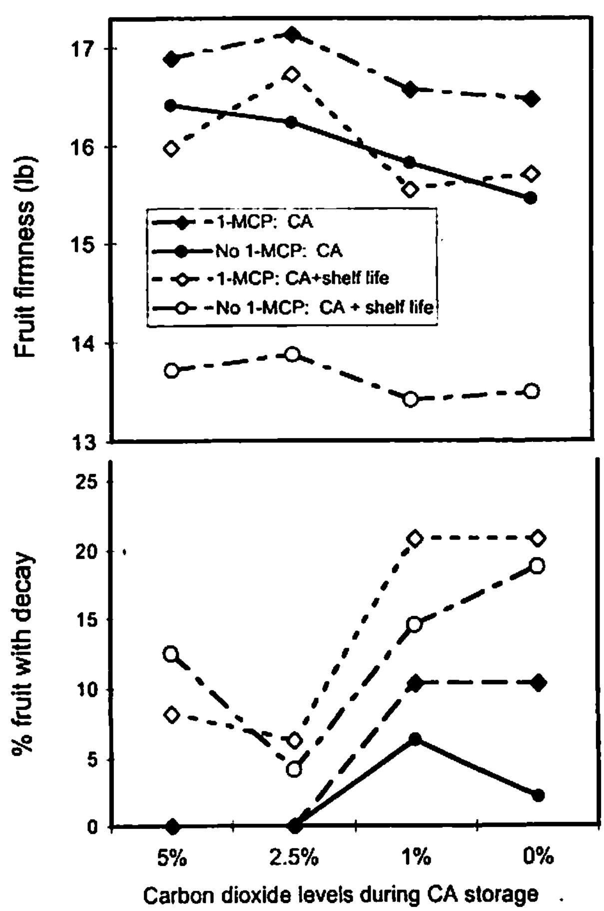

Figure 2. Effects of 1-MCP-treatment and CO_2 concentration on fruit firmness and on development of stem-end decay in inoculated Empire apples that were stored at 2% O_2 from 29 September until 6 June. Evaluations were made one day after removal from controlled-atmosphere and again after fruit had been held at 70° F for 15 days.

Characterization of Armillaria root rot pathogens from South Carolina and elsewhere

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Summary. In this study we verified that *A. tabescens* and *A. mellea* are the causal agents of oak root rot in South Carolina. Molecular analysis of DNA revealed genetic diversity in *A. tabescens* from South Carolina that was supported by cultural incompatibility. Our data will be useful for characterizing individuals of *Armillaria* and for distinguishing *Armillaria* species.

Introduction. The oak root rot disease is caused by members of the *Armillaria* fungi. Recent surveys have documented the presence of *Armillaria tabescens* and *A. mellea* in commercial orchards from South Carolina. The surveys used mushroom morphology for species identification but non-fruiting specimens were not included in the studies. *Armillaria* mushroom production is seasonal, can be somewhat erratic (Fox 2000) and some species may not produce mushrooms at all (Sierra and Henricot 2002), therefore it is possible that the surveys may not have reflected all *Armillaria* species causing oak root rot in South Carolina. Knowledge about the species composition will provide information about survival and spread of the disease and will give clues for disease management.

The genetic background of the *Armillaria* fungi causing oak root rot in South Carolina is not known. That leaves several open questions such as (i) is the disease caused by the same fungus, are there genetic variants that may differ in virulence and pathogenicity and what is the host range of the pathogens.

Material and Methods. A total of 58 isolates were collected for this study. Forty-one isolates were obtained from bark or root tissue of dead or dying peach trees from commercial peach orchards in South Carolina and from various ornamental plants that were sent for diagnosis from South Carolina residents to the Clemson University's Plant Problem Clinic between 2001 and 2003 (Table 1). Isolates from peach trees were primarily from the two largest peach production areas in South Carolina, the 'Piedmont' and the 'Ridge' areas.

The fungi were cultured and integrated in a permanent culture collection maintained in Dr. Schnabel's laboratory. DNA was extracted and several molecular tests were performed.

Results and Discussion. Previous surveys identified *A. tabescens* and *A. mellea* as the primary causal agent of Armillaria root rot on peach in the southeastern United States (Rhoads 1954; Petersen 1960) based on mushroom occurrence at the base of diseased trees. In this study we verified the predominance of *A. tabescens* in South Carolina, a result consistent with a survey based on basidome occurrence in Georgia (Savage, Weinberger et al. 1953), and the absence of other species that may have been overlooked in the earlier surveys due to possible erratic or lacking formation of mushrooms during the time of collection.

Our study revealed diversity of the ITS1 region in *A. tabescens* from South Carolina (Table 2). Other data on the genetic diversity of *A. tabescens* is not available from North America but genetic diversity of IGS1 and ITS1 in *A. tabescens* from Italy has been documented previously (Sicoli, Fatehi et al. 2003). Heterozygosity (the presence of divergent copies of DNA) within the ITS1 region in *A. tabescens* from North America can explain some of the variability. Other explanations include somatic mutations and mitotic recombination. Diversity of the ITS regions was also described for isolates of *A. mellea* collected from different parts of North America, Asia and

Europe, but variability was also found among isolates within the same region (Coetzee, Wingfield et al. 2000).

Diploid-diploid pairings between isolates of different ITS1 genotypes verified the existence of different genets in South Carolina. Compatible interactions were observed between isolates of different ITS1 genotypes. For example, compatible interactions were found between isolate SC.MF-3.01 and isolates SC.LS.01, SC.BD-2.02, SC.L.02, and SC.GJ-2.02, representing ITS1 genotypes F, B, C, and Q, respectively. However, the latter four isolates were incompatible with each other indicating that these isolates from Oconee, Horry, Pickens, Cherokee and Spartanburg county, respectively, do not form a single genet.

A total of 24 ITS1 genotypes were identified in this *A. tabescens* collection, 17 of which were present in South Carolina (Figure 1). ITS1 genotypes A, C, D, and I were most commonly found in South Carolina and covered areas in the Piedmont as well as the Ridge indicating that these genotypes are widely distributed. Genotype A was also found in the Coastal Plains (Figure 1). It was not determined in this study whether individuals of identical ITS1 genotypes from different locations belong to the same genet. ITS1 genotypes A, C, and D were found in *Prunus persica* and other woody plants, including *Ilex cornuta, Juniperis squamata, J. virginiana, Liquidambar stryaciaflua,* and *P. domestica* suggesting that these genotypes have a wide host range. Other isolates from single hosts had unique ITS1 genotypes such as F, Q, and E. The host specificity of these ITS1 genotypes was not determine.

Figure 1. Distribution of ITS1 genotypes A to S from *Armillaria* isolates collected from South Carolina. Most isolates were obtained from dead or dying peach trees in counties with significant commercial peach production (counties are highlighted with grey). The commercial peach production areas, 'Piedmont', 'Ridge', and 'Coastal Plains' are indicated with ovals.

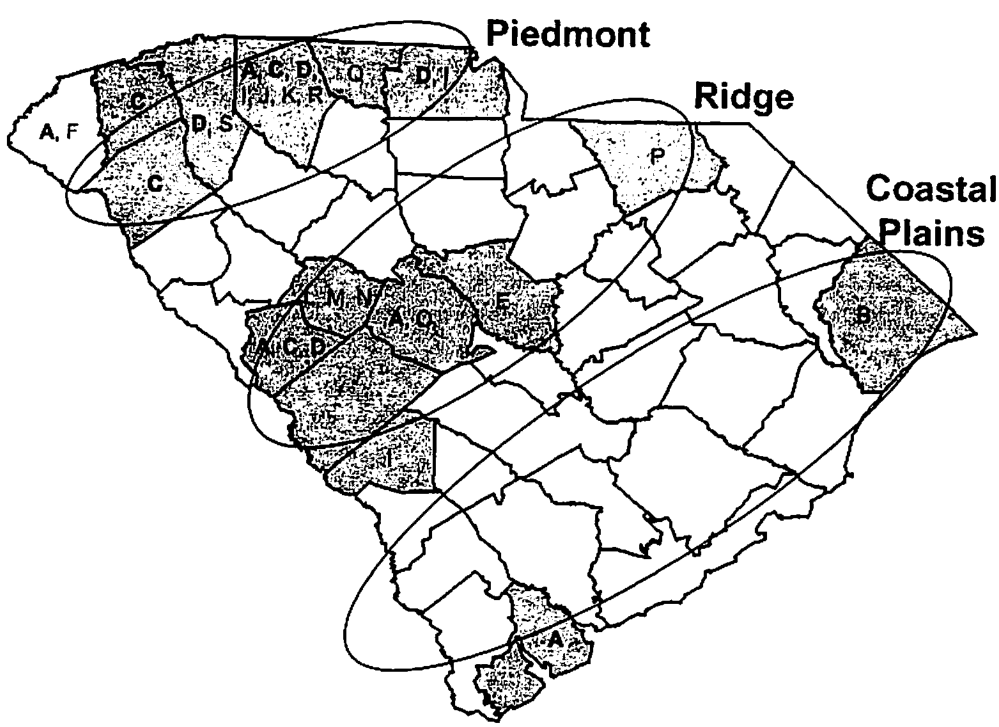

Table 1. Characteristics of *Armillaria tabescens* isolates from North America

Host	Isolate name	Source tissue[w]	Geographic origin: City	State	County	Year isolated	Source[x]
Ilex sp.	SC.BD.02	B	Clemson	SC	Pickens	2002	this study
I. cornuta	SC.GZ.02	H	Greenville	SC	Greenville	2003	this study
Juniperis squamata	SC.ME.02	H	Beaufort	SC	Beaufort	2002	this study
J. virginiana	VA.FP-71409-T	B	Arlington	VA	Arlington	1936	USDA
Liquidambar stryaciaflua	MS.Filer-1-R	H	Stoneville	MS	Tunica	1972	USDA
Malus sylvestris	GA.Apple[x]	n/a	Blue Ridge	GA	Fannin	1953	USDA
Prunus domestica	SC.BD-2.02	B	Clemson	SC	Pickens	2002	this study
	SC.MF-3.01	H	Seneca	SC	Oconee	n/a	this study
	SC.JBE.02	H	Trenton	SC	Edgefield	2002	this study
P. persica	SC.L.02	H	Cooley Springs	SC	Cherokee	2002	this study
	GA.00i210	B	Watkinsville	GA	Oconee	2000	UGA
	GA.00199	B	Byron	GA	Peach	n/a	UGA
	GA.B-8-1-R	H	n/a	GA	n/a	1965	USDA
	SC.MF-1.01	B	Seneca	SC	Oconee	2001	this study
	SC.JB.02	H	Filbert	SC	York	2002	this study
	SC.BS-1.02	H	Filbert	SC	York	2002	this study
	SC.EN.02	H	Gramling	SC	Spartanburg	2002	this study
	SC.BJ.02	H	Inman	SC	Spartanburg	2002	this study
	SC.MB.02	H	Spartanburg	SC	Spartanburg	2002	this study
	SC.MC.02	H	Fort Mill	SC	York	2002	this study
	SC.KC.02	H	Cowpens	SC	Spartanburg	2002	this study
	SC.FM.02	H	Chesnee	SC	Spartanburg	2002	this study
	SC.LH.02	H	Johnston	SC	Edgefield	2002	this study
	SC.LY-1.02	H	Johnston	SC	Edgefield	2002	this study
	SC.LY-2.02	H	Johnston	SC	Edgefield	2002	this study
	SC.CC.02	H	Ridge Springs	SC	Saluda	2002	this study
	SC.KH.02	H	Johnston	SC	Edgefield	2002	this study
	SC.JW.02	H	Monetta	SC	Saluda	2002	this study
	SC.TC.02	H	Monetta	SC	Saluda	2002	this study
	SC.JC-1.02	H	Chesnee	SC	Spartanburg	2002	this study
	SC.JC-2.02	H	Chesnee	SC	Spartanburg	2002	this study
	SC.JC-3.02[y,z]	H	Chesnee	SC	Spartanburg	2002	this study
	SC.PC.02	H	Kline	SC	Barnwell	2002	this study
	SC.MK-1.02	H	Lexington	SC	Lexington	2002	this study
	SC.MK-2.02	H	Lexington	SC	Lexington	2002	this study
	SC.KM-1.02	H	McBee	SC	Chesterfield	2002	this study
	SC.KM-2.02	H	McBee	SC	Chesterfield	2002	this study
	SC.LD-1.02	H	Greer	SC	Greenville	2002	this study
	SC.LD-2.02	H	Greer	SC	Greenville	2002	this study
	SC.GJ-1.02	H	Campobello	SC	Spartanburg	2002	this study
	SC.GJ-2.02	H	Campobello	SC	Spartanburg	2002	this study
	SC.JCA.02	H	Greer	SC	Greenville	2002	this study
	SC.EZ.02	B	Sandy Springs	SC	Anderson	2002	this study
Quercus sp.	VA.FP-59094-T	B	Clarendon	VA	Arlington	1934	USDA
	FL.TA-1(T-3)	SS	n/a	FL	n/a	1988	USDA
	LA.TJV-93-261-T	B	New Orleans	LA	Orleans	1993	USDA
	MD.OKM-3694-T	B	Laurel	MD	Prince Georges	1965	USDA
	SC.KO-1.01	B	Anderson	SC	Anderson	2001	this study
Q. nigra	FL.TA-1 55-2	SS	n/a	FL	Alachua	1988	USDA
	FL.TA-1 (T-1)	SS	n/a	FL	n/a	1988	USDA
	GA.FP-103448-T	B	Athens	GA	Clarke	1952	USDA
Raphiolepis indicus	SC.AR.02	H	Columbia	SC	Richland	2002	this study
Thuja occidentalis	SC.LS.01	H	Conway	SC	Horry	2001	this study
n/a	LA.MB-2081 55-5	SS	Baton Rouge	LA	Baton Rouge	1984	USDA
	IL.9-24-85-1 55-1[y]	SS	Carbondale	IL	Jackson	1985	USDA
	MD.Big-14740-T	B	Laurel	MD	Prince Georges	1966	USDA
	IL.9-24-85-2(T-1)	SS	Carbondale	IL	Jackson	1985	USDA

[w] Cultures were from host tissue (H), basidiome (B), or single spore (SS)

[x] Cultures were obtained from K. Tayler, University of Georgia, GA (UGA), the USDA Forest Product Laboratory, Madison, WI (USDA), or were collected by the authors for this study (this study)

[y] Sequence analysis of the ITS1 region revealed that these isolates were *A. mellea*

[z] Two ITS1 alleles were found in the PCR product amplified with primers ITS1-F and ITS2. The alleles were designated SC.JC-3.02-1 and SC.JC-3.02-2

Table 2. Variable nucleotide positions in the ribosomal ITS1 region of *Armillaria tabescens* isolates from the United States

ITS1-pattern	Isolate[y]	Nucleotide positions[z] 8	14	21	22	38	59	71	120	121	125	138	145	184	217	220
A	SC.MF-1.01, SC.BJ.02, SC.MK-1.02, VA.FP-59094-T, SC.LH.02, SC.ME.02	T	C	T	G	C	T	G	C	T	G	T	C	C	C	A
B	SC.LS.01	W	.	.	.	.	.	.	Y	.	R	.	.	.	.	.
C	SC.BD.02, SC.BD-2.02, SC.EZ.02, VA.FP-71409-T, SC.KC.02, SC.LY-1.02, SC.JBE.02, GA.B-8-1-R	C	.	.	.	.	.	.	T	.	.	.	.	.	.	.
D	SC.GZ.02, MS.Filer-1-R, SC.MC.02, SC.KH.02, SC.JC-1.02, SC.LD-1.02, SC.LD-2.02, SC.LY-2.02	Y	.	.	.	.	.	.	Y	.	.	.	.	.	.	.
E	SC.AR.02	C	.	.	.	.	.	.	T	.	.	.	.	S	.	.
F	SC.MF-3.01	Y	.	.	.	.	.	R	Y	.	.	.	.	.	.	.
G	MD.Big-14740-T	Y	.	.	.	.	.	.	Y	.	.	.	.	.	Y	.
H	GA.FP-103448-T	C	.	C	.	.	.	.	T	.	.	.	.	.	.	.
I	SC.JB.02, SC.PC.02, SC.EN.02	Y	.	.	.	Y	.	.	Y	.	.	.	.	.	.	.
J	SC.MB.02	C	.	.	.	.	.	.	T	.	R	.	.	.	.	.
K	SC.FM.02, SC.JC-2.02	Y	.	.	R	.	.	.	Y	.	.	.	.	.	.	.
L	SC.CC.02	Y	.	.	.	.	.	.	Y	.	.	.	.	.	.	R
M	SC.JW.02	Y	.	.	.	.	.	.	Y	.	R	.	.	.	.	.
N	SC.TC.02	M	.	.	.	.	.	.	T	.	R	.	.	.	.	.
O	SC.MK-2.02	C	.	.	.	.	.	.	T	.	A	.	.	.	.	.
P	SC.KM-1.02, SC.KM-2.02	C	.	.	R	.	.	.	T	.	.	.	.	.	.	.
Q	SC.L.02	Y	.	.	.	.	Y	.	Y	.	.	Y	.	.	.	.
R	SC.GJ-1.02, SC.GJ-2.02	C	.	.	.	.	.	.	T	.	.	.	Y	.	.	.
S	SC.JCA.02	C	.	.	.	.	.	.	T	.	.	.	T	.	.	.
T	MD.OKM-3694-T	C	.	.	.	.	.	.	T	Y	R	.	.	.	.	.
U	GA.OOi210	.	.	.	.	.	Y	.	.	.	.	.	.	.	.	.
V	LA.TJV-93-261-T	.	T	.	A	.	.	A	T	.	A	.	.	.	.	.
W	FL.TA-1 T-1	C	.	.	.	.	.	.	.	.	.	.	.	.	.	.
X	IL.9-24-85-2(T-1)	C	.	.	.	.	.	.	Y	.	.	.	.	.	.	.

[y]GA.Apple and SC.JC-3.02 were not included because ITS1 sequences revealed that they were *A. mellea* not *A. tabescens*. SC.KO-1.01 was not included because the ITS1 sequence revealed heterozygosity in the ITS1 resulting in double peak sequences. SC.BS-1.02, LA.MB-2081 55-5, and FL.TA-1 (T-3) were not included because no PCR fragments could be obtained.

[z]W=A&T, Y=C&T, R=A&G, S=C&G, M=A&C

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Fungicide efficacy trials for brown rot control and DMI fungicide resistance issues

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Summary. Our results indicate a shift towards reduced sensitivity has developed in some *M. fructicola* populations from Georgia, and isolates with reduced sensitivity to propiconazole may be more difficult to control in the field. Field testing of DMI fungicides, Captan, newly registered QoI fungicides and fenhexamid in experimental orchards indicated that the DMI fungicides are still among the most efficacious products for brown rot control and that new products containing QoI fungicides may be viable disease control alternatives or rotation partners. This research is necessary to develop and maintain new fungicide-based control strategies for effective peach disease control in the southeastern United States.

Introduction. Some growers in Georgia have experienced significant outbreaks of brown rot in recent years, despite preharvest applications of DMI fungicides such as Orbit, Indar or Elite. The reason for these outbreaks is not known. The outbreaks usually coincided with very moist, rainy weather during the peach ripening periods, which may indicate that materials were either washed off by rain during or after application or that the materials were not effective enough to prevent brown rot epidemics, possibly due to favorable weather for rapid disease development. It is possible that the recent outbreaks are connected with reduced sensitivity in *M. fructicola* to DMI fungicides.

In recent years, new products with modes of action different from DMI fungicides have been registered for brown rot control. The usefulness of these compounds for the southeastern United States is being explored in field tests (5,6). The objective of this study was to determine (i) if *M. fructicola* collected from commercial peach orchards in Georgia and South Carolina with prolonged exposure to DMI fungicides exhibit reduced sensitivity to propiconazole, (ii) if isolates with reduced sensitivity *in vitro* can be controlled effectively in peach assays with a DMI fungicide, and (iii) if fungicides newly registered for brown rot control could be useful in resistance management programs.

Material and Methods. Field trials at Musser Farm were conducted as described above. Lab experiments were conducted at Clemson University. Brown rot infected peaches were collected in 2000 from an abandoned orchard (Baseline DL) in Anderson county, SC, and between 2001 to 2003 from various commercial sites in SC and GA. The Baseline DL orchard had never been sprayed with DMI fungicides. Commercial peach orchards in South Carolina (CC02, EZ, SY, CC03, MC, and BS) and Georgia (DF, LO, JO, AP, and DL03) had been treated regularly with DMI fungicides during bloom and preharvest for 3 to 10 years. Sensitivity of the brown rot fungus *Monilinia fructicola* to DMI fungicide propiconazole (Orbit) was determined in poison agar tests. Sensitivity is indicated as EC_{50}, the concentration of propiconazole necessary to inhibit 50% of the mycelial growth. Experiments on peach fruit were conducted with full (0.3 liter/ha) and half (0.15 liter/ha) label rates of propiconazole (Orbit).

Results and Discussion. The mean EC_{50} values from two out of five *M. fructicola* populations collected from commercial orchards in Georgia were significantly higher than the baseline value (P = 0.05), indicating that the populations were less sensitive to propiconazole (Table 1). Isolates with high EC_{50} values were more difficult to control in infection studies on mature peaches than isolates with low EC_{50} values (Table 2). These results indicate that populations with reduced sensitivity to DMI fungicides *in vitro* may not be controlled as effectively in the field

The latest outbreaks of brown rot in Georgia (harvest seasons in 2001 and 2003) may have resulted from reduced sensitivity in *M. fructicola* populations, combined with favorable wet conditions for disease epidemics. Populations from South Carolina had lower EC_{50} values, which is consistent with observations that brown rot incidences in South Carolina are less frequent than in Georgia. The reason for this is not known. A preliminary survey of South Carolina and Georgia growers indicated that South Carolina growers use at least as many or even more applications of DMI fungicides for brown rot control.

With few exceptions, azoxystrobin (Abound) and the boscalid + pyraclostrobin (Pristine) product were as effective as the DMI fungicides, and these may be suitable rotation partners for DMI fungicides. Other studies have confirmed that the fungicidal activity of the boscalid + pyraclostrobin program against brown rot may be equal or even superior to DMI fungicides (1-4).

Table 1. Characteristics of *M. fructicola* isolates from South Carolina and Georgia and their sensitivity to propiconazole

Origin of isolates[x]			Year of	Isolate	EC_{50} values (ug/ml)	
Orchard	County	State	isolation	(no.)	Range	Mean[z]
DL	Anderson	SC	2001	33	0.012-0.054	0.025 a
CC02	Saluda	SC	2001	13	0.002-0.034	0.014 a
EZ	Anderson	SC	2001	9	0.003-0.014	0.01 a
SY	Edgefield	SC	2001	15	0.003-0.027	0.013 a
DF	Crawford	GA	2002	12	0.012-0.913	0.216 b
LO	Peach	GA	2002	11	0.019-0.217	0.081 a
JO	Hall	GA	2002	12	0.011-0.035	0.027 a
CC03	Saluda	SC	2003	21	0.001-0.074	0.036 a
AP	Macon	GA	2003	8	0.007-0.435	0.224 b
DL03	?	GA	2003	18	0.003-0.95	0.021 a
MC	York	SC	2003	14	0.015-0.175	0.047 a
BS	York	SC	2003	31	0.005-0.049	0.022 a

[x]isolates were obtained from established peach orchards (at least 7 years old) that either had not been exposed to DMI fungicides (DL isolates) or had been subjected regularly to two to five DMI fungicide applications for at least three years (CC02, EZ, SY, DF, LO, JO, CC03, AP, DL03, MC and BS isolates). Isolates from orchards with DMI history were collected from areas with brown rot incidence despite DMI fungicide treatments in the collection year.

[y]Kruskal-Wallis one way analysis of variance on ranks; all pairwise multiple comparison with Dunn's method ($P < 0.05$)

[z]One way Anova; FLSD ($P < 0.05$)

Table 2. Effect of propiconazole treatments on brown rot disease incidence on peach fruit.

		Disease incidence (%)[x]					
		Propiconazole (liters/ha), protective treatment			Propiconazole (liters/ha), curative treatment		
Isolate	EC_{50} value[y]	0	0.15	0.3	0	0.15	0.3
DL71	0.02	100.0	54.5 a	42.2 a	100.0	21.0 a	14.3 a
DL72	0.02	100.0	58.7 a	42.4 a	100.0	25.2 a	15.0 a
AP5	0.42	100.0	85.4 a	72.9 ab	100.0	60.4 b	32.7 ab
AP6	0.43	100.0	89.3 a	86.6 b	100.0	83.7 b	42.2 b

[x]lower case letters indicate significant differences within a column (P=0.05). The absence of letters indicates no significant differences among treatments. Values are means of three independent experiments.

[y]The EC_{50} values were determined in mycelial growth tests and represent means of three different experiments.

Table 3. Effect of fungicide programs on brown rot incidence on peach and nectarine fruit in 2001, 2002, and 2003

			Disease Incidence (%)[z]											
			2001				2002				2003			
			Redgold		Redskin		Redgold		Redskin		Redgold		Coronet	
Fungicide program	Fungicide formulation	Rate/ha	days of incubation after harvest											
			5	8	4	7	4	7	4	7	4	7	4	7
control	untreated	–	50.0 a	60.0 a	12.8 a	23.4 a	5.2 a	13.7 a	3.6 a	16.1a	95.3 a	98.4 a	88.0 a	93.7 a
Fenbuconazole	Indar 75WSP +	0.14 kg												
	Latron B1956	1.2 liters	1.4 c	1.4 c	1.0 ab	2.8 ab	2.6 a	8.3 a	1.5 a	15.6 a	8.3 c	11.9 c	5.2 ef	5.2 f
Propiconazole-1	Orbit 3.6EC	0.3 liters	2.4 c	2.8 c	1.0 ab	2.8 ab	1.0 a	4.2 a	2.6 a	7.8 a	15.1 c	27.1 c	5.2 ef	10.9 f
Propiconazole-2	Propimax EC	0.3 liters	-	-	-	-	3.1 a	10.4 a	0.5 a	8.8 a	9.4 c	14.1 c	1.6 f	3.6 f
Tebuconazole	Elite 45DF+	0.43 kg												
	Induce	0.06% V/V	-	-	-	-	-	-	-	-	-	-	7.3 def	7.8 ef
Azoxystrobin	Abound 2.08F	1.14 liters	8.0 bc	11.1 bc	0.7 ab	1.7 ab	6.3 a	15.1 a	0.5 a	8.8 a	12.5 c	26.6 c	20.3 cde	30.7 cd
Boscalid + pyraclostrobin-1	Pristine	0.74 kg a.i.	5.2 c	9.0 c	1.7 ab	3.0 ab	2.6 a	7.3 a	1.5 a	6.2 a	11.5 c	20.8 c	5.7 ef	13.5 ef
Boscalid + pyraclostrobin-2	Pristine	1.04 kg a.i.	5.6 c	8.3 c	0.0 b	1.0 b	2.1 a	9.9 a	0.5 a	14.1a	14.6 c	24.5 c	29.6 bc	34.4 bc
Fenhexamid	Elevate 50WDG	1.70 kg	17.3 b	21.9 b	0.0 b	0.3 b	3.7 a	8.3 a	2.1 a	6.8 a	42.6 b	57.8 b	17.7 cde	20.8 cde
Captan	Captan 50W	9.07 kg	10.5 bc	17.4 bc	0.7 ab	2.8 ab	2.6 a	5.7 a	3.1 a	6.8 a	52.6 b	67.7 b	44.8 b	46.3 b

[z] Values within columns for each year followed by the same letter are not significantly different according to Fisher's protected LSD ($P > 0.05$). Values are means of four replicates, each replicate consisted of 48 peaches.

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

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EVALUATION OF FUNGICIDE SCHEDULES AND MIXTURES FOR BROAD SPECTRUM DISEASE MANAGEMENT ON STAYMAN, IDARED, AND GINGER GOLD APPLES, 2003: Ten treatments involving registered fungicides and an experimental package mix of pyraclostrobin and boscalid (Pristine) were tested for season-long disease management on 17-yr-old trees. The test was conducted in a randomized block design with four three-cultivar replicate tree sets separated by untreated border rows. Treatment rows had been used as non-treated border rows in 2002 to stabilize mildew inoculum pressure for 2003. Tree-row-volume was determined to require a 400 gal/A dilute base for adequate coverage. Treatments were applied to both sides of the trees on each indicated application date with a Swanson Model DA-400 airblast sprayer at 100 gal/A as follows: 28 March (GT, green-tip; trts. #4, 5, & 6 only); 14 Apr (TC, tight cluster –open cluster, all treatments); 24 Apr (Bl, bloom, all treatments); 7 May (PF, petal fall, all treatments); 1st-7th covers, 1C-7C, 20 May, 5 June, 19 June, 2 July, 17 July, 31 July, and 26 Aug. Maintenance materials, applied separately to the entire test block with the same equipment, included Supracide + Oil, Lannate LV, NAA + Sevin XLR, Acramite, Provado, and Imidan 70WSB. Cedar rust galls, quince rust cankers, and bitter rot mummies were placed over each Idared test tree 21 Apr, and wild blackberry canes with the sooty blotch and flyspeck fungi were placed over each Idared test tree 18 June. Other diseases developed from inoculum naturally present in the test area. Foliar data represent averages of counts of all leaves on 10 terminal shoots from each of four replicates 28 June (Ginger Gold), 10 July (Stayman), or 22 July (Idared). Ginger Gold trees were harvested 25 Aug and rated 27 Aug; Stayman trees were sampled 16 Sep and Idared 17 Sep, and the 25-fruit samples were rated after storage at 1C 49 days (Idared), 58 days (Stayman). Percentage data were converted by the square root arcsin transformation for statistical analysis.

Weather was favorable for development of the major diseases in 2003, presenting a strong test for scab, mildew and summer diseases. Scab pressure was at it s highest in more than 20 years. Standard schedules involving SI + EBDC's, and alternating schedules of strobilurins and SI + EBDC's were generally effective for scab control under these conditions. Full season Pristine and alternating schedules of Pristine with SI + EBDC's gave excellent control considering the scab pressure. Rubigan + Dithane was significantly less effective for foliar scab control than Nova + Dithane on Stayman but these two treatments were equally effective for fruit scab control. Treatments # 7 and 8 which began the season with reduced rates of Penncozeb + sulfur were the weakest for control of scab on foliage and fruit, and Topsin M 70W initiated at first cover was less effective than Topsin M 4.5F. Cuprofix MZ + Microthiol Disperss applied from tight cluster to 2nd cover, was less effective for scab and mildew control than Nova + Polyram/ Sovran + Polyram, and resulted in the only significantly deleterious fruit russet effects compared to non-treated fruit. Nova gave good control of mildew, as expected; treatments involving Rubigan, alternating schedules with strobilurins, Pristine and sulfur/Topsin M were less effective on one or more cultivars. Cumulative wetting totals throughout 2003 were among the highest in ten years. All treatments except Penncozeb gave adequate control of Brooks spot. Nearly all non-treated fruit were infected with sooty blotch and fly speck. Under these rigorous test conditions, most treatments performed as expected, and Pristine gave excellent control. All treatments gave adequate control of potential rots.

Table 1. Control of scab, Brooks spot and rots on Stayman, Idared and Ginger Gold apples, Virginia Tech AREC, Winchester, 2003

			Scab, % leaves, leaf area, or fruit infected									%Brooks spot		% fruit rots	
			Stayman			Idared			Ginger Gold			Ida-	Ginger	Ginger	Stay-
	Treatment and rate/A	Timing	lvs	area	fruit	lvs	area	fruit	lvs	area	fruit	red	Gold	Gold	man
0	No fungicide	---	77 e	70 e	99 f	28 d	5 d	75 d	73 e	37 e	98 f	33 c	10 b	23 c	33 c
1	Nova 40W 5 oz + Dithane RSNT 75DF 3 lb Captan 50W 3 lb + Ziram 76DF 3 lb	TC –2C 3C–7C	4 a	1 a	3 a-c	1 a	<1 a	1 ab	6 ab	1 a	3 ab	2 ab	0 a	2 ab	0 a
2	Rubigan 9 fl oz + Dithane RSNT 75DF 3 lb Captan 50W 3 lb + Ziram 76DF 3 lb	TC –2C 3C–7C	16 b	3 ab	1 ab	<1 a	<1 a	2 ab	8 ab	1 a	0 a	5 ab	0 a	1 ab	0 a
3	Flint 50WG 2 oz Procure 50WS 10 oz + Dithane RSNT 3 lb Captan 50W 3 lb + Ziram 76DF 3 lb	TC, 1C P, Bl, PF, 2C 3C–7C	6 a	2 ab	1 ab	<1 a	<1 a	2 ab	7 ab	1 a	2 ab	3 ab	0 a	1 ab	0 a
4	Cuprofix Disperss 20DF 5 lb Sovran 50WG 3.2 oz + Polyram 80DF 3 lb Nova 40W 5 oz + Polyram 80DF 3 lb Captan 50W 3 lb + Ziram 76DF 3 lb	GT TC, Bl, 2-3C PF, 1C 4C–7C	7 a	2 ab	4 bc	<1 a	<1 a	2 ab	2 a	1 a	2 ab	6 ab	0 a	0 a	0 a
5	Cuprofix Disperss 20DF 10 lb Sovran 50WG 3.2 oz + Polyram 80DF 3 lb Nova 40W 5 oz + Polyram 80DF 3.0 lb Cuprofix Disperss 20DF 3 lb	GT TC, Bl, 2C PF, 1C 3C–7C	7 ab	2 ab	0 a	<1 a	<1 a	0 a	10 b	2 a	6 b	2 ab	0 a	1 ab	0 a
6	Cuprofix Disperss 20DF 10 lb Cuprofix MZ30 42DF 5 lb + Microthiol Disperss 80DF 3 lb Cuprofix Disperss 20DF 3 lb	GT TC-2C 3C–7C	40 c	7 bc	21 d	6 b	1 b	1 ab	30 c	6 b	21 c	0 a	0 a	2 ab	0 a
7	Penncozeb 75DF 3.2 lb + Microthiol Disperss 80DF 3 lb Topsin M 70W 10 oz	 TC-PF 1C-7C	58 d	31 d	47 e	18 c	4 cd	31 c	60 de	22 d	61 e	9 b	2 a	3 b	2 b
8	Penncozeb 75DF 3.2 lb + Microthiol Disperss 80DF 3 lb Topsin M 4.5F 12.4 fl oz	 TC-PF 1C-7C	43 c	13 c	49 e	14 c	3 c	29 c	47 d	14 c	41 d	6 b	0 a	0 a	0 a
9	Pristine 38WDG 14.5 oz	TC-7C	7 a	1 ab	8 c	<1 a	<1 a	4 b	4 ab	1 a	5 ab	0 a	0 a	0 a	0 a
10	Pristine 38WDG 14.5 oz Nova 40W 5 oz + Polyram 80DF 3.0 lb Captan 50W 3 lb + Ziram 76DF 3 lb Pristine 38WDG 14.5 oz	TC-Bl PF - 1C 2C, 4-5C 3C, 6-7C	5 a	1 a	4 bc	<1 a	<1 a	2 ab	8 ab	2 a	1 ab	3 ab	0 a	2 ab	0 a

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Counts based on ten terminal shoots from each of four single-tree reps 28 June (Ginger Gold), 10 July (Stayman), or 22 July (Idared).

Fungicide application dates: 28 March (GT, green-tip; trts. #4, 5, & 6 only); 14 Apr (TC, tight cluster –open cluster, all treatments); 24 Apr (Bl, bloom, all treatments); 7 May (PF, petal fall, all treatments); 1st-7th covers, 1C-7C, 20 May, 5 June, 19 June, 2 July, 17 July, 31 July, and 26 Aug.

Table 2. Mildew control on Stayman, Idared and Ginger Gold apples, Virginia Tech AREC, 2003

			Mildew, % leaves, % leaf area, or % fruit infected								Fruit russet*		
			Stayman		Idared			Ginger Gold					
	Treatment and rate/A	Timing	% lvs	area	% lvs	area	fruit	% lvs	area	fruit	Stay-man	Idared	Ginger Gold
0	No fungicide	---	66 d	64 d	69 e	62 d	56 d	73 c	83 d	98 f	2.3 e	2.0 d	1.9 de
1	Nova 40W 5 oz + Dithane RSNT 75DF 3 lb Captan 50W 3 lb + Ziram 76DF 3 lb	TC –2C 3C–7C	3 a	1 a	8 a	2 a	21 a-c	10 a	2 a	3 ab	1.4 ab	0.8 b	0.8 a
2	Rubigan 9 fl oz + Dithane RSNT 75DF 3 lb Captan 50W 3 lb + Ziram 76DF 3 lb	TC –2C 3C–7C	13 b	3 a	24 b	5 a	21 a-c	22 ab	5 a	0 a	1.6 bc	0.9 bc	1.2 a-c
3	Flint 50WG 2 oz Procure 50WS 10 oz + Dithane RSNT 3 lb Captan 50W 3 lb + Ziram 76DF 3 lb	TC, 1C P, Bl, PF, 2C 3C–7C	14 b	3 a	21 b	4 a	16 a-c	19 ab	3 a	2 ab	1.8 cd	0.8 b	1.0 ab
4	Cuprofix Disperss 20DF 5 lb Sovran 50WG 3.2 oz + Polyram 80DF 3 lb Nova 40W 5 oz + Polyram 80DF 3 lb Captan 50W 3 lb + Ziram 76DF 3 lb	GT TC, Bl, 2-3C PF, 1C 4C–7C	8 ab	2 a	13 a	2 a	13 a	10 a	2 a	2 ab	2.1 de	1.0 bc	1.1 ab
5	Cuprofix Disperss 20DF 10 lb Sovran 50WG 3.2 oz + Polyram 80DF 3 lb Nova 40W 5 oz + Polyram 80DF 3.0 lb Cuprofix Disperss 20DF 3 lb	GT TC, Bl, 2C PF, 1C 3C–7C	14 b	3 a	15 ab	3 a	10 ab	21 ab	4 a	6 b	1.8 b-d	1.9 d	1.6 cd
6	Cuprofix Disperss 20DF 10 lb Cuprofix MZ30 42DF 5 lb + Microthiol Disperss 80DF 3 lb Cuprofix Disperss 20DF 3 lb	GT TC-2C 3C–7C	38 c	8 b	50 d	19 b	**	58 c	22 b	21 c	4.2 f	4.3 e	2.4 e
7	Penncozeb 75DF 3.2 lb + Microthiol Disperss 80DF 3 lb Topsin M 70W 10 oz	TC-PF 1C-7C	49 c	22 c	55 d	33 c	38 cd	67 c	57 c	61 e	2.0 c-e	1.1 c	1.7 cd
8	Penncozeb 75DF 3.2 lb + Microthiol Disperss 80DF 3 lb Topsin M 4.5F 12.4 fl oz	TC-PF 1C-7C	42 c	15 bc	56 d	32 c	35 b-d	65 c	53 c	41 d	2.0 c-e	1.1 c	1.8 d
9	Pristine 38WDG 14.5 oz	TC-7C	15 b	3 a	36 c	11 b	28 a-d	22 b	4 a	5 ab	1.4 ab	0.9 bc	1.4 b-d
10	Pristine 38WDG 14.5 oz Nova 40W 5 oz + Polyram 80DF 3.0 lb Captan 50W 3 lb + Ziram 76DF 3 lb Pristine 38WDG 14.5 oz	TC-Bl PF - 1C 2C, 4-5C 3C, 6-7C	10 b	2 a	23 b	4 a	21 a-c	13 ab	2 a	1 ab	1.2 a	0.5 a	1.0 ab

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Foliar counts of four single-tree reps 28 June (Ginger Gold), 10 July (Stayman), or 22 July (Idared). Post-harvest counts of 25 fruit from each of four single-tree reps.
* Stem end russet presumed to be unrelated to powdery mildew infection rated on a scale of 0-5 (0=perfect finish; 5=severe russet).
** Severe copper russetting likely obscured any mildew infection.
Fungicide application dates: 28 March (GT, green-tip; trts. #4, 5, & 6 only); 14 Apr (TC, tight cluster –open cluster, all treatments); 24 Apr (Bl, bloom, all treatments); 7 May (PF, petal fall, all treatments); 1st-7th covers, 1C-7C, 20 May, 5 June, 19 June, 2 July, 17 July, 31 July, and 26 Aug.

Table 3. Evaluation of sooty blotch and fly speck control on Stayman, Idared and Ginger Gold apples, 2003.

			Sooty blotch, % fruit or % fruit area infected						Flyspeck, % fruit or fruit area infected					
			Stayman		Idared		Ginger Gold		Stayman		Idared		Ginger Gold	
	Treatment and rate/A	Timing	fruit	area	fruit	area	fruit	area	fruit	area	fruit	area	fruit	area
0	No fungicide	---	100 e	26 f	100 e	37 d	95 e	19 e	100 f	12 g	98 e	12 f	95 f	8 f
1	Nova 40W 5 oz + Dithane RSNT 75DF 3 lb Captan 50W 3 lb + Ziram 76DF 3 lb	TC –2C 3C–7C	46 a-c	4 b-d	48 bc	6 a-c	11 a-c	<1 a-c	39 de	2 de	34 bc	2 bc	9 b-d	<1 a-c
2	Rubigan 9 fl oz + Dithane RSNT 75DF 3 lb Captan 50W 3 lb + Ziram 76DF 3 lb	TC –2C 3C–7C	65 cd	6 de	66 b-d	7 bc	16 a-c	1 a-c	58 e	4 f	45 c	3 d	2 ab	<1 ab
3	Flint 50WG 2 oz Procure 50WS 10 oz + Dithane RSNT 3 lb Captan 50W 3 lb + Ziram 76DF 3 lb	TC, 1C P, Bl, PF, 2C 3C–7C	51 b-d	4 b-d	59 b-d	6 a-c	10 a-c	<1 a-c	44 de	3 d-f	47 c	3 cd	8 a-c	<1 bc
4	Cuprofix Disperss 20DF 5 lb Sovran 50WG 3.2 oz + Polyram 80DF 3 lb Nova 40W 5 oz + Polyram 80DF 3 lb Captan 50W 3 lb + Ziram 76DF 3 lb	GT TC, Bl, 2-3C PF, 1C 4C–7C	57 b-d	5 c-e	56 b-d	7 bc	14 bc	<1 bc	15 a-c	1 a-c	16 ab	1 ab	5 ab	<1 ab
5	Cuprofix Disperss 20DF 10 lb Sovran 50WG 3.2 oz + Polyram 80DF 3 lb Nova 40W 5 oz + Polyram 80DF 3.0 lb Cuprofix Disperss 20DF 3 lb	GT TC, Bl, 2C PF, 1C 3C–7C	56 b-d	5 c-e	67 cd	7 bc	20 c	1 c	47 de	3 d-f	76 d	6 e	19 cd	1 d
6	Cuprofix Disperss 20DF 10 lb Cuprofix MZ30 42DF 5 lb + Microthiol Disperss 80DF 3 lb Cuprofix Disperss 20DF 3 lb	GT TC-2C 3C–7C	76 d	8 e	80 d	11 c	59 d	8 d	49 c-e	4 ef	72 d	6 e	49 e	3 c
7	Penncozeb 75DF 3.2 lb + Microthiol Disperss 80DF 3 lb Topsin M 70W 10 oz	 TC-PF 1C-7C	52 b-d	6 c-e	66 cd	8 bc	23 c	2 c	34 cd	2 cd	29 bc	2 bc	20 d	<1 cd
8	Penncozeb 75DF 3.2 lb + Microthiol Disperss 80DF 3 lb Topsin M 4.5F 12.4 fl oz	 TC-PF 1C-7C	31 ab	3 a-c	55 b-d	5 a-c	8 a-c	<1 a-c	18 bc	1 bc	30 bc	2 cd	6 ab	<1 ab
9	Pristine 38WDG 14.5 oz	TC-7C	23 a	1 a	18 a	2 a	1 a	<1 a	6 a	<1 a	7 a	<1 a	1 a	<1 a
10	Pristine 38WDG 14.5 oz Nova 40W 5 oz + Polyram 80DF 3.0 lb Captan 50W 3 lb + Ziram 76DF 3 lb Pristine 38WDG 14.5 oz	TC-Bl PF - 1C 2C, 4-5C 3C, 6-7C	29 ab	2 ab	36 ab	3 ab	6 ab	<1 ab	9 ab	<1 ab	7 a	<1 a	2 ab	<1 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: 28 March (GT, green-tip; trts. #4, 5, & 6 only); 14 Apr (TC, tight cluster –open cluster, all treatments); 24 Apr (Bl, bloom, all treatments); 7 May (PF, petal fall, all treatments); 1st-7th covers, 1C-7C, 20 May, 5 June, 19 June, 2 July, 17 July, 31 July, and 26 Aug. Ginger Gold trees were sampled 25 Aug and fruit rated 27 Aug; Stayman trees were sampled 16 Sep and Idared 17 Sep, and rated after storage at 1C 49 days (Idared), 58 days (Stayman).

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
Fly speck; *Zygophiala jamaicensis*
Rots (unidentified)
Fruit finish

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EVALUATION OF DELAYED EARLY SEASON APPLICATION OF FUNGICIDES ON THREE APPLE CULTIVARS, 2003: An experimental fungicide (Pristine) and a recently registered copper formulation (Cuprofix) were tested for fungal disease and fruit finish effects on three apple cultivars. Nine treatments were evaluated on 14-yr-old, three-cultivar tree sets in a four-replicate randomized block design. The Rome trees used in the test had not been treated in 2002 to allow buildup of powdery mildew inoculum. Treatments were applied dilute to the point of runoff with a single nozzle handgun at 450 psi. The first application, Cuprofix on Trt.#1 only, at green tip on Red Delicious 28 Mar, was before any scab infection occurred. The second application involving all treatments was made on 14 Apr after scab infection periods had occurred 4-5 Apr and 7-9 Apr (Rome and Golden open cluster – pink; Red Delicious full pink). Later applications were as follows: 24 Apr (Rome bloom- petal fall; Red and Golden petal fall;); 7 May Rome petal fall); 1st to 7th covers (1C-7C): 20 May, 6 June, 23 June, 9 July, 24 July, 8 Aug, and 26 Aug. Maintenance sprays, applied separately with a commercial airblast sprayer, included Agri-Mycin 17 (bloom only), Supracide + Oil, NAA 10 ppm + Sevin XLR, Imidan 70 WSB Lannate LV, and Provado. Bitter rot mummies and wild blackberry canes with the sooty blotch and flyspeck fungi were placed over each Golden Delicious test tree 19 June. Other diseases developed from inoculum naturally present in the test area. Foliar counts were conducted on ten terminal shoots from each of four single-tree reps 7 July (Red Del.), 14 July (G. Del.) and 17 July (Rome). Golden Delicious fruit scab was rated by counting 25 fruit/tree on the tree, 25 Aug. Later fruit counts are means of 25-fruit samples picked from each of four single-tree reps 16 Sep (Red and Golden Delicious), or 29 Sep (Rome) and placed in cold storage at 1C. Red Delicious was rated after 50 days cold storage; Golden Delicious after 59 days cold storage and Rome after 44 days cold storage. Percentage data were converted by the square root arcsin transformation for statistical analysis.

Six timely primary infection periods in April and ten secondary periods in May, with cool weather continuing into early summer, resulted in the heaviest scab pressure in 27 years. Heavy scab infection occurred on leaves and fruit. Scab control by Trts 2 and 4 indicates that it is not deleterious to tank-mix of Cuprofix with Vangard. The green tip Cuprofix application (Trt. 1) did not improve scab control compared to a delayed start of Vangard (Trt. 4), suggesting that protective copper residue did not weather through the 1.9 in. rainfall that occurred with the infection period 7-9 Apr. Significantly more Red Delicious fruit infection on Trt. 3 than Trt. 4 indicates that Vangard was more active than Cuprofix when applied several days after infection. Strobilurins Sovran and Flint and the strobilurin containing package mix Pristine all gave excellent leaf and fruit scab control under these conditions, better than Nova or Rubigan. All treatments significantly reduced quince rust infection which appeared on 10% of non-treated fruit; Vangard + sulfur and copper-related treatments were less effective for control of cedar-apple rust. Nova gave the best control of mildew; Rubigan, Pristine, Flint, and Sovran were about equal and sulfur was significantly weaker. Throughout most of the post-bloom period, the cumulative wetting hour total was the highest in the past ten years. The 250-hr threshold for presence of the sooty blotch and flyspeck fungi on fruit was met in late May and sooty blotch and flyspeck were present by mid-August in this test block on fruit treated with captan + ziram on 2-wk schedules. Under this disease pressure the strobilurin materials performed well, with Pristine being significantly more effective on sooty blotch but somewhat less effective on flyspeck. Cuprofix was slightly less effective than captan + ziram for control of sooty blotch and flyspeck. Pristine, Flint, and Sovran all gave excellent control of Brooks spot infection which was not well controlled by Vangard, Nova or Rubigan. Under light pressure, all treatments gave adequate control of bitter rot on Rome but were more variable on unidentified rots on Golden Delicious. None of these treatments worsened fruit finish of any cultivar; several treatments reduced Golden Delicious russetting.

Table 4. Scab and rust control on Red Delicious, Golden Delicious and Rome Beauty apples, Va. Tech AREC, Winchester, 2003

	Treatment and rate/100 gal dilute		Scab, % leaves, leaf area, or fruit infected									Quince rust,%	C-apple rust % lvs inf.	
			Red Delicious			Golden Delicious			Rome					
			lvs	area	fruit	lvs	area	fruit	lvs	area	fruit	R. Del.	G. Del.	Rome
0	No fungicide	---	67 e	63 d	98 g	51 e	32 d	63 d	64 f	16 f	81 d	10 b	10 c	23 b
	Cuprofix Disperss 20DF 20 oz	½" G												
1	Vangard 75WG 1 oz+													
	Microthiol Disperss 80DF 1 lb ...	OC-7C	21 c	5 bc	35 de	29 d	5 c	12 c	18 c	2 b-d	29 bc	0 a	3 b	17 b
	Cuprofix Disperss 20DF 20 oz +													
	Vangard 75WG 1 oz +													
2	Microthiol Disperss 80DF 1 lb	OC												
	Vangard 75WG 1 oz +													
	Microthiol Disperss 80DF 1 lb ..	P-2C	20 c	4 b	25 cd	19 c	4 c	5 bc	26 cd	4 cd	41 bc	2 a	4 b	18 b
	Cuprofix Disperss 20DF 12 oz	3C-7C												
	Cuprofix Disperss 20DF 20 oz	OC												
3	Vangard 75WG 1 oz +													
	Microthiol Disperss 80DF 1 lb	P-7C	26 cd	5 bc	53 f	25 cd	5 c	14 c	30 d	4 cd	43 bc	0 a	4 b	22 b
4	Vangard 75WG 1 oz +													
	Microthiol Disperss 80DF 1 lb	OC-7C	25 cd	6 bc	36 de	18 c	4 c	9 bc	26 cd	3 cd	26 b	1 a	4 b	17 b
5	Nova 40W 1 oz	OC-2C	23 cd	4 bc	16 bc	17 c	3 bc	6 bc	32 d	5 d	29 bc	1 a	0 a	<1 a
	Captan 50W 1lb + Ziram 76DF 1 lb	3C-7C												
6	Rubigan 1E 2.25 fl oz	OC-2C	33 d	8 c	42 ef	23 cd	4 c	4 ab	47 e	11 e	46 c	0 a	0 a	1 a
	Captan 50W 1lb + Ziram 76DF 1 lb	3C-7C												
7	Pristine 38WDG 3.6 oz	OC-7C	5 b	1 a	8 ab	4 ab	1 ab	0 a	9 b	2 a-c	4 a	1 a	<1 a	1 a
8	Sovran 50WG 1 oz	OC-7C	2 ab	<1 a	3 a	5 b	1 ab	0 a	3 a	1 a	7 a	1 a	<1 a	2 a
9	Flint 50WG 0.5 oz	OC-7C	1 a	<1 a	2 a	1 a	<1 a	0 a	3 a	1 ab	1 a	0 a	<1 a	2 a

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Counts of ten terminal shoots from each of four single-tree reps 7 July (Red Del.), 14 July (G. Del.) and 17 July (Rome); fruit counts, Golden Delicious fruit scab rated on the tree, 25 fruit/tree 25 Aug.

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

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

Table 5. Mildew and cedar-apple rust control on Red Delicious, Golden Delicious and Rome Beauty apples, 2003

		Mildew, % leaves, leaf area, fruit or fruit area infected								
		Red Del.			G. Del.		Rome			
Treatment and rate/100 gal dilute		leaves	area	fruit	leaves	area	leaves	area	fruit	fruit area
0 No fungicide	---	34 g	7 f	19 a	39 d	9 e	48 c	23 d	43 e	8 f
1 Cuprofix Disperss 20DF 20 oz .... / Vangard 75WG 1 oz+ Microthiol Disperss 80DF 1 lb	½" G / OC-7C	14 ef	3 de	8 a	34 cd	6 d	43 c	8 bc	14 c	3 de
2 Cuprofix Disperss 20DF 20 oz + Vangard 75WG 1 oz + Microthiol Disperss 80DF 1 lb .... / Vangard 75WG 1 oz + Microthiol Disperss 80DF 1 lb ...... / Cuprofix Disperss 20DF 12 oz	OC / P-2C / 3C-7C	7 de	2 cd	8 a	31 cd	6 d	42 c	10 c	18 cd	3 e
3 Cuprofix Disperss 20DF 20 oz .... / Vangard 75WG 1 oz + Microthiol Disperss 80DF 1 lb	OC / P-7C	20 f	4 e	22 a	27 c	4 b-d	45 c	12 c	28 de	5 e
4 Vangard 75WG 1 oz + Microthiol Disperss 80DF 1 lb	OC-7C	19 f	3 de	17 a	31 cd	5 cd	42 c	10 c	13 c	3 e
5 Nova 40W 1 oz / Captan 50W 1lb + Ziram 76DF 1 lb	OC-2C / 3C-7C	5 cd	1 bc	12 a	8 a	1 a	7 a	2 a	1 ab	<1 ab
6 Rubigan 1E 2.25 fl oz / Captan 50W 1lb + Ziram 76DF 1 lb	OC-2C / 3C-7C	5 b-d	1 bc	6 a	16 b	3 a-c	17 b	3 ab	7 b	2 cd
7 Pristine 38WDG 3.6 oz	OC-7C	1 a	<1 a	5 a	15 b	2 ab	22 b	3 ab	0 a	0 a
8 Sovran 50WG 1 oz	OC-7C	1 ab	<1 ab	12 a	13 ab	2 ab	15 b	2 a	3 b	1 bc
9 Flint 50WG 0.5 oz	OC-7C	2 a-c	<1 ab	11 a	14 ab	3 a-c	18 b	3 ab	4 ab	1 a-c

Mean separation by Waller-Duncan K-ratio t-test (p=0.05).
Counts of ten terminal shoots from each of four single-tree reps 7 July (Red Del.), 14 July (Golden Del.) and 17 July (Rome).

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

Table 6. Control of sooty blotch and flyspeck on Red Delicious, Golden Delicious and Rome Beauty, 2003.

		Sooty blotch, % fruit and fruit area						Flyspeck, % fruit and fruit area					
		Red Delicious		Golden Del.		Rome		Red Delicious		Golden Del.		Rome	
Rate per 100 gal dilute		fruit	area	fruit	area	fruit	area	fruit	area	fruit	area	fruit	area
0 No fungicide	---	100 f	24 f	100 g	22 e	100 d	14 f	100 h	10 e	99 d	12 c	87 e	7 f
1 Cuprofix Disperss 20DF 20 oz	½" G												
Vangard 75WG 1 oz+													
Microthiol Disperss 80DF 1 lb....	OC-7C	71 de	7 de	80 ef	8 cd	82 c	8 de	72 e-g	6 cd	71 bc	5 b	42 bc	3 de
2 Cuprofix Disperss 20DF 20 oz +													
Vangard 75WG 1 oz +													
Microthiol Disperss 80DF 1 lb	OC												
Vangard 75WG 1 oz +													
Microthiol Disperss 80DF 1 lb ...	P-2C												
Cuprofix Disperss 20DF 12 oz	3C-7C	48 cd	4 cd	69 de	7 cd	58 bc	6 cd	64 ef	5 b-d	68 b	6 b	55 cd	5 d-f
3 Cuprofix Disperss 20DF 20 oz	OC												
Vangard 75WG 1 oz +													
Microthiol Disperss 80DF 1 lb	P-7C	82 e	8 e	88 f	9 d	97 d	12 ef	84 g	6 cd	73 bc	6 b	82 de	6 ef
4 Vangard 75WG 1 oz +													
Microthiol Disperss 80DF 1 lb	OC-7C	70 de	6 de	82 ef	9 cd	71 c	6 cd	76 fg	6 d	79 c	7 b	59 c-e	5 d-f
5 Nova 40W 1 oz	OC-2C												
Captan 50W 1lb + Ziram 76DF 1 lb	3C-7C	31 bc	2 bc	49 c	6 cd	14 a	<1 ab	38 cd	3 b	55 b	5 b	21 ab	1 bc
6 Rubigan 1E 2.25 fl oz	OC-2C												
Captan 50W 1lb + Ziram 76DF 1 lb	3C-7C	33 bc	2 bc	53 cd	5 bc	42 b	3 bc	53 de	4 bc	65 bc	5 b	40 bc	3 cd
7 Pristine 38WDG 3.6 oz	OC-7C	1 a	<1 a	10 a	1 a	8 a	<1 a	19 bc	<1 a	20 a	1 a	9 a	<1 ab
8 Sovran 50WG 1 oz	OC-7C	17 b	1 b	27 b	2 a	7 a	<1 a	9 ab	<1 a	12 a	1 a	2 a	<1 a
9 Flint 50WG 0.5 oz	OC-7C	17 b	1 b	31 b	2 ab	12 a	<1 a	6 a	<1 a	13 a	1 a	6 a	<1 ab

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

Counts of ten terminal shoots from each of four single-tree reps 7 July (Red Del.), 14 July (Golden Del.) and 17 July (Rome).

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

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

Table 7. Treatment effects on Brooks spot, rot incidence and fruit finish of Red Delicious, Golden Delicious and Rome.

		% fruit with Brooks spot		Rots (%)		Russet ratings or USDA grade *				Opalescence rating (0-5)	
						Ratings (0-5)			G. Del. %		
Rate per 100 gal dilute	Timing	G. Del	Rome	G. Del rots	Rome, bitter	R. Del.	Rome	G. Del.	fancy/x-fcy	R. Del.	Rome
0 No fungicide	---	22 b	3 ab	6 d	8 b	1.4 b	2.1 a	3.1 cd	42 de	1.2 a	1.9 a
1 Cuprofix Disperss 20DF 20 oz ..... Vangard 75WG 1 oz+ Microthiol Disperss 80DF 1 lb....	½" G OC-7C	20 b	5 ab	1 ab	2 a	1.3 b	1.5 a	2.4 ab	74 a-c	1.2 a	1.5 a
2 Cuprofix Disperss 20DF 20 oz + Vangard 75WG 1 oz + Microthiol Disperss 80DF 1 lb ...... Vangard 75WG 1 oz + Microthiol Disperss 80DF 1 lb ... Cuprofix Disperss 20DF 12 oz	 OC P-2C 3C-7C	15 b	7 b	4 b-d	1 a	1.1 ab	1.7 a	3.2 d	39 e	1.2 a	1.6 a
3 Cuprofix Disperss 20DF 20 oz ..... Vangard 75WG 1 oz + Microthiol Disperss 80DF 1 lb	OC P-7C	18 b	3 ab	2 a-c	1 a	1.4 b	2.0 a	2.8 b-d	58 c-e	1.1 a	1.7 a
4 Vangard 75WG 1 oz + Microthiol Disperss 80DF 1 lb	OC-7C	23 b	5 ab	6 cd	3 a	1.2 ab	1.4 a	2.6 b	70 a-c	1.2 a	1.4 a
5 Nova 40W 1 oz Captan 50W 1lb + Ziram 76DF 1 lb	OC-2C 3C-7C	17 b	7 b	3 a-d	0 a	1.2 ab	1.6 a	2.4 ab	64 b-d	1.0 a	1.5 a
6 Rubigan 1E 2.25 fl oz Captan 50W 1lb + Ziram 76DF 1 lb	OC-2C 3C-7C	17 b	0 a	1 ab	0 a	1.2 ab	1.6 a	2.6 bc	69 a-c	1.0 a	1.7 a
7 Pristine 38WDG 3.6 oz	OC-7C	0 a	0 a	0 a	0 a	0.9 a	1.5 a	2.0 a	84 a	0.9 a	1.3 a
8 Sovran 50WG 1 oz	OC-7C	1 a	0 a	0 a	0 a	1.1 ab	1.4 a	2.5 ab	69 a-c	1.3 a	1.6 a
9 Flint 50WG 0.5 oz	OC-7C	1 a	0 a	0 a	0 a	1.1 ab	1.7 a	2.4 ab	77 ab	1.3 a	1.6 a

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

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

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

* 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* 'Golden Delicious')
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*
Rot spots (unidentified)
Fruit russet

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CONCENTRATE APPLICATIONS OF EXPERIMENTAL FUNGICIDES ON GOLDEN DELICIOUS APPLE, 2003: Eleven treatments involving several experimental compounds, were compared on 31-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: 28 Mar (GT, green-tip, trt. #10 only); 4 Apr (TC, tight cluster; treatments applied in reverse order; shower 20 min. after last treatment applied); 14 Apr (P, pink; trts. #2-4 Dithane); 24 Apr (Bl, bloom-petal fall); 1st – 7th covers (1C-7C, 9 May, 27 May, 10 June, 24 June, 9 July, 24 July, 7 Aug and 28 Aug). Note: Although is listed as alternating with Captan, KP481 + Captan, was applied as both 6th and 7th covers in treatments #2, 3, & 4. Insecticides applied to the entire test block with the same equipment included Supracide, Lannate LV, Imidan 70WSB, Provado, and Sevin XLR. Cedar rust galls, quince rust cankers and bitter rot mummies were placed over each test tree 21 Apr, and wild blackberry canes with the sooty blotch and flyspeck fungi were placed over each test tree 18 June. Foliar data represent averages of counts of all leaves on 10 terminal shoots from each of four replicate trees 1 July. A 25-fruit sample from each replicate tree was harvested 15 Sep and rated after 35 days' storage at 1C.

Six timely primary infection periods in April and ten secondary periods in May, with cool weather continuing into early summer, resulted in the heaviest scab pressure in 27 years. Moderately heavy scab infection occurred on Golden Delicious leaves and fruit. V10116 gave excellent control of scab and mildew, equal to or better than the Nova + Dithane standard. Control of mildew by V10116 was significantly better at the higher rate and was also increased by the addition of Induce. The schedule involving Scala alternated with Flint also gave scab and mildew control equal to Nova +Dithane. Dithane alone at 3 lb/A and treatments involving KP481 + Dithane alternated with Dithane did not adequately control scab under these conditions; however, fruit scab was less severe than might have been anticipated for the amounts of foliar infection. JMS Stylet Oil and Cuprofix/Penncozeb + sulfur both gave significant but relatively weak control of scab and mildew. Under light pressure all treatments gave significant suppression of cedar-apple rust leaf infection. Under moderate pressure with infection likely occurring around 2nd cover, KP481 + Dithane and Flint/captan treatments gave excellent control while V10116 and JMS Stylet Oil were noticeably weaker. Throughout most of the post-bloom period, the cumulative wetting hour total was the highest in the past ten years. The 250-hr threshold for presence of the sooty blotch and flyspeck fungi on fruit was met in late May and sooty blotch and flyspeck were present by mid-August in this test block on fruit treated on 2-wk schedules. Under this disease pressure schedules involving KP481 + Dithane/captan and Captan (2C-4C)/Flint (5C7C) performed well for sooty blotch control; Captan / Flint was best for flyspeck. KP481 + Dithane/captan gave good suppression of rots which were moderately light and variable in this test block. Fruit russetting was significantly improved by V10116 at 6.1 fl oz per acre but worsened by adding Induce. Russet was increased by Trt. 10, likely due to copper in the third cover spray. No other treatments significantly increased the amount or severity of russetting and several improved it.

Table 8. Early season diseases and fruit finish after treatment with experimental fungicides, Golden Delicious apple, 2003.

	Treatment, rate/A, and timing	Scab infection (%)				Mildew %		C-A rust	% fruit USDA finish		Russet
		% lvs	lf. area	fruit	les	% lvs	area	% lvs	X-Fancy/Fcy	% utility	rating*
0	No fungicide	55 f	27 f	93 g	39 c	38 f	7 f	4 b	30 c	16 cd	3.4 cd
1	Nova 40W 5 oz + Dithane RSNT 75DF 3 lb; TC–2C Captan 50W 6 lb; 3C–7C	13 b	2 ab	5 a-d	<1 a	18 bc	2 b-d	<1 a	68 a	8 a-c	2.8 ab
2	KP481 50WG 8 oz + Dithane RSNT 75DF 2 lb // alternated with Dithane RSNT 75DF 3 lb; TC–2C KP481 50WG 8 oz +Captan 50W 3 lb; 4C, 6C, 7C Captan 50W 6 lb; 3C, 5C	30 c	5 bc	7 c-e	<1 a	27 de	3 c-e	0 a	63 a	6 a	2.8 ab
3	KP481 50WG 10 oz + Dithane RSNT 75DF 2 lb // alternated with Dithane RSNT 75DF 3 lb; TC–2C KP481 50WG 10 oz +Captan 50W 3 lb; 4C, 6C, 7C Captan 50W 6 lb; 3C, 5C	43 de	9 e	12 de	<1 a	35 ef	4 e	0 a	64 a	5 ab	3.0 a-c
4	KP481 50WG 8 oz + Dithane RSNT 75DF 3 lb // alternated with Dithane RSNT 75DF 3 lb; TC–2C KP481 50WG 8 oz +Captan 50W 3 lb; 4C, 6C, 7C Captan 50W 6 lb; 3C, 5C	48 ef	7 c-e	7 b-d	<1 a	37 f	4 e	0 a	54 ab	8 a-c	3.0 a-c
5	Dithane RSNT 75DF 3 lb; TC–2C Captan 50W 6 lb; 3C–7C	46 de	9 de	14 e	<1 a	38 f	5 ef	0 a	67 a	1 a	2.7 a
6	V10116 1.67SC 6.1 fl oz; TC–7C	9 b	2 ab	0 a	0 a	25 cd	3 b-e	0 a	56 ab	5 a-c	3.0 a-c
7	V10116 1.67SC 8.2 fl oz; TC–7C	3 a	1 a	2 ab	<1 a	13 b	2 b	<1 a	29 c	25 de	3.6 de
8	V10116 1.67SC 6.1 fl oz/A + Induce 12.8 fl oz/100 gal; TC–7C	3 a	1 a	3 ab	<1 a	4 a	1 a	0 a	12 d	38 ef	4.1 ef
9	Scala 60SC 4.5 fl oz; TC, pink Flint 50WG 2 oz; Bl, 1C Captan 50W 6 lb; 2C-4C Flint 50WG 2 oz; 5C–7C	14 b	2 ab	2 ab	<1 a	15 b	2 bc	0 a	52 ab	14 b-d	3.1 a-c
10	Cuprofix Disperss 20DF 5 lb; GT Penncozeb 75DF 3.0 lb + Microthiol Disperss 80DF 3 lb; TC–2C Cuprofix Disperss 20DF 3 lb; 3C–7C	33 c	4 b-d	3 a-c	<1 a	25 cd	3 b-e	0 a	4 d	45 f	4.3 f
11	JMS Stylet Oil 1 gal; TC–7C	37 cd	5 c-e	36 f	3 b	27 de	4 de	0 a	43 bc	15 b-d	3.2 b-d

Foliar counts of ten terminal shoots from each of four single-tree reps 1 Jul; on-tree fruit counts 25 Aug; finish ratings after harvest. Mean separation by Waller-Duncan K-ratio t-test (p=0.05).

Fungicide application dates:: 28 Mar (GT, green-tip, trt. #10 only); 4 Apr (TC, tight cluster); 14 Apr (P, pink; trts. #2-4 Dithane); 24 Apr (Bl, bloom- petal fall); 1st – 7th covers (1C-7C, 9 May, 27 May, 10 June, 24 June, 9 July, 24 July, 7 Aug and 28 Aug).

Table 9. Summer diseases on fruit treated with experimental fungicides, Golden Delicious apple, 2003.

	Treatment, rate/A, and timing	Fruit disease, % fruit or % area infected					
		Brooks spot, %	Sooty blotch		Flyspeck		Rot spots
			% fruit	% area	% fruit	% area	
0	No fungicide	20 d	100 g	28 d	100 f	8.3 g	21 c
1	Nova 40W 5 oz + Dithane RSNT 75DF 3 lb; TC–2C Captan 50W 6 lb; 3C–7C	11 bc	10 ab	0.6 a	36 cd	2.6 e	1 ab
2	KP481 50WG 8 oz + Dithane RSNT 75DF 2 lb // alternated with Dithane RSNT 75DF 3 lb; TC–2C KP481 50WG 8 oz +Captan 50W 3 lb; 4C, 6C, 7C Captan 50W 6 lb; 3C, 5C	0 a	7 ab	0.4 a	17 ab	1.2 ab	1 ab
3	KP481 50WG 10 oz + Dithane RSNT 75DF 2 lb // alternated with Dithane RSNT 75DF 3 lb; TC–2C KP481 50WG 10 oz +Captan 50W 3 lb; 4C, 6C, 7C Captan 50W 6 lb; 3C, 5C	0 a	8 ab	0.4 a	20 a-c	1.2 a-d	0 a
4	KP481 50WG 8 oz + Dithane RSNT 75DF 3 lb // alternated with Dithane RSNT 75DF 3 lb; TC–2C KP481 50WG 8 oz +Captan 50W 3 lb; 4C, 6C, 7C Captan 50W 6 lb; 3C, 5C	0 a	3 a	0.2 a	14 ab	0.8 ab	0 a
5	Dithane RSNT 75DF 3 lb; TC–2C Captan 50W 6 lb; 3C–7C	0 a	15 ab	1.2 a	19 a-c	1.1 a-c	2 ab
6	V10116 1.67SC 6.1 fl oz; TC–7C	13 b-d	62 d-f	6.7 c	42 d	2.5 de	3 ab
7	V10116 1.67SC 8.2 fl oz; TC–7C	11 b-d	53 c-e	5.1 bc	27 b-d	1.4 b-e	2 ab
8	V10116 1.67SC 6.1 fl oz/A + Induce 12.8 fl oz/100 gal; TC–7C	8 b	71 ef	6.8 c	38 d	2.1 c-e	1 ab
9	Scala 60SC 4.5 fl oz; TC, pink Flint 50WG 2 oz; Bl, 1C Captan 50W 6 lb; 2C-4C Flint 50WG 2 oz; 5C–7C	2 a	23 bc	1.4 ab	5 a	0.3 a	2 ab
10	Cuprofix Disperss 20DF 5 lb; GT Penncozeb 75DF 3.0 lb + Microthiol Disperss 80DF 3 lb; TC–2C Cuprofix Disperss 20DF 3 lb; 3C–7C	10 b	41 cd	7.9 c	68 e	5.6 f	6 b
11	JMS Stylet Oil 1 gal; TC–7C	19 cd	81 f	8.4 c	97 f	12.1 h	5 b

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Counts of 25-fruit samples harvested 15 Sep and stored at 1 C 35 days until rating 20 Oct.

Fungicide application dates:: 28 Mar (GT, green-tip, trt. #10 only); 4 Apr (TC, tight cluster); 14 Apr (P, pink); 24 Apr (Bl, bloom- petal fall); 1st – 7th covers (1C-7C, 9 May, 27 May, 10 June, 24 June, 9 July, 24 July, 7 Aug and 28 Aug).

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

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FIREBLIGHT BLOOM TREATMENTS ON GOLDEN DELICIOUS AND ROME BEAUTY APPLES, 2003

A blossom blight control test with experimental materials was conducted on pairs of adjacent 31 yr-old trees of each cultivar in four randomized blocks. Dilute treatments were applied to the point of runoff with a single nozzle handgun at 400 psi. Treatments were applied dilute to run-off to both Golden Delicious and Rome on the morning 10 Apr (tight cluster, Brotomax only), 14 Apr (open cluster-pink, Brotomax only), 16 Apr (all treatments; full bloom, Golden; early bloom, Rome), 22 Apr (full bloom, all treatments); 28 Apr, all treatments, (late bloom on Rome). Four selected branches per tree with 30-50 blossom clusters were inoculated by spraying to wet with a bacterial suspension containing$1X10^6$ E. amylovora cells/ml, in the evening of 16 Apr (Golden & Rome) and 28 Apr (Rome only). Infection was assessed by counting number of clusters infected per total clusters on inoculated branches. Golden Delicious was rated 7-9 May '03. A cluster was rated as infected if it had at least one blossom showing fire blight symptoms. Development of infection symptoms from the second inoculation of Rome were delayed by cool weather, so was Rome not rated until 20-21 May. Maintenance materials, applied throughout the season with a commercial airblast sprayer at 100 gal per acre, included Nova, Captan, Flint, Sovran, Topsin-M, Ziram, Supracide + oil Imidan 70WSB, Lannate LV, and Provado, Sevin XLR + Ethrel (as a thinning spray) and $CaCl_2$, Harvest ratings of fruit finish were based on a 25-fruit sample from each tree.

Cool weather followed the first inoculation 16 Apr and conditions were not again favorable for fireblight infection until the second inoculation of Rome 28 Apr. Generally, Golden Delicious had less infection than Rome but also had less statistical separation of treatment means. All treatments gave approximately 50% or greater control compared to non-treated Golden Delicious trees, but only the higher rate of the standard, streptomycin (Agri-Mycin 17 8 oz/ 100 gal), gave significant (p=0.05) suppression of blossom cluster infection. On Rome, Agri-Mycin 17 8 oz and 4 oz treatments were the most effective, but Serenade, QRD 141 and and Brotomax gave significant blossom blight suppression; only treatments involving GWN 9200 and GWN 9250 did not give significant suppression. The was no significant effect by any treatment on fruit finish of either Golden Delicious or Rome Beauty.

Table 10. Fireblight blossom treatments on Golden Delicious and Rome apples, 2003

	Treatment and rate/100 gal dilute	Application dates	% clusters with fire blight symptoms * Golden Del.	Rome
0	No treatment	---	20.5 b	24.7 ef
1	Agri-Mycin 17 8 oz + Regulaid 4 fl oz	16, 22,& 28 Apr	1.8 a	9.3 ab
2	Agri-Mycin 17 4 oz + Regulaid 4 fl oz	16, 22,& 28 Apr	5.4 ab	7.5 a
3	Agri-Mycin 17 4 oz + Regulaid 4 fl oz Serenade 10WPO 2 lb+ QRD 601 1 lb	16 Apr 22 & 28 Apr	7.5 ab	11.7 abc
4	Agri-Mycin 17 4 oz + Regulaid 4 fl oz QRD 141 10W 2 lb	16 Apr 22 & 28 Apr	6.3 ab	15.5 a-d
5	QRD 141 10W 2 lb	16, 22,& 28 Apr	8.4 ab	14.4 a-d
6	Brotomax 1.5 pt + Kinetic 4 fl oz Applied at TC, pink, & three during bloom	10, 14, 16, 22 & 28 Apr	5.7 ab	14.1 a-d
7	GWN 9200 10W 56.7 g + Regulaid 4 fl oz	16, 22,& 28 Apr	7.3 ab	23.0 def
8	GWN 9250 10W 18.9 g + Regulaid 4 fl oz	16, 22,& 28 Apr	10.3 ab	26.1 f
9	GWN 9250 10W 37.8 g + Regulaid 4 fl oz	16, 22,& 28 Apr	11.7 ab	21.4 def
10	GWN 9250 10W 56.7 g + Regulaid 4 fl oz	16, 22,& 28 Apr	10.3 ab	16.0 b-e
11	GWN 9250 10W 94.5 g + Regulaid 4 fl oz	16, 22,& 28 Apr	7.3 ab	18.5 c-f

Means of four replications; mean separation by Waller-Duncan K-ratio t-test (p=0.05).
* Infection assessed by counting number of clusters infected/total clusters on inoculated branches. Golden Delicious rated 7-9 May; Rome rated 20-21 May.

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, 2003: Several experimental fungicides were compared to registered programs for broad spectrum disease control on 11-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 2002 to allow the buildup of scab inoculum, and Redhaven peach, which were left untreated in 2003. 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 four replications. Applications were as follows: 26 Mar (BS, bud swell, treatments #1, 2, 3, 5, 6, & 12 only); 3 Apr (P, pink); 14 Apr (full bloom); 24 Apr (PF, petal fall); 30 Apr (SS, shuck split); 1st-5th covers, 1C-5C, 14 May, 28 May, 10 June, and 24 June, and 10 July; Pre-harvest sprays (3PH, 25 July and 1PH, 12 Aug) were aimed at 3 weeks and 1 week before Loring harvest. Treatments #1 and 7, which were not treated at 5th cover or 3 weeks and 1 week to harvest, received a 1-day preharvest application of Orbit 18 Aug (Loring) and 21 Aug (Redgold). Harvest dates were 19 Aug for Loring and 21 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, Lannate LV Provado, and Sevin XLR. Leaf curl incidence was rated on 25 shoots per tree 27 May. Because of unusually heavy disease pressure, brown was also counted on the tree (25 fruit/tree) 15 Aug Loring and Redgold and 19 Aug (Redgold). Samples of 20 apparently rot-free fruit per replicate tree were harvested 19 Aug Loring) and 21 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 25-30C (mean 27.3C) before assessing rot development at the indicated intervals.

Following a year without fungicides, leaf curl infected nearly all shoots on non-treated trees. Ziram Granuflo and Bravo Weather Stik applied at bud swell gave excellent leaf curl control (Table 1); Scala was ineffective when applied at bud swell. When the first application was delayed until pink, Ziram was significantly more effective than Bravo for leaf curl control. V10116 and Pristine gave more leaf curl suppression than Indar, which also gave significant suppression when first applied at pink, but were less effective than ziram or Bravo. Sulfur, first applied at pink did not suppress leaf curl. Pristine was relatively more effective for leaf curl control on nectarine than on peach.

Under strong test conditions with more than 90% of untreated Loring fruit infected with scab, several treatments applied in the shuck split to 2nd cover spray period gave excellent control including: Elite + Flint, Pristine, V10116 and USF2010. A bud swell application of Ziram significantly (Trt. #1) improved scab control with sulfur applied pink to 4th cover (Trt. #8). With more severe disease pressure on nectarine (30 and 18 scab lesions per non-treated nectarine and peach fruit, respectively), the higher rates of V10116 and Elite + Flint gave strong control. Scala gave only moderate scab suppression on peach and nectarine. Under moderate rusty spot pressure, Pristine, V10116, USF2010, and Indar all gave significant suppression.

With frequent wetting periods throughout the 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 incidence in the orchard was unusually high, postharvest inoculation was not necessary to produce a strong test (Tables 1 & 2). Pre harvest applications of Elite + Flint, Pristine, V10116, USF2010, and Indar all gave excellent brown rot control on the tree and after a two-day postharvest incubation. Pristine suppressed brown rot through 6 days incubation on peach and nectarine. Preharvest Scala applications gave no postharvest brown rot suppression. Several treatments with sulfur applications only through 4th cover and no preharvest application (Trts. 3, 4, & 8) significantly increased brown rot incidence compared to non-treated fruit.

Table 11. Control of leaf curl, scab, rusty spot and brown rot by experimental fungicides on Loring peach and Redgold nectarine, 2003

			Leaf curl, % shoots infected		Scab, % fruit inf. or lesions/fruit				Rusty spot, %	Brown rot (%), on tree		
					Loring		Redgold			Loring	Redgold	
	Treatment and rate/100 gal dilute	Timing	Loring	Redgold	fruit	lesions	fruit	lesions	Loring	15 Aug	15 Aug	19 Aug
0	No fungicide	—	100 g	100 f	90 f	18 c	100 f	30 d	6 b	20 d	54 e	84 d
1	Ziram Granuflo 76WDG 2 lb	BS	4 b	3 ab								
	Microfine Sulfur 90W 3 lb	P- 4C			14 cd	<1 a	--	--	3 ab	5 b	27 cd	55 c
	Orbit 3.6E 2 fl oz	*1 day PH only*										
2	Scala 60SC 9.0 fl oz	BS, SS-2C, 3 & 1PH	92 f	91 e	64 e	8 a	71 e	13 c				
	Microfine Sulfur 90W 3 lb	P-PF, 3C-5C							5 ab	7 bc	12 b	31 b
3	Bravo Weather Stik 6F 1 pt	BS - 1C	1 ab	1 ab								
	Microfine Sulfur 90W 3 lb	2C-4C			23 d	<1 a	--	--	8 b	8 bc	38 de	45 bc
	No preharvest	*No PH*										
4	Ziram Granuflo 76WDG 2 lb	P, SS-2C	4 ab	4 ab								
	Microfine Sulfur 90W 3 lb	Bl-PF, 3C-4C			10 a-d	1 a	50 de	3 ab	6 b	5 bc	18 bc	33 b
	No preharvest	*No PH*										
5	Ziram Granuflo 76WDG 2 lb	BS	3 ab	2 ab								
	Microfine Sulfur 90W 3 lb	P-PF, 3C-5C										
	Elite 45DF 1.45 oz + Flint 50WG 1.3 oz	SS-2C, 3 & 1PH			1 ab	<1 a	26 cd	2 ab	5 ab	0 a	2 a	1 a
6	Ziram Granuflo 76WDG 2 lb	BS	0 a	2 ab								
	Microfine Sulfur 90W 3 lb	P-PF, 3C-5C										
	Elite 45DF 1.74 oz + Flint 50WG 1.56 oz	SS-2C, 3 & 1PH			0 a	0 a	8 ab	<1 a	4 ab	0 a	0 a	0 a
7	Bravo Weather Stik 6F 1 pt	Pink	20 c	27 c								
	Microfine Sulfur 90W 3 lb	Bl - 4C			24 d	1 a	--	--	3 ab	9 c	27 cd	47 bc
	Orbit 3.6E 2 fl oz	*1 day PH only*										
8	Microfine Sulfur 90W 3 lb	P- 4C	97 fg	93 e	71 e	10 b	--	--	5 ab	19 d	36 d	49 bc
	No preharvest	*No PH*										
9	Pristine 38WDG 7.25 oz	Pink - PH	38 d	8 b	1 ab	<1 a	55 e	8 bc	1 ab	0 a	1 a	1 a
10	V10116 1.67SC 3.05 fl oz	Pink- PH	46 d	60 d	1 ab	<1 a	16 bc	<1 a	0 a	0 a	0 a	0 a
11	V10116 1.67SC 4.1 fl oz	Pink-PH	44 d	44 cd	11 a-d	<1 a	1 a	<1 a	0 a	0 a	0 a	0 a
12	Ziram Granuflo 76WDG 2 lb	BS	1 ab	4 ab								
	Microfine Sulfur 90W 3 lb	P-PF, 3C-5C										
	USF2010 500SC 2.5 fl oz	SS-2C, 3 & 1PH			0 a	0 a	16 bc	<1 a	0 a	0 a	1 a	4 a
13	Ziram Granuflo 76WDG 2 lb	BS	0 a	0 a								
	Microfine Sulfur 90W 3 lb	P-PF, 3C-5C										
	USF2010 500SC 3.0 fl oz	SS-2C, 3 & 1PH			4 a-c	<1 a	15 a-c	1 ab	0 a	1 a	2 a	4 a
14	Indar 75W 1 oz+ B-1956 4 fl oz	P-1C, 3 & 1PH	67 e	55 d					0 a	0 a	0 a	2 a
	Microfine Sulfur 90W 3 lb	2C-5C			11 b-d	2 a	62 e	5 ab				

Averages of four single tree reps. Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Leaf curl was rated 27 May; Pre-harvest brown rot counts, 25 fruit per tree. Harvest evaluations (Loring peach, 19 Aug; Redgold nectarine 21 Aug) for scab and rusty spot. Treatments dates: 18 Mar (BS, bud swell, treatments #1, 2, 3, 5, 6, & 12 only); 3 Apr (P, pink); 14 Apr (full bloom); 24 Apr (PF, petal fall); 30 Apr (SS, shuck split); 1st-5th covers, 1C-5C, 14 May, 28 May, 10 June, and 24 June, 10 July; Pre-harvest sprays (3PH, 25 July and 1PH, 12 Aug) were aimed at 3 weeks and 1 week before Loring harvest. Actual harvest dates: Loring- 19 Aug; Redgold-21 Aug. **Note**: Data are aligned with the treatment timing most likely to have affected brown rot. Italicized treatments were not timed for pre-harvest brown rot control.

Table 12. Treatment effects on preharvest and postharvest rot development on Loring peach and Redgold nectarine

			Loring, % of fruit with brown rot				Redgold, % of fruit with brown rot				
			on tree	% rot after days incubation			% rotted on tree		rot after days incubation		
	Treatment and rate/100 gal dilute	Timing	15 Aug	2 days	4 days	6 days	15 Aug	19 Aug	2 days	4 days	6 days
0	No fungicide	---	20 d	5 bc	60 fg	99 f	54 e	84 d	--	--	--
1	Ziram Granuflo 76WDG 2 lb Microfine Sulfur 90W 3 lb *Orbit 3.6E 2 fl oz*	BS P- 4C *1 day PH only*	5 b	6 bc	45 ef	88 e	27 cd	55 c	--	--	--
2	Scala 60SC 9.0 fl oz Microfine Sulfur 90W 3 lb	BS, SS-2C, 3 & 1PH P-PF, 3C-5C	7 bc	8 bc	68 gh	100 f	12 b	31 b	11 b	53 d	88 e
3	Bravo Weather Stik 6F 1 pt Microfine Sulfur 90W 3 lb *No preharvest*	BS - 1C 3C-4C *No PH*	8 bc	11 c	91 ij	100 f	38 de	45 bc	--	--	--
4	Ziram Granuflo 76WDG 2 lb Microfine Sulfur 90W 3 lb *No preharvest*	P, SS-2C BI-PF, 3C-4C *No PH*	5 bc	15 c	78 hi	99 f	18 bc	33 b	19 c	61 d	100 f
5	Ziram Granuflo 76WDG 2 lb Microfine Sulfur 90W 3 lb Elite 45DF 1.45 oz + Flint 50WG 1.3 oz	BS P-PF, 3C-5C SS-2C, 3 & 1PH	0 a	0 a	5 ab	45 c	2 a	1 a	0 a	3 a	39 cd
6	Ziram Granuflo 76WDG 2 lb Microfine Sulfur 90W 3 lb Elite 45DF 1.74 oz + Flint 50WG 1.56 oz	BS P-PF, 3C-5C SS-2C, 3 & 1PH	0 a	0 a	9 b	54 cd	0 a	0 a	0 a	5 a	28 c
7	Bravo Weather Stik 6F 1 pt Microfine Sulfur 90W 3 lb *Orbit 3.6E 2 fl oz*	Pink BI - 4C *1 day PH only*	9 c	3 ab	29 de	79 e	27 cd	47 bc	--	--	--
8	Microfine Sulfur 90W 3 lb *No preharvest*	P- 4C *No PH*	19 d	16 c	88 j	100 f	36 d	49 bc	--	--	--
9	Pristine 38WDG 7.25 oz	Pink - PH	0 a	0 a	0 a	3 a	1 a	1 a	0 a	0 a	4 a
10	V10116 1.67SC 3.05 fl oz	Pink- PH	0 a	0 a	0 a	19 b	0 a	0 a	0 a	0 a	11 ab
11	V10116 1.67SC 4.1 fl oz	Pink-PH	0 a	0 a	0 a	23 b	0 a	0 a	0 a	0 a	6 a
12	Ziram Granuflo 76WDG 2 lb Microfine Sulfur 90W 3 lb USF2010 500SC 2.5 fl oz	BS P-PF, 3C-5C SS-2C, 3 & 1PH	0 a	0 a	16 bc	58 d	1 a	4 a	0 a	5 ab	36 c
13	Ziram Granuflo 76WDG 2 lb Microfine Sulfur 90W 3 lb USF2010 500SC 3.0 fl oz	BS P-PF, 3C-5C SS-2C, 3 & 1PH	1 a	0 a	24 cd	61 d	2 a	4 a	0 a	16 c	61 d
14	Indar 75W 1 oz+ B-1956 4 fl oz Microfine Sulfur 90W 3 lb	P-1C, 3 & 1PH 2C-5C	0 a	0 a	1 a	59 d	0 a	2 a	0 a	3 ab	26 bc

Four single tree reps. Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Treatments dates: 26 Mar (BS, bud swell, treatments #1, 2, 3, 5, 6, & 12 only); 3 Apr (P, pink); 14 Apr (full bloom); 24 Apr (PF, petal fall); 30 Apr (SS, shuck split); 1st-5th covers, 1C-5C, 14 May, 28 May, 10 June, and 24 June, and 10 July; Pre-harvest sprays (3PH, 25 July and 1PH, 12 Aug) were aimed at 3 weeks and 1 week before Loring harvest. Actual harvest dates: Loring- 19 Aug; Redgold- 21 Aug.
Note: Data are aligned with the treatment timing most likely to have affected brown rot. Italicized treatments were not timed for pre-harvest brown rot control.