(FOR ADMINISTRATIVE USE ONLY)

Proceedings of the

CUMBERLAND-SHENANDOAH

FRUIT WORKERS CONFERENCE

78TH ANNUAL MEETING

December 5 and 6, 2002
Winchester Holiday Inn
Winchester, Virginia

Conference Chair
J. Christopher Bergh
Virginia Tech
Agricultural Research and Extension Center
Research Specialist in Tree Fruit Entomology

78TH CUMBERLAND-SHENANDOAH FRUIT WORKERS CONFERENCE
December 5-6, 2002
Winchester, VA

Thursday morning, December 5, 2002 (Apple Blossom I and II)

8:30 Registration

9:00 Welcome and Call of the States

General Session
Moderator – Chris Bergh
(Apple Blossom 1 and 11)

9:30 **The Pest Management Center concept: Structure and function of the Northeastern Center–**
John Ayers, Dept. of Plant Pathology, Penn State University, University Park, PA
The Southern Region Pest Management Center–
Russ Mizell and Norm Nesheim, University of Florida NFREC, Quincy, FL

10:15 Break

10:30 **Kitchen incubators: Opportunities for economic development –**
Julie Elmer, Rutgers NJAES Food Innovation Research and Extension Center, Bridgeton, NJ

11:15 **Fire blight management in the 21st century: Using new technologies that enhance host resistance –**
Jay Norelli, USDA-ARS, Appalachian Fruit Research Station, Kearneysville, WV

12:00 **The National Technology Roadmap For Tree Fruit Production–**
Dariusz (Darek) Swietlik, USDA-ARS, Appalachian Fruit Research Station, Kearneysville, WV

12:05 Buffet lunch (included in registration)

Thursday Afternoon, December 5, 2002

1:00 Breakout sessions for individual research disciplines
5:30 Social sponsored by DuPont and Syngenta (Ballroom)
7:30 Dinner (On your own)

Friday Morning, December 6, 2002

8:00 Continue breakout sessions

10:00 Break
10:30 Discipline Summary and Business Meeting
11:30 Adjourn

Breakout Session – Entomology
Thursday Afternoon, December 5, 2002
Moderator – Tracy Leskey
(Apple Blossom II)

1:00 **Host plant effects on the reproduction and population dynamics of Oriental fruit moth–**
Clayton Myers, Larry Hull, Penn State University, FREC, Biglerville, PA

1:20 **Has the worm turned? Internal Lepidoptera problems in apples in western New York in 2002–**
Harvey Reissig, Art Agnello, NYS Agric. Expt. Sta., Geneva, NY

1:40 **Examination of sublethal effects of methoxyfenozide on oriental fruit moth–**
Daniel Borchert, Jim Walgenbach, North Carolina State University, Raleigh, NC

2:00 **Control of internal Lepidopteran pests in Pennsylvania apples with non-OP/Carbamate insecticides–**
David Biddinger, Larry Hull, Greg Krawczyk, Penn State University, FREC, Biglerville, PA

2:20 **Multi-species pheromone disruption in orchards under a selective pesticide program–**
Art Agnello, Harvey Reissig, Jan Nyrop, Richard Straub, NYS Agric. Expt. Sta., Geneva, NY

2:40 **Comparing release technologies for pheromone-based mating disruption of codling moth and oriental fruit moth in Virginia – 2002–**
Doug Pfeiffer, Zhang Xing, Mary Rhoades, Virginia Tech, Blacksburg, VA; Chris Bergh, Jean Engelman, Brent Short, Virginia Tech, AREC, Winchester, VA; Kenner Love, Brad Jarvis, Virginia Cooperative Extension Service

3:00 Break

3:20 **Novel approaches for mating disruption of CM/OFM–**
Larry Hull, Nicolas Ellis, Penn State University, FREC, Biglerville, PA

3:40 **Oriental fruit moth mating disruption: what rate is too low?–**
Jim Walgenbach, Orkum Kovanci, North Carolina State University, Raleigh, NC

4:00 **New Jersey peach entomology results–**
Peter Shearer, Atanas Atanassov, Ann Rucker, Rutgers Cooperative Extension, Bridgeton, NJ

4:20 **Reduced risk arthropod management program in New Jersey peach orchards–**
Atanas Atanassov, Peter Shearer, Rutgers Cooperative Extension, Bridgeton, NJ

4:40 **Commercial use of reduced risk pesticides in New Jersey peach orchards–**
Dean Polk, Rutgers Cooperative Extension, Bridgeton, NJ

Breakout Session – Plant Pathology
Thursday Afternoon, December 5, 2002
Moderator – Keith Yoder
(Apple Blossom I)

1:00 **Summer disease management with new fungicides–**
Turner Sutton, Osama Anas, Jean Harrison, North Carolina State University, Raleigh, NC

1:20 **Evaluation of fungicides/bactericides for apple disease management–**
Jim Travis, Ken Hickey, Noemi Halbrendt, Penn State University, FREC, Biglerville, PA

1:40 **Evaluation of fungicides for control of peach scab and brown rot in the 2002 season–**
David Ritchie, North Carolina State University, Raleigh, NC

2:00 **Comparison of bacterial spot incidence and severity on peach from 1999-2002–**
David Ritchie, North Carolina State University, Raleigh, NC

2:20 **Peach rusty spot epidemics: Temporal analysis, optimizing management, and effect on fruit growth–**
Laura Furman, Norman Lalancette, James White, Rutgers University, Agricultural Research and Extension Center, Bridgeton, NJ and Dept. of Plant Biology and Pathology, New Brunswick, NJ

2:40 **2002 stone fruit fungicide and bactericide efficacy studies–**
Norman Lalancette, Kathleen Foster, Jody Veler, Rutgers University, Agricultural Research and Extension Center, Bridgeton, NJ

3:00 Break

3:20 **Rotation crops for control of nematodes pathogenic to tree and small fruit crops–**
James LaMondia, Connecticut Agricultural Experiment Station, Windsor, CT; John Halbrendt, Penn State University, FREC, Biglerville, PA

3:40 **Overwintering sites of *Colletotrichum acutatum* in highbush blueberry–**
Anne DeMarsay, Peter Oudemans, Rutgers University, Philip Jarucci Center for Blueberry and Cranberry Research and Extension, Chatsworth, NJ

4:00 **The hidden danger of fire blight: Apple trees with live cankers may harbor bacteria in symptomless shoots–**
Tom van der Zwet, USDA-ARS, Kearneysville, WV (retired); Steve Miller, USDA-ARS, Appalachian Fruit Research Station, Kearneysville, WV; Ken Hickey, Penn State University, FREC, Biglerville, PA

4:20 **The role of epiphytic bacteria in the shoot blight phase of fire blight–**
Jay Norelli, USDA-ARS, Appalachian Fruit Research Station, Kearneysville, WV

4:40 **Shoot blight management with Apogee in 2002: Experimental materials for blossom blight control–**
Keith Yoder, Virginia Tech, AHS-AREC, Winchester, VA; Jay Norelli, USDA-ARS, Appalachian Fruit Research Station, Kearneysville, WV; Alan Biggs, WVU, Kearneysville, WV

Breakout Session – Horticulture
Thursday Afternoon
Moderator – Steve Miller
(Apple blossom III)

1:00 **Food safety training in the tropics: Fruit production through a global lens–**
Chris Walsh, University of Maryland, College Park, MD

1:20 **Weed suppression in orchards with organic mulch–**
Thomas Tworkoski, USDA-ARS, Appalachian Fruit Research Station, Kearneysville, WV

1:40 **Nondestructive fruit texture assessment–**
Nate Reed, Penn State University, FREC, Biglerville, PA

2:00 **Managing fruit quality and flavor following 1-MCP treatment–**
Nate Reed, Penn State University, FREC, Biglerville, PA

2:20 **Light pattern in apple trees treated with Surround Crop–**
Michael Glenn, USDA-ARS, Appalachian Fruit Research Station, Kearneysville, WV

2:40 **Calcium, boron, and stink bugs: What is causing cork spot?–**
Mark Brown, USDA-ARS, Appalachian Fruit Research Station, Kearneysville, WV

4:00 **Apple and peach thinning results in 2002–**
Ross Byers, Virginia Tech, AHS-AREC, Winchester, VA

4:20 **Other PGR research: Apogee adjuvants, pre-harvest drop, return bloom in 2002–**
Ross Byers, Virginia Tech, AHS-AREC, Winchester, VA

4:40 Discussion

Breakout Session – Entomology
Friday Morning, December 6, 2002
Moderator – Tracy Leskey
(Apple Blossom II)

8:00 **Monitoring weather data and peach twig borer activity helps time sprays in southern Utah orchards–**
Rick Heflebower, Diane Alston, Extension Agent and IPM Coordinator, Utah State University, Logan UT

8:20 **Comparison of two trap types for stink bug monitoring in apples and peaches–**
Henry Hogmire, WVU, Kearneysville, WV; Tracy Leskey, USDA-ARS, Appalachian Fruit Research Station, Kearneysville, WV

8:40 **Refining the pheromone-based monitoring system for dogwood borer–**
Chris Bergh, Virginia Tech, AHS-AREC, Winchester, VA; Tracy Leskey, USDA-ARS, Appalachian Fruit Research Station, Kearneysville, WV

9:00 **Monitoring plum curculio in apple and peach orchards in the mid-Atlantic–**
Tracy Leskey, Starker Wright, USDA-ARS, Appalachian Fruit Research Station, Kearneysville, WV

9:20 **Are leafminers serious pests of apple?–**
Jan Nyrop, A. Lakso, K. Li, NYS Agric. Expt. Sta., Geneva, NY

9:40 **Phenology and management of the apple maggot in North Carolina–**
Raul Villanueva, Jim Walgenbach, North Carolina State University, Raleigh, NC

10:00 **Comparison of application technologies for apple maggot control–**
David Combs, Harvey Reissig, Andrew Landers and Wendell Roelofs, NYS Agric. Expt. Sta., Geneva, NY

Breakout Session – Plant Pathology
Friday morning, December 6, 2002
Moderator – Keith Yoder
(Apple Blossom I)

8:00 **Highlights of fungicide testing on apples and peaches, 2002–**
Keith Yoder, Virginia Tech, AHS-AREC, Winchester, VA

8:20 Discussion

Breakout Session – Horticulture
Friday Morning, December 6, 2002
Moderator – Ross Byers
(Apple Blossom III)

8:00 **Horticultural performance of apple cultivars in the NE-183 planting in West Virginia–**
Steve Miller, USDA-ARS, Appalachian Fruit Research Station, Kearneysville, WV

8:20 Discussion

IN THIS ISSUE

PLANT PATHOLOGY TITLE/AUTHOR(S) PAGE

HORTICULTURE TITLE/AUTHORS PAGE

2002 ATTENDEES

Arthur Agnello
NYSAES
Dept. of Entomology
Geneva, NY 14456
315-787-2341
ama4@nysaes.cornell.edu

Atanas Atanassov
Rutgers Ag. Res. & Ext. Center
121 Northville Rd.
Bridgeton, NY 08302
856-455-3100
atanassov@aesop.rutgers.edu

John Ayers
Penn State Dept. of Plant Pathology
211 Buckhout Lab
University Park, PA 16802
814-865-7776
jea@psu.edu

Silvia Bautista-Banos
USDA, ARS, AFRS
45 Wiltshire Rd.
Kearneysville, WV 25430
304-725-3451 Ext. 220
sbautis@afrs.ars.usda.gov

Robert Belding
Rutgers Ag. Res. & Ext. Center
121 Northville Rd.
Bridgeton, NJ 08302
856-455-3100
belding@aesop.rutgers.edu

Chris Bergh
Virginia Tech AHS, AREC
595 Laurel Grove Rd.
Winchester, VA 22602
540-869-2560
cbergh@vt.edu

David J. Biddinger
PSU Fruit Research & Extension Center
290 University Dr.
Biglerville, PA 17307
717-677-6116 Ext. 235
djb134@psu.edu

Deborah Breth
Cornell University
PO Box 150
Abion, NY
585-589-5561
dib1@cornell.edu

Mark Brown
USDA, ARS, AFRS
45 Wiltshire Rd.
Kearneysville, WV 25430
304-725-3451
mbrown@afrs.ars.usda.gov

Ross Byers
Virginia Tech AHS, AREC
595 Laurel Grove Rd.
Winchester, VA 22602
540-869-2560
rossebye@vt.edu

Juliet Carroll
NYS IPM Program
630 W. North St.
Geneva, NY 14456-0462
315-787-2430
jec3@cornell.edu

Neil Carter
Ontario Ministry of Ag. & Food
PO Box 8000, 4890 Victoria Ave. N
Vineland, ON L0R 2E0
905-562-3833
neil.carter@omaf.gov.on.ca

David Combs
NYSAES
Barton Lab
Geneva, NY 14456
315-787-2465
dcb10@cornell.edu

Rob Crassweller
Penn State Unicersity
102 Tyson Building
University Park, PA 16802
814-863-6163
rmc7@psu.edu

V. Larry Crim
USDA, ARS, AFRS
45 Wiltshire Rd.
Kearneysville, WV 25430
304-725-3451 Ext. 360
lcrim@afrs.ars.usda.gov

Anne DeMarsay
Rutgers Blueberry-Cranbery Res. Ctr.
125A Lake Oswego Rd.
Chatsworth, NY 08019
609-726-1590
demarsay@eden.rutgers.edu

Julie Elmer
Dean's Office
88 Lipman Drive
New Brunswick, NJ 08901
856-459-1125
elmer@aesop.rutgers.edu

Jean Engelman
Virginia Tech AHS, AREC
595 Laurel Grove Rd.
Winchester, VA 22602
540-869-2560
jengelma@vt.edu

Kathleen Foster
Rutgers Ag. Res. & Ext. Center
121 Northville Rd.
Bridgeton, NJ 08302
856-455-3100
kfoster01@mindspring.com

Jerry Frecon
County Government Services Building
1200 N. Delsea Drive
Clayton, NJ 08312
856-307-6450
frecon@rce.rutgers.edu

Michael Glenn
USDA, ARS, AFRS
45 Wiltshire Rd.
Kearneysville, WV 25430
304-775-3491 Ext. 321
mglenn@afrs.ars.usda.gov

George M. Green
Penn State University, FREC
PO Box 330
Biglerville, PA 17307
717-677-6116 Ext. 6
gmgb@psu.edu

John M. Halbrendt
Penn State University, FREC
PO Box 330
Biglerville, PA 17307
717-677-6116 Ext. 3
jmh23@psu.edu

Rick Heflebower
Utah State University
197 E. Tabernacle St.
St. George, Utah 84770
435-652-5815
rickh@ext.usu.edu

Wilbur Hershberger
USDA, ARS, AFRS
45 Wiltshire Rd.
Kearneysville, WV 25430
304-725-3451 Ext. 304
whersbe@afrs.ars.usda.gov

Kenneth D. Hickey
Penn State University, FREC
PO Box 330
Biglerville, PA 17307-0330
717-677-6116
kdh4@psu.edu

Erin Hitchner
Rutgers Agr. Res. & Ext. Center
121 Northville Rd.
Bridgestone, NJ 08302
856-455-3100
hitchner@aesop.rutgers.edu

Henry W. Hogmire
WVU KTRFEC
PO Box 609
Kearneysville, WV 25430-0609
304-876-6353
hhogmire@wvu.edu

Larry A. Hull
Penn State University, FREC
PO Box 330
Biglerville, PA 17307-0330
717-677-6116 Ext. 6
lah4@psu.edu

Norman Lalancette
Rutgers Ag. Res. & Ext. Center
121 Northville Rd.
Bridgeton, NJ 08302
856-455-3100 Ext.4124
lalancette@aesop.rutgers.edu

James LaMondia
CAES Valley Lab
153 Cook Hill Rd.
Windsor, CT 06095
860-683-4982
James.LaMondia@po.state.ct.us

Tracy Leskey
USDA, ARS, AFRS
45 Wiltshire Road
Kearneysville, WV 25430
304-725-3451- Ext. 329
tleskey@afrs.ars.usda.gov

Kara Lewallen
USDA, ARS, AFRS
45 Wiltshire Road
Kearneysville, WV 25430
304-725-3451
klewallen@afrs.ars.usda.gov

Roger Lewis
USDA, ARS, AFRS
45 Wiltshire Rd.
Kearneysville, WV 25430
304-725-3451 Ext. 303
rlewis@afrs.ars.usda.gov

Gail Lokaj
Rutgers Ag. Res. & Ext. Center
121 Northville Rd.
Bridgeton, NJ 08302
856-455-3100 Ext. 4138
lokaj@aesop.rutgers.edu

Stephen Miller
USDA, ARS, AFRS
45 Wiltshire Rd.
Kearneysville, WV 25430
304-725-3451
smiller@afrs.ars.usda.gov

Clayton Myers
Penn State University, FREC
30 Middle Road
Biglerville, PA 17307
717-677-6116
ctm134@psu.edu

Jay Norelli
USDA, ARS, AFRS
45 Wiltshire Rd.
Kearneysville, WV 25430
304-725-3451 Ext. 264
jnorelli@afrs.ars.usda.gov

Jan Nyrop
Cornell University
Entomology NYSAES
Geneva, NY 14456
315-787-2355
jpn2@cornell.edu

Dean Polk
Rutgers Fruit R & E Center
283 Route 539
Cream Ridge, NJ 08514
609-758-7311
polk@aesop.rutgers.edu

Nathan Reed
Penn State University
0229 Ag. Admin. Bldg.
University Park, PA 16802
717-677-6116
anr2@psu.edu

Harvey Reissig
Barton Laboratory
NYSAES
Geneva, NY 14456
315-787-2336
whrl1@nysaes.cornell.edu

E. Larry Rossell
Rutgers Ag. Res. & Ext. Center
121 Northville Rd.
Bridgestone, NJ 08302
856-455-3100
rossell@aesop.rutgers.edu

Dave Schmitt
County Government Services Building
1200 N. Delsea Drive
Clayton, NJ 08312
856-307-6450
SCHMITT@aesop.rutgers.edu

Peter W. Shearer
Rutgers Ag. Res. & Ext. Center
121 Northville Rd.
Bridgeton, NJ 08302
856-455-3100
shearer@aesop.rutgers.edu

Dariusz Swietlik
USDA, ARS, AFRS
45 Wiltshire Rd.
Kearneysville, WV 25430
304-725-3451 Ext. 326
dswietlik@afrs.ars.usda.gov

Bill Tietjen
Rutgers Cooperative Extension
165 County Rd. 595 South
Belvidere, NJ 07823
908-475-6505
tietjen@aesop.rutgers.edu

Carol Veale
Rutgers Ag. Res. & Ext. Center
121 Northville Rd.
Bridgestone, NJ 08302
856-455-3100

Raul Villanueva
MHCREC
455 Research Drive
Fletcher, NC 28732
828-684-3562
raul_villanueva@ncsu.edu

Jim Walgenbach
MHCREC
455 Research Dr.
Fletcher, NC 28732
828-684-3562
jim_walgenbach@ncsu.edu

Starker Wright
USDA, ARS, AFRS
45 Wiltshire Rd.
Kearneysville, WV 25430
304-725-3451 Ext. 211
swright@afrs.ars.usda.gov

Keith Yoder
Virginia Tech AHS, AREC
595 Laurel Grove Rd.
Winchester, VA 22602
540-869-2560
ksyoder@vt.edu

INDUSTRY REPRESENTATIVE 2002 ATTENDEES

Donald Ganske
Dupont
125 Cotton Ridge Rd.
Winchester, VA 22603
540-662-6022
donald.d.ganske@usa.dupont

Jeff Huether
Cerexagri
443 Turk Rd.
Walhalla, SC 29691
864-944-6672
jeff.huether@cerexagri.com

Brian Olson
Dow Agro Sciences LLD
PO Box 753
Geneva, NY 14456-0753
315-781-0140
bdolson@dowagro.com

Patti L. Schurr
Dow AgroSciences LLC
148 Quaker Hill Rd.
Magnolia, DE 19962
302-698-3635
plschurr@dowagro.com

Greg Stamm
CBC (AMERICA) Corp.
4 Owenwood Drive
Lincoln University, PA 19352
610-255-0836
gstamm@cbcamerica.com

Jim Steffel
LAB Services
342 South Third Street
Hamburg, PA 19526
610-562-5055
Jim@LABServices.com

78th Cumberland-Shenandoah Fruit Workers Conference
Program Highlights and Business Meeting

The 78th annual meeting of the Cumberland-Shenandoah Fruit Workers Conference was hosted by Virginia Tech and held at the Holiday Inn in Winchester, VA on December 5-6, 2002. There were 87 registered participants for the meeting and 43 submitted papers, including 4 General Session presentations, but a snow storm on December 5 reduced the number in attendance to 59 and the number of delivered presentations to 33. Registration was $50.00 and covered the costs of the Proceedings, breaks, and lunch on Thursday. Chris Bergh was general chair and secretary and Steve Miller served as treasurer. Chris Bergh organized and chaired the General and Entomology Sessions, Keith Yoder was the chair of the Plant Pathology Session and Ross Byers chaired the Horticulture Session.

The meeting began at 9:00 a.m. on Thursday. Chris Bergh thanked Peter Shearer for acting as general chair of the 2001 meeting and for organizing the 2001 Proceedings. This was followed by the "Call of the States", in which representatives provided a synopsis of the crop, weather conditions and pest and disease pressure for their respective states during the 2002 season. Members of the Cumberland-Shenandoah Fruit Workers Conference who had won awards during the previous year were recognized and congratulated. The 2002 General Session followed and included 4 invited speakers. Russ Mizell was unable to travel to Winchester to introduce the Southern Region Pest Management Center, but John Ayers spoke about the Pest Management Center concept and provided specifics about the Northeastern center. Julie Elmer gave a presentation on kitchen incubators and their role in economic development and the enhancement of agricultural business opportunities. Jay Norelli provided timely information on new technologies for managing fire blight based on host resistance. Following lunch on Thursday, the remaining presentations were delivered during concurrent sessions (Entomology, Plant Pathology and Horticulture) that spanned Friday morning. A Social on Thursday evening, sponsored by DuPont and Syngenta, provided an opportunity for the meeting participants to mingle over refreshments and was extremely well received.

The business meeting was called to order by Chris Bergh on Friday at 10:30 a.m. Summaries of the concurrent sessions were given by Chris Bergh, Keith Yoder and Steve Miller. A motion to extend the deadline for submission of reports for the 2002 Proceedings to January 10 was made by Steve Miller, seconded by Anne DeMarsay and carried. Steve Miller gave the treasurer's report. Total income in 2001/2002 from the carryover balance, registrations, interest, and sale of 2000 Proceedings was $5,159.13. Expenses attributed to the 2001 meeting, printing and postage costs for the 77th Proceedings, and materials amounted to $4,150.87. The CSFWC account balance prior to the 2002 meeting was $1,008.26, which included interest of $5.76. Receipts for registration received by Dec. 5 for the 2002 meeting were $3,550.00. Sale of past Proceedings represented income of $40.00. The CSFWC Account had a balance of $4,598.26 at the conclusion of the 78th meeting. Several late registrations were anticipated, but not available at the time of the treasurer's report. The treasurer updated information on facilities and printing costs beginning with the 1997 meeting through the 2001 meeting. Facilities costs in 2001 were $2,453.93. Publication costs for 2001 were $1,481.17. Chris Bergh expressed appreciation on behalf of the members to Steve Miller for continuing to act as treasurer.

Other business included a discussion about changing the meeting format to accommodate the interests of members from all disciplines. Peter Shearer moved to eliminate the Discipline Summary reports from the business meeting. The motion was seconded by Steve Miller and carried. Peter Shearer moved to modify meeting format as follows:

1. To limit the General Session to one speaker
2. To end the General Session at the morning break on Thursday
3. To begin breakout sessions after the morning break on Thursday
4. To hold the business meeting from 8-9 on Friday morning
5. To continue breakout sessions after the business meeting on Friday.

The motion was seconded by Henry Hogmire and carried by the CSFWC members.

The members of the CSFWC wish to express their appreciation to Syngenta and Dupont and their respective representatives, Rick Schmenk and Don Ganske, for their generous sponsorship of the Social on Thursday evening.

The 2003 meeting will be held on November 20-21 at the Holiday Inn in Winchester, VA.

Future Meetings and Host States:

2003 – Maryland/Delaware
2004 – North Carolina
2005 – USDA
2006 – Pennsylvania
2007 – West Virginia
2008 – New Jersey/South Carolina

Respectfully submitted,

J. Christopher Bergh, General Chair, Secretary

Stephen S. Miller, Treasurer

2002 CSFWC
NEW JERSEY STATE REPORT
Robert Belding

Redhaven peaches began blooming in southern New Jersey April 4th with full bloom occurring about April 9th. There were 3 frost events between bloom and shuck split with temperatures dropping to 17 degrees damaging low-lying orchards. Over all, the peach crop in New Jersey was down 25% from 75 million pounds to about 55 million.

Apple bloom was short (~4 days) and was marked with record high temperatures with highs ranging from 80 to 99 degrees. Red Delicious came into bloom about April 14th in southern New Jersey resulting in a light crop. In Northern New Jersey, snow was recorded on the 14th of May and there was crop loss in low orchards. Many wholesale apple operations have been pushed out while New Jersey added 8 to 10 new wine grape plantings.

San Jose and White Peach Scale exploded this season. 63% of peach growers in southern New Jersey received measurable levels of scale injury at harvest. Our top three insect problems on peach remain: catfacing, thrips, and tufted apple budmoth with scales moving into the 4th position. Fireblight was a major problem this spring. Infections occurred after bloom and were, for the most part, uncontrollable. Peaches prices were good this year but irrigation costs were up due to the drought. Water was a big issue and water certificates were difficult to get.

Weather. Temperatures during spring were mostly cool; only two brief warm periods occurred during mid-April and early June when average daily temperatures exceeded 70F. In contrast, summer temperature maximums exceeded 90F on 31 days, and average daily temperatures were greater than 80F on 26 days (16 more days than in 2001).

Rainfall occurred frequently throughout spring and early summer; 26 days had > 0.10 in rain accumulation during this period. However, 40-day drought began on 15 July, with little or no significant rain occurring until 24 August. Monthly rainfall accumulations (inches) were 3.36 (Apr), 3.86 (May), 5.83 (Jun), 2.08 (Jul), 2.91 (Aug), and 2.53 (Sep).

Plant Pathology

Blossom blight infection was light to non-existent in stone fruit blocks. At RAREC (Bridgeton), no blight was observed on non-sprayed trees. Sporulation on overwintering mummies was minimal. **Brown rot** infection pressure was light to moderate, depending on time of harvest in relation to the drought. Cultivars harvested from mid-July through mid-August experienced few rains, making disease control easier. Although rainfall occurred during ripening of late-season cultivars, rot incidence was lower than usual. **Peach Rusty Spot** incidence was very high, particularly on highly susceptible cultivars such as 'Jerseyqueen' and 'Autumnglo'. Disease levels on non-sprayed trees exceeded 90% fruit infection. **Bacterial Spot** infection on fruit was minimal, perhaps due to low temperatures during the susceptible period following shuck split. However, a significant amount of foliar infection occurred on susceptible cultivars prior to the drought. **Peach Scab** disease pressure was particularly severe as a result of the frequent spring rains. Non-sprayed fruit at RAREC had 100% incidence, with large areas of the fruit surface covered by scab. Disease control was difficult in orchards harboring many overwintering twig lesions. **Rhizopus rot** was only occasionally observed preharvest, and only on late-maturing cultivars. However, rot incidence was higher than usual in postharvest studies.

Information sources: Robert Belding, David Schmitt, Dean Polk, Jerry Frecon, Bill Tietjen, and *Norman Lalancette*

2002 CALL OF THE STATES REPORT - NEW YORK
Reporting: Art Agnello, NYS Agric. Expt. Sta., Geneva

Similarly to what we saw last year, this season's weather patterns seemed to exhibit a tendency to flirt with extreme conditions. Temperatures were hot-cold-hot, and precipitation was dry-wet-dry (with a few apparently annual devastating hailstorms thrown in), so the insect and mite activity this year seemed almost tame by comparison. Once again, early pest problems were relatively moderate overall, generally occurring and progressing about as expected, so that once the tumultuous spring-to-summer changeover was complete, things tended to settle down.

Unfortunately, we may be experiencing the beginnings of a major problem after a number of years without one. Despite a redoubling of efforts to maintain late season fruit protection, internal worm infestations showed up regularly in harvest inspections this year, particularly in the state's western counties. There were quite high trap catches of oriental fruit moth in western NY and of lesser appleworm in the eastern half, so this was not entirely unexpected. A few of the blocks surveyed had remarkably high damage levels, but more troubling was the large number of orchards that were affected just enough to cause a load or two to be rejected, something that happened to some growers this year for the first time in their long history of growing fruit.

The key pests initially offered few surprises. European red mite control seemed to be good during the early season, with some predictable outbreaks (plus a few of twospotted mites) provoked by the midsummer heat. Plum curculio probably entered the orchards quite early, perhaps during the mid-April heat wave, and then was generally undetectable for the next few weeks, but enjoyed another extended oviposition period amidst the intermittent showers and finished up about the middle of June, so a full protectant program of 2–3 sprays was needed in most orchards. Obliquebanded leafroller appeared on schedule, but generally responded well to treatment in orchards with reliably heavy populations. Once again, some growers may have been misled by an apparent absence of July larval populations that ended up turning into fruit damage later on.

The dry weather also had an effect on foliar feeders such as aphids, leafhoppers and leafminers, which were increasingly hard to find as the summer wore on. Apple maggot normally would have been expected to show a similar effect, but some startlingly high populations showed up in the eastern part of the state (Champlain Valley down to the Capital District and into the Hudson Valley). Of particular note this year was a troubling high incidence of woolly apple aphid throughout the state. Perhaps owing to the changing pesticide profile in apples, this pest is becoming more problematic each year, and there doesn't seem to be much in the toolbox that's capable of solving it.

In the category of running concerns that we hope don't become a crisis, dogwood borers continue to be in evidence as more growers turn their attention to potential infestation sites in dwarf and interstem plantings. This was another year that Comstock mealybug showed up in processing pears, after taking it easy for the last 2 or 3 years. San Jose scale was likewise an unpleasant late-season problem that has seemed to rebound in recent years, probably in response to the elimination of some key OP materials from the registered products list.

Pennsylvania State Report for CSFWC, 2002.

G. Krawczyk, R. Crassweller[1], N. Reed and L. A. Hull.
Penn State University
Fruit Research and Extension Center, Biglerville, PA
[1] Department of Horticulture, University Park, PA

Horticulture:
A week of very warm temperatures April 15 through18th pushed apple flower development. Full bloom came early. Full bloom on York in the Cashtown area of Adams County occurred on April 22. In central PA however, a cold front pushed through on Friday April 19th bringing much cooler temperatures and rain. The following Tuesday temperatures dropped to 29°F and over the next few days we had a series of low temperatures in the upper 20's to low 30's. The cold weather essentially stopped flower development outside of south central and eastern PA on apples and led to a prolonged bloom of 14 days on some cultivars. This delay posed a serious problem later in the season for application of chemical thinners due to the variable fruit size on the tree. Other frost events associated with this weather pattern occurred on 4/27 and 5/4.

The second serious frost pattern occurred the week of May 20 with 3 consecutive nights of temperatures in the mid-20's. Damage was extensive with several fruit cracking due to the cold. Unfortunately these "frost crevices" did not cause the fruit to drop and they persisted until harvest making the fruit essentially useless. Hard hit were Ginger Gold, and Fuji. Gala was not affected as much. Fruit that did remain on the tree tended to have a low seed count. Many growers in applying their thinners also noted that a lot of the fruit had few seeds. Defying conventional thought many of these low seeded fruit persisted to harvest. An examination of an old textbook (Modern Fruit Science by Gourley & Howlett, 1941) made reference that the authors had seen that after a severe frost event if any fruit does remain on the tree it may have very few seeds.

June was fairly wet, but the remainder of the season until September was very dry. A wet harvest lead to excessive fruit cracking especially in Gala. Leaves remained on the tree for a relatively long time until a sudden cold snap the end of October caused them to drop. In central & northern PA 5 inches of snow fell October 30 resulting in a heavy buildup of snow & ice on trees that caused some structural damage.

Even though it was very dry during the growing season apple fruit buds seem to look large and abundant for this time of year. 1-MCP was registered in July and used commercially from September to November. Data on exact amount of fruit treated is currently being gathered. Size of rooms and filling rate is an important consideration for future MCP use. (*Nate Reed & Rob Crassweller*)

Entomology:
From entomological perspective the 2002 season was quite normal for Pennsylvania fruit growers. In Biglerville the biofix for OFM was established on April 09, for CM on May 02, for TABM on May 07, and for OBLR on May 31,
For the fifth year in a row the **oriental fruit moth** was the most destructive pest in orchards. Over two hundreds loads were rejected due to the presence of this species in fruit delivered to our local processors. Our other internal fruit feeder **codling moth** surpassed tufted apple bud moth and was the second most commonly found species in rejected loads (110 loads) during the 2002 season. Adult moth insecticide's sensitivity bioassays revealed multiple fold resistance level in some populations of this pest. Often, the CM problem areas were located close to large bin piles, which may serve as a possible source of infestations. Also, for the first time a single fruit load was rejected due to the presence of **apple maggot** larvae in the fruit.

Hot and dry summer contributed to the above threshold **European red mite** populations observed in most grower' orchards. While biological control with predatory mites and *Stethorus*

beetle was observed in some locations late in the season, in most orchards summer acaricide applications were necessary.
The **obliquebanded leafroller** outbreaks were again observed in some isolated orchards, mostly when spray coverage was not adequate. The **tufted apple bud moth** fruit injuries were again at low to average levels when compared to previous years. Many orchards, including west part of the State (Pittsburgh area) experienced heavy infestation from **European apple sawfly**. Extended bloom time and late timing for petal fall insecticide applications can be in part responsible for this problem. (*Greg Krawczyk and Larry Hull*)

Virginia report for Call of the States

- Virginia's 2002 crops were about average in volume. Three frosts over a six-week period: April 7, May 4, and May 20-22 thinned fruit set and caused some russetting, frost rings and severely distorted fruit in some lower elevations, but with minimal damage at better orchard sites. Moisture was adequate throughout the growing season in the Winchester area but was limited farther south and east of the Blue Ridge. Hail occurred in some of the same orchards that were hit in 2001.
- Depressed processing and fresh apple prices and rising costs of production are causing a major concern for the fruit industry. Apple prices world wide are approximately 30% below 5 years ago and approximately what they were in 1985.
- Strong demand for land to support the housing sector is putting additional pressure on ideal fruit sites due to superior views and septic requirements.
- Fire blight was the most serious disease concern, the worst in more than 15 years. With hot weather and showers at the peak of bloom, the major fruit areas of Virginia had four to six infection periods during the week of April 15-20. Hail injury in mid to late May, as noted above, aggravated secondary blight spread to shoots in some Shenandoah Valley areas.
- Fruit rots and mummy carry-over are an ongoing disease problem.
- Generally, oriental fruit moth continues to be the main pest management concern. As in 2001, OFM was responsible for the great majority of rejected loads at Virginia processors.
- Codling moth problems are spotty but severe in some locations.
- *Campylomma verbasci*, the common mullein bug caused considerable damage in some locations in northern VA.
- European apple sawfly appeared to have increased in abundance and distribution in 2002.
- We continue to observe increasing problems with San Jose scale.

Virginia Tech's College of Agriculture and Life Sciences has been severely impacted by three rounds of budget cuts in 2002. Horticulturists Ross Byers and John Barden chose to take ASO's (Alternate Severance Options), which amount to early retirements. However, Dr. Byers intends to continue on a part-time basis as Scientist- in-Charge and maintain a research program. In major fruit counties, County Agricultural Extension agents Gary DeOms (Frederick county) and Lance Kauf (Clarke county) have also taken ASO's. So far, all reductions in State-funded personnel in the College have been voluntary. It is not yet known when vacated positions will be filled but some positions across the State will not likely be filled for several years, and maybe never in their previous capacity.

Call of States – West Virginia

Alan Biggs, Henry Hogmire, Steve Miller and Richard Zimmerman

Another mild winter and early spring resulted in early bloom. With one freeze event and several light frosts, the area fruit crops were down slightly from the five-year norm. The WV apple crop was estimated at 2.4 million boxes, nearly a 13% decline from the previous year. The peach crop was estimated at about 282,000 bushels, which was the same as 2001. Peaches seemed to escape the early freeze that affected sweet cherry and some apples. Peach production has declined about 13% over the past 5 years. The spring was cool, which was partially responsible for smaller fruit size. This made thinning a particularly challenging task and some apple blocks were over cropped. Moisture received in the first 8 months of the year was below normal, primarily due to a very dry January, February, and to some extent August. Moisture received in March, July, and September thru November brought the yearly total to near normal. The lack of moisture in August was also a contributing factor to the small fruit size. Fruit sugar levels were up in 2002, while red color was down slightly. The overall crop quality was good for apples and excellent for peaches. A severe hailstorm on May 26 with 30 minutes of pea to golf-ball sized hail affected several orchards in the eastern most county (Jefferson). The production at the WVU Tree Fruit Research and Education Center was totally destroyed by the storm. Acreage devoted to tree fruit crops continues to decline in West Virginia and the remaining orchards are turning more and more to local sales and diversified production. Prices for processing apples were poor, which only contributes to the transition of orchards into housing developments. There is increased interest in small fruit production and agri-tourism with new plantings of raspberries, grapes and plasticulture strawberries being established.

Biofix of moth pests was earlier than in 2001 by 3 days for oriental fruit moth and codling moth, and 6 days for tufted apple bud moth. Compared with last year, development of these pests as a function of degree days was about 3-7 days earlier through early July and 7-12 days earlier for the remainder of the season.

Mullein plant bug injury was seen this year for the first time in a few orchards during the latter part of May. Rosy apple aphids were more troublesome this year in a few orchards, continuing to increase on apple trees through most of June. Potato leafhopper populations were quite abundant, causing significant injury in some young orchards. Populations of European red mites predictably increased to above threshold levels with increasing temperatures in July, however, predators appeared to be more abundant than last year. Codling moth was more responsible for internal worm injury than oriental fruit moth this year, with some orchards near bin storage areas experiencing significant levels of fruit injury. Silvering injury, caused by western flower thrips, was prevalent in some peach orchards, especially on early season varieties.

On apples, fire blight was the disease that received the most discussion during the 2002 growing season; however, moderate levels of scab and cedar-apple rust were observed as well. The weather during the week beginning on April 14 helped set the scene for a series of interesting disease conditions that dominated the early part of the growing season. With many fruit varieties at the tight cluster to pink stage, daily high temperatures moved into the high 70's, 80's and 90's every day from the 14th through the 20th. Rain occurred on 13th, 14th and 15th, and again on the 19th, 20th, 21st, and 22nd. Conditions were favorable for apple scab and cedar-apple rust infections and were ideal for fire blight infection beginning on the 13th in locations with open blossoms. Blossom blight symptoms on non-sprayed Golden Delicious and York trees were observed on May 3. In unprotected blocks, we observed Gala with 50% of trees infected, Romes with 35%, Golden Delicious near 100%, Red Delicious at less than 5%, and Jonathan at about 40% of trees with infections. Similar blocks that were treated with streptomycin according to Maryblyt forecasts had little or no fire blight. Two trauma events occurred in May and included high winds on May 14 and severe hail on May 26. Both events led to increased fire blight in blocks where the disease was already present. Sooty blotch, flyspeck and rot diseases were well managed in most commercial orchards in West Virginia.

FOOD BUSINESS INCUBATORS- AN OPPORTUNITY FOR ECONOMIC DEVELOMENT

Julie Elmer
Food Innovation Research and Extension Center
87 E. Commerce St.
Bridgeton, NJ 08302

Business incubation is a dynamic process of business enterprise development. Incubators nurture young firms, helping them to survive and grow during the start-up period when they are most vulnerable. Incubators provide hands-on management assistance, access to financing and orchestrated exposure to critical business or technical support services (that may otherwise be unaffordable, inaccessible, or unknown to the entrepreneur.) [© National Business Incubation Association, 2002]

There have been major trends in industry that have contributed to this phenomena include industry restructuring, downsizing, and our economy evolving from a base of natural resources and industry to information and services. Technology creates choices and market niches, while the internet and e-commerce has made a whole new way to do business.

According to the US Small Business Administration, 47% of jobs generated are by companies of 20 or less. In 1980 there were 10-15 incubators in the US. This year there are 1,000 incubators in North America. Thirty are kitchen/food business incubators with an equal number in the planning stages. Results indicate that the return to local tax revenue on public investment in business incubation was greater than $16 for every $1 investment.(1997 Data) [© National Business Incubation Association, 2002]

Community Kitchens are more often implemented in rural settings where economies of scale are limited or the kitchen incubator model is not financially viable. These kitchens are small and do not have the staff or funding to develop business training and technical assistance services.

Food business incubations have the following key features: They provide rental of commercial kitchens, food manufacturing facilities and equipment on an hourly basis and rental of storage space (dry, refrigerated and frozen) to clients on a monthly basis. They have on site product development and technical assistance. They offer marketing assistance to gain access to niche food markets in addition to business development and finance information. There are a variety of structures, which include economic development initiatives by government, non-profit organizations, universities and colleges, for profit and collaborations.

The Food Innovation Research and Extension Center grew naturally out to an in-depth study in 1997 of the NJ food processing industry by Dr. Soji Adelaja, which identified obstacles to growth for people interested in entering the field. The mission of the center is to stimulate and support sustainable economic growth and prosperity to the agricultural and food industries in New Jersey by providing business development and technical services through research, education and outreach. The companies that are targeted include farmers desiring to create new businesses based on value-added agricultural products and/or developing new markets for their existing commodities; startup companies coping with challenges such as financing, technology, regulations, market development, and infrastructure requirements; and food companies seeking to access new technologies, upgrade quality assurance capabilities, enter new markets, and expand and improve their operations.

The Food Innovation Research & Extension Center has 6 central capabilities. These include business development, market development, product and process development, quality assurance and food safety, regulations and compliance, and workforce development and training. They have provided educational seminars, held a Food Business Incubation Summit, and developed a network of food entrepreneurs to accelerate the learning curve among industry startups.

The proposed food business incubator is based on feasibility study results and visits and discussions with other incubator facilities across the country. It will be a 32,000 sq.ft. shared-use processing facility. It will include a test kitchen and sensory evaluation center, analytical laboratory, training and education area and an administrative area. The processing section will have a cold and vegetable processing area, a hot processing area, a dry process and packaging area along with storage areas.

With a team of on-site specialists and linkage to the vast resources at Rutgers University, the Food Innovation Center offers its client companies a full array of services. The Center is built on public-private partnerships between higher education institutions, local governments and industry to address critical agricultural and food industry development issues. The Center is poised to be the catalyst that will promote a viable and prosperous food processing and agriculture base in New Jersey, translating into considerable economic development benefits for the region.

The Food Industry is projected to grow 1.6% per year and approach $800 billion by 2005. Food Service is expected to capture 100% of the $100 billion in incremental sales from 1995-2005. [McKinsey & Company, "Foodservice 2005"] Within the food industry, there has been steady growth in the last several years in both specialty and functional food categories. The National Association for the Specialty Food Trade defines gourmet and specialty foods as food, beverage or confections that are of the highest grade, style or quality in their category. Over the last decade, the specialty food market had benefited from growing consumer interest in high quality food products. By 2002, sales of gourmet or specialty foods are expected to exceed $54 billion. [MarketLooks] Currently, about 53% of all specialty foods are sold through supermarkets, with another 35% sold in gourmet and specialty food stores. Some of the product categories include baked goods, dressings, vinegars, oils, meats, dairy products, beverages such as herbal teas, specialty juices or nutritionally fortified drinks and Ethnic Foods. A growing new category growing is artisan foods. These are described as foods made by skilled and often hand crafted labor, which is usually not mass produced. Thus, cheese makers, bread bakers and beer brewers are artisans and now their products are in high food fashion.

Functional and nutritional foods are another growth area. In the United States, sales figures for functional foods in 1999, reached $14.2 billion, and projected sales for 2002 are expected to be $20 billion. [Sloan Report] This is a growing trend, fueled by an aging population, who are interested in maintaining health and vitality through diet, exercise and supplements. Functional foods are foods that exert a health benefit beyond the traditional nutrients they contain. They contain biologically active, non-nutrient compounds that provide health benefits, such as phytocompounds. Or they are specially formulated to have higher levels of phytocompounds than would naturally occur in that food. Some of the more popular health platforms targeted by functional foods are heart, bone and joint health, aging, memory, energy, menopause and digestive health.

The history of a group of growers that joined with Rutgers University to develop both a food and nutritional product began in 1998. Blueberry growers approached Rutgers Agricultural Economics Department, wanting to find other opportunities outside of fresh market or frozen berries. Dr. Soji Adelaja and Mr. Brian Schilling successfully submitted a grant proposal to the USDA to develop new products around blueberries. A number of prototypes were developed. These included several beverages and a solid extract. The growers formed a company called Blueberry Health to launch two products, Jersey Blues, a Blueberry Ice Tea and Solid Blueberry Extract, a functional food. In 2001, The Herbalist and the Alchemist Company partnered with Rutgers and the growers. They had a quality reputation and established channels of distribution which made them a perfect partner to promote and sell the solid extract.

Solid Blueberry Extract carries the structure function claim: Supports healthy vision. The concentration is 4.2:1 and is sweetened with apple juice concentrate. Two tablespoons are equal to a half cup of berries. It is sold in two sizes, a 3 ounce and 6 ounce glass jar and retails for $16.75 and $30.00, respectively. By 2002 the extract has become the Herbalist & Alchemist's top seller. The product has been featured in a number of newspapers and magazines, such as Prevention. Blueberry Solid Extract sales have grown 100% every year since its introduction.

Blueberries are a hot commodity at this time. Blueberry research is well reported in consumer news and has become a media darling among the food press. Blueberry consumption has never been higher. More fresh and frozen berries were consumed or purchased this year than ever before, according to industry experts. Blueberries are among the fruits and vegetables with the highest antioxidant capacity. Preliminary research in rats show blueberries may improve cognitive function. Like cranberries, blueberries may help prevent urinary tract infections. Research has indicated that blueberries improves night vision and prevents tired eyes.

Could apples be the next super fruit? The reported number of phytonutrients in apples is 150. The skin of the apple is rich in flavonoids, including quercetin. Of all fruits, apples contain the highest levels of quercetin. Quercetin is both a strong antioxidant and combined with other flavonoids, fights inflammation. Apples may also reduce cancer risk since quercetin inhibits the growth of malignant cells. Another large component with health benefits is the soluble fiber called pectin. Pectin lowers cholesterol and maintains blood sugar. Also insoluble fiber is provided in the skin which aids digestion.

A product called Phytonutriance Apple Extract is being manufactured by a French Ingredient Company called Diana Vegetal. The extract is made from fresh, mature apples. It is standardized to high levels of Phloridzin, a phenolic compound believed to have the following health benefits: balance blood sugar, cardio-protection and free radical scavenging ability. Applications include functional foods, dietary supplements, and cosmetic products

Apples may also be used as an artisan food and supplement. Pierre Gingras Orchards in Quebec, Canada is a 3rd generation apple grower. He produces natural apple juice which is fermented to wine and then cultured to vinegar. The vinegar, which is un-pasteurized and unfiltered, is aged in oak barrels for over 1 year. The orchard staff conducts tours and tasting at their facility. There are many health remedies associated with cider vinegar, so the product is also available in capsule form. Real handcrafted cider vinegar contains over 30 nutrients, a dozen minerals, and more than a half dozen essential vitamins and acids. It contains a large number of enzymes as well as pectin. It is particularly rich in potassium and other trace elements such as phosphorus, calcium, magnesium, sulfur, iron, fluorine, silicon and boron.

In summary, business incubators are a growing phenomenon in our business world. Food business incubators offer the marketing and business know-how which is essential for success, particularly for new people entering or those transitioning, i.e. from farmer to food manufacturer. Food business incubators are the ideal place to develop and bring your product to market by allowing affordable access to technology and manufacturing. Research dollars from private and government agencies can help fund the feasibility of your idea. There are some trends to be aware of to help identify new food business ideas. Unique offerings can provide a successful niche for small manufacturers.

Overview of the USDA-CSREES Regional Pest Management Centers

Russell F. Mizell, III[1], O. Norman Nesheim[1] and James Van Kirk[2]
University of Florida[1], Cornell University[2]

Purpose. In September 2000, the Congress through USDA-CSREES created four Region Pest Management Centers (PMCs) as part of a nationwide pest management information network The regional PMCs were established to respond quickly to information needs in both the public and private sectors. PMCs will also help USDA and its partner institutions identify, prioritize, and coordinate national pest management research, extension, and education programs.

Funding. Funding for the national network of Pest Management Centers was authorized by Section 406 of the Agricultural Research, Extension, and Education Reform Act of 1998. As the result of a competitive process, four PMCs across the United States were first funded in FY 2000. Management of PMCs is a partnership between USDA-CSREES, the Office of Pest Management Policy and the Land Grant Universities. Presently the four regional Centers are "virtual" and are managed in the Northeastern region by the The Pennsylvania State University and Cornell University; in the North Central region by Michigan State University and the University of Illinois; in the Western region by the University of California-Davis; and in the Southern region by the University of Florida.

Organization. The Pest Management Centers are designed to maximize collaboration among individuals and groups with diverse perspectives across the regions. Broad-based regional participatory leadership assures stakeholder needs are being met. The Center's Directors provide leadership and management. The Steering Committee directs Center staff (Directors or Coordinators, and support staff) in managing information flow. Advisory Councils/Committees play a key role in gathering input from pest management stakeholders. Project leaders funded by the competitive information network grants program not only develop new information as needed but also extend the communications network to the local level.

Function. The PMCs primary function is to develop and maintain a pest management information network that will contribute to environmentally and economically sound pest management decisions. The network serves three major purposes: to collect current commodity-related information on pest management practices that provide critical data to advise EPA and other stakeholders on issues related to the FQPA, to facilitate two-way communication among key groups of stakeholders, and to provide these groups with broad access to pest management information.

The PMCs are working to connect a diverse array of people who have an interest in pest management policy and implementation throughout the U.S. These include pest management users (farmers, nurserymen, park and turf managers, building superintendents, pest control operators, homeowners, gardeners, and others), consumer and environmental groups, governmental regulatory agencies, researchers, and educators. PMCs are networking these groups both through the Center's own organization (Advisory Councils/Committees, Steering Committee, Commodity Work Groups, Project Leaders) and through development of electronic communications structures such as email lists, online bulletin boards, and web pages (see www.pmcenters.org).

Center Leadership and Information: Regional and National Implications. PMCs administer USDA-CSREES grant funds to state cooperators who develop crop profiles, pest management strategic plans and other forms of baseline data to support pest management needs. PMCs are part of a myriad of federally-funded programs that are directed to support the development and implementation of pest management through research and extension by land grant and other interested stakeholders. These programs award funds to pest management professionals by formula funds (3d programs) to individual states or provide competitive funding in peer reviewed competitions at the regional and national levels. The grant programs are targeted to basic (NRI) and applied research (PMAP, CAR, RAMP, regional IPM) and to the needs of both conventional and organic producers (SARE, Organic Transition).

The recent General Accounting Office (GAO) report on IPM strongly supported the concept and implementation of IPM but criticized the USDA and its agencies for lack of federal coordination and leadership of pest management programs. In response to the report USDA is currently developing a new "roadmap" for pest management. In the meantime the grant programs will continue. It is important that the role of the PMCs and the benefits from the data they collect are understood by all stakeholders. The first key to this understanding is the realization that most grants programs now require specific justification and documented support from stakeholder groups for proposal objectives. Some programs require formal participation by stakeholders or are open for direct stakeholder funding (SARE, PMAP). Data from crop profiles and pest management strategic plans gathered through the PMCs are designed and collected using a methodology that meets the stakeholder-input requirements of the grant programs.

Knowledge of the purpose and breadth of the current pest management grant programs is the second key to understanding the interrelationships between PMCs and other programs. Full program descriptions can be found on the USDA website at www.reeusda.gov. In brief all of the programs are administered regionally except the NRI, PMAP, CAR, and RAMP programs which are national competitions. NRI (National Research Initiative) mainly funds cutting-edge science posing basic biological and ecological questions. PMAP (Pest Management Alternatives Program) addresses narrow, critical needs occurring as a result of FQPA decisions made by EPA that eliminate individual chemical pesticides in specific crops. The CAR (Crops At Risk) and the RAMP (Risk Avoidance and Mitigation Program) are designed to address commodity pest management at a broader "systems" level. Both programs are multi-disciplinary and longer term than the other programs with CAR targeting minor fruits and vegetables with near-term risks from FQPA and RAMP targeting major crops. Because of the national nature of the competitions, it is imperative that PMC-sponsored research that provides background data and justification for proposals be completed in a timely manner. One may also argue that a strategic approach to development of PMC-sponsored state proposals as well as regional IPM and PMAP proposals should be followed to insure that the research/extension personnel in each region are positioned to compete favorably nationally for PMAP, CAR and RAMP funds. Regions that do not adequately plan and execute proposals to develop appropriate data will likely not fare as well in national grants competitions.

Not for Citation or Publication
Without the Consent of the Author

NOVEL APPROACHES FOR MATING DISRUPTION OF CM/OFM

Larry A. Hull and Nicolas H. Ellis
Penn State University
Fruit Research and Extension Center
Biglerville, PA 17307

Introduction

Since 1998, researchers at the Penn State Fruit Research and Extension Center (FREC) have evaluated the efficacy of a number of pheromone release technologies for implementing mating disruption including the industry standard - hand-applied dispensers and more recently, new novel technologies including - paraffin emulsions, puffers, and sprayable formulations against a variety of lepidopteran orchard pests. Encouraging results from our initial studies on sprayable pheromones for controlling the Oriental fruit moth (OFM), *Grapholita molesta*, on commercial farms have paved the way for addressing questions of rate thresholds and application methods for sprayable pheromone efficacy. Given the inevitable discontinuation of broad-spectrum insecticide use in orchards, rapid characterization of sprayable pheromone efficacy in practical use patterns is imperative. In 2002, we evaluated the efficacy of two formulations of OFM sprayable pheromones (Phases 1 and 5) applied as alternate row middle (ARM) applications at lower-than-recommended and recommended rates, at two commercial orchard operations with a history of successful OFM control with reduced broad-spectrum insecticide input. We also evaluated a sprayable pheromone formulation for the codling moth (CM), *Cydia pomonella*, and a new hand-applied dispenser technology that releases both CM and OFM pheromone from a single dispenser.

Materials and Methods

Oriental Fruit Moth: One apple orchard site (Grower 1) was approximately 2 miles west of Biglerville, PA. One of two plots (ca. 5-6 acres each) was treated with sprayable Phase 5 OFM pheromone at a rate of either 1.25 g a.i. per acre per side, or 2.5 g a.i. per acre per side. Each of these 5-6 acre plots was a sub-plot within a larger orchard block. In addition, a single 10-acre plot was treated with Phase I OFM pheromone at a rate of 5.0 g a.i. per acre per side and a single 15-acre plot was treated with insecticides only. At the Grower 2 apple site, approximately 2 miles north of Biglerville, each Phase 1 and 5 rates as described above were each applied to 10-acre plots, and a single 10-acre block was treated with insecticides only. At both sites, all applications were made as ARM applications, and pheromones were incorporated into the respective growers' normal insecticide schedules, every 7-12 days throughout the season (Figs. 1-2). All pheromone and insecticide applications at the Grower 1 and 2 sites were applied at a water volume rate of 100 GPA, 50 GPA per side or 50 GPA, 25 GPA per site, respectively.

Three Delta-style pheromone traps with 0.11 mg OFM lures (Scenturion, Inc., Clinton, WA) were deployed in each plot designated for an individual rate treatment (with the exception of the 15-acre conventional orchard at the Grower 1 site, where four traps were used, to cover the larger area). A single Delta-style codling moth (CM) trap was also hung in each treatment plot. All traps were hung in early June and monitored weekly for the duration of the season; lures and bottoms were replaced monthly until the end of August, unless the condition of the trap bottom indicated the need for more frequent replacement.

Prior to normal harvest, *in situ* evaluations of apples showing evidence of internal lepidopteran larvae were conducted in each plot. For Grower 1, 30 trees were randomly selected within each plot and 100 apples were randomly evaluated for the presence of entries from internal lepidopteran larvae. Any apples showing such injury were returned to the laboratory, examined for live larvae; those found were identified to species. For Grower 2, 25 trees and 100 apples per tree were evaluated in each plot according to the above criteria.

<u>Codling Moth</u>: A large apple orchard block (ca. 40 acres in size) located near Peach Glen, Pa. was selected for this study. This block had a history of problems with the codling moth. The block was divided into three large plots, each plot receiving one of the following three treatments: 1) 3M-CM Sprayable Pheromone Phase 4E formulation [12.4 acres], 2) Isomate CM/OFM Combo [11.6 acres, and 3) a conventional insecticide program [8.0 acres]. The grower removed a portion of the block (ca. 7-8 acres) between the CM Sprayable plot and the Conventional plot at the start of the study. Applications of the Sprayable Phase 4E pheromones were made using the alternate row middle (ARM) system of spraying with each application delivering 7.5 g a.i./A of pheromone. The adjuvant LI-700 was added to the first two applications and the adjuvant Nu-Film 17 was added to the last four ARM applications of pheromone (Fig. 3). The Isomate CM/OFM Combo dispensers were hung in the top one-third of the trees on 30 April. Since this block had a history of codling moth problems, the grower continued to apply his normal schedule of insecticides to the entire block. The first two ARM pheromone applications were applied in a water volume of 25 GPA per side with an airblast sprayer. The last four ARM pheromone applications were applied in a water volume of 50 GPA per side.

Two Delta-style pheromone traps with 1 mg CM lures (Scenturion, Inc., Clinton, WA) were deployed in each of the Sprayable Pheromone Phase 4E and Isomate CM/OFM Combo blocks, whereas, four traps with 1 mg lures were deployed in the conventional plot. In addition, two Delta-style pheromone traps with 10 mg CM lures (Trece Inc., Salinas, CA) were deployed in the each of the Sprayable Pheromone Phase 4E and Isomate CM/OFM Combo plots only. Also, three Delta-style pheromone traps with 0.11 mg OFM lures were also hung in each treatment plot. All traps were placed in late April and monitored twice weekly for the duration of the season; lures and bottoms were replaced monthly until the end of August, unless the condition of the trap bottom indicated the need for more frequent replacement.

On 16 Jul and just prior to normal harvest (6 Sep), *in situ* evaluations of apples showing evidence of internal lepidopteran larvae were conducted in each plot. For the 16 Jul and 6 Sep evaluations, 21 and 24 trees, respectively, were randomly selected within each plot and 200 apples were randomly evaluated per tree. Any apples showing such injury were returned to the laboratory, examined for live larvae; those found were identified to species.

Results and Discussion

Oriental Fruit Moth: Grower 1 made a total of seven ARM applications of both Phase 1 and 5 sprayable pheromones starting with the first application on 10 Jun and ending with the last application on 20 Aug (Fig. 1). At the Grower 1 site, a seasonal total amount of 8.75 g a.i. (Phase 5, 1.25 g a.i./A/side), 17.5 g a.i. (Phase 5, 2.5 g a.i./A/side), and 35.0 g a.i. (Phase 1, 5.0 g a.i./A/side) was applied in each of the three respective plots. Grower 2 made six ARM applications of both Phase 1 and 5 sprayable pheromones beginning with the first application on 12 June and ending with the last application on 12 Aug (Fig. 2). At the Grower 2 site, a seasonal total amount of 7.5 g a.i. (Phase 5, 1.25 g a.i./A/side), 15.0 g a.i. (Phase 5, 2.5 g a.i./A/side), and 30.0 g a.i. (Phase 1, 5.0 g a.i./A/side) was applied in each of the three respective plots. Both growers continued to apply a reduced program of insecticides in all pheromone treated blocks.

The mean numbers of OFM adults captured per trap per week, and mean cumulative adult captures were highest in the conventional orchards at both sites (Figs. 1-2). The Phase 1 formulation began to show signs of reduced efficacy in mid-September at both sites, and did not suppress trap capture through the end of the sampling period (mid-October). This observation suggests that the Phase 5 formulation, despite being applied at rates 50 and 75% lower than the rate of the Phase I formulation, was much more residual and effective in preventing adult capture. Nonetheless, suppression of trap capture was evident for 3-4 consecutive weeks following the final sprayable pheromone applications, regardless of the formulations or rates applied. There was a 94.6% and an 87.0% reduction in cumulative adult captures observed between the Phase I and conventional plots at both the Grower 1 and 2 sites, respectively (Table 1). In addition and perhaps more interesting, there was an approximate 98.1% and 97.7% reduction in cumulative adult captures between the lowest ARM rate (1.25 g a.i./A/side – Phase 5) and the conventional plots at both Grower 1 and 2 sites, respectively. These data thus indicate that although Phase 1 apparently has a shorter residual time than Phase 5, it nonetheless exerts a considerable effect on the ability of male OFM to locate pheromone traps while it is active. These data also strongly suggest that the Phase 5 is more effective than the Phase 1 MEC even when applied at either 50% and or 75% of the rate of Phase I.

No fruit injury was found in any of the mating disruption plots at the Grower 1 site, while 0.3% of the fruit in the standard insecticide block had evidence of internal larval feeding (Table 1). At the Grower 2 site, there was no difference among the treatments in the percentage of apples showing evidence (*i.e.*, frass). All larvae found in injured fruit were OFM.

Based on these results, it can be concluded that the Phase 5 formulation is effective for preventing OFM capture in pheromone traps, and has a longer residual time than the Phase 1 formulation--even at rates 50 and 75% lower than the Phase 1 rates. Also, the addition of sprayable pheromones to a reduced program of insecticides can significantly contribute to the prevention of fruit injury from OFM. More importantly though, these data show that the alternate row middle technique of spraying can be used to successfully apply sprayable pheromones, and still achieve reduced adult capture and prevention of fruit injury.

This finding may have valuable utility during seasons of normal or above average rainfall. In such seasonal situations, the pheromone deposit is renewed more often with the ARM method than when full applications are made to both row middles. However, our study was conducted during the 2002 season in Pennsylvania, which was characterized by drought-type conditions. Additional work should be conducted to determine the effect of applying sprayable pheromones at reduced rates *via* the alternate row middle method of spraying under periods of normal or above-average rainfall. Further work should also investigate if these low rates and ARM applications are effective against OFM population densities higher than those present in the orchards we surveyed for this project.

Codling Moth: A total of six ARM applications of CM Sprayable pheromone were made during the course of the season (Fig. 3), applying a total seasonal amount of 45 g. a.i./A. The Isomate CM/OFM dispensers were placed in the orchard on 30 Apr. The total amount of pheromone present in the dispensers at the start of the study was 56 and 16 g a.i./A for CM and OFM, respectively (Table 2).

The mean numbers of CM adults captured per trap per week, and mean cumulative adult captures were highest in the CM Sprayable plot through the end of first brood flight in late Jun (Figs. 3 A, B). Beginning with the flight of second brood in mid-Jul, more CM adults were found in the conventional plot than in either the CM Sprayable or Isomate CM/OFM Combo plots (Figs. 3 A, B). At the end of the season, the mean seasonal trap capture of CM adults in the conventional plot (32) exceeded the number captured in the both CM Sprayable (28) and Isomate CM/OFM Combo (4) plots. The mean numbers of OFM adults captured per trap per week, and mean cumulative adult captures were highest in the conventional plot followed by the CM Sprayable plot (Fig. 4 A, B). Only one OFM adult was caught in the Isomate CM/OFM Combo plot after the placement of dispensers in the end of April.

During the 16 Jul evaluation, the CM Sprayable plot had the highest percentage of apples (0.45%) showing evidence of frass followed by the conventional plot (0.24%) and the Isomate CM/OFM Combo plot (0.02%) (Table 2). From apples harboring live larvae, seven CM larvae were found in the CM Sprayable plot and three CM larvae from the conventional plot. During the 6 Sep evaluations, the conventional plot had the highest percentage of apples showing evidence of frass (3.58%) followed by the CM Sprayable (2.50%) and Isomate CM/OFM Combo (0.31%) plots (Table 2). Forty-nine live CM larvae were collected from apples in the conventional plot; whereas, 24 and 3 live CM larvae were collected from the CM Sprayable and Isomate CM/OFM Combo plots (Table 2). In addition, nine live larvae from the conventional plot were identified as OFM while three live OFM larvae were each recovered from the CM Sprayable and Isomate CM/OFM Combo plots.

Based on these results and under these test conditions, it can be concluded that the CM/OFM Combo is very effective in preventing mating of CM and OFM adults and subsequent fruit injury from these two pests while the CM Sprayable 4E formulation is not yet effective in preventing mating of CM adults and subsequent fruit injury from this pest. There did appear to be some activity of the CM Sprayable on CM trap capture during the second brood. Part of this may have been due to the addition of Nu-Film-17 to the last four ARM applications of the pheromone. It also appears that CM Sprayable plot did not have a high enough concentration of codlemone present throughout the season since the 1X lures (75) captured more total male adults and than the 10X lures (39). In the CM/OFM Combo plot, the opposite was found in that the10X lures captured more total male adults (12) than the 1X lures (3).

Additional work for next year using the CM/OFM Combo is certainly warranted to determine if this product can continue to be effective in preventing fruit injury from these two pests, especially in blocks that do not receive a full supplemental insecticide program. Also, more efficacy work should be done in blocks that have varying population levels of both pests. As for the CM Sprayable formulation, additional work for next year is also certainly warranted to determine if the formulation can be made more effective for preventing fruit injury from this pest. Because of the diversity of pest problems in the eastern U.S. and the need to apply other insecticides and fungicides, this technology is ideally suited to complement the other tactics employed by eastern U.S. growers.

Table 1. Evaluation of two formulations (P1 and P5) of OFM Sprayables (3M Canada) applied as alternate row middle applications on the prevention of fruit injury and pheromone trap capture, Biglerville, PA., 2002.

Grower	Treatment	g a.i./acre (each applic.)	No. ARM applic.	Seasonal g a.i./acre	% Apples-frass[1]	Cum. no. OFM moths caught[2]
1	OFM Sprayable - P5	1.25	7	8.8	0.00 a	7
1	OFM Sprayable - P5	2.50	7	17.5	0.00 a	9
1	OFM Sprayable - P1	5.00	7	35.0	0.00 a	20
1	Std. Insecticide	--	--	--	0.30 b	372
2	OFM Sprayable - P5	1.25	6	7.5	0.08 a	6
2	OFM Sprayable - P5	2.50	6	15.0	0.00 a	16
2	OFM Sprayable - P1	5.00	6	30.0	0.08 a	34
2	Std. Insecticide	--	--	--	0.04 a	261

* Means followed by the same letter(s) are not significantly different, (Fisher's Protected LSD, $P < 0.05$).
1 Number of apples examined per treatment: 3000 (Grower 1, 12 Sep) and 2500 (Grower 2, 13 Sep).
2 Cumulative number of male adults caught in 3 pheromone traps per treatment from 13 Jun - 10 Oct (Grower 1) and 6 Jun - 10 Oct (Grower 2)

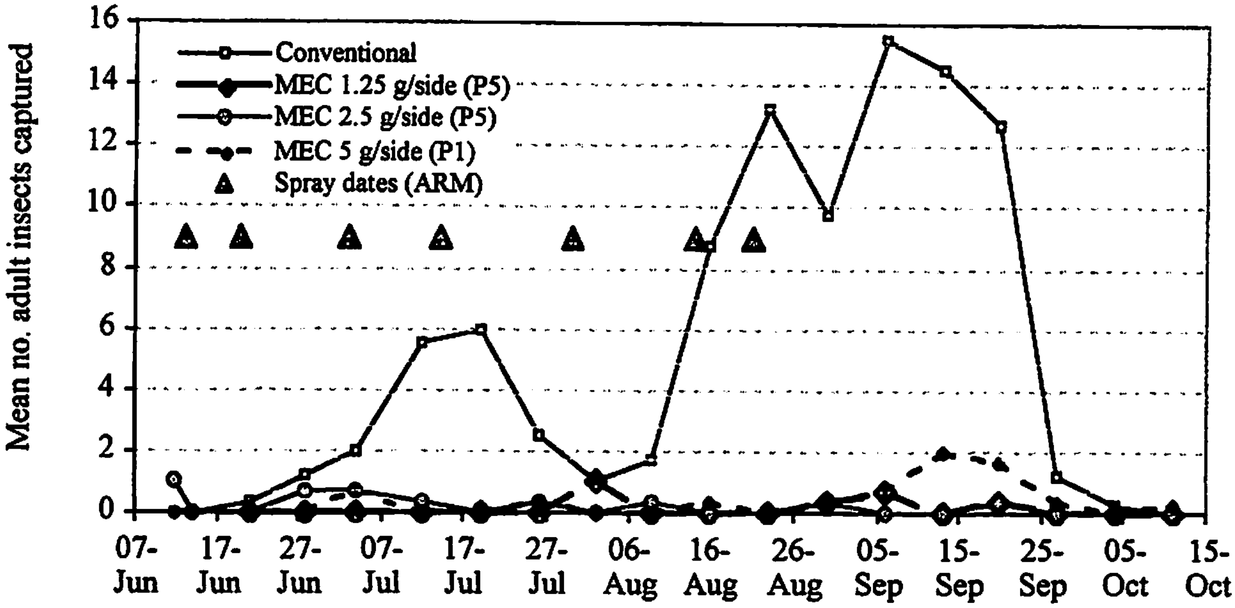
Table 2. Evaluation of two forms of mating disruption for codling moth control, Peach Glen, PA, 2002.

Grower	Treatment	Seasonal g AI/acre	Total fruit sampled 16 Jul	Total fruit sampled 6 Sep	% Apples - frass 16 Jul	% Apples - frass 6 Sep	ID and number of larvae 16 Jul CM	ID and number of larvae 6 Sep CM	ID and number of larvae 6 Sep OFM
K	3M Canada CM Spray - P4E	CM (45)[1]	4200	4800	0.45 b	2.50 b	7	24	3
K	Isomate CM/OFM Combo[2]	CM (56) OFM (16)	4200	4800	0.02 a	0.31 a	0	3	3
K	Conv. Insecticide	- -	4200	4800	0.24 ab	3.58 b	3	49	9

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

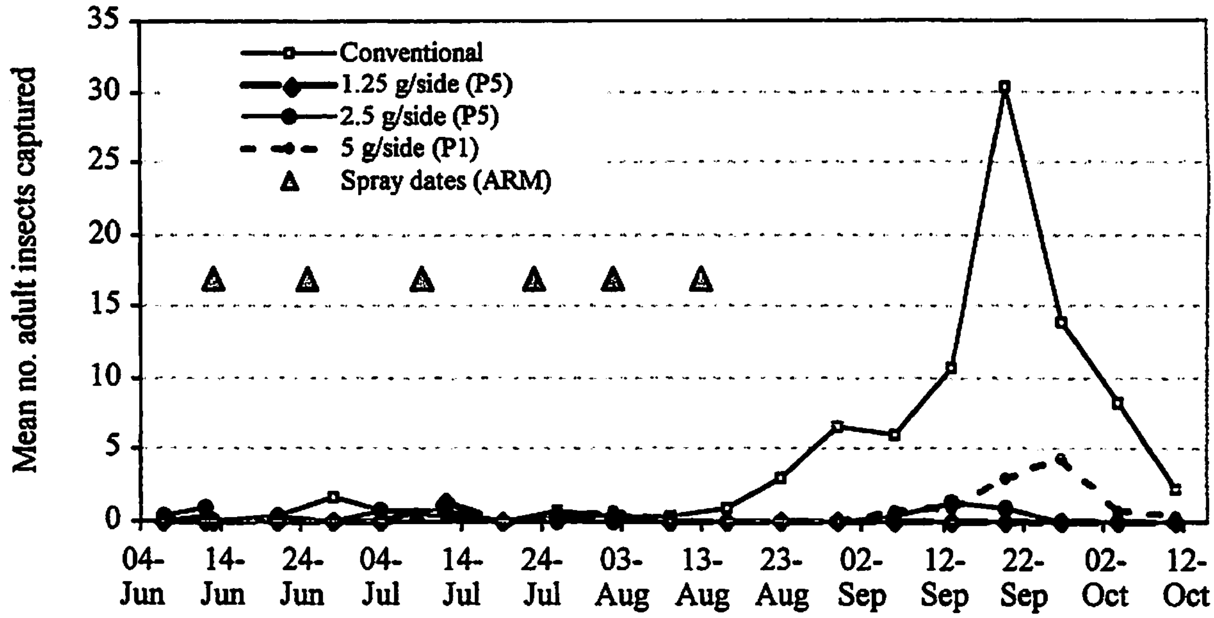
[1] Six alternate row middle applications at 100 GPA, use Nu-Film-17 (1 pt/100) during last four ARM applications.

[2] 200 dispensers/acre



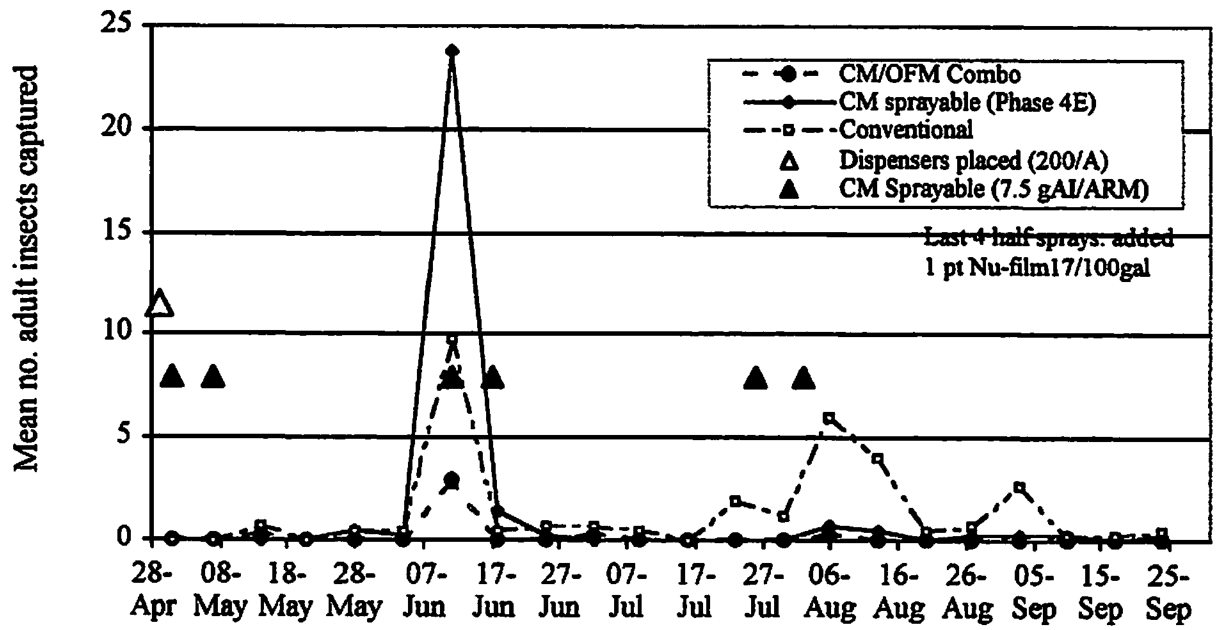
* Mean of 3 sex pheromone traps/block

Fig. 1. Comparison of two formulations of 3M Canada OFM Sprayables (P1 and P5) applied using the alternate row middle application technique on Oriental fruit moth trap capture through time, Grower 1, Biglerville, PA - 2002



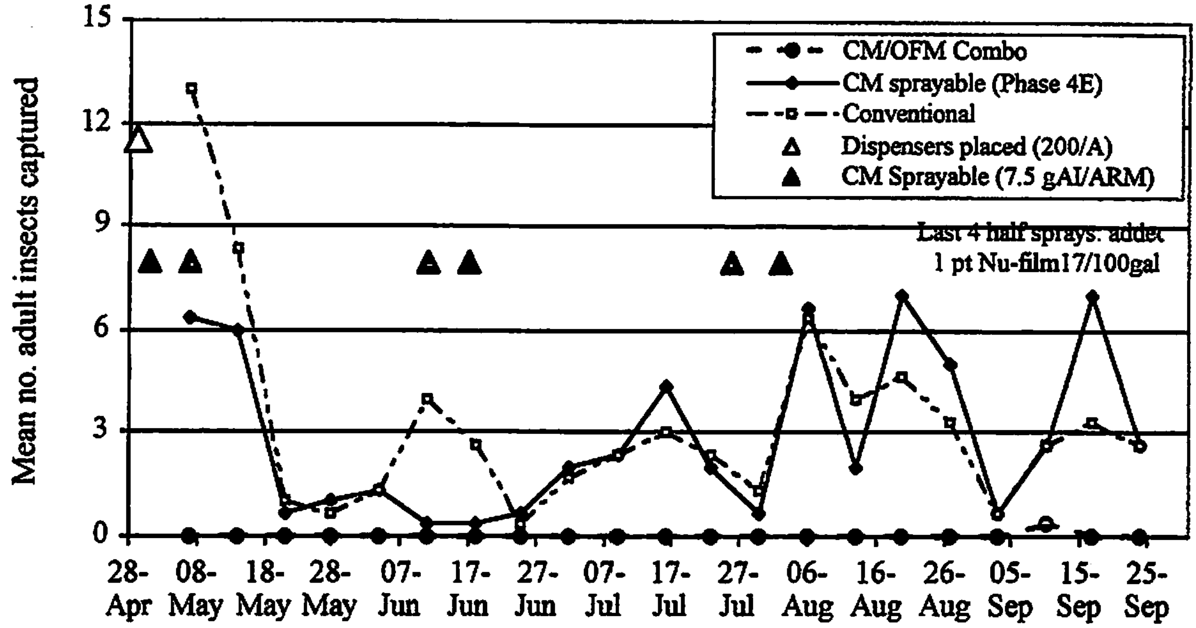
* Mean of 3 sex pheromone traps/block

Fig. 2. Comparison of two formulations of 3M Canada OFM Sprayables (P1 and P5) applied using the alternate row middle application technique on Oriental fruit moth trap capture through time, Grower 2, Biglerville, PA - 2002



* Mean of 4 sex pheromone traps/block

Fig 3. Comparison of 3M Canada CM Sprayable (P4E) versus Isomate CM/OFM Combo dispensers on codling moth trap capture through time, Peach Glen, PA - 2002.



* Mean of 3 sex pheromone traps/block

Fig. 4 Comparison of 3M Canada CM Sprayable (P4E) versus Isomate CM/OFM Combo dispensers on Oriental fruit moth trap capture through time, Peach Glen, PA - 2002.

Comparing Release Technologies for Pheromone-Based Mating Disruption of Codling Moth and Oriental Fruit Moth in Virginia - 2002

D. G. Pfeiffer[1], X. Zhang[1], M. H. Rhoades[1], J. C. Bergh[2], J. Engleman[2], Brent Short[2], K. Love[3] and B. Jarvis[3]
[1]Department of Entomology, Virginia Tech, Blacksburg, VA 24061
[2]Alson H. Smith Agric. Research & Extension Center, Winchester VA 22602
[3]Virginia Coop. Extension, Rappahannock and Madison Counties, respectively

I. Introduction: Codling moth (CM), *Cydia pomonella* (L.), has been the subject of mating disruption in Virginia since 1987; this work has become more intensive since 1989 (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, Hercon laminate dispensers, and 3M Canada sprayable pheromones.

Mating disruption is known to be most effective at low to moderate pest densities, with control failures more likely in high pressure situations. In 2002, we decided to employ mating disruption in a high pressure orchard as an adjunct to a normal insecticide program to determine its potential as part of a multi-pronged program to control high populations of internal feeders.

II. Materials and Methods: Mating disruption research was carried out in four orchards in 2002, two in northern and two in central Virginia. These orchards had the following characteristics:

- **Frederick** – in 2002, second year treated with MD; moderate internal feeder problems
- **Albemarle** – by 2002, had been in MD program for several years; low intensity of internal feeders
- **Botetourt** – 2002 first year of MD; light population of internal feeders
- **Rappahannock** – 2002 first 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. Except for the Rappahannock orchard, no sprays were applied thereafter unless needed for leafrollers. Intrepid (methoxyfenozide) was the usual material for this use. 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, 300 fruit per plot were collected for final damage evaluation.

Winchester: A study comparing hand-placed and sprayable mating disruption formulations for CM and OFM control was conducted in a 17-acre block of 9- to 10-yr-old 'York' (M7), 'Golden Delicious' (M7), 'Rome' (M111) and 'Ida Red' (M111). Trees were 14 ft tall and 15 ft wide and planted at a spacing of 14x22 ft (140 trees/A). A second orchard located approx. 0.5 miles from the mating disruption orchard served as a standard. The standard orchard consisted of 15 acres of 12-yr-old trees of the same varieties/rootstocks as in the mating disruption orchard, planted at a spacing of 16 ft x 24 ft (110 trees/A). Trees were 11.5 ft tall and 13 ft wide. A routine maintenance schedule of fungicides applied to both orchards during the test included copper, Nova, Dithane, sulfur, Captan and Ziram. The same insecticide program was used in the mating disruption and standard orchards through May 29 (Table 1). Thereafter, the mating disruption orchard received no further insecticide. Insecticides were applied as ARM sprays with a Durand-Wayland PTO-driven airblast sprayer calibrated to deliver 60 gpa at 2.3 mph. Sprayable pheromone was applied as complete sprays with a PTO-driven FMC model 252S airblast sprayer calibrated to deliver 100 gpa at 3 mph. The Isomate C/OFM, Hercon Disrupt OFM and CM X-tra, and 3M OFM and MEC CM sprayable formulation were applied to 5.8, 5.8 and 5.4 A, respectively. Two pheromone traps for CM and two for OFM were placed in each block on May 3 and the number of male CM and OFM captured was recorded weekly. In-season evaluations of damage by internal feeders included counts of OFM-infested terminals and fruit with frass (OFM and CM) taken during 5-min examinations/3-tree plot.

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 combination ropes were compared with Hercon laminate dispensers for each species. The following insecticides were applied during the season: Asana (16, 24 Apr), Guthion (2 May), Guthion/Intrepid (18 May, 8 Jun), Imidan/Intrepid (1 Jul), Guthion/Avaunt (15 Jul), Imidan/Sevin (30 Jul), Asana/Avaunt (14 Aug), Guthion/Intrepid (28 Aug), Asana/Avaunt (8 Sep), Imidan (20 Sep). Sprays were applied at 100 gal/A.

Albemarle County: Sections of an apple orchard composed primarily of 'Delicious' trees at Miller School, Albemarle County, were treated with several types of pheromone dispensers for CM and OFM. Trees were 2.4-3.0 m tall (8-10 ft), in a 10'x15' spacing (290 trees/A). In section A, a rope-style dispenser combining pheromone of CM and OFM was used (500/ha (200/A) on 1 May) (ca 10 A (4 ha)). In section B, Hercon Disrupt CM-Extra (200/A) and OFM (108/A) laminate pheromone dispensers (Hercon Environmental Company) were applied (at petal fall). In section C, 3M Sprayable Pheromone was applied for OFM (2 fl oz/A; 12 g ai/A) and CM (6 fl oz/A; 18 g ai/A). Section D was a conventionally treated control. Fruit were examined on the tree periodically during the season (21 June, 19 Jul, and 13 August); 10 fruit were examined on each of 20 trees. Harvest injury was assessed on 10 September. At that time, 300 fruit from the edge and center of each block were picked and returned to Blacksburg for examination.

Botetourt County: In a 'Rome' and 'Jonathan' orchard block in Troutville, Botetourt County, the same pheromone treatments were established in 5-acre blocks. Trees were about 15' tall, in a 15'x25' spacing (120 trees/A). Pheromone dispensers were place on 28 May. In pheromone-treated blocks, a conventional insecticide program was followed through first cover. Three pheromone traps each for CM, OFM, VLR, TBM, and RBL were placed in each block and monitored weekly. Periodic counts 21 June, 19 Jul, 1 and 13 August, and 10 Sept. Leafroller injury in early August necessitated an Intrepid spray. Harvest injury was assessed on 24 September. At that time, 300 fruit from the edge and center of each block were picked and returned to Blacksburg for examination.

III. Results and Discussion:

Flight data: Moth flight differed markedly among the orchards for both moth species. Codling moth and oriental fruit moth captures are presented in Tables 2 and 3, respectively (numbers given are cumulative moths per trap over the season). The two numbers given for the 3M treatments in each orchard reflects the late receipt and application of the products; the first number shows captures before treatments began, the second number reflects captures thereafter. This is especially critical in the Botetourt orchard, where CM pressure was quite high (the cumulative per trap average of 65.8/trap includes two peak flights of 9/trap on 26 June, and 17.5/trap on 1 Aug). Once treatments began with the sprayable, trap shutdown was total, even with this high population (higher in fact than the control). The Rappahannock orchard had the highest CM capture, with 151moths collected in the standard block. The Albemarle orchard had the lowest pressure from CM as indicated by trap captures, with only 1.6 per trap collected. The Winchester orchard had the greatest OFM pressure, with a cumulative 722 moths collected per trap. The Botetourt orchard had the lowest OFM pressure, with 13.7 collected per trap over the season. In the Winchester, Rappahannock, and Albemarle orchards, OFM greatly outnumbered CM in the traps; in Botetourt numbers of the two species were similar.

Pheromone traps for CM and OFM were placed in the Isomate and Hercon blocks 1 day after the deployment of the mating disruption treatments for OFM and CM in the Isomate block and for CM in the Hercon block. Although traps in the 3M block were deployed prior to the application of sprayable pheromone for both OFM and CM, the proximity of that block to the other blocks may have affected the trap catch of both species. Consequently, we do not have information on the pressure of either species prior to mating disruption. After the disruptants were deployed, no CM or OFM were captured in the Isomate block, and only a single moth of each species was captured in the Hercon block (Tables 3 and 4). In the 3M block, applications of the CM sprayable pheromone eliminated capture of CM males (Table 4) and a total of 3 OFM males were captured following applications of the OFM sprayable pheromone (Table 3). In the Standard block, located approx. 0.5 miles away, CM pressure was relatively light, never exceeding threshold (5 moths/trap/week), although OFM pressure was heavy and exceeded threshold levels (>11 moths/trap/week) on 15 of 18 weeks (Table 3). Harvest evaluations in October will determine the percentage of 'Golden Delicious' and 'York' fruit, respectively, damaged by CM, OFM, the leafroller complex and miscellaneous pests in samples of 100 apples/tree from 10 trees/block.

Damage data: Winchester: Although few infested terminals were found, the number recorded was not significantly different between the Isomate, Hercon and Standard blocks (Table 4). Trees in the Isomate block had significantly more twig attacks than in the Hercon or 3M blocks, but not more than the control; numbers of twig strikes were low in all treatments. No apples showing infestation by internal feeders were observed on June 20. In the harvest samples, all treatments gave acceptable control of internal feeders Table 5).

Rappahannock County: Internal feeder injury was higher in this orchard than in most of the other mating disruption orchards (Table 6). However, the levels of damage were reduced from previous years, and the chances of mating disruption to make a meaningful contribution in multi-tactic control of even high internal feeder populations seem good.

Albemarle County: The periodic evaluations of 200 fruit per block showed good control during the season. A single fruit injured by an internally feeding caterpillar (species unknown) was detected on 1 August. Harvest damage data are presented in Table 7. Pest pressure was low, and there were no distinguishable differences in injury caused by internal feeders. The most common injury was caused by tarnished plant bug.

Botetourt County: OFM captures were suppressed and control was good for the duration of the season in all treatments. Harvest injury data are presented in Table 8. CM injury exceeded acceptable levels, especially in the block edge, apparently because of the late initiation of pheromone sprays for that species. Once treatments were applied, damage did not increase. Injury levels were highest in mid-August (about 5.5% on 13 Aug); the apparent decrease in injury is probably the result of injured fruits dropping from the trees.

Summary: All three pheromone-dispensing technologies resulted in complete or nearly complete trap shutdown, and provided control of internal feeders, once treatments were initiated. While mating disruption is not appropriate as a stand-alone tactic for high populations, it appears to be useful in high-pressure orchards as a component of a multi-pronged management program for such internal feeder populations.

Table 1. Mating disruption formulation study: Materials and dates of application in Winchester (2002).

Program	Treatment	Amt/A		Dates of application
Standard	Lorsban 4E +	2 pt	......	April 3 and 7
	Asana XL +	5.0 fl oz	.....,	April 28, May 8 and 29, June
	Oil	1 pt		25, July 5 and 19, August 5
	Guthion 50WP	1.5 lb		and 19
	Intrepid 2F	16.0 fl oz	......	June 7 and 12
3M	Lorsban 4E +	2 pt	......	April 3 and 7
	Asana XL +	5.0 fl oz	......	April 28, May 8 and 29
	Oil	1 pt		
	Guthion 50WP	1.5 lb	......	May 29
	OFM sprayable (Phase V) +	1.75 fl oz	......	July 17, Aug 19
	Intrepid 2F	16.0 fl oz	......	July 8, Aug 19
	OFM sprayable pheromone (Phase V)	1.75 fl oz		
	CM MEC sprayable pheromone	5.0 fl oz		
			...	
Hercon	Lorsban 4E +	2 pt	...	April 3 and 7
	Asana XL +	5.0 fl oz	...	April 28, May 8 and 29
	Oil	1 pt	...	May 2 - May 16
	Guthion 50WP	1.5 lb	...	June 4
	Disrupt CM-Xtra	200 clips	...	
	Disrupt OFM	108 clips	.....	
			....	
Isomate	Lorsban 4E +	2 pt	......	April 3 and 7
	Asana XL +	5.0 fl oz	......	April 28, May 8 and 29
	Oil	1 pt	......	May 2 - May 16
	Guthion 50WP	1.5 lb		
	Isomate-C/OFM	200 ropes		

Table 2. Cumulative codling moths per trap in four mating disruption orchards using three pheromone dispensing technologies (2002).

Orchard	Control	Hercon	Isomate	3M[1]
Winchester	16.5	0.5	0	2.5 0
Rappahannock	151	3.0	3.5	na
Albemarle	1.6	0	0	1.5 0
Botetourt	10.6	1.3	0.3	65.8 0

[1]The two numbers in 3M treatments reflects late receipt of product. The first number reflects captures before pheromone application, the second number captures after initiation of application.

Table 3. Cumulative oriental fruit moths per trap in four mating disruption orchards using three pheromone dispensing technologies (2002).

Orchard	Control	Hercon	Isomate	3M[1]
Winchester	721.5	0.5	0	5.0 0.5
Rappahannock	372	50.5 5.0	0.5 1.0	na
Albemarle	64.6	1.3	1.4	6.1 0
Botetourt	13.7	0	1.0	49.5 2.0

[1]The two numbers in 3M treatments reflects late receipt of product. The first number reflects captures before pheromone application, the second number captures after initiation of application.

Table 4. Mating disruption formulation study: OFM infested shoots and damage to fruit (Winchester 2002).

Treatment	Mean no. OFM infested shoots/3 min (June 12)	Mean no. infested apples/5 min (June 20)
Standard	0.40 ab*	0.0 a
3M sprayable	0.0 b	0.0 a
Hercon	0.0 b	0.0 a
Isomate	0.50 a	0.0 a

* Means within columns followed by the same letter(s) are not significantly different at the 5% probability level according to Analysis of Variance and Fisher's Protected LSD tests.

Table 5. Percent fruit injury in mating disruption plots compared with conventional standard in Winchester orchard (2002) (mean of 10 trees, 100 fruit/tree)

Treatment	Stings	Entries	OFM larvae	CM larvae	TBM	RBL	TPB
Standard	0.4	0	0.2	0	2.6	0	0.1
3M	0	0	0	0	0.3	0	0.5
Isomate	0.1	0	0.2	0.1	3.3	1.3	0.5
Hercon	0.1	0	0	0	1.2	1.0	0.1

Table 6. Percent fruit injury in mating disruption plots compared with conventional standard in Rappahannock orchard (2002) (mean of 10 trees, 100 fruit/tree)

Treatment	Stings	Entries	Larvae	TBM	RBL	TPB
Standard	0.2	0.1	0.1	0.5	0	1.1
Hercon	0.1	0.6	0.4	0.9	0	0.3
Isomate	0	1.3	0.5	0.6	0.1	0.9

Table 7. Percent fruit injury in mating disruption plots compared with conventional standard in Albemarle orchard (2002) (two sample of 75 fruit in each plot section; 300 fruit per pheromone treatment)

Treatment	Internal	Platynota	RBL	TPB
Control - Edge	0	8.7	0	1.3
Center	1.3	6.0	1.3	0
Hercon - Edge	0.7	4.7	0	0
Center	0	4.7	0	0.7
Isomate - Edge	0	5.3	0	0
Center	0	4.7	0	0
3M - Edge	0	4.0	0.7	2.0
Center	0.7	0.7	0.7	0.7

Table 8. Percent fruit injury in mating disruption plots compared with conventional standard in Botetourt orchard (2002) (two sample of 75 fruit in each plot section; 300 fruit per pheromone treatment)

Treatment	Internal	Platynota	RBL	TPB
Control - Edge	0	0	0.7	0.7
Center	0.7	0.7	0.7	0
Hercon - Edge	2.7	2.7	0.7	0
Center	0	0.7	2.0	0
Isomate - Edge	0	0	0	1.3
Center	0	1.3	0	0.5
3M - Edge	4.0	0.7	0	0
Center	2.0	0	0	0.7

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.

MULTI-SPECIES PHEROMONE DISRUPTION IN ORCHARDS UNDER A SELECTIVE PESTICIDE PROGRAM

Art Agnello, Jan Nyrop, Harvey Reissig, and Dick Straub, Entomology, NYSAES, Geneva

Research sites were set up 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). Each research site was a "split-plot design" in which the entire block received a program of reduced risk insecticides, and a 5-A portion of the block was additionally treated with pheromones for mating disruption of the later summer 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 grower selection and appropriate seasonal interactions was taken by Cornell PI's or field extension personnel (K. Iungerman). Materials used in the blocks receiving a soft pesticide program included: Apollo or dormant oil plus Pyramite (as needed) for mites, Avaunt for early season pests (including spotted tentiform leafminer, plum curculio and tarnished plant bug) and apple maggot plus internal Lepidoptera, and Confirm and SpinTor for leafrollers. All sprays were applied by the grower.

From April 16–30, Trécé Pherocon IIB pheromone traps were hung in all three plots at each commercial orchard site as follows: a CM , OFM, and an 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 Soft Pesticides, Pheromone+Soft Pesticides, and Comparison blocks at each site. Also, additional CM and OFM trap groups were placed in two trees situated halfway between each end tree and the center tree in the Pheromone+Soft Pesticides block, to make a total of five trapping stations for this treatment, and three trapping stations in the remaining two treatments. All traps were checked and cleaned weekly until mid-August, and lures were changed during the first two weeks of July. From June 21–July 9, polyethylene pheromone tie dispensers were hung in the Pheromone+Soft Pesticides blocks at each site, using two products to disrupt two separate moth species: Isomate C+ at 400 ties/A for codling moth, and Isomate M-100 at 100 ties/A for oriental fruit moth. 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. Time requirements for deploying the pheromone ties (500 per acre) were as follows:
Hand-applied: 1.4 hr/A/person (or 0.8 A/hr/person); 422 ties/hr/person
Pole+hoop: 3.8 hr/A/person (or 0.3 A/hr/person); 136 ties/hr/person

From July 22–26, fruit was examined for internal larval feeding damage in each block 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 block, 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. All fruits were inspected for damage caused by diseases and insects, including the three internal Lepidoptera species.

Pheromone trap catches from around the state revealed unanticipated population patterns 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 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, however, was 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 100 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, however, the application of pheromone ties appeared to suppress trap catches of not only the two target species (CM and OFM), but also LAW, at levels at or near zero for the remainder of the 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 soft pesticide blocks, with or without pheromones, and the grower standards. Some distinct differences did occur among the stratified samples taken within respective blocks, so that for instance, localized damage of up to 8–13% was noted along a specific orchard edge in two cases. 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, Emily Fitzgibbons, Laura Gillespie, Bruce Wadhams, Rachel Mussack, David Whelan, Peter Jentsch, Tim Mallet and Rebecca Habernig. We are grateful for support and material received from CBC America Corp., Dow AgroSciences and Makhteshim Agan. 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 soft pesticides, soft pesticides only, or under the grower's standard management program. 2002

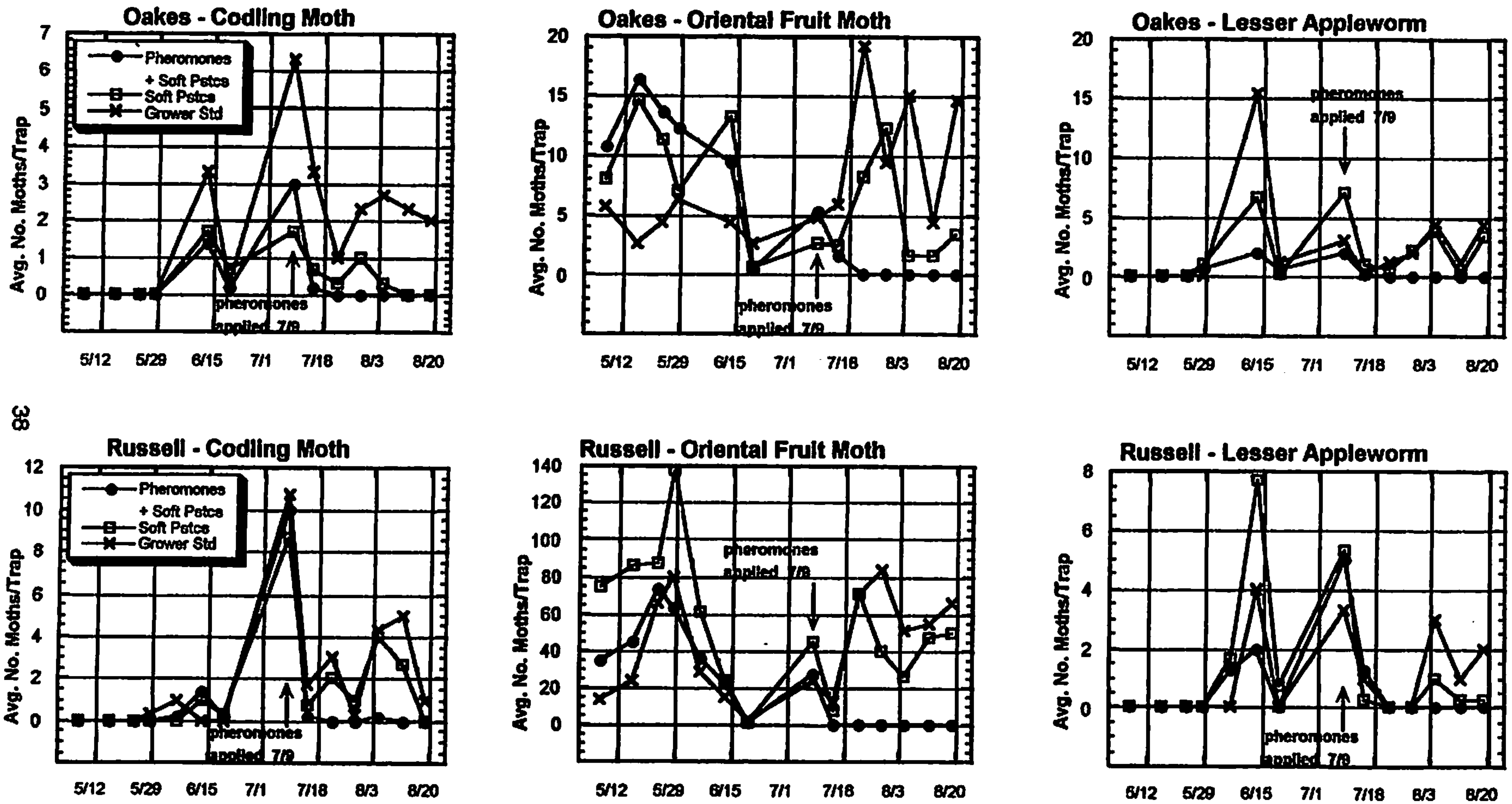


Fig. 2. Pheromone trap catches of internal lepidopteran moth pests in Eastern N.Y. apple orchards receiving a program of pheromones plus soft pesticides, soft pesticides only, or under the grower's standard management program. 2002

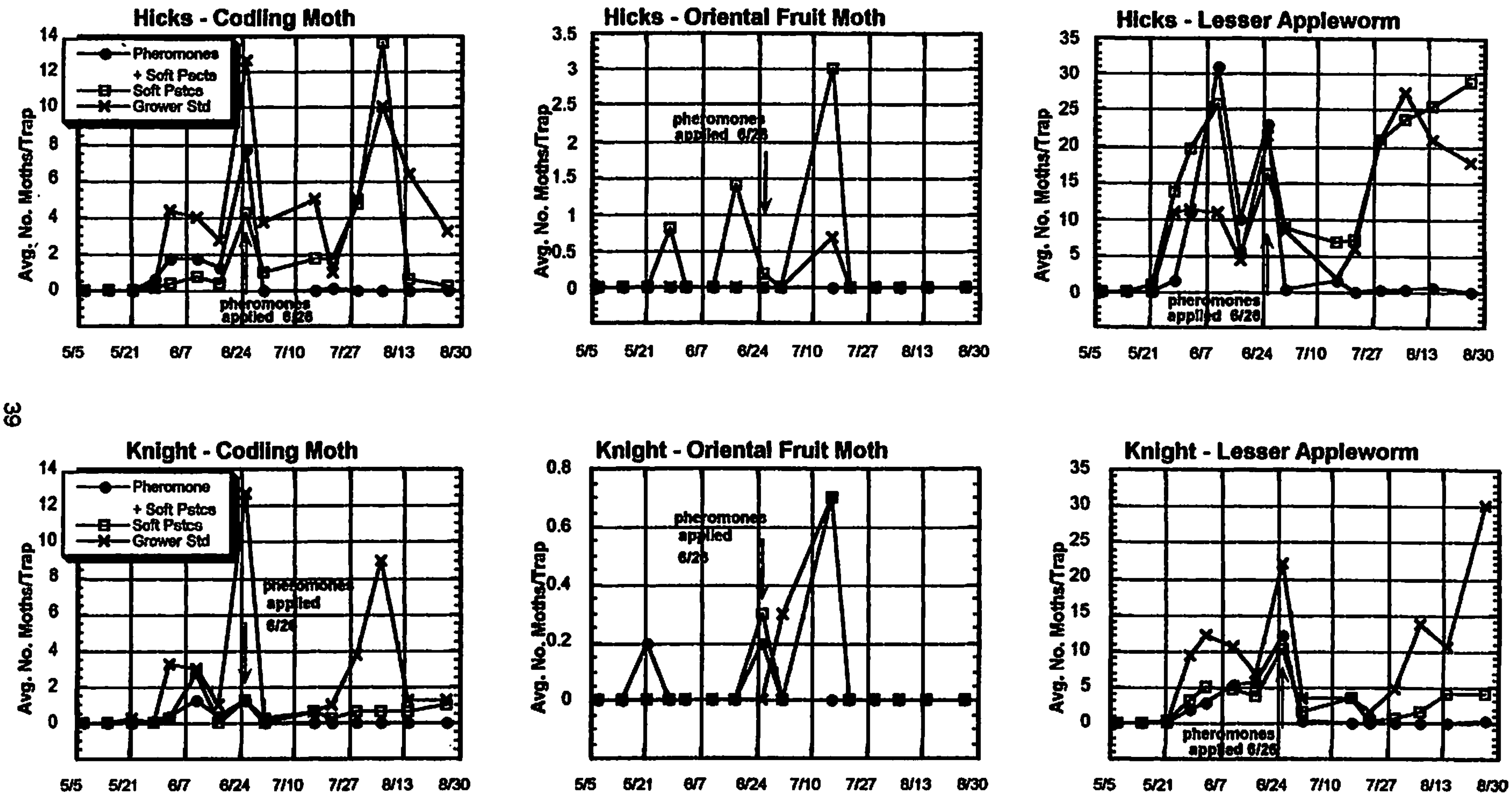


Table 1. RAMP plots 2002, summary of Internal Lep Fruit Damage

		Mean % fruit damage	
Orchard	Treatment	Internal Leps	
		July 22-26	Harvest
Apple	Pher+Soft Pstc	0.8	0.19
Acres	Soft Pstc	1.2	0.00
	Grower Std	0.5	0.00
Beak &	Pher+Soft Pstc	0.7	0.00
Skiff	Soft Pstc	-	0.03
	Grower Std	0.3	0.00
Brown	Pher+Soft Pstc	0.2	0.07
	Soft Pstc	-	0.19
	Grower Std	0.5	0.28
Burnap	Pher+Soft Pstc	0.2	0.00
	Soft Pstc	0.0	0.00
	Grower Std	0.0	0.00
Chazy	Pher+Soft Pstc	0.0	0.14
	Soft Pstc	-	0.07
	Grower Std	0.0	0.07
Datthyn	Pher+Soft Pstc	0.0	0.00
	Soft Pstc	-	0.00
	Grower Std	0.0	0.00
Forrence	Pher+Soft Pstc	0.0	0.00
	Soft Pstc	-	0.00
	Grower Std	0.0	0.22
Furber	Pher+Soft Pstc	0.2	0.19
	Soft Pstc	-	0.00
	Grower Std	0.0	0.00
Hicks	Pher+Soft Pstc	0.0	3.19
	Soft Pstc	0.0	0.76
	Grower Std	0.0	0.00
Knight	Pher+Soft Pstc	0.0	0.07
	Soft Pstc	-	0.00
	Grower Std	0.0	0.00
Lamont	Pher+Soft Pstc	0.0	0.00
	Soft Pstc	-	0.14
	Grower Std	0.3	0.19

		Mean % fruit damage	
Orchard	Treatment	Internal Leps	
		July 22-26	Harvest
Oakes	Pher+Soft Pstc	0.0	0.00
	Soft Pstc	-	0.19
	Grower Std	0.2	0.56
Russell	Pher+Soft Pstc	0.0	0.56
	Soft Pstc	-	0.37
	Grower Std	0.2	0.24
Trammel	Pher+Soft Pstc	0.3	1.12
	Soft Pstc	-	3.68
	Grower Std	0.3	3.09
Means	**Pher+Soft Pstc**	**0.17 a**	**0.40 a**
	Soft Pstc	**0.40 a**	**0.25 a**
	Grower Std	**0.16 a**	**0.33 a**

Means followed by the same letter not signifcantly different (P = O.05, Fisher's Protected LSD test).

Values transformed by arcsine-square root before analysis.

Not for Citation or Publication
Without Consent of the Authors

HAS THE WORM TURNED ?: INTERNAL LEPIDOPTERA DAMAGE IN NEW YORK APPLES, 2002

Harvey Reissig, Arthur Agnello and Jan Nyrop
Department of Entomology, NYSAES, Geneva, NY 14456

Ever since the introduction of organophosphate insecticides in the late 1950's control of the complex of lepidopteran larvae that are classified as internal feeders in apple, codling moth,*Cydia pomonella*, oriental fruit moth *Grapholita* molesta, and the lesser appleworm *Grapholita prunivora*, in NY apple orchards has been excellent. In general, damage levels from this pest complex in commercial apple orchards throughout NY State has been so low that it has been unusual to find even a single damaged apple at harvest no matter how many fruits were sampled. Although growers had observed excessive damage from oriental fruit moth larvae in peaches in Niagara county in NY for the last 5 years, this type of extensive damage from internal lepidoptera had not been widely observed in commercial apple orchards until the 2001 growing season. At present, excessive infestations of internal lepidopterous larvae have only been observed in orchards in the western NY production area. No problems have yet been reported from othe major production areas, the Champlain Valley, Hudson Valley, Lafayette area, and the Saratoga region and Washington County orchards.

During the 2001 growing season, Cadbury Schweppes, the largest apple processor in western NY, rejected approximately 20 loads of apples because of excessive infestation levels of internal lepidopteran larvae. During the 2002 season the problem became more severe and pervasive and more than 80 loads of apples from approximately 42 growers were rejected. Unacceptable damage was observed in a wide range of processing apple cultivars including: Rhode Island Greenings (12 loads), Monroe (12 loads), Cortland (7 loads), Idared (7 loads), Johagold (6 loads), Rome (4 Loads) and Golden Delicious, Ben Davis, and Empire (< 4 loads). In subsequent informal inspections of orchards on farms from which apple loads had been rejected, lepidopteran larval damage in fruit on trees was commonly observed in most cultivars of apples except McIntosh, which appeared to be one of the least preferred varieties.

Fruit inspectors at apple processing plants cut a sample of apples from each load received and the entire load is rejected as soon as at least one live worm is found in sampled fruit. It is impossible to quantify infestation levels using this type of monitoring system. Therefore, the authors sampled both harvested apples from bins and also monitored fruit on trees from selected farms that had loads rejected in order to estimate actual damage levels in problem orchards. Although levels of fruit infestation varied widely among different bins sampled from rejected truck loads, whenever multiple samples were taken from the same bin damage levels were remarkably similar. In general, infestation levels averaging from 5-10 % were observed either in bins or in fruit sampled on trees in which fruit was consistently rejected by the processor. Informal observations conducted throughout the harvest season in Western apple orchards revealed that 3-4 orchards had very severe levels of damage (30-40%) from internal lepidoptera; approximately 40-50 growers had from 1-10 % infestation levels. In addition, at least a few infested apples were observed in several growers' orchards although the average damage levels were less than 1% and apparently undetectable by normal fruit inspections of fruit marketed for either fresh or processing consumption.

Of the 677 worms that were dissected from infested apples collected from 20 problem orchards; 72% had anal combs and are presumed to be either lesser appleworms or oriental fruit moths; 21 % did not have anal combs and are presumed to be codling moths; and 7% could not be identified. Adequate samples of larvae (25-50) were actually collected from 10 sites in commercial orchards. All of the larvae from 5 of these orchards had anal combs. The majority of larvae from 4 of the rest of the orchards had anal combs, but 3-15 % did not have anal combs. In only one site, 95% of the larvae had no anal combs, and are therefore presumed to be predominantly codling moth. Additional studies of larvae from each site with anal combs will be conducted to determine if these populations have a mixture of the two species (oriental fruit moths or lesser appleworm).

Future studies will be conducted during the 2003 growing season to continue to identify internal worms infesting apples in NY in different orchards in Western NY at various times throughout the growing season and at harvest.

Mating Disruption of Grape Berry Moth - 2002

Douglas G. Pfeiffer
Department of Entomology, Virginia Tech, Blacksburg, VA 24061

I. Introduction: Mating disruption has been performed for grape berry moth (GBM) in Virginia since 1990. Most work done previously in this system has been performed in vineyards in New York and other northern areas (Dennehy et al. 1990; Trimble et al. 1991). The technique has worked fairly well in Virginia but with some exceptions that confirm the need for regional testing. In 2000, high infestation rates by GBM in mating disruption blocks (as well as most conventionally managed blocks) raised concern that perhaps the first flight must be targeted by disruption, instead of waiting for the second (first post-bloom) flight. This trial compares the two placement timings, as well as two disruption technologies.

II. Materials and Methods: Rope timing study: In a vineyard in Nelson County, Shin Etsu dispensers were placed at 30 April (before the first flight) and on 5 Jun (just before the second flight). Each treated block was about 1.6 ha. Several times during the season (21 Jun, 19 Jul, 13 Aug), injury in the pheromone-treated blocks was evaluated by examining 200 clusters per treatment were examined on the vine, quantifying percent injured clusters. Harvest injury was estimated by harvesting 4 clusters from each of 5 vines per section (edge and middle of each treatment block). Clusters were returned to Blacksburg, where berries were removed from the rachis and injured berries counted.

GBM Sprayable trial: A vineyard block in Fauquier County was treated with 3M sprayable grape berry moth pheromone on 19 Jun and 3 Jul. A nearby conventionally managed block was treated with Confirm (tebufenozide) on 11 and 21 Jul. At harvest time, 4 clusters per vine were collected from each of 5 vines per section (edge and middle of each treatment block). Clusters were brought to Blacksburg for dissection.

III. Results and Discussion: Harvest fruit injury data from the placement timing trial revealed low GBM injury in both blocks. The early placement resulted in 0.27 % injured berries in the edge and 0% injured berries in the block center (22.2% and 0% injured clusters, respectively). The late placement resulted in 0.19% injured berries in the edge and 0.10% injured berries in the block center (17.6 and 10.0 % injured clusters, respectively). The two placement timings of rope dispensers provided equivalent control.

The sprayable formulation of GBM pheromone appeared to give effective control in 2002. The sprayable pheromone resulted in 0.05% injured berries in the edge and 0.12% injured berries in the block center (5% and 10% injured clusters, respectively). The Confirm treatment resulted in 0.62% injured berries in the edge (25% injured clusters) and 0% injured berries in the block center.

IV. References Cited:

Dennehy, T.J., W.L. Roelofs, E.F. Taschenberg & T.N. Taft. 1990. Mating disruption for control of grape berry moth in New York vineyards, pp. 223-240. *In* R.L. Ridgeway, R. N. Silverstein & M.N. Inscoe [eds.]. Behavior-Modifying Chemicals for Insect Management: Applications of Pheromones and Other Attractants. Marcel Dekker, N.Y.

Trimble, R.M., D.J. Pree & P.M. Vickers. 1991. Potential of mating disruption using sex pheromone for controlling the grape berry moth, *Endopiza viteana* (Clemens) (Lepidoptera: Tortricidae), in Niagara Peninsula, Ontario vineyards. Can. Entomol. 123:451-460.

COMMERCIAL USE OF REDUCED RISK AND MATING DISRUPTION IN NEW JERSEY PEACH PRODUCTION 2002

Dean Polk[1], Peter Shearer[2], Atanas Atanasov[2], George Hamilton[3], Robin Brumfield[4], and David Schmitt[5]

Rutgers Cooperative Extension, [1]Rutgers Fruit R&E Center, 283, Rt 539, Cream Ridge, NJ 08514, [2]Rutgers Agricultural Research & Extension Center, 121 Northville Rd., Bridgeton, NJ 08302, [3]Dept. of Entomology, 93 Lipman Dr., Rutgers University, New Brunswick, NJ 08901, [4]Dept. of Agricultural Economics, 55 Dudley Rd., Rutgers University, New Brunswick, NJ 08901, [5]Rutgers Cooperative Extension of Gloucester County, 1200 N. Delsea Dr., Clayton, NJ 08312

Results from various mating disruption and ground cover projects have been previously reported at earlier CSFW conferences. The use of a 'Reduced Risk (RR)' approach that combines the use of turf ground cover to manage catfacing insects and mating disruption for oriental fruit moth has also been discussed. These practices were used together commercially, in a multiyear project. This report summarizes the second year's results for 2002.

The objectives of this project are to: 1) Demonstrate the Reduced Risk Arthropod Management Program on commercial peach farms using side by side comparisons, 2) Determine the reductions in insecticide use and food residues for the Reduced Risk Program compared to conventional programs, and 3) Determine true costs of the Reduced Risk Program while developing budget enterprise sheets for early, mid and late season varieties. This is a progress report that covers highlights from commercial experiences during the second season of data collection.

Methods

We selected 4 varieties that represented early, mid, and late season picking dates. These were Redhaven (averages July 27-August 3), John Boy (August 4-10), Bounty (August 11-18), and Encore (September 3-10). Varieties tended to ripen 1 to 2 weeks earlier in 2002 than they did in 2001. Nine growers provided plantings such that a RR block could be compared to a separate block under conventional (conv.) insecticide use, or a large planting that was split between RR and conv. practices. One grower set was dropped in 2002, leaving eight participants with two John Boy replicates. RR block size ranged from 3 to 15 acres (avg. 6.7 acres), with similar acreage in conventional practices. Data was collected from 24 blocks, with RR practices on just over 66 acres. Hard fescue ground cover was established in RR blocks during the fall of 2000 on 3 farms, and had already been established on 2 other farms. The 3 other growers used K-31 tall fescue, 2 of whom had fescue established in both RR and conv. blocks. Herbicides were used to maintain pure fescue stands in all established RR plantings.

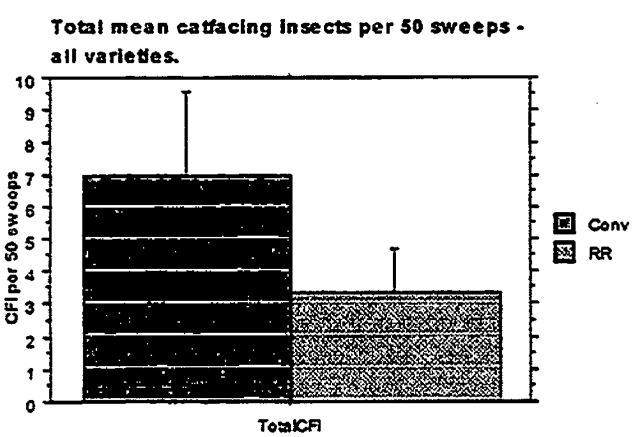
Our objective in controlling OFM with mating disruption dispensers was to disrupt generations 2 through 4, while allowing for normal pruning activities between March and late May. This also permitted insecticide treatments to be applied for early season management of tarnished plant bugs and stink bugs, as well as coverage for 1st generation OFM. In 2002 pheromone dispensers were placed in RR plantings between

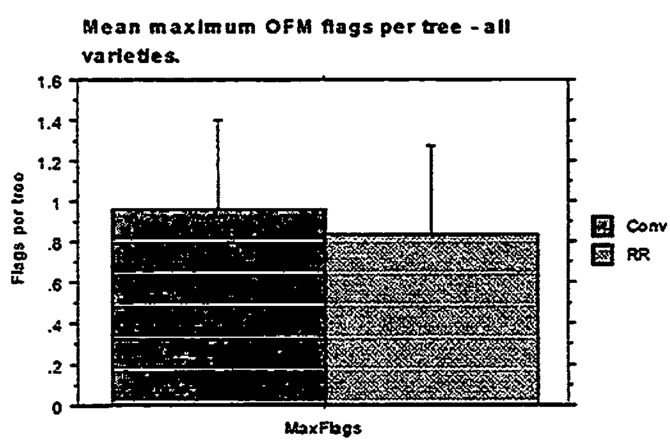
May 6 to May 12, or just after the first flight peak, but prior to any 2nd flight emergence. One grower with John Boy delayed placement until May 21 to May 27. Isomate-M 100 (Shin Etsu) (243.8 mg a.i. per dispenser) were placed at the rate of 100 ties per acre in Redhaven and John Boy plantings. Isomate-M Rosso (264.3 mg a.i. per dispenser) were placed at the rate of 200 ties per acre in Bounty and Encore plantings. In 2002 two of the Encore sets were split such that the RR treatments were divided into two treatments - a 200 dispenser per acre and a 150 dispenser per acre treatment. All Encore RR plots had been under mating disruption for the previous 3 years. All other plots had not previously been under mating disruption programs until 2001.

All plantings were scouted every 7 days for arthropods and disease incidence. OFM pheromone traps were placed to monitor male emergence (conv.) and trap shut down (RR). OFM larval populations were monitored by examining the number of flags present per tree, as well as any damage present (from all insects and disease) on developing fruit. Tarnished plant bug and stink bugs were monitored with sweep net sampling, as well as beating trays. Random at-harvest fruit samples were taken in all plantings for the presence of all insect and disease damage. At harvest samples consisted of 3 - 100 fruit samples taken from each plot for a total of 7,200 fruit sampled. Grower pesticide use records were collected at the end of the season and analyzed for comparative pesticide use. Actual use was analyzed and compared to suggested retail prices for various insecticides. Growers were also asked to maintain records for all labor time and other production expenses associated with establishing and maintaining turf ground cover and dispenser placement (but not examined here).

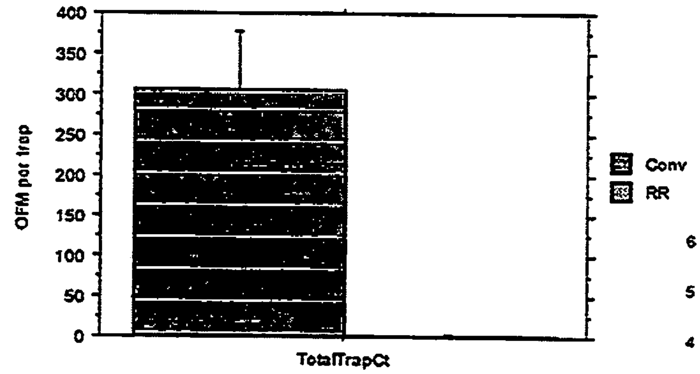
Results

Catfacing insects and other in-season measurements –



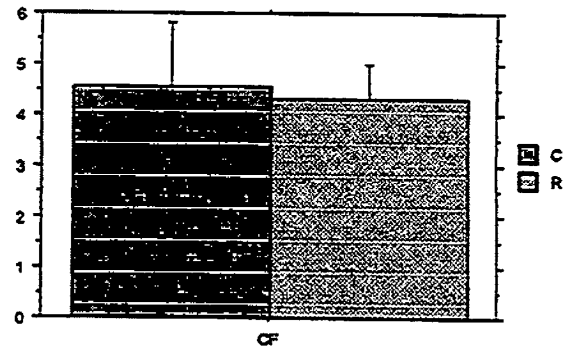


Mean total OFM trap captures - all varieties.

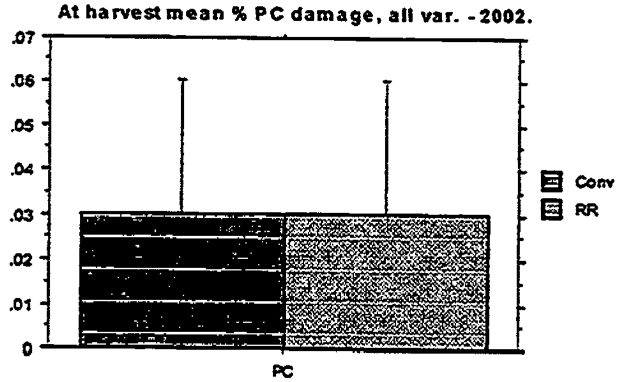


At Harvest Ratings –

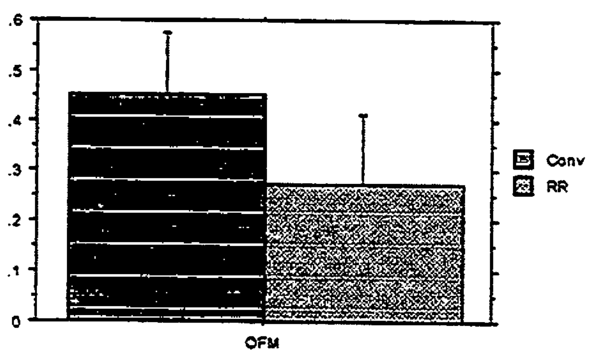
At harvest mean % catfacing damage, all var. - 2002.



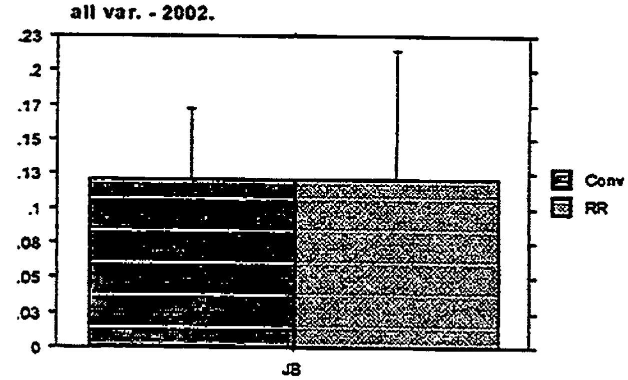
At harvest mean % PC damage, all var. - 2002.

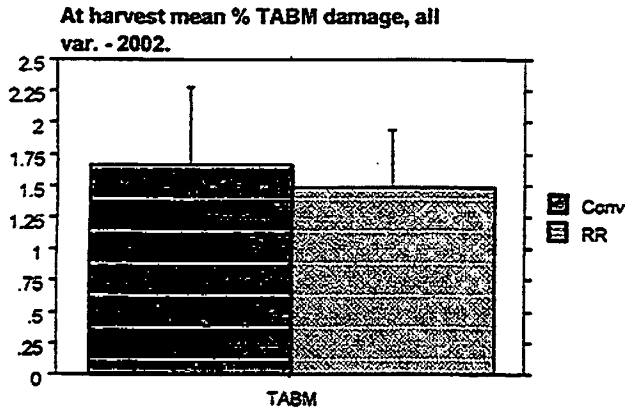


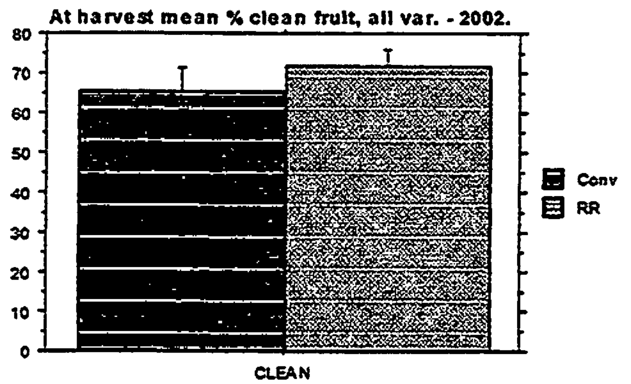
At harvest mean % OFM damage, all var. - 2002.



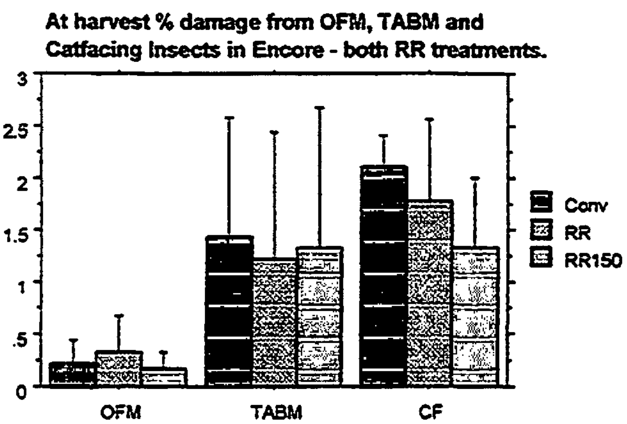
At harvest mean % Japanese beetle damage, all var. - 2002.

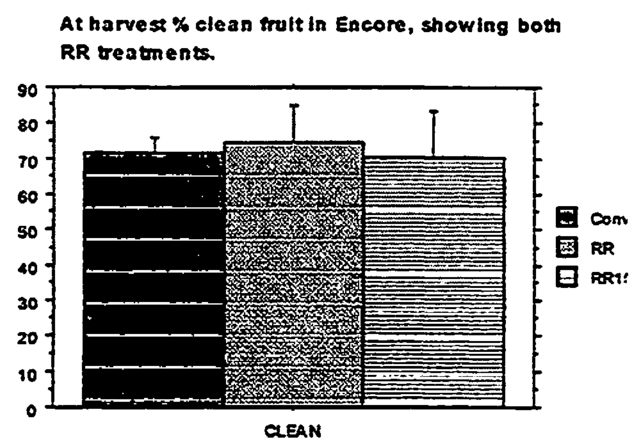






Pesticide Use –





Insecticide use compared between treatments and varieties.

Variety	Trt	No. Appl. Full Cov. Eq.	Total Form. Amt Per Ac (lb, pt)	Total AI Amt per Ac (lb, pt)	AI Difference
RH	Conv	5.50	14.26	4.79	
RH	RR	3.50	8.75	2.78	2.01
JB*	Conv	6.25	17.79	4.85	
JB	RR	4.50	13.29	3.33	1.51
Bo	Conv	6.17	17.03	4.58	
Bo	RR	4.00	10.25	2.87	1.71
Enc	Conv	10.17	22.16	6.09	
Enc	RR	5.50	9.86	2.46	3.63

*= 2 farms

Insecticide costs between treatments and varieties.

Variety	Trt	Total Avg Cost/Ac	Cost Difference
RH	Conv	$62.49	
RH	RR	$31.59	$30.90
JB*	Conv	$86.75	
JB	RR	$58.31	$28.44
Bo	Conv	$75.35	
Bo	RR	$41.64	$33.71
Enc	Conv	$152.10	
Enc	RR	$90.75	$61.35

* = 2 farms   Avg. Savings = $38.60

Both conventional and reduced risk treated blocks had populations of tamished plant bugs and other catfacing insects. Populations as measured by sweep sanples were slightly higher in concentionally managed blocks than in the reduced risk sections, although the difference was not significant at P=.05. There was a low level of OFM flagging in all plots with no differences between treatments. Conventional and RR blocks never averaged more than just under 1 flag per tree. OFM trap captures were virtually shut down after dispenser placement, with total trap captures averaging just over 300 moths compared to 2 moths in the RR treatments.

Evaluations of mature fruit showed that both Conv. and RR blocks experienced problems with catfacing and tufted apple budmoth feeding injury. While these insects were problematic on several farms, there were no differences between treatments. The percent clean fruit was virtually the same between treatments, although numerically higher values were associated with the RR blocks, possibly corresponding to the reduced number of sprays used and possible reduced spray injury. Fruit quality as influenced by major insect pests and % clean fruit was the same among Conv., RR and RR 150 dispenser blocks. These two blocks had very low OFM pressure. After several years of mating disruption and reduced pressure, a reduced rate of 150 dispensers per acre of Isomate M Rosso may be sufficient.

Overall a.i. insecticide use in RR plots was about 43% less than that used in conventional blocks. Savings varied by grower and the variety grown. Some growers reduced a.i. use by 80% while others reduced use only by about 20% compared to their conventional blocks. Insecticide costs were reduced by an average of almost $39 per acre, but varied between $21 to $83 per acre. Growers with Encore blocks tended to use more in conventional blocks and therefore realize greater reductions in insecticide costs.

Not for Citation or Publication
Without Consent of the Authors

REDUCED RISK MANAGEMENT PROGRAM FOR KEY PESTS IN NEW JERSEY PEACH ORCHARDS

Atanas Atanassov and Peter Shearer
Rutgers, The State University of New Jersey, Rutgers Agricultural Research & Extension Center
121 Northville Road, Bridgeton, NJ 08302-5919

Introduction

In 2002, we implemented a peach Reduced Risk (non-organophosphate, non-carbamate) program to control *Grapholita molesta* (Busck), Oriental fruit moth (OFM); *Platynota idaeusalis* (Walker), tufted apple bud moth (TABM); *Lygus lineolaris* (Palisot de Beauvois), tarnished plant bug and various stink bugs, collectively called catfacing insects (CF); and *Conotrachelus nenuphar* (Herbs), plum curculio (PC). Evaluation of the Reduced Risk program was based on pheromone trap captures of male OFM, abundance of CF and beneficial insects, and shoot and fruit injury compared with adjacent conventionally farmed peach orchards.

The objectives of this study were to determine the effectiveness of reduced-risk tactics for managing key peach pests and to measure changes in biological systems resulting from use of reduced-risk tactics.

Materials and Methods

This study was conducted in eight commercial orchards on two farms in Cumberland County (Grower 1 and 2) and one farm in Camden County (Grower 3), New Jersey in 2002 (Table 1). Male OFM moths were monitored weekly with delta traps baited with standard *G. molesta* pheromone lures (0.11 mg / lure) (Scenturion, Clinton, WA). Two traps per block were used. Lures were changed every 5 weeks; trap bottoms were replaced when needed. Levels of shoot infestations were determined for 1st, 2nd, and 4th OFM generation by checking 10 interior and 10 border trees in each block. Two or more observations per generation were made. Seasonal fruit damage was evaluated weekly until harvest for each variety by checking 200 fruit per block (10 fruit / 10 interior and 10 border trees). Only damaged fruit were brought to the laboratory for further analysis. Harvest fruit damage was evaluated by checking 600 fruit per block (20 fruit / 10 interior and 20 border trees). Catfacing numbers were assessed weekly until harvest by 4 x 25 sweeps per block. Beneficial insects were monitored in intervals of 7-15 days until harvest by three-minute-observations of peach canopies (10 trees per block).

Results

The arthropod management programs applied during this study are presented in Tables 2, 3, 4. Organophosphate use was strongly diminished in Reduced Risk blocks when compared with conventional programs. Reduced Risk orchards used esfenvalerate for PC, CF, and 1st generation OFM control. Mating disruption (OFM 3M Sprayable pheromone) was then applied against the 2nd-4th OFM flights. The program used spinosad against TABM. Azinphosmethyl was applied to PC after insufficient control of esfenvalerate was recorded. Then, in Grower 3 orchards, OPs were applied to both Reduced Risk and conventional blocks until harvest due to high plum curculio pressure. Conventional orchards used esfenvalerate, azynphosmethyl, phosmet, and methomyl for control of target pests. As an exception, spinosad was applied to orchards with a history of TABM infestations ("Cresthaven", Flaming Raymond", and "Encore" varieties). Both programs used imidacloprid against aphids when needed.

The mating disruption treatments suppressed trap capture of male OFM for most of the season (Figs. 1, 2, 3, 4, 5, 6, 7, 8). Few OFM damaged shoots were observed in both Reduced Risk and conventional program orchards (Table 5). Shoot injury was recorded in both border and interior trees only in Flaming Raymond orchard (Grower 2) and as well in Grower 3 orchards with a history of high population pressure (mostly "PF 17" variety) but the percentage of injury was low.

Early season PC fruit injury was observed in all the orchards (Fig. 9, 10, 11). It was obvious that four alternate row middle sprays of esfenvalerate did not adequately control PC. This was the first time PC damage observed in Grower 1 and 2 orchards. "Encore" orchards of Grower 3 were more heavily infected and this Grower had already history of PC larvae in fruit at harvest. At harvest, PC damaged fruit were recorded in all the farms (Table 7). There was more fruit injury in border trees of both programs, particularly in those orchards close to woods.

Catfacing insects were the most damaging pests in the study. Levels of CF insects were variable and present in both program orchards with highest abundance recorded in Flaming Raymond orchard (Fig. 12). Tarnished plant bug was the predominant species in all the orchards throughout the season. For a short time, approximately ten days at the end of August that cover ripping period of late varieties this particular year, we recorded a sudden increase of dusky stink bug in the Flaming Raymond orchard. Ground cover in this orchard was not maintained properly. Most frequently, broadleaf weeds were predominant vegetation throughout the season. Very high percentage fresh stink bug fruit damage was recorded at harvest samples of this particular variety (Fig. 13). This finding was unexpected because the last seasonal fruit observation of this variety, a week before harvest samples, showed few catfacing fruit injury (Fig. 13). As a whole, catfacing damaged fruit were observed through the season in all varieties but they increased at harvest almost (Figs. 13, 14).

During the season, Oriental fruit moth and TABM fruit damage was recorded sporadically (Table 6). Practically no OFM damaged fruit were observed at harvest in both management program orchards (Table 7). Trace amount of TABM damage was detected in the border trees of six orchards. TABM was not a problem in orchard interiors.

Neuroptera eggs, larvae, and adults, Coccinellidae larvae, pupae, and adults, Anthocoridae nymphs and adults, Hymenoptera adults, Syrphidae adults, and Araneae (spiders) were monitored in both programs orchards. Neuroptera eggs, adult coccinelids and syrphids were the most frequently observed beneficial insects. Neuroptera eggs (mostly green lacewing eggs) were the most abundant in both RR and conventional orchards at the second half of the growing season (Fig. 15). As a whole, low numbers of natural enemies were observed in all the orchards (Fig. 16).

Conclusions

The Reduced Risk program provided excellent control of OFM and TABM. In general, CF control was not satisfactory in both RR and conventional orchards. We attributed CF damage to the weedy ground cover. Growers will be urged to maintain broadleaf weed-free orchards to minimize CF abundance and damage. Early season control of PC with esfenvalerate was not satisfactory. Applications of azinphosmethyl prevented further damage. We will recommend to our growers to use organophosphate early in the season to control PC to maintain populations at low levels through the season until new PC insecticides are registered. Numbers of beneficial insects were low in both program orchards and was mostly due to intensive use of pyrethroids.

Ackonowledgement

This study was supported by a grant received by the USDA CSREES Risk Avoidance and Mitigation Program (RAMP).

Table 1. Experiment design: 2002

Grower	Orchard / Variety	Approximate Acreage	
		Conventional	Reduced Risk
1	Cresthaven	1.0	9.0
2	Sentry	9.4	9.4
	Harcrest	7.4	7.4
	Flaming Raymond	15.7	15.7
3	PF 17	5.5	5.5
	PF 23	6.5	6.5
	Buddy's Pride	7.5	7.5
	Encore	9.5	9.5

Table 2. Dates and rates of various pest control products applied to Reduced Risk (RR) and Conventional (Conv.) "Cresthaven" peach orchard, Grower 1: 2002

Trade Name	Common Name	Rate / A[1]	Unit	Date of Application	RR	Conv
Diazinon 50 WP	Diazinon	3.0	lb	15-Mar	+	+
Guthion 50 WP	Azinphosmethyl	0.75	lb	16-Apr	+	+
Asana .66 XL	Esfenvalerate	2.0	fl oz	27-Apr	+	+
Guthion 50 WP	Azinphosmethyl	0.5	lb	27-Apr	+	+
Asana .66 XL	Esfenvalerate	2.5	fl oz	1-May	+	+
OFM 3M Sprayable		0.9	oz	2-May	+	
Guthion 50 WP	Azinphosmethyl	0.5	lb	11-May		+
Provado 1.6 FL	Imidacloprid	3.0	fl oz	11-May	+	+
Asana .66 XL	Esfenvalerate	5.0	fl oz	11-May	+	
Guthion 50 WP	Azinphosmethyl	0.5	lb	19-May		+
Provado 1.6 FL	Imidacloprid	2.0	fl oz	19-May		+
Provado 1.6 FL	Imidacloprid	3.0	fl oz	19-May	+	
Asana .66 XL	Esfenvalerate	5.0	fl oz	19-May	+	
Guthion 50 WP	Azinphosmethyl	0.5	lb	27-May		+
Spintor 2 SC	Spinosad	4.0	fl oz	29-May	+	
Imidan 70 WP	Phosmet	1.0	lb	8-Jun		+
Imidan 70 WP	Phosmet	1.0	lb	19-Jun		+
OFM 3M Sprayable		1.05	oz	8-Jun	+	
Spintor 2 SC	Spinosad	4.0	fl oz	8-Jun	+	
Imidan 70 WP	Phosmet	1.0	lb	24-Jun		+
OFM 3M Sprayable		1.05	oz	25-Jun	+	
Spintor 2 SC	Spinosad	4.0	fl oz	25-Jun	+	
Guthion 50W	Azinphosmethyl	0.5	lb	10-Jul		+
OFM 3M Sprayable		1.05	oz	12-Jul	+	
Spintor 2 SC	Spinosad	4.0	fl oz	12-Jul	+	
Guthion 50 WP	Azinphosmethyl	0.5	lb	19-Jul		+
OFM 3M Sprayable		0.5	oz	26-Jul	+	
Imidan 70 WP	Phosmet	1.0	lb	30-Jul		+
Spintor 2 SC	Spinosad	3.2	fl oz	30-Jul		+
OFM 3M Sprayable		0.5	oz	3-Aug	+	
Provado 1.6 FL	Imidacloprid	3.0	fl oz	3-Aug	+	

[1]All sprays alternate row middle, with an exception of the complete first date spray

Table 3. Dates and rates of various pest control products applied to Reduced Risk (RR) and conventional (Conv.) peach orchards, Grower 2: 2002

Orchard/ Variety	Trade Name	Common Name	Rate / A[1]	Unit	Date of Application	RR	Conv
Sentry	Asana .66 XL	Esfenvalerate	4.0	fl oz	16-Apr	+	+
	Provado 1.6 FL	Imidacloprid	2.5	fl oz	22-Apr	+	+
	Asana .66 XL	Esfenvalerate	4.0	fl oz	22-Apr	+	+
	Asana .66 XL	Esfenvalerate	4.0	fl oz	30-Apr	+	+
	Asana .66 XL	Esfenvalerate	4.0	fl oz	4-May	+	+
	Asana .66 XL	Esfenvalerate	4.0	fl oz	6-May	+	+
	Guthion 50 WP	Azinphosmethyl	0.5	lb	17-May	+	+
	Guthion 50 WP	Azinphosmethyl	0.5	lb	21-May	+	+
	Guthion 50 WP	Azinphosmethyl	0.5	lb	23-May	+	+
	OFM 3M Sprayable		1.25	oz	1-Jun	+	
	Asana .66 XL	Esfenvalerate	4.0	fl oz	2-Jun		+
	Asana .66 XL	Esfenvalerate	4.0	fl oz	9-Jun		+
	OFM 3M Sprayable		1.25	oz	10-Jun	+	
	OFM 3M Sprayable		1.25	oz	18-Jun	+	
Harcrest	Asana .66 XL	Esfenvalerate	4.0	fl oz	16-Apr	+	+
	Provado 1.6 FL	Imidacloprid	2.5	fl oz	22-Apr	+	+
	Asana .66 XL	Esfenvalerate	4.0	fl oz	22-Apr	+	+
	Asana .66 XL	Esfenvalerate	4.0	fl oz	30-Apr	+	+
	Asana .66 XL	Esfenvalerate	4.0	fl oz	4-May	+	+
	Asana .66 XL	Esfenvalerate	4.0	fl oz	6-May	+	+
	Guthion 50 WP	Azinphosmethyl	0.5	lb	17-May	+	+
	Guthion 50 WP	Azinphosmethyl	0.5	lb	21-May	+	+
	Guthion 50 WP	Azinphosmethyl	0.5	lb	23-May	+	+
	OFM 3M Sprayable		1.25	oz	1-Jun	+	
	Asana .66 XL	Esfenvalerate	4.0	fl oz	2-Jun		+
	Asana .66 XL	Esfenvalerate	4.0	fl oz	9-Jun		+
	OFM 3M Sprayable		1.25	oz	10-Jun	+	
	Asana .66 XL	Esfenvalerate	4.0	fl oz	17-Jun		+
	OFM 3M Sprayable		1.25	oz	18-Jun	+	
	Asana .66 XL	Esfenvalerate	4.0	fl oz	21-Jun		+
	Guthion 50 WP	Azinphosmethyl	0.5	lb	2-Jul		+
	OFM 3M Sprayable		1.25	oz	3-Jul	+	
	Asana .66 XL	Esfenvalerate	4.0	fl oz	11-Jul		+
	Guthion 50 WP	Azinphosmethyl	0.5	lb	21-Jul		+
	OFM 3M Sprayable		1.25	oz	24-Jul	+	
	Spintor 2 SC	Spinosad	3.5	fl oz	5-Aug	+	
	OFM 3M Sprayable		1.25	oz	9-Aug	+	

Table 3. Dates and rates of various pest control products applied to Reduced Risk (RR) and conventional (Conv.) peach orchards, Grower 2: 2002 (Cont.)

Orchard/ Variety	Trade Name	Common Name	Rate /A[1]	Unit	Date of Application	RR	Conv
Flaming	Asana .66 XL	Esfenvalerate	4.0	fl oz	19-Apr	+	+
Raymond	Provado 1.6 FL	Imidacloprid	2.5	fl oz	26-Apr	+	+
	Asana .66 XL	Esfenvalerate	4.0	fl oz	26-Apr	+	+
	Asana .66 XL	Esfenvalerate	4.0	fl oz	1-May	+	+
	Asana .66 XL	Esfenvalerate	4.0	fl oz	5-May	+	+
	Asana .66 XL	Esfenvalerate	4.0	fl oz	8-May	+	+
	Guthion 50 WP	Azinphosmethyl	0.5	lb	17-May	+	+
	Guthion 50 WP	Azinphosmethyl	0.5	lb	22-May	+	+
	Guthion 50 WP	Azinphosmethyl	0.5	lb	27-May	+	+
	OFM 3M Sprayable		1.25	oz	1-Jun	+	
	Asana .66 XL	Esfenvalerate	4.0	fl oz	2-Jun		+
	Asana .66 XL	Esfenvalerate	4.0	fl oz	8-Jun		+
	OFM 3M Sprayable		1.25	oz	10-Jun	+	
	Asana .66 XL	Esfenvalerate	4.0	fl oz	16-Jun		+
	OFM 3M Sprayable		1.25	oz	18-Jun	+	
	Asana .66 XL	Esfenvalerate	4.0	fl oz	21-Jun		+
	Guthion 50 WP	Azinphosmethyl	0.5	lb	30-Jun		+
	OFM 3M Sprayable		1.25	oz	3-Jul	+	
	Asana .66 XL	Esfenvalerate	4.0	fl oz	10-Jul		+
	Guthion 50 WP	Azinphosmethyl	0.5	lb	20-Jul		+
	OFM 3M Sprayable		1.25	oz	24-Jul	+	
	Asana .66 XL	Esfenvalerate	4.0	fl oz	3-Aug		+
	OFM 3M Sprayable		1.25	oz	4-Aug	+	
	Lannate 90 SP	Methomyl	0.375	lb	13-Aug		+
	Spintor 2 SC	Spinosad	3.5	fl oz	18-Aug	+	+

[1]All sprays alternate row middle

Table 4. Dates and rates of various pest control products applied to Reduced Risk (RR) and conventional (Conv.) peach orchards, Grower 3: 2002

Variety	Trade Name	Common Name	Rate/A [1]	Unit	Date of Application	RR	Conv
PF 17	Asana .66 XL	Esfenvalerate	4.0	fl oz	15-Apr	+	+
	Asana .66 XL	Esfenvalerate	4.0	fl oz	21-Apr	+	+
	Asana .66 XL	Esfenvalerate	4.0	fl oz	29-Apr	+	+
	Asana .66 XL	Esfenvalerate	4.0	fl oz	6-May	+	+
	Guthion 50 WP	Azinphosmethyl	0.5	lb	12-May	+	+
	Guthion 50 WP	Azinphosmethyl	0.5	lb	20-May	+	+
	OFM 3M Sprayable		1.25	oz	3-Jun	+	
	Spintor 2 SC	Spinosad	3.5	fl oz	3-Jun	+	
	Spintor 2 SC	Spinosad	3.5	fl oz	10-Jun	+	
	Guthion 50 WP	Azinphosmethyl	0.5	lb	1-Jul		+
	OFM 3M Sprayable		1.25	oz	1-Jul	+	
	Guthion 50 WP	Azinphosmethyl	1.0	lb	9-Jul	+	+
	Guthion 50 WP	Azinphosmethyl	1.0	lb	16-Jul	+	+
PF 23	Asana .66 XL	Imidacloprid	4.0	fl oz	14-Apr	+	+
	Asana .66 XL	Esfenvalerate	4.0	fl oz	24-Apr	+	+
	Asana .66 XL	Esfenvalerate	4.0	fl oz	29-Apr	+	+
	Asana .66 XL	Esfenvalerate	4.0	fl oz	6-May	+	+
	Provado 1.6 FL	Imidacloprid	2.5	fl oz	6-May	+	+
	Guthion 50 WP	Azinphosmethyl	0.5	lb	11-May	+	+
	Provado 1.6 FL	Imidacloprid	2.5	fl oz	11-May	+	+
	Guthion 50 WP	Azinphosmethyl	0.5	lb	21-May	+	+
	OFM 3M Sprayable		1.25	oz	3-Jun	+	
	Spintor 2 SC	Spinosad	3.5	fl oz	3-Jun	+	
	Spintor 2 SC	Spinosad	3.5	fl oz	10-Jun	+	
	Guthion 50 WP	Azinphosmethyl	0.5	lb	1-Jul		+
	OFM 3M Sprayable		1.25	oz	1-Jul	+	
	Guthion 50 WP	Azinphosmethyl	1.0	lb	9-Jul	+	+
	Guthion 50 WP	Azinphosmethyl	1.0	lb	16-Jul	+	+
	Imidan 70 WP	Phosmet	1.2	lb	24-Jul		+
Buddy's	Asana .66 XL	Esfenvalerate	4.0	fl oz	15-Apr	+	+
Pride	Asana .66 XL	Esfenvalerate	4.0	fl oz	23-Apr	+	+
	Asana .66 XL	Esfenvalerate	4.0	fl oz	29-Apr	+	+
	Asana .66 XL	Esfenvalerate	4.0	fl oz	6-May	+	+
	Provado 1.6 FL	Imidacloprid	2.5	fl oz	6-May	+	+
	Guthion 50 WP	Azinphosmethyl	0.5	lb	11-May	+	+
	Provado 1.6 FL	Imidacloprid	2.5	fl oz	11-May	+	+
	Guthion 50 WP	Azinphosmethyl	0.5	lb	20-May	+	+
	OFM 3M Sprayable		1.25	oz	3-Jun	+	

Table 4. Dates and rates of various pest control products applied to Reduced Risk (RR) and conventional (Conv.) peach orchards, Grower 3: 2002 (Cont.)

Variety	Trade Name	Common Name	Rate / A[1]	Unit	Date of Application	RR	Conv
	Spintor 2 SC	Spinosad	3.5	fl oz	3-Jun	+	
	Spintor 2 SC	Spinosad	3.5	fl oz	10-Jun	+	
	Guthion 50 WP	Azinphosmethyl	0.5	lb	1-Jul		+
	OFM 3M Sprayable		1.25	oz	1-Jul	+	
	Guthion 50 WP	Azinphosmethyl	1.0	lb	9-Jul	+	+
	Guthion 50 WP	Azinphosmethyl	1.0	lb	16-Jul	+	+
	Guthion 50 WP	Azinphosmethyl	1.0	lb	23-Jul	+	+
	Imidan 70 WP	Phosmet	1.2	lb	5-Aug		+
Encore	Asana .66 XL	Esfenvalerate	4.0	fl oz	14-Apr	+	+
	Asana .66 XL	Esfenvalerate	4.0	fl oz	21-Apr	+	+
	Asana .66 XL	Esfenvalerate	4.0	fl oz	29-Apr	+	+
	Asana .66 XL	Esfenvalerate	4.0	fl oz	7-May	+	+
	Guthion 50 WP	Azinphosmethyl	0.5	lb	11-May	+	+
	Provado 1.6 FL	Imidacloprid	2.5	fl oz	11-May	+	+
	Guthion 50 WP	Azinphosmethyl	0.5	lb	20-May	+	+
	OFM 3M Sprayable		1.25	oz	3-Jun	+	
	Spintor 2 SC	Spinosad	3.5	fl oz	3-Jun	+	
	Spintor 2 SC	Spinosad	3.5	fl oz	10-Jun	+	
	Guthion 50 WP	Azinphosmethyl	0.5	lb	1-Jul		+
	OFM 3M Sprayable		1.25	oz	1-Jul	+	
	Guthion 50 WP	Azinphosmethyl	1.0	lb	9-Jul	+	+
	Guthion 50 WP	Azinphosmethyl	1.0	lb	16-Jul	+	+
	Guthion 50 WP	Azinphosmethyl	1.0	lb	23-Jul	+	+
	Guthion 50 WP	Azinphosmethyl	1.0	lb	5-Aug		+
	Pyramite 60 WSP	Pyridaben	2.2	oz	8-Aug	+	+
	Imidan 70 WP	Phosmet	1.2	lb	8-Aug	+	+
	Spintor 2 SC	Spinosad	2.0	fl oz	8-Aug	+	+

[1]All sprays alternate row middle

Table. 5. Average seasonal number of OFM damaged shoots from the interior and border trees: 2002

Grower	Orchard / Variety	Mean no. ± SEM per tree			
		Reduced Risk		Conventional	
		Interior	Border	Interior	Border
1	Cresthaven	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
2	Sentry	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
	Harcrest	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
	Flaming Raymond	0.0 ± 0.0	0.1 ± 0.0	0.1 ± 0.0	0.0 ± 0.0
3	PF 17	0.2 ± 0.2	0.2 ± 0.1	0.1 ± 0.1	0.2 ± 0.2
	PF 23	0.0 ± 0.0	0.1 ± 0.1	0.0 ± 0.0	0.0 ± 0.0
	Buddy's Pride	0.0 ± 0.0	0.1 ± 0.1	0.0 ± 0.0	0.0 ± 0.0
	Encore	0.1 ± 0.1	0.1 ± 0.1	0.1 ± 0.0	0.3 ± 0.2

Table 6. Seasonal percent (mean ± sem) damaged fruit: 2002

Variety	Number of sample dates	Pest	Reduced Risk		Conventional	
			Interior	Border	Interior	Border
Sentry	7	OFM	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		TABM	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
PF17	9	OFM	0.0 ± 0.0	0.0 ± 0.0	0.1 ± 0.1	0.0 ± 0.0
		TABM	0.0 ± 0.0	0.0 ± 0.0	0.3 ± 0.2	0.0 ± 0.0
PF23	10	OFM	0.0 ± 0.0	0.1 ± 0.1	0.0 ± 0.0	0.0 ± 0.0
		TABM	0.1 ± 0.1	0.1 ± 0.1	0.1 ± 0.1	0.1 ± 0.1
Buddy's Pride	10	OFM	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		TABM	0.0 ± 0.0	0.3 ± 0.3	0.1 ± 0.1	0.0 ± 0.0
Encore	12	OFM	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		TABM	0.3 ± 0.3	0.3 ± 0.3	0.2 ± 0.2	0.2 ± 0.1
Cresthaven	12	OFM	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		TABM	0.1 ± 0.1	0.2 ± 0.1	0.1 ± 0.1	0.0 ± 0.0
Harcrest	14	OFM	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		TABM	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
Flaming Raymond	18	OFM	0.0 ± 0.0	0.0 ± 0.0	0.2 ± 0.2	0.0 ± 0.0
		TABM	0.1 ± 0.1	0.0 ± 0.0	0.1 ± 0.1	0.1 ± 0.1

Table 7. Percent (mean ± sem) damaged fruit at harvest: 2002

Variety	Harvest Date	Pest	Reduced Risk		Conventional	
			Interior	Border	Interior	Border
Sentry	1-Jul	OFM	0.0	0.0	0.0	0.0
		TABM	0.0	0.0	0.0	0.0
		PC	0.5	1.0	0.0	1.0
PF17	24-Jul	OFM	0.0 ± 0.0	0.3 ± 0.3	0.0 ± 0.0	0.0 ± 0.0
		TABM	0.0 ± 0.0	0.5 ± 0.3	0.5 ± 0.5	0.3 ± 0.3
		PC	0.5 ± 0.5	2.0 ± 0.8	1.5 ± 0.8	1.0 ± 0.5
PF23	5-Aug	OFM	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		TABM	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		PC	0.0 ± 0.0	0.5 ± 0.3	2.0 ± 1.1	2.0 ± 0.8
Cresthaven	7-Aug	OFM	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		TABM	0.0 ± 0.0	0.3 ± 0.3	0.0 ± 0.0	0.0 ± 0.0
		PC	0.5 ± 0.5	0.5 ± 0.3	0.5 ± 0.5	1.8 ± 0.7
Harcrest	9-Aug	OFM	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		TABM	0.0 ± 0.0	0.3 ± 0.3	0.0 ± 0.0	0.0 ± 0.0
		PC	0.0 ± 0.0	0.0 ± 0.0	0.5 ± 0.5	0.8 ± 0.4
Buddy's Pride	12-Aug	OFM	0.0 ± 0.0	0.3 ± 0.3	0.0 ± 0.0	0.0 ± 0.0
		TABM	0.0 ± 0.0	0.5 ± 0.3	0.0 ± 0.0	0.0 ± 0.0
		PC	1.0 ± 0.7	1.5 ± 0.5	1.0 ± 0.7	2.0 ± 0.6

Encore	20-Aug	OFM	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		TABM	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.5 ± 0.5
		PC	0.0 ± 0.0	3.8 ± 1.5	2.0 ± 1.1	2.8 ± 0.8
Flaming Raymond	4-Sep	OFM	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
		TABM	0.0 ± 0.0	0.3 ± 0.3	0.0 ± 0.0	0.0 ± 0.0
		PC	0.0 ± 0.0	1.0 ± 0.3	1.5 ± 0.7	0.3 ± 0.3

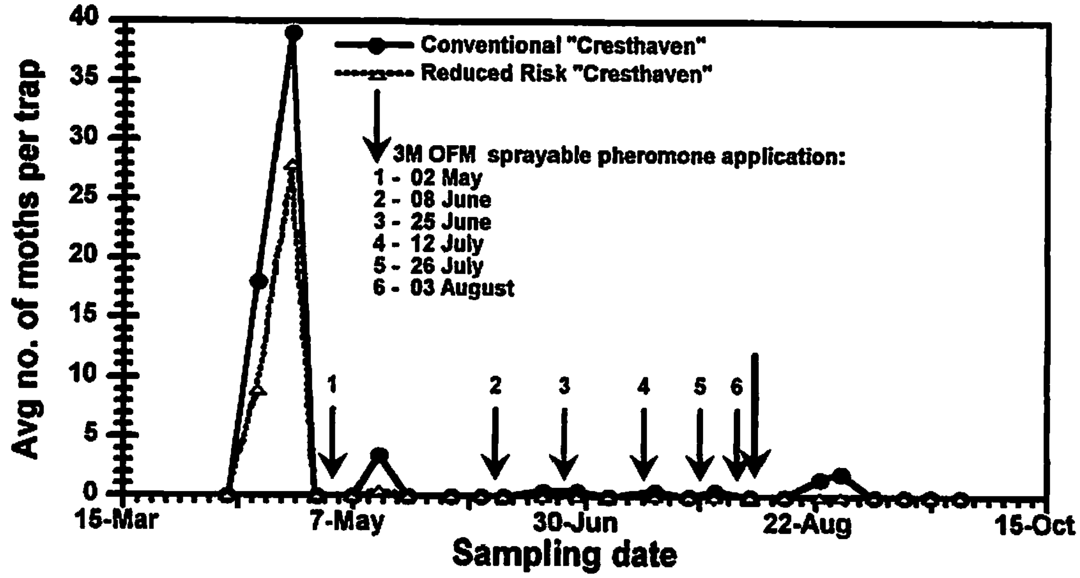


Fig. 1. Pheromone trap catches of Oriental fruit moth in the "Cresthaven" orchard, Grower 1: 2002.

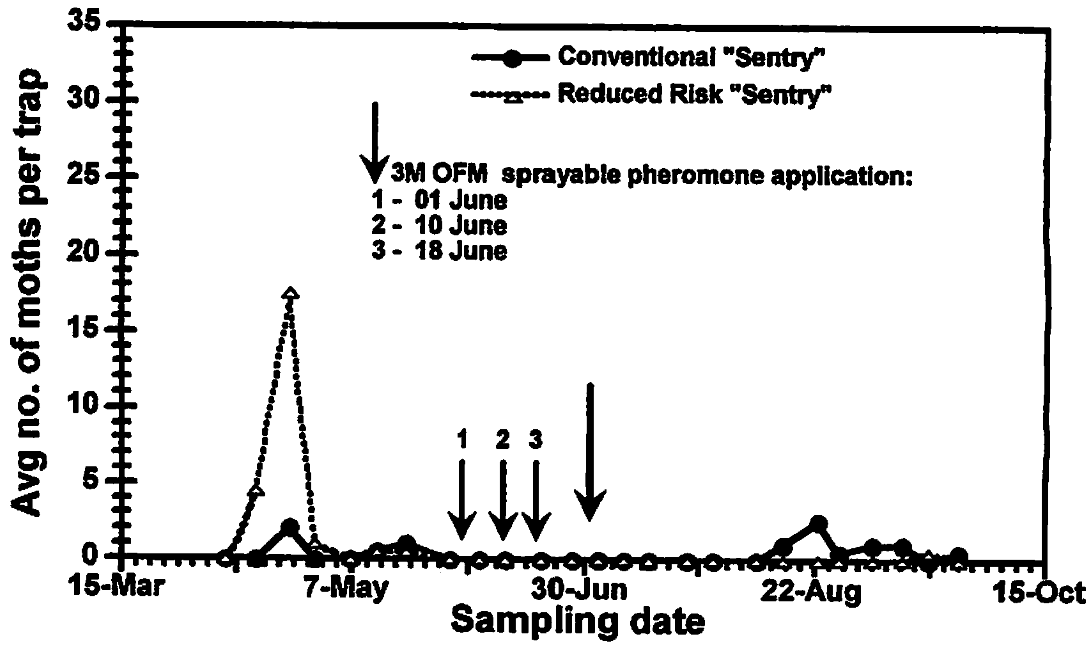


Fig. 2. Pheromone trap catches of Oriental fruit moth in the "Sentry" orchard, Grower 2: 2002.

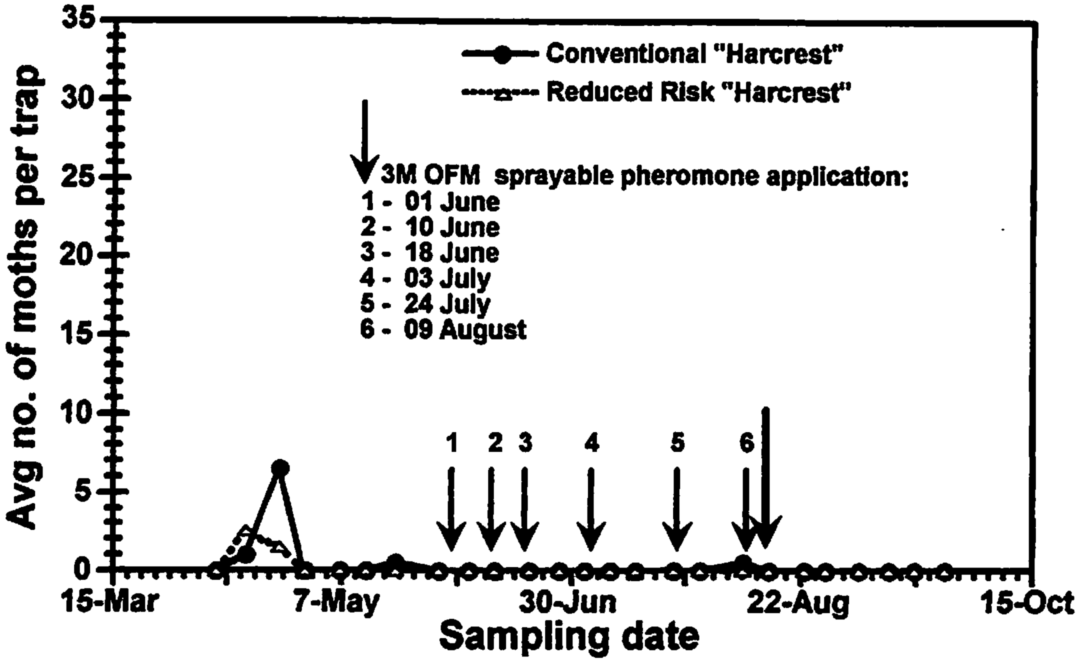


Fig. 3. Pheromone trap catches of Oriental fruit moth in the "Harcrest" orchard, Grower 2: 2002.

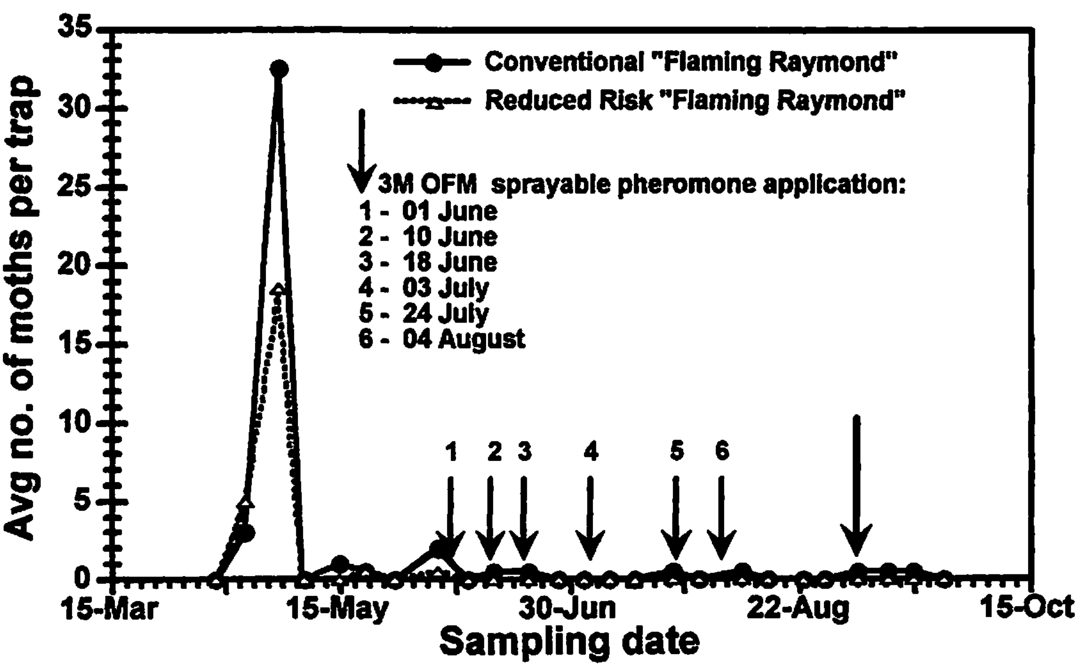


Fig. 4. Pheromone trap catches of Oriental fruit moth in the "Flaming Raymond" orchard, Grower 2: 2002.

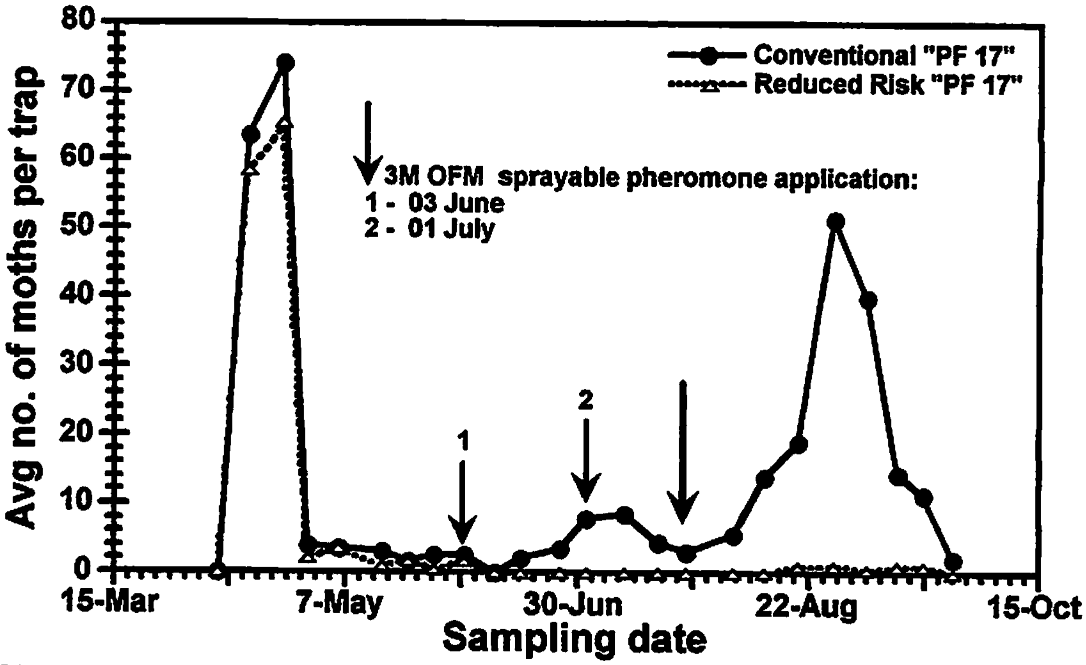


Fig. 5. Pheromone trap catches of Oriental fruit moth in the "PF 17" orchard, Grower 3: 2002.

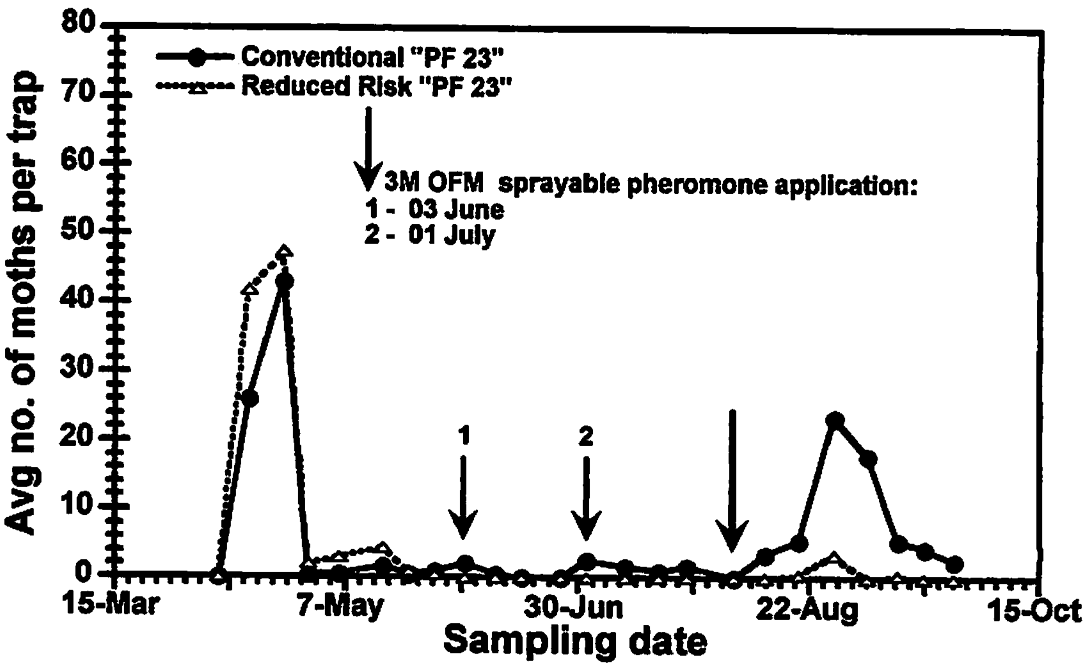


Fig. 6. Pheromone trap catches of Oriental fruit moth in the "PF 23" orchard, Grower 3: 2002.

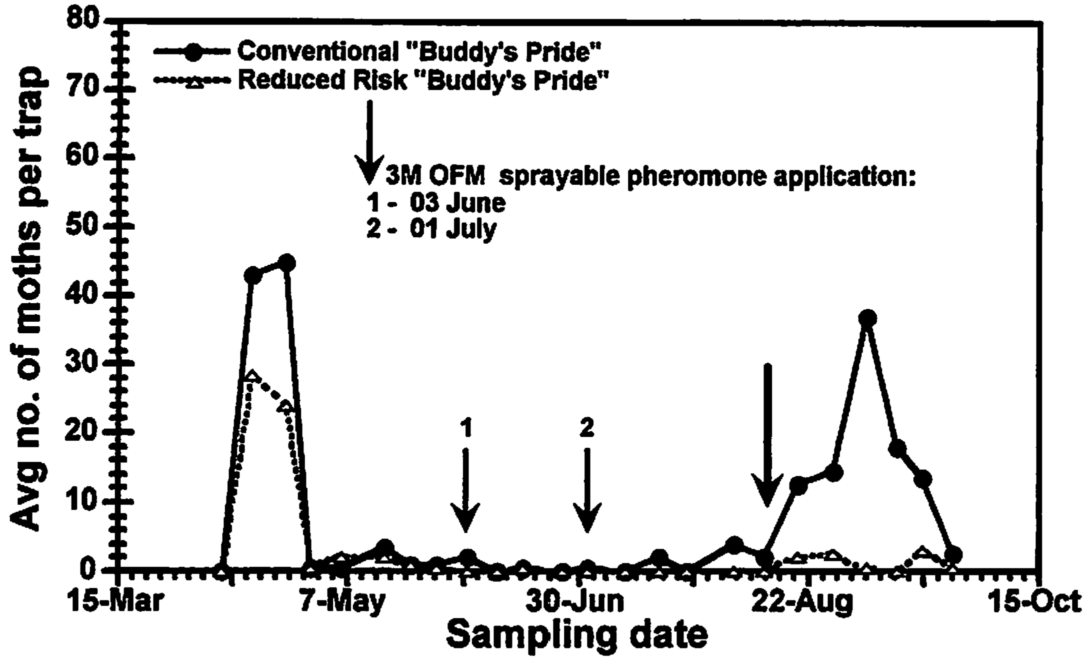


Fig. 7. Pheromone trap catches of Oriental fruit moth in the "Buddy's Pride" orchard, Grower 3: 2002.

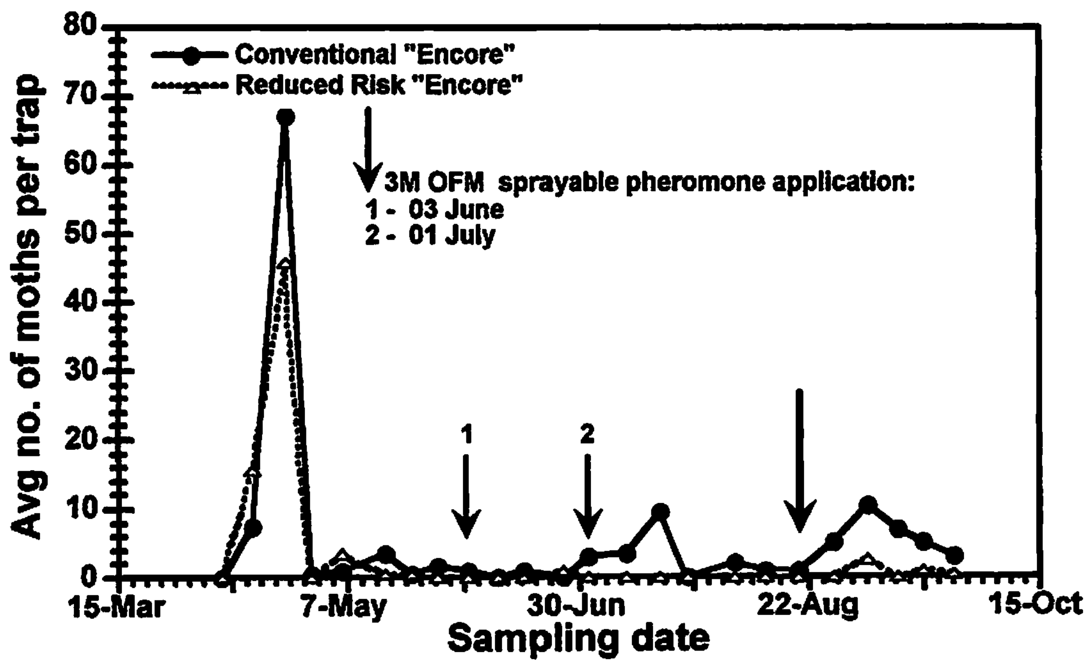


Fig. 8. Pheromone trap catches of Oriental fruit moth in the "Encore" orchard, Grower 3: 2002.

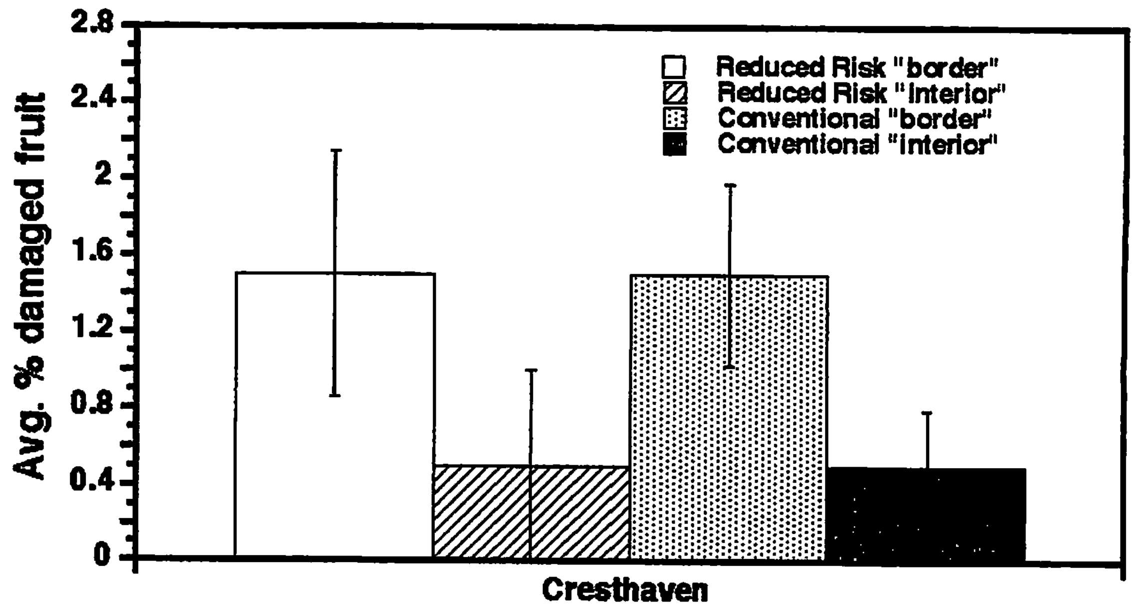


Fig. 9. Mean (±SEM) percent of early season plum curculio fruit injury in Grower 1 orchard: 2002.

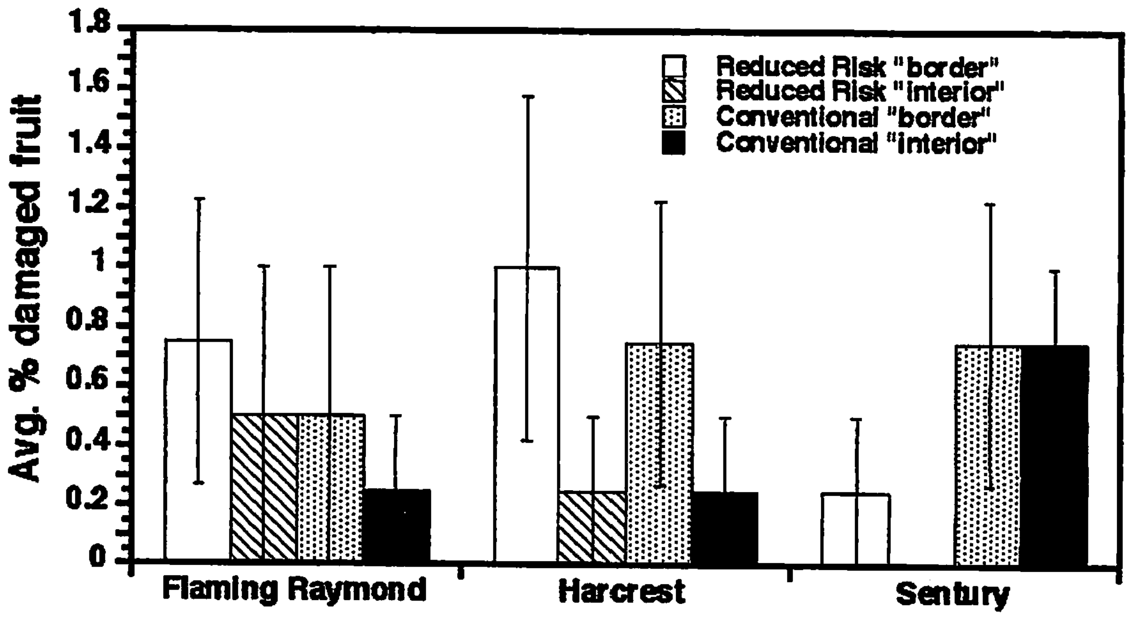


Fig. 10. Mean (±SEM) percent of early season plum curculio fruit injury in Grower 2 orchards: 2002.

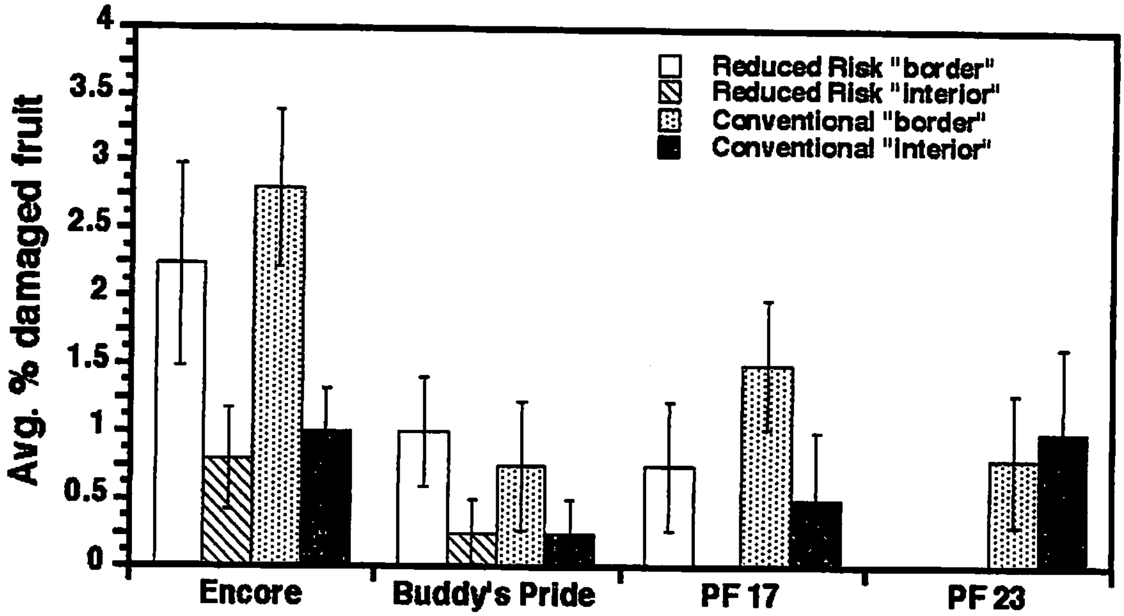


Fig. 11. Mean (±SEM) percent of early season plum curculio fruit injury in Grower 3 orchards: 2002.

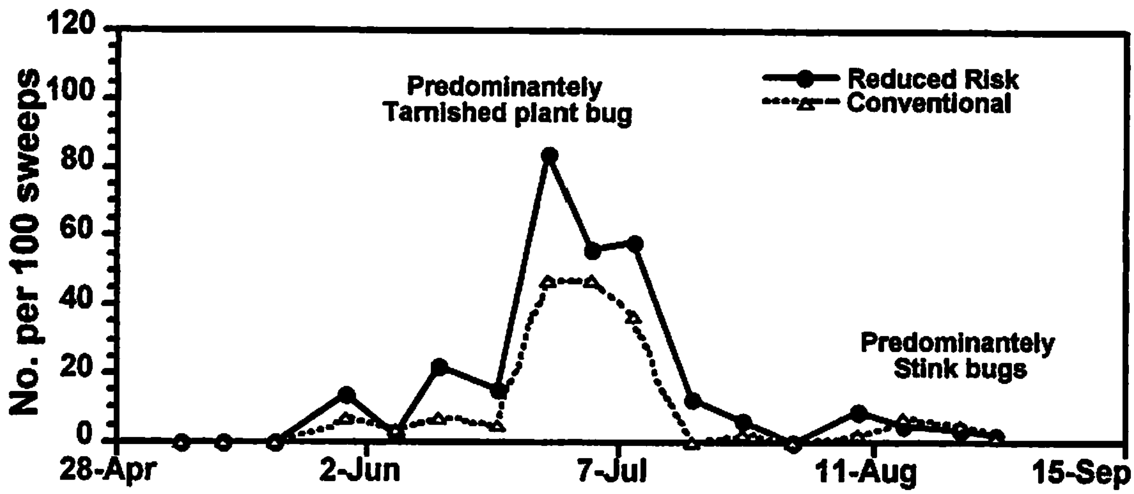


Fig. 12. Seasonal numbers of catfacing insects in Flaming Raymond orchard: 2002.

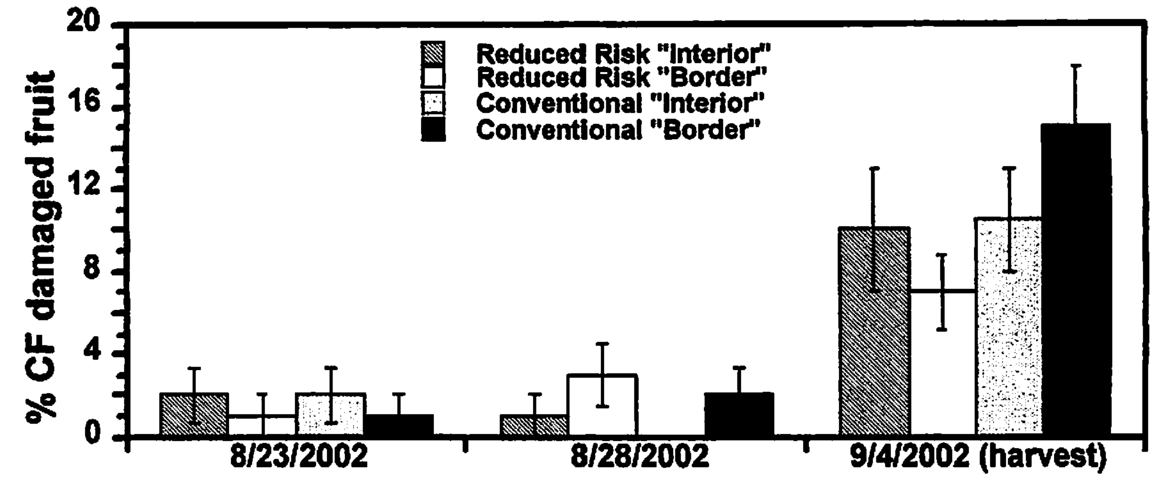


Fig. 13. Late season catfacing damaged fruit in Flaming Raymond orchard: 2002.

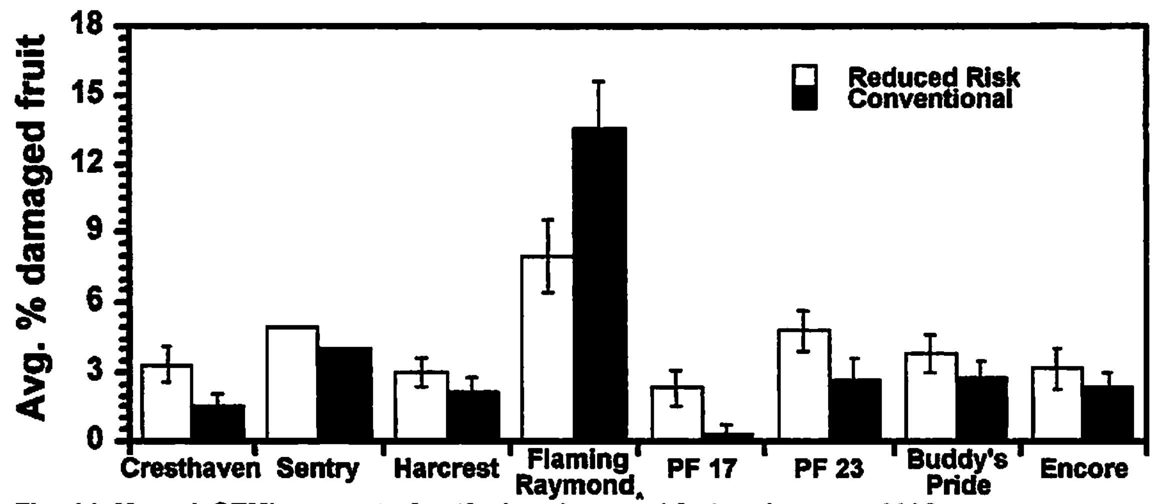
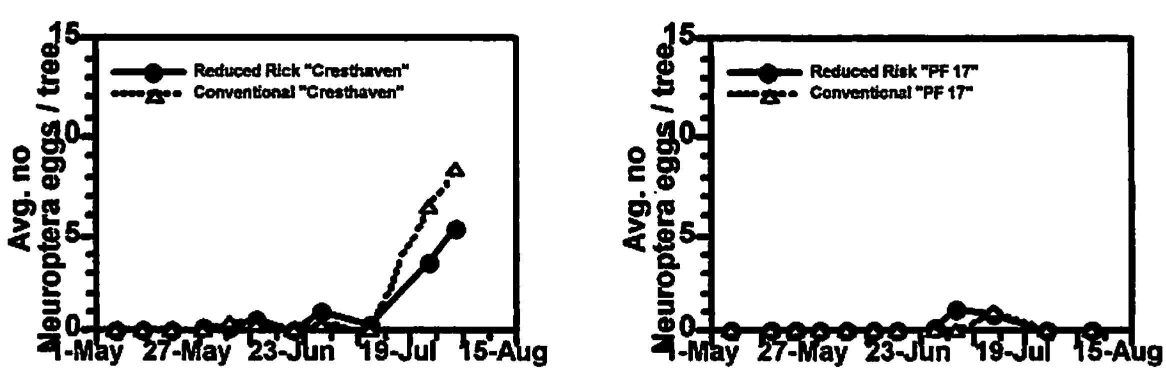


Fig. 14. Mean (±SEM) percent of catfacing damaged fruit at harvest: 2002.



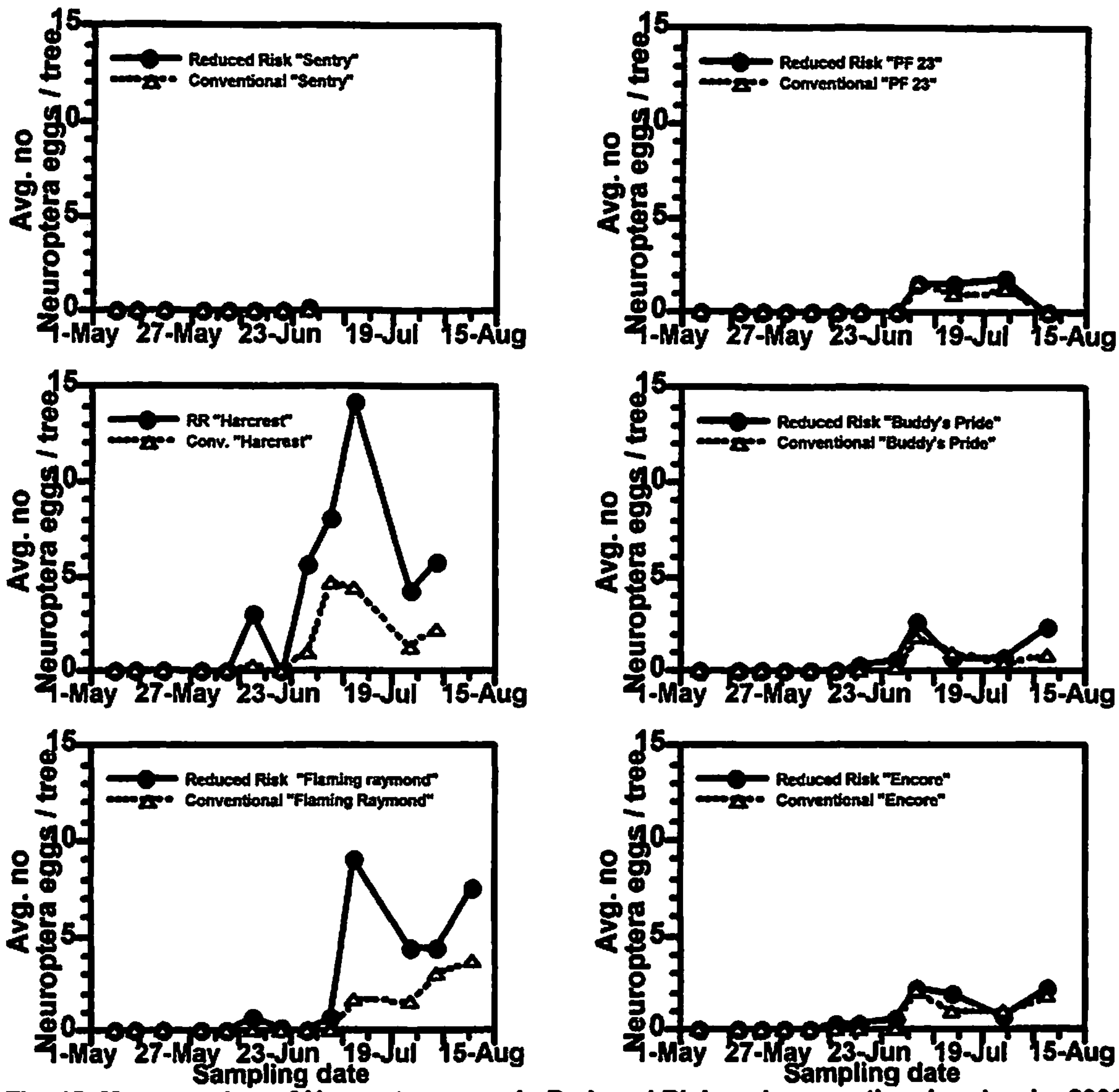


Fig. 15. Mean number of Neuroptera eggs in Reduced Risk and conventional orchards: 2002

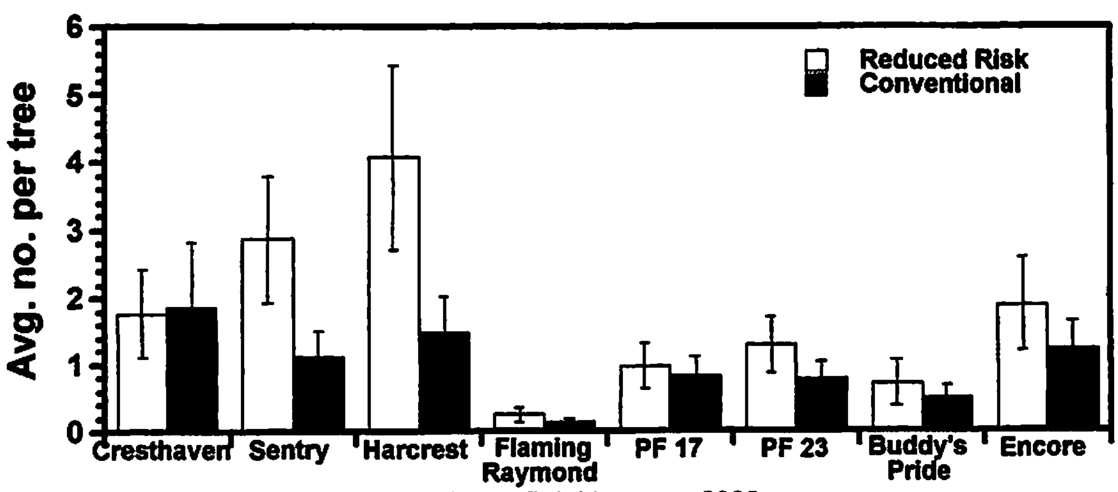


Fig. 16. Mean (±SEM) seasonal numbers of beneficial insects: 2002.

Monitoring Weather Data and Insect Activity to Build a Database and Assist in Spray Recommendations for Washington County Orchards

A Research Report Compiled by
Rick Heflebower, Extension Agent, Horticulture
Utah State University

In Cooperation with
Diane Alston, IPM Coordinator and Professor, Utah State University
Bud Scow, Scow Orchards, Hurricane Utah

Introduction

Washington County is located in the southwest corner of Utah. It is characterized by mild winters and hot summers. High temperatures in the summer average 100+ degrees. Winter lows are around 10 degrees above. The growing season lasts for approximately six months. Peaches are well suited to this climate as long as irrigation is available. The most serious pest has been the Peach Twig Borer, Anarsia lineatella. Larvae of this insect emerge during bloom and burrow into developing shoots. This can result in substantial damage to young trees. Larvae of later generations emerge during the summer and attack the fruit. Three generations have been documented in northern Utah. Until now, little has been done to document Peach Twig Borer activity in southern Utah.

Purpose

The purpose of this study was: 1) to determine how many generations of Peach Tree Borer there are in Washington County; 2) when they occur; 3) if we could match degree day calculations to the flights; and 4) if this modeling could be used to time sprays for control.

Methods

In the spring of 2002, a "Watch Dog" weather station was purchased from Spectrum Technologies. The station was set up at Bud Scow's orchard in Hurricane, Utah, located about 15 miles east of St. George. The elevation there is approximately 3,287 feet. Scow Orchards has successfully grown peaches at this location for many years.

Wing-style pheromone traps were placed in the orchard in early May. Daily catches were recorded and pheromone lures were replaced every 3-4 weeks. The Watchdog station was programmed to record temperature readings every hour. Degree Day accumulations were calculated from the daily high and low readings using a 50-degree threshold.

Results

Adult moths caught in pheromone traps were used to determine biofix (first consistent flight). To predict the recommended time to apply pesticides for control, 400 degree days above 50 degrees Fahrenheit were used. This was consistent with a control program developed in California (University of California IPM of Stone Fruits).

We were able to determine five separate flights (generations) using the trapping information (see Table 1). The flights appeared at fairly regular intervals with the shortest time between flights being 24 days and the longest time being 36 days. Recommended spray dates were projected by calculating 400 degree days after biofix for each generation. Protective sprays were applied within four days or less of the predicted spray timing. (See table below.) Timing was based on the California Model referred to earlier. Excellent control was reported the entire season. Fruit damage due to twig borer was less than 1%.

Peach Twig Borer Spray Schedule

	1st Spray	2nd Spray	3rd Spray	4th Spray	5th Spray
DD Model Predicated Spray Dates	May 21	June 15	July 7	August 13	September 8
Bud's Actual Spray Dates	May 15-17	June 17	July 10	August 13-15	Sept. 12 & 14

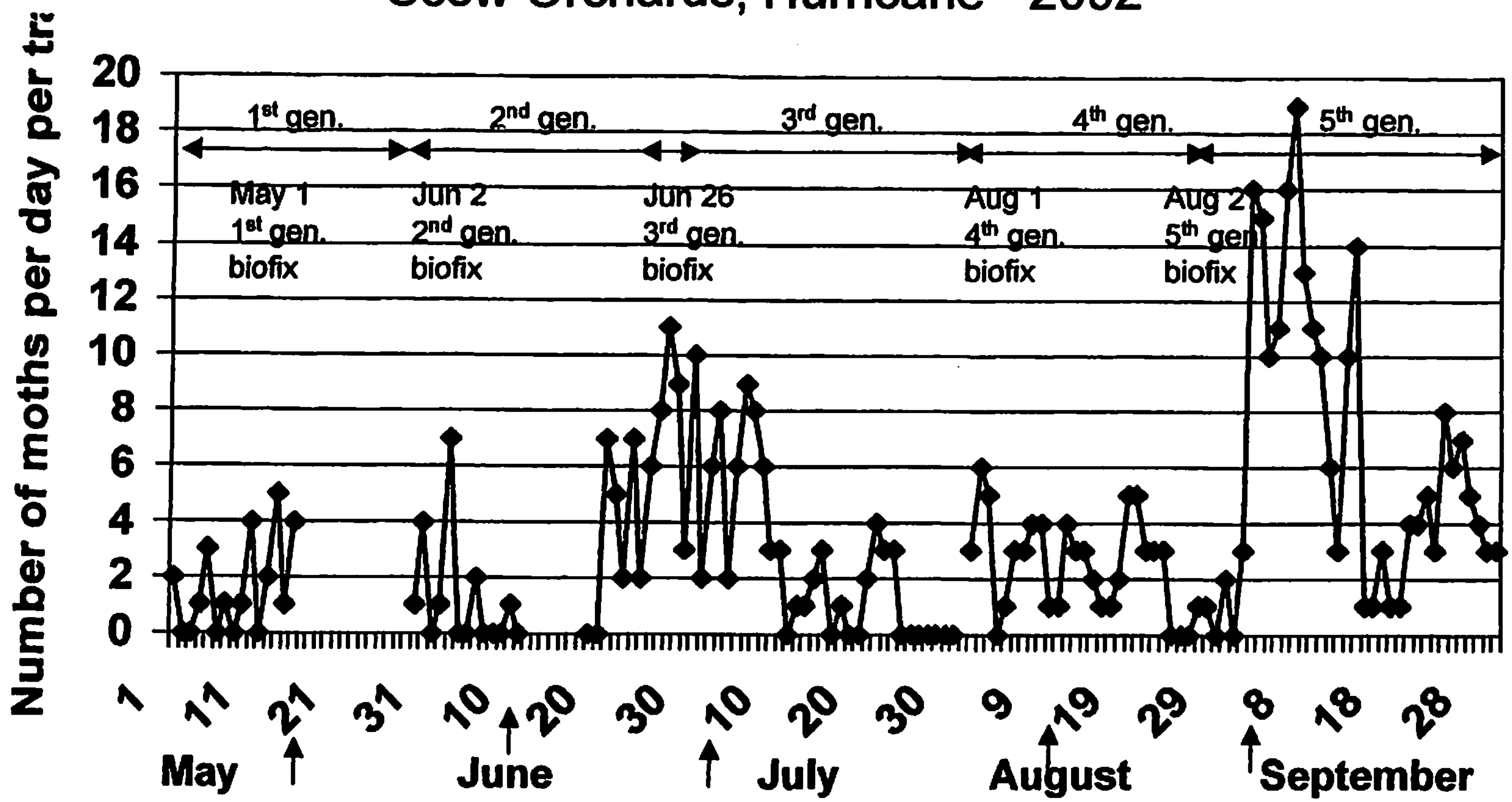
Five different peach varieties were included in the study:

Red Globe	Early
Canadian Harmony	Early
Lemon Elberta	Mid
Elberta	Mid
Fairtime	Late

All varieties were sprayed in March with Thiodan, Bravo, and Oil. The Early varieties received three additional sprays, one with Guthion and two with Success. The Mid varieties received four additional sprays, one with Success and two with Guthion, and one with Acrimite. The Late varieties received seven additional sprays, one with Success, three with Guthion, one with Vendex and two with Dipel. (See Table 2)

Table 1

Peach Twig Borer Trap Catch
Scow Orchards, Hurricane - 2002



DD model predicted spray dates:	May 21 1st spray	Jun 15 2nd spray	July 7 3rd spray	Aug 13 4th spray	Sep 8 5th spray
Bud's actual spray dates:	May 15-17	Jun 17	Jul 10	Aug 13-15	Sep 10 & 14

Not for Citation or Publication
Without Consent of the Author

REFINING THE PHEROMONE-BASED MONITORING SYSTEM FOR DOGWOOD BORER

J. Christopher Bergh[1] and Tracy C. Leskey[2]

[1] Virginia Tech, Alson H. Smith, Jr. Agricultural Research
and Extension Center, Winchester, VA, 22602
[2] USDA-ARS Appalachian Fruit Research Station, Kearneysville, WV, 25430

Introduction

The dogwood borer (DWB), *Synanthedon scitula* Harris has been recognized as an economically important pest of ornamental and nut trees for many years. Since the 1980's, DWB has become an increasingly important pest of apple grown on size-controlling rootstocks in eastern North America. Many apple producers monitor populations of the key pests of apple using sex pheromone traps, and may base their management decisions on pheromone trap data. Pheromone lures for capturing DWB are marketed by several companies, although they appear to have been used more as research tools than by commercial growers, especially in tree fruit. Research studies using pheromone lures to monitor DWB populations in both apple and in managed, urban landscapes have produced discrepant results in terms of the relative effectiveness or attractiveness of different commercial lures. Furthermore, since many clearwing moth species use similar compounds in their pheromone blends, lures marketed for capturing a particular species of Sesiid tend to be rather generic and catch males from several species and/or genera. Given the increased importance of DWB in apple and the increasing use of size-controlling rootstocks in high-density apple plantings, the availability of a refined, reliable and standardized pheromone-based monitoring system for DWB is becoming critical. In this study, we compared the capture of DWB and other clearwing moths among traps baited with several commercial pheromone lures and evaluated the effect of pheromone concentration on DWB trap catch.

Materials and Methods

Lure comparison. These tests were conducted in commercial orchards in VA (Cedar Creek Grade 1 and 2 and Buffalo Marsh Road) and WV (Arden and Kearneysville). Pheromone lures obtained from commercial suppliers included the Scenturion DWB lure, the Trécé lilac borer and DWB lures, and the Scentry DWB lure. Lures were deployed in Pherocon 1C traps, including blank control traps, placed in trees at about 4 ft above the ground and replicated 3 times per orchard. At the orchards in VA, lures were randomized within each of 3 rows separated by 3 buffer rows, and traps were spaced at 70 ft intervals within a row. Traps remained in their original locations for the duration of each trial. At the WV orchards, lures were also randomized within each of three rows separated by 1 buffer row, and traps were spaced at about 80 ft intervals within a row. Traps were rotated among positions within each row at weekly intervals for the duration of each test.

The number of male DWB, lilac borer (LB), peachtree borer (PTB) and lesser peachtree borers (LPTB) captured were recorded weekly for periods ranging from 3 – 6 wk among orchards. The number of PTB and LPTB captured were pooled, and the total number of each species captured per trap during the trial was compared among lures for each orchard using ANOVA and Tukey's multiple range tests at the 5% probability level.

Dose-response. Red rubber septa lures containing different loadings of the attractant used to manufacture the Scenturion DWB lures were obtained from Scenturion Inc. The 1X lures contained the commercial loading. In the first repetition of this trial, lures with 0.01X, 0.10X, 0.5X and 1X and blank controls were tested. In the second repetition, a 2X loading (2 x 1X lures) was added to the array. All lure loadings were replicated 3 times per orchard using Pherocon 1C traps, with the exception of the Cedar Creek Grade 1 orchard, in which Pherocon IIID traps were used. Trap/lure deployment at the different orchards was the same as described previously and all traps were checked weekly (3 – 6 wk) for the capture of DWB and other clearwing moths. The same analyses described previously were used to compare the capture of each species among lure loadings for each orchard.

Results

Lure comparison. Numerically, the Scenturion DWB lure was most effective for trapping male DWB at all 5 orchards (Table 1) and captured significantly more DWB than the other lures at three locations; Cedar Creek Grade 2 ($F_{0.05,4,10} = 7.17, P > 0.005$), Arden ($F_{0.05,4,10} = 64.27, P < 0.0001$) and Kearneysville ($F_{0.05,4,10} = 7.49, P > 0.0047$). The Scentry DWB lure captured the most PTB/LPTB at all 5 sites and significantly more than all other lures at 4 orchards; Cedar Creek Grade 1 ($F_{0.05,4,10} = 41.60, P < 0.0001$), Cedar Creek Grade 2 ($F_{0.05,4,10} = 12.51, P > 0.0007$), Buffalo Marsh Road ($F_{0.05,4,10} = 51.18, P < 0.0001$) and Kearneysville ($F_{0.05,4,10} = 12.32, P > 0.0007$) (Table 1). The Scentry DWB lure also captured the greatest number of LB at 4 orchards (only a single male LB was captured at the Kearneysville orchard), although differences among the lures were not significant (Table 1). Both the DWB and LB lures from Trécé LB captured numerically more PTB/LPTB than did the Scenturion DWB lure at 4 orchards. A qualitative evaluation of the effectiveness of the lures, based on pooled data among the 5 locations, shows the following rank orders for each of the clearwing moths (lures indicated as being equal had pooled totals of □10 moths):

DWB	Scenturion DWB > Scentry DWB > Trécé DWB = Trécé LB
PTB/LPTB	Scentry DWB > Trécé LB > Trécé DWB > Scenturion DWB
LB	Scentry DWB > Scenturion DWB > Trécé DWB = Trécé LB

Dose-response. When a series of lures containing from 0 – 1.0X loadings of DWB pheromone from Scenturion, Inc. were tested, the numerical capture of DWB males was dose-dependent at the Cedar Creek Grade 1 and Arden orchards, although statistical comparisons did not show significant differences among all loadings (Table 2). There was also an indication of a dose-dependent capture of both PTB/LPTB and LB at the Arden site. Addition of the 2X loading to the series showed a numerical, but not statistically significant, increase in the number of DWB, PTB/LPTB captured at the Cedar Creek Grade 2 and Kearneysville locations, and of LB at Kearneysville (Table 2). Interestingly, the Pherocon IIID traps at the Cedar Creek Grade 1 orchard captured numerous DWB, but only a single individual of the other species, at a time when PTB/LPTB and LB were obviously present (see Cedar Creek Grade 1 in Table 1).

Discussion

The Scenturion DWB lure (now manufactured by Suterra) was the most effective lure for capturing male DWB, concurring with our earlier, albeit less extensive, comparison conducted in 2001. Furthermore, the Scenturion lure was the most selective for DWB, being least attractive to the peachtree borer complex and less attractive to LB than the Scentry lure. Compared with the Scenturion and Scentry products, the Trécé DWB and LB lures were least effective for capturing both DWB and LB. We have shown a dose-dependent response of male DWB, and to a lesser degree, of male PTB/LPTB and LB, to lures containing a series of loadings of the Scenturion attractant.

The differences among the lures tested may be due to factors associated with the compounds used, their isomeric purity and/or pheromone loading. Pure Z,Z-3,13 octadecadien-1-ol acetate (Z,Z-ODDA) has been shown to be attractive to male DWB and other Sesiids in numerous field-trapping and electrophysiological studies and is considered a sex attractant for this and other species. However, male DWB have also been reported in traps baited with grape root borer sex pheromone, which contains a 99:1 blend of E,Z-2,13 ODDA and Z,Z-3,13 ODDA. Other studies have reported that binary combinations containing small amounts of the E,Z –3,13 isomer appear to inhibit the response of DWB to the Z,Z isomer, but enhances the response of PTB males.

Different pheromone loading among lures from different manufacturers would translate into different release rates. Furthemore, release rates from microfiber tapes, like those manufactured by Scentry, may also be quite different from those from the rubber septa sold by Scenturion and Trécé. Given the response of male DWB to different pheromone source concentrations that we have shown, the aforementioned factors could also influence the outcome of comparisons among lures from different sources.

The main impediment to determining the factor(s) responsible for the differences in attractiveness and selectivity we have shown is that the sex pheromone of the DWB has not been identified specifically. Elucidation of these factors awaits such identification in concert with a comparison of the compounds collected from virgin female DWB and those eluted from the different lures.

In the meantime, while our lure comparison data suggest that the Scenturion (now Suterra) lure is the most effective for monitoring DWB, other data suggest that they do not fully reflect emergence patterns or population density of DWB in the orchard. In 2002, we monitored the emergence of DWB in commercial apple orchards using both weekly collections of fresh pupal exuvia from burr knot tissue (30 trees/orchard) and pheromone traps baited with Scenturion lures. Gender determinations of the pupal exuviae collected were based on anatomical differences between males and females (Leskey and Bergh, unpublished data). Figure 1 shows the cumulative number of male and female pupal exuviae collected and the cumulative number of male moths captured at two orchards in Virginia during the early flight peak of DWB in 2002. Gender determinations of pupal exuviae suggested that the emergence of DWB adults from the overwintering population shows protandry. Despite the fact that traps with Scenturion lures were deployed prior to finding the first male or female pupal exuvia, the cumulative capture of male moths in traps was less than the cumulative number of pupal exuviae collected from only 30 trees within each orchard block from 6 May until 10 June at Cedar Creek Grade, and from 6 May through June 17 at Buffalo Marsh Road. The difference between the cumulative counts of male exuviae and trap catch was most pronounced at the Buffalo Marsh Road location, which was very heavily infested with DWB and had the highest larval density. This evidence for more DWB flying within the orchard than were found in traps suggests that the pheromone lures may not be competing effectively with calling virgin females and further highlights the need for correct identification of the DWB sex pheromone. Such information will enable significant advances in our ability to use pheromone traps as monitoring and management decision tools and in the development of behaviorally-based management strategies, including mating disruption and attract-and-kill technology.

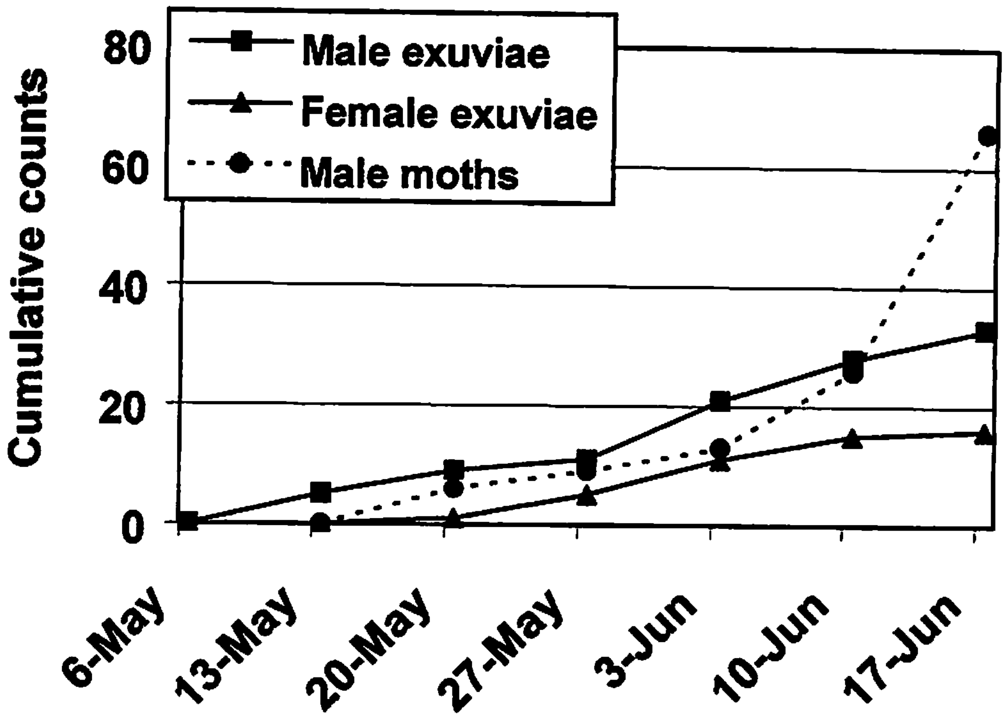
Table 1. The capture of male dogwood borer and other clearwing moths in traps baited with different commercial pheromone lures.

Lure	Mean ± SD no. moths captured per trap (3 traps/lure)					
	DWB	PTB/LPTB	LB	DWB	PTB/LPTB	LB
	Cedar Creek Grade 1, VA (28 May – 9 Jul, 2002)			Cedar Creek Grade 2, VA (18 June – 9 July, 2002)		
Scenturion DWB	3.0 ± 2.6 a	4.7 ± 3.1 a	6.7 ± 2.3 ab	18.7 ± 10.1 a	3.7 ± 3.1 a	0.3 ± 0.6 a
Scentry DWB	0.7 ± 0.6 a	39.3 ± 2.1 c	12.0 ± 8.0 a	3.3 ± 3.5 b	34.0 ± 12.2 b	3.0 ± 2.6 a
Trécé DWB	0.0 a	17.3 ± 8.4 b	4.0 ± 4.4 ab	1.3 ± 1.5 b	12.3 ± 2.5 a	0.7 ± 1.2 a
Trécé LB	0.7 ± 0.6 a	9.3 ± 1.5 ab	2.0 ± 0.0 ab	2.0 ± 2.6 b	9.0 ± 6.9 a	0.0 a
Blank	0.0 a	0.0 a	0.0 b	0.0 b	0.0 a	0.0 a
	Buffalo Marsh Road, VA (7 Aug – 18 Sept, 2002)			Arden ,WV (29 May – 9 July, 2002)		
Scenturion DWB	16.3 ± 14.7 a	2.0 ± 1.7 a	0.7 ± 0.6 a	52.7 ± 7.2 a	4.3 ± 0.6 ab	4.0 ± 3.6 a
Scentry DWB	12.3 ± 10.1 a	13.7 ± 2.3 c	1.0 ± 1.0 a	12.3 ± 4.2 b	25.3 ± 8.1 c	7.0 ± 5.6 a
Trécé DWB	1.7 ± 1.5 a	1.0 ± 1.0 a	0.7 ± 1.2 a	8.7 ± 5.1 bc	10.0 ± 4.4 abc	2.3 ± 1.2 a
Trécé LB	2.0 ± 1.0 a	9.0 ± 1.0 b	0.0 a	7.7 ± 2.3 bc	18.0 ± 11.4 bc	2.0 ± 1.0 a
Blank	0.0 a	0.0 a	0.0 a	0.0 c	0.0 a	0.0 a
	Kearneysville, WV (21 August – 25 Sept, 2002)					
Scenturion DWB	16.7 ± 10.1 a	3.7 ± 2.5 a	0.0 a			
Scentry DWB	1.7 ± 0.6 b	72.0 ± 27.5 b	0.0 a			
Trécé DWB	0.7 ± 0.6 b	14.0 ± 15.1 a	0.0 a			
Trécé LB	0.3 ± 0.6 b	17.7 ± 6.7 a	0.3 ± 0.6 a			
Blank	0.0 b	0.0 a	0.0 a			

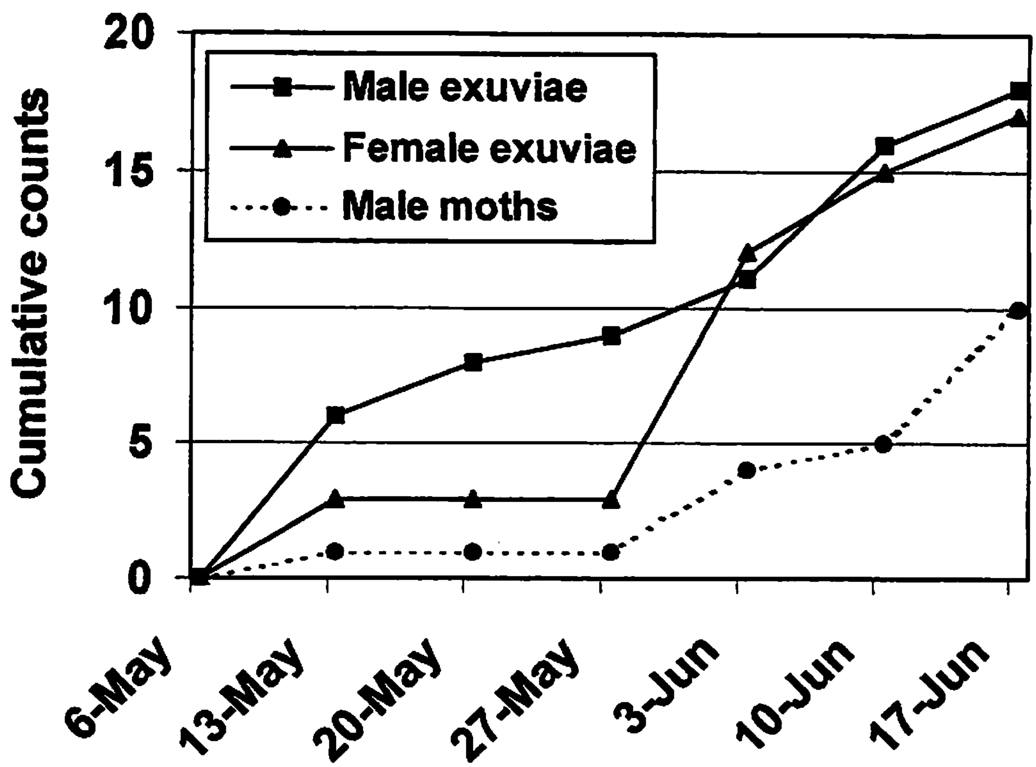
Table 2. The capture of male dogwood borer and other clearwing moths in traps baited with different loadings of pheromone from Scenturion, Inc.

Lure	Mean ± SD no. moths captured per trap (3 traps/lure)					
	DWB	PTB/LPTB	LB	DWB	PTB/LPTB	LB
	Cedar Creek Grade 1, VA (18 June – 9 July, 2002)			Arden, WV (28 May – 9 July, 2002)		
1.0X	16.7 ± 11.0 a	0.0 a	0.0 a	79.7 ± 12.7 a	10.0 ± 3.0 a	1.3 ± 2.3 a
0.5X	12.3 ± 3.8 ab	0.3 ± 0.6 a	0.0 a	64.3 ± 9.1 a	6.3 ± 3.2 ab	0.7 ± 1.2 a
0.10X	6.3 ± 6.8 ab	0.0 a	0.0 a	9.7 ± 6.8 b	3.3 ± 2.1 bc	0.0 a
0.01X	2.3 ± 2.3 ab	0.0 a	0.0 a	3.3 ± 2.3 b	0.0 c	0.0 a
Blank	0.0 b	0.0 a	0.0 a	0.0 b	0.0 c	0.0 a
	Cedar Creek Grade 2, VA (14 Aug – 18 Sept, 2002)			Kearneysville, WV (21 August – 1 October, 2002)		
2.0X	18.3 ± 10.2 a	20.0 ± 9.5 a	0.0 a	24.3 ± 13.7 a	17.7 ± 13.6 a	2.0 ± 2.0 a
1.0X	9.0 ± 4.6 ab	10.3 ± 3.2 ab	0.3 ± 0.6 a	15.3 ± 7.5 ab	13.0 ± 3.0 a	0.3 ± 0.6 a
0.5X	6.3 ± 7.6 ab	11.3 ± 7.6 ab	0.0 a	17.7 ± 6.8 ab	12.7 ± 7.2 a	0.3 ± 0.6 a
0.10X	1.7 ± 1.5 b	1.7 ± 0.6 b	0.0 a	1.0 ± 0.0 b	1.0 ± 1.0 a	0.0 a
0.01X	1.3 ± 1.2 b	0.3 ± 0.6 b	0.0 a	1.0 ± 1.7 b	1.0 ± 1.7 a	0.0 a
Blank	0.0 b	0.0 b	0.0 a	0.0 b	0.0 a	0.0 a

Cedar Creek Grade, VA



Buffalo Marsh Road, VA



Not for Citation or Publication
Without Consent of the Authors

RESPONSE OF STINK BUGS TO TWO TRAP TYPES AND COMMON MULLEIN IN APPLES AND PEACHES

Henry W. Hogmire[1], Tracy C. Leskey[2], and Starker E. Wright[2]

[1]West Virginia University
Kearneysville Tree Fruit Research and Education Center
Kearneysville, WV

[2]USDA – ARS
Appalachian Fruit Research Station
Kearneysville, WV

Introduction

Various species of stink bugs have historically been major pests of peach, inflicting catfacing, scarring, dimpling, water-soaked and gummosis type injuries (Hogmire 1995). Although injury to apple has been reported (Phillips and Howell 1980), stink bugs have not traditionally been thought of as important pests of this pome fruit. Injury to apple may be more common than realized due to the similarity and potential for misdiagnosis as the physiological disorder known as cork spot (Brown 2001). The potential for stink bugs to become more important pests of apple could be influenced by further cancellations or restrictions of current pest management tools as the result of FQPA.

Monitoring and management of stink bugs is especially challenging because of their high mobility and use of numerous weed hosts. Population monitoring by beating tray and sweep net sampling has typically not been well correlated with fruit injury. The ability to monitor stink bugs was significantly enhanced by the discovery of a *Euschistus* spp. aggregation pheromone (Aldrich et al. 1991). Plastic jar traps have been commercially available since 1996 for use with the pheromone to monitor stink bugs. The use of the pheromone in combination with a pyramidal type (modified Tedders) trap was shown to be an effective monitoring tool for determining the seasonal occurrence and canopy distribution of *Euschistus servus* (Say) and *E. tristigmus* (Say) in pecan orchards (Cottrell et al. 2000).

Stink bugs reproduce on numerous weed species throughout the season (McPherson and McPherson 2000), and it is from these hosts that movement to fruit trees occurs resulting in fruit injury. Common mullein, *Verbascum thapsus* (L.), was found to be a favored weed host of *Euschistus* spp in May and June (Woodside 1947, 1950). Munyaneza and McPherson (1994) reported that *E. servus* (Say) was frequently found on mullein upon emergence in the spring, which would indicate that this weed probably serves as an overwintering host.

The first objective of this research was to determine stink bug response to jar and pyramidal type traps in apple and peach orchards. A second objective was to determine if *Euschistus* spp. response to common mullein, a favored weed host, could be enhanced when combined with commercially available pheromone lure.

Materials and Methods

Trapping experiment. Four study sites were used to evaluate stink bug response to traps in 2002. Commercial orchards of 1.2 ha Rome apples on M7 rootstock planted in 1989, and 3.2 ha Newhaven peaches on Lovell rootstock planted in 1988 were located in Hampshire County, WV. Two additional sites planted in 1997 consisting of adjoining apple (Granny Smith on EMLA 26 and Empire on EMLA 9/EMLA 111 rootstocks) and peach (Loring on Lovell rootstock) orchards of 1 ha each were located at the USDA–ARS Appalachian Fruit Research Station (USDA–AFRS) in Jefferson County, WV. Crop protection chemicals were applied for pest management in the commercial orchards, but not in the USDA orchards.


Fig. 1. Jar trap.

Two trap types were used. Jar traps commercially available from Scenturion, Inc. (Clinton, WA) were modified as follows. Traps were constructed from 3.8-liter clear plastic Rubbermaid® jars with screw-cap lids (Fig. 1). 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 (New York Wire Co., Mt. Wolf, PA) was formed into a cone and fastened with hot glue, with each cone positioned flush with the hole opening and secured 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.

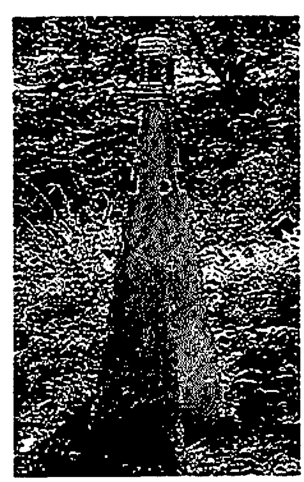


Fig. 2. Pyramid trap.

Pyramid traps (Mizell and Tedders 1995, Mulder et al. 1997) were constructed of two panels of 1.3 cm thick exterior grade plywood that were painted with two coats of exterior latex gloss enamel paint, color-matched to professional industrial safety yellow (R. Mizell, personal communication) (Fig. 2). Each panel was 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. A 1.9-liter clear plastic Rubbermaid® jar with screw-cap lid was prepared for placement on the top of each 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 jar opening and attached at the wide end to the jar with hot glue. The jar was vented around the perimeter with four equidistant 5.5 cm diameter openings, and in the lid with two 3 cm diameter openings, which were covered with pieces of plastic pet screening 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 trap. The jar was secured to the panels of the pyramid with spring clips attached to wires extending from four holes in the base of the jar.

Three replications of four treatments were established at each orchard site: baited and unbaited jar and pyramid traps. Traps were baited with wax puck lures containing 100 mg of the *Euschistus* spp aggregation pheromone (Scenturion, Inc., Clinton, WA) that were suspended inside the jars from the lids. All traps contained ¼ piece of a Atroban® Extra insecticide ear tag (Schering-Plough Animal Health Corporation, Union, NJ) (Cottrell 2001) impregnated with 10% permethrin and 13% PBO that was attached with wire under the jar lid above the lure. Traps were installed on 30 May in the commercial orchards and on 6 June at the USDA–AFRS. Pyramid traps were installed between trees and jar traps suspended within the tree canopy in the border row of the orchard adjacent to a woods, rock break or hedgerow. Traps were inspected weekly through the end of August or September in peach and apple orchards, respectively, with lures and ear tags replaced every 3 weeks. Stink bugs were collected in labeled vials of 70% ethanol and identified with taxonomic keys found in McPherson and McPherson (2000). Data were subjected to ANOVA with mean separation by Tukey's Studentized Range Test at P = 0.05 level.

Common mullein plant experiment. This experiment was conducted in 2002 in a Gala and two Empire apple orchards at the USDA–AFRS, and consisted of four treatments: baited and unbaited mullein plants and mullein mimics. Common mullein plants approximately 1.5 m tall and 2.5 cm diameter at the flower stalk were dug from the field and placed into 26.6 liter pots containing potting soil (Fig. 3). Two yellow unbaited Pherocon® AM traps (Trece, Inc., Salinas, CA) were stapled to a wooden stake adjacent to the potted plant. Traps were centered at 0.5 and 1 m above ground with the sticky side facing away from the orchard. Mullein mimics consisted of 1.5 m tall by 2.5 cm diameter CPVC that were painted with yellow #20109 and hunter green #8-20111 (Yenkin-Majestic Paint Corporation, Columbus, OH) to achieve a mottled appearance (Fig. 4). Mullein mimics were potted and provisioned with yellow panel traps identical to

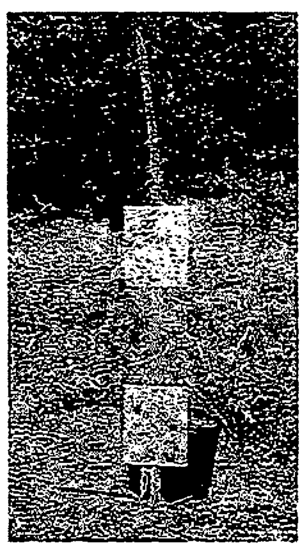


Fig. 3. Baited mullein.

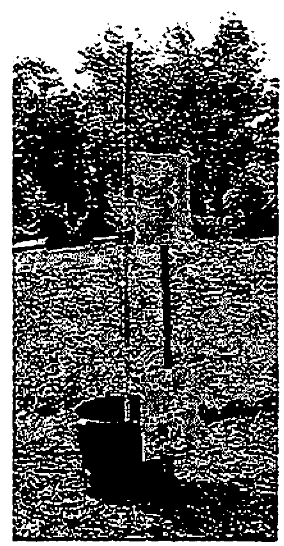


Fig. 4. Baited mullein mimic.

those deployed with mullein plants. Mullein plants and mullein mimics were baited with wax puck lures containing 100 mg of the *Euschistus* spp aggregation pheromone with the lure attached to the flower head or CPVC above the upper panel trap.

Three replications (one per orchard) of each treatment were centered between border-row trees on 10 August and checked daily through 16 August. Tangle-trap (Tanglefoot Co., Grand Rapids, MI) was added to yellow panel traps as needed to maintain a uniform thickness of 4 mm. The experiment was repeated by installing new treatments on 18 August, with daily inspection through 21 August. Stink bug numbers were totaled for the entire 11-day sampling period for each replication. Data were subjected to ANOVA with mean separation by Tukey's Studentized Range Test at P = 0.05 level.

Results and Discussion

Trapping experiment. In the commercial apple orchard, the highest number of stink bugs was captured in baited pyramid traps (Fig. 5A). Significantly lower, but similar levels were captured in unbaited pyramid and baited jar traps. The fewest number of stink bugs was captured in unbaited jar traps, which was significantly less than captures in baited jar traps. A similar pattern of stink bug capture was observed in apples at the USDA–AFRS, but there were no significant differences among the trap types (Fig. 5A). Stink bug capture in the commercial peach orchard was also highest for the baited pyramid trap, but levels were not significantly greater than those in unbaited pyramid or baited jar traps (Fig. 5B). No stink bugs were captured in unbaited jar traps in the commercial peach orchard. In peaches at the USDA–AFRS there were no significant differences in stink bug capture among the trap types, with similar numbers captured in baited pyramid and jar traps (Fig. 5B). A total of 186 stink bugs were captured in apples and peaches at both locations, with baited pyramid, unbaited pyramid, baited jar and unbaited jar traps accounting for 57, 18, 23 and 2 percent of the total capture, respectively.

The yellow color of the pyramid trap base likely serves as an attractive visual cue for foraging stink bugs. The potential influence of this particular visual cue in pyramid trap captures can be illuminated by comparing the number of trap captures in unbaited and baited traps. Here we assume that all captures in baited traps greater than those numbers recorded for unbaited traps are due to the presence of the pheromone lure. In other words, visual and olfactory cues provided by baited pyramid traps are merely additive in terms of stink bug responses. Thus, if the influence of the pheromone lure is removed, 34 and 39 percent of captures in baited pyramid traps in commercial apple and peach orchards, respectively, could be due to trap color (Fig. 5A & 5B). In apples at the USDA–AFRS, only 25 percent of captures in baited pyramid traps was likely due to color using this same comparison, and only baited pyramid traps captured stink bugs in peaches at USDA–AFRS so no such comparison could be made. However, we cannot discount the possibility that stink bug responses to baited pyramid traps are synergistic between visual and olfactory cues, and not just additive as we assume here.

More stink bugs were captured in the commercial orchards than at the USDA–AFRS (Fig. 5A & 5B), even though the commercial orchards received insecticide applications and the USDA–AFRS did not. Lower levels of capture at the USDA–AFRS was attributable to a lighter crop load due to spring frost and less suitable adjacent habitats for stink bug populations. In the commercial orchards, more stink bugs were captured in apples than in peaches (Fig. 5A & 5B). The apple orchard was used in a RAMP (Reduced-risk and Mitigation Program) project in which only soft, selective insecticides (no organophosphates) were applied for insect control. A harvest evaluation of fruit revealed 1.9 percent injury that was believed to be due to stink bug feeding. The lower level of stink bugs in the commercial peach orchard is most likely due to a more rigorous control program during the past three seasons, in an effort to reduce mid to late season stink bug feeding that has resulted in increased incidence of brown rot during and after harvest.

In the commercial apple orchard, brown stink bug, *Euschistus servus* (Say), was the predominant species captured by baited pyramid and jar traps (Fig. 6A). Dusky stink bug, *E. tristigmus*, green stink bug, *Acrosternum hilare* (Say), and other stink bugs (primarily *Brochymena* spp. and unidentified nymphs) were also captured by these traps at similar but significantly lower levels. There were no significant differences among stink bug species captured in unbaited pyramid and jar traps. All species were represented at low levels in unbaited pyramid traps, but only brown and dusky stink bugs were captured at very low levels in unbaited jar traps. In the commercial peach orchard there were no significant differences among stink bug species in any of the trap types (Fig. 6B). All species were represented in both baited and unbaited pyramid traps, but only dusky stink bug was captured in jar traps that were baited.

At the USDA–AFRS orchards, capture of brown stink bugs was numerically but generally not significantly higher than other species in baited pyramid and jar traps in both apples and peaches (Fig. 7A & 7B). Brown stink bugs were captured at significantly higher levels than green stink bugs only in baited pyramid traps in apples (Fig. 7A). No significant differences among stink bug species captured were found with unbaited pyramid and jar traps in apples, and there was no capture in these trap types in peaches.

Brown stink bug represented 55 percent of all stink bugs captured on apples and peaches in both locations, with dusky, green and other representing 20, 16 and 9 percent, respectively. Brown stink bug was determined (McPherson and McPherson 2000) to be almost entirely (98%) *E. servus euschistoides* (Vollenhoven), with the remainder *E. s. servus* (Say). Dusky stink bugs were identified as *E. tristigmus tristigmus* (Say), except for one specimen which was *E. t. luridus* Dallas.

Stink bugs were found to respond to baited pyramid traps throughout the season in both apples and peaches (Fig. 8A & 8B). Response to baited jar traps did not occur until mid-July in apples (Fig. 8A) and early August in peaches (Fig. 8B), but did coincide with peaks in capture as recorded with baited pyramid traps. Considering that pyramid traps were placed between trees and jar traps within the canopy, capture in jar traps may better represent stink bug movement into trees. The lack of capture until early August in baited jar traps in peach is probably at least partly due to the grower's rigorous insecticide program to minimize stink bug injury to fruit. In this situation stink bugs would more likely be detected in the canopy during the spray-to-harvest interval, when no further insecticide applications would be made and minimal insecticide residues would be present.

Stink bug lures were replaced every 3 weeks. Capture of stink bugs increased during the first week following three of five lure installations in apple and then declined (Fig. 8A). This same pattern was seen following all three lure installations in peach (Fig. 8B). These data indicate that lures need to be replaced more frequently, or more longer-lasting lures should be used to maintain stink bug response to traps.

Common mullein plant experiment. Significantly more stink bugs (over four fold) were found on baited mullein than on unbaited mullein plants, with none found on mullein mimics (Fig. 9), indicating that the presence of pheromone lure increased *Euschistus* spp. responses to mullein plants under field conditions. All stink bugs (six brown, two dusky, and five nymphs) were found on mullein plants, not on traps, with tangle-trap found on one specimen as evidence of trap contact. The mullein plants began to wilt soon after transplanting to pots, which may explain the lack of significant difference in number of stink bugs found on unbaited mullein versus mullein mimics. Results of this experiment highlight the possibility that response of *Euschistus* spp. to olfactory cues can be enhanced when the pheromone is combined with host plant odors.

Acknowledgments

The authors thank the technical support provided by Kimberly Arbogast, Deborah Blue, Samantha Hoover, Mike Noll, Shelley Pearson, and Tim Winfield. Appreciation is also expressed to Garry Shanholtz, Hampshire County fruit grower, and to Dr. Mark Brown, USDA scientist, for the use of their orchards in this study.

References Cited

Aldrich, J. R., M. P. Hoffmann, J. P. Kochansky, W. R. Lusby, J. E. Eger, and J. A. Payne. 1991. Identification and attractiveness of a major pheromone component for nearctic *Euschistus* spp. stink bugs (Heteroptera: Pentatomidae). Environ. Entomol. 20: 477-483.

Brown, M. W. 2001. Is it stink bug or cork spot? Proceedings 77th Cumberland-Shenandoah Fruit Workers Conference. Winchester, VA. November 15-16.

Cottrell, T. E. 2001. Improved trap capture of *Euschistus servus* and *Euschistus tristigmus* (Hemiptera: Pentatomidae) in pecan orchards. Florida Entomologist 84: 731-732.

Cottrell, T. E., C. E. Yonce, and B. W. Wood. 2000. Seasonal occurrence and vertical distribution of *Euschistus servus* (Say) and *Euschistus tristigmus* (Say) (Hemiptera: Pentatomidae) in pecan orchards. J. Entomol. Sci. 35: 421-431.

Hogmire, H. W. (ed.). 1995. Mid-Atlantic Orchard Monitoring Guide. NRAES-75. Northeast Regional Agricultural Engineering Service. Ithaca, NY. 361 pp.

McPherson, J. E., and R. M. McPherson. 2000. Stink Bugs of Economic Importance in America North of Mexico. CRC Press. Boca Raton, FL. 253 pp.

Mizell, R. F. III, and W. L. Tedders. 1995. A new monitoring method for detection of the stinkbug complex in pecan orchards. Proceedings Southeastern Pecan Growers Assoc. 88: 36-40.

Mulder, P. G., B. D. McCraw, W. Reid, and R. A. Grantham. 1997. Monitoring adult weevil populations in pecan and fruit trees in Oklahoma. Oklahoma State University Extension Facts F-7190. 8 pp.

Munyaneza, J., and J. E. McPherson. 1994. Comparative study of life histories, laboratory rearing, and immature stages of *Euschistus servus* and *Euschistus variolarius* (Hemiptera: Pentatomidae). Great Lakes Entomol. 26: 263-274.

Phillips, K. A., and J. O. Howell. 1980. Biological studies on two *Euchistus* [sic] species in central Georgia apple orchards. J. Georgia Entomol. Soc. 15: 349-355.

Woodside, A. M. 1947. Weed hosts of bugs which cause catfacing of peaches in Virginia. J. Econ. Entomol. 40: 231-233.

Woodside, A. M. 1950. Catfacing and dimpling of peaches. Va. Agric. Exp. Sta. Bull. 435. 18 pp.

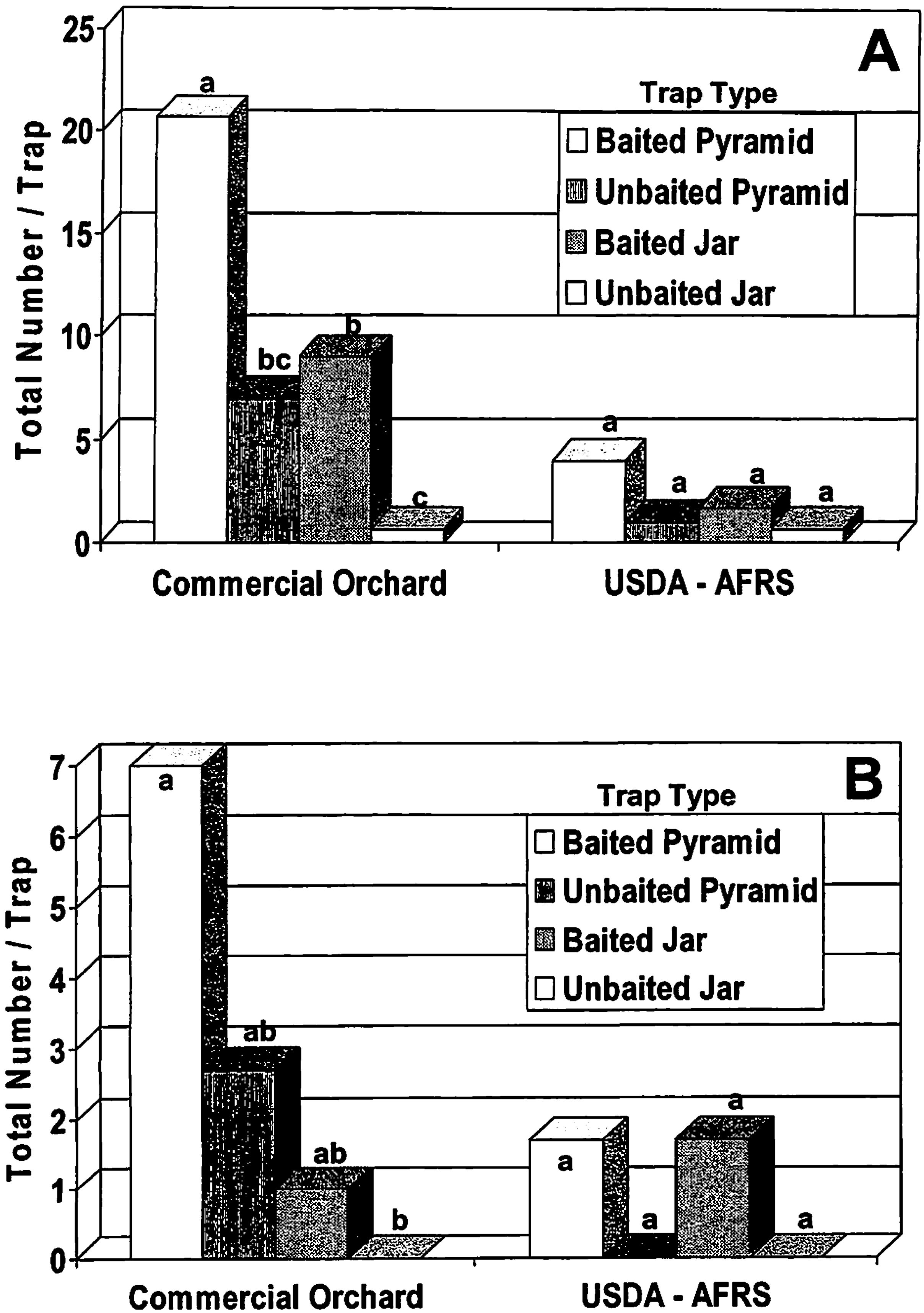
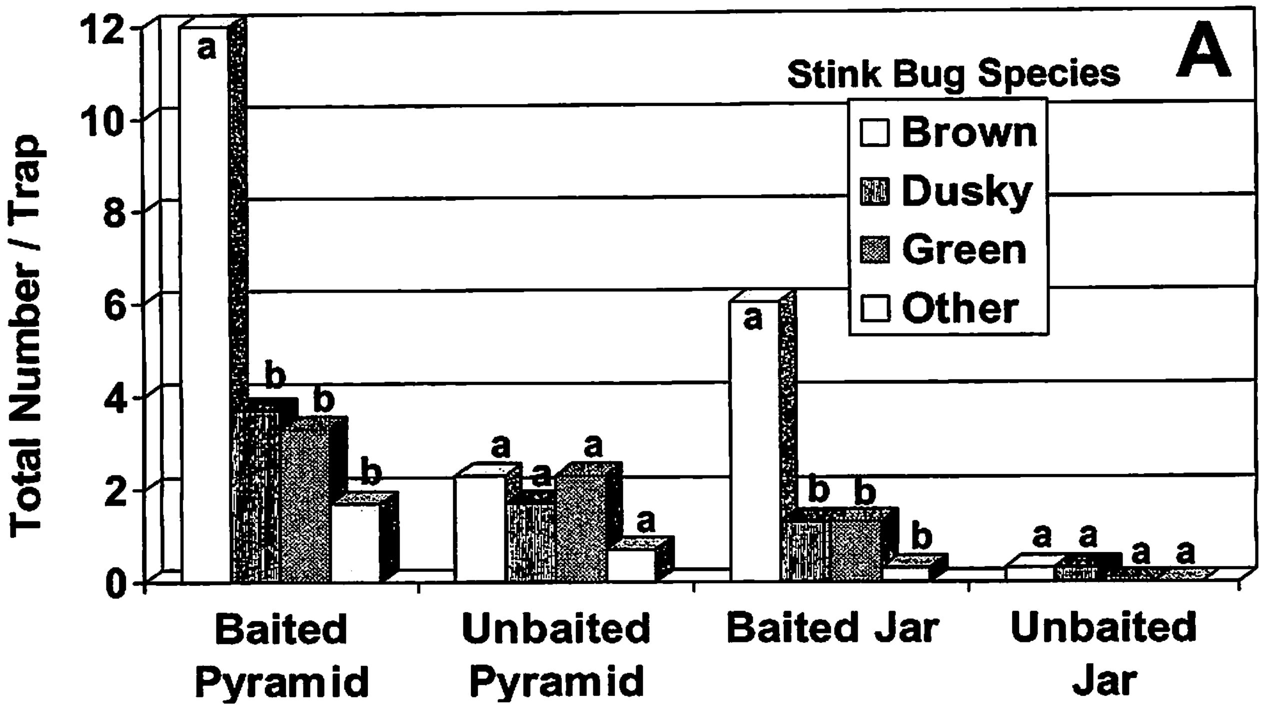


Fig. 5. Stink bugs captured in various trap types in apple (A) and peach (B) orchards in 2002.



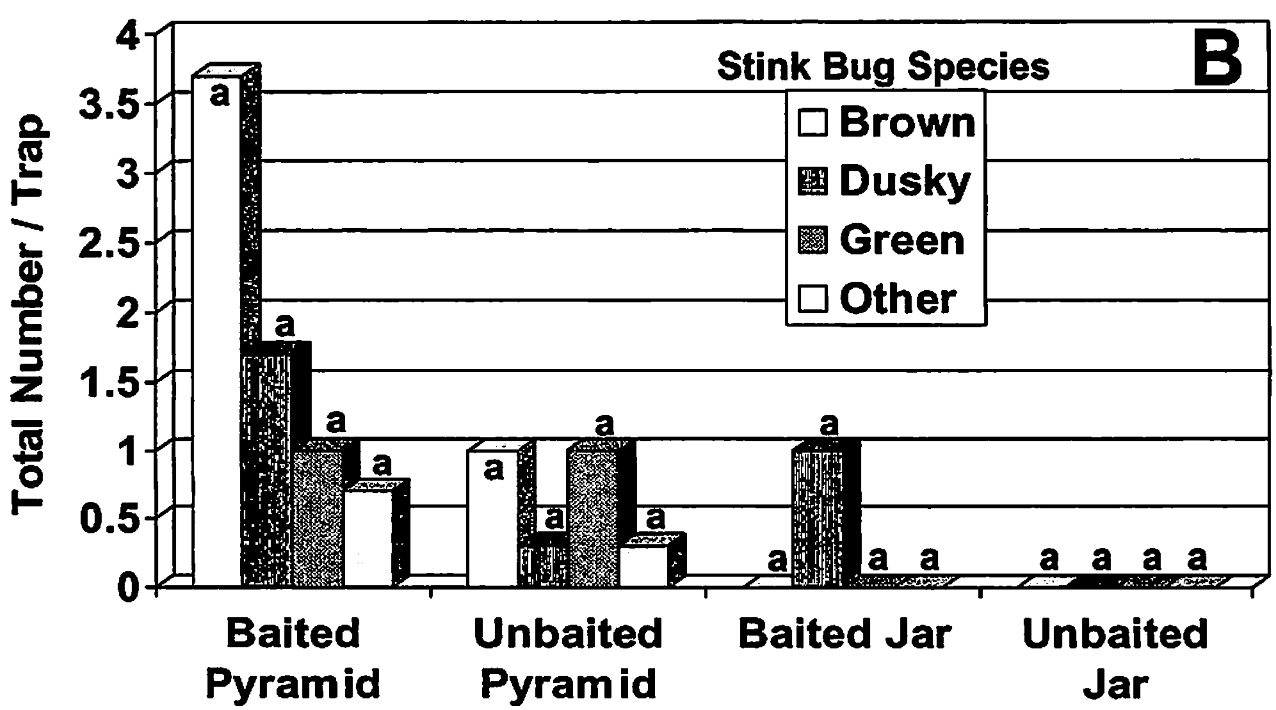


Fig. 6. Stink bug species captured in various trap types in a commercial apple (A) and peach (B) orchard in 2002.

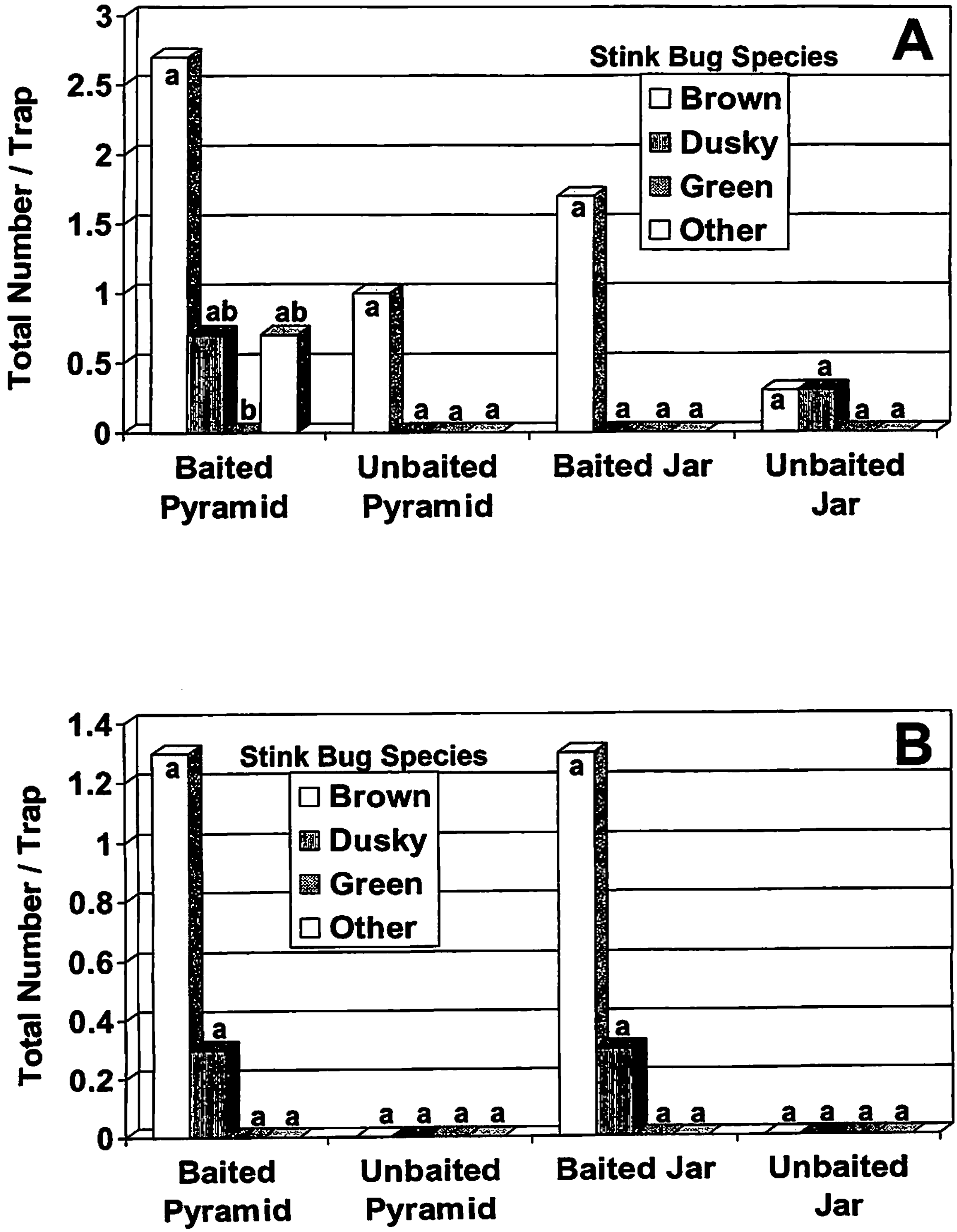


Fig. 7. Stink bug species captured in various trap types at the USDA – ARS Appalachian Fruit Research Station in apple (A) and peach (B) orchards in 2002.

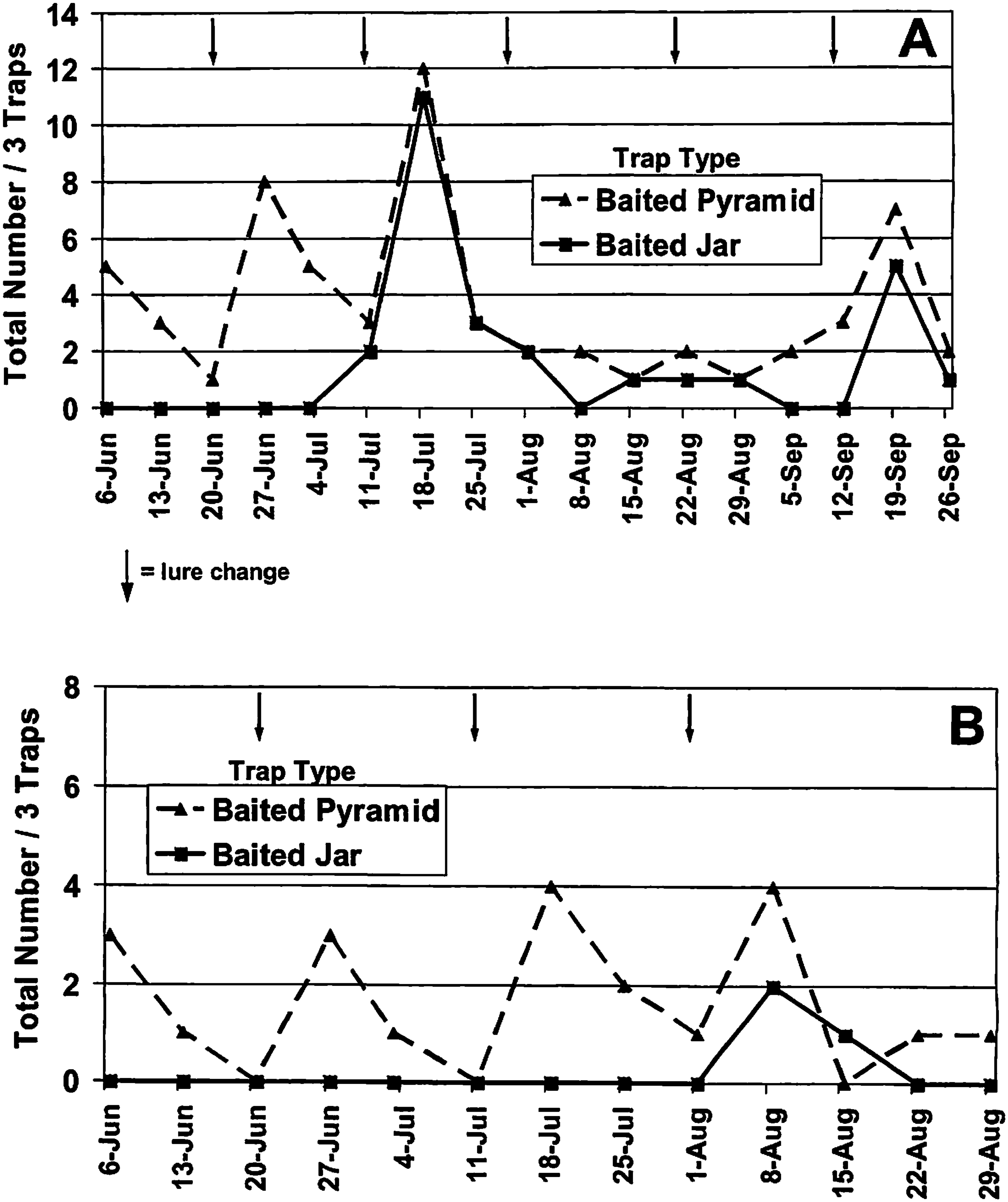


Fig. 8. Seasonal occurrence of stink bugs captured in baited traps in a commercial apple (A) and peach (B) orchard in 2002

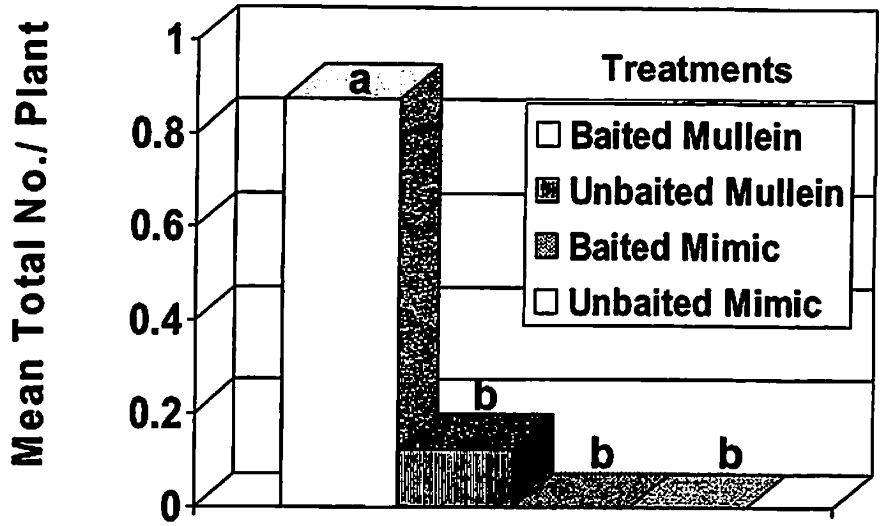


Fig. 9. Stink bugs found on mullein and mullein mimic treatments at the USDA – ARS Appalachian Fruit Research Station in 2002.

Not for Citation or Publication Without Consent of the Authors

MONITORING PLUM CURCULIO POPULATIONS IN APPLE AND PEACH ORCHARDS IN THE MID-ATLANTIC

Tracy C. Leskey and Starker E. Wright

USDA-ARS, Appalachian Fruit Research Station, Kearneysville, WV

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, limited-spectrum strategies and chemistries have begun to supplant seamless applications of OPs and SPs for control of key insect pests in both crops. As reliance on OPs and SPs is alleviated, it is likely that secondary pests (such as PC in the mid-Atlantic) will emerge as an increasing annual threat. In order to effectively manage PC in a narrow-spectrum, reduced-spray environment, 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 for plum curculio. The pyramid trap is 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). Panel traps, clear Plexiglas panels covered with Tangletrap and attached to wooden posts, do not have a specific visual cue associated with them, and are designed to capture flying adult plum curculios (Prokopy et al 2000). The Circle trap is made of folded screen attached to a boll weevil trap top; it is wrapped around an orchard tree and is designed to intercept crawling individuals on the tree trunk (Mulder et al. 1997) or within the canopy. The black cylinder trap, constructed of ABS pipe and topped with a boll weevil trap top, provides the visual stimulus of an upright vertical tree branch and is designed to capture crawling adults in the orchard tree canopy (Leskey and Prokopy 2002).

In studies in which these traps have been evaluated for their ability to be used as monitoring tools in Massachusetts, amount or timing of trap captures have failed to reflect amount or timing of oviposition injury observed in fruit trees (Prokopy et al. 1999, Prokopy et al. 2000, Prokopy et al. 2002) and hence, have thus far, failed to serve as a reliable tool to determine need for and timing of insecticide application. The intent of our study was to advance development of an effective trap-based monitoring system for mid-Atlantic PCs by evaluating monitoring technology tested in other regions such as Massachusetts and Michigan in order to learn how mid-Atlantic PC populations respond to these particular trap styles and bait combinations and to identify potential shortcomings associated with these monitoring strategies.

Materials and Methods

Traps were deployed to capture immigrating PCs in plots located in three commercial apple and three commercial peach orchards, as well as one unmanaged apple and one unmanaged peach orchard. Each orchard plot consisted of at least 32 border-row apple trees (four plots of four to eight trees and buffer trees between plots). To intercept PCs prior to orchard entry, we placed two trap types at least 2 meters from the border row. They included (1) sticky-coated Plexiglas squares, each mounted five feet above the ground on wooden posts and designed to capture flying PCs and (2) 48-inch tall trunk-mimicking black pyramid traps. Within the border row of the orchard, we affixed (1) "Circle" traps consisting of folded vinyl screen and attached at the base of tree trunks and (2) 12 inch by 2.5 inch black plastic branch-mimicking cylinder traps on horizontal limbs within tree canopies. We evaluated four bait treatments: (1) the synthetic fruit volatile benzaldehyde (Aldrich Chemical Co., Milwaukee, WI), (2) aggregation pheromone, grandisoic acid, (ChemTica International, S.A., San Jose, Costa Rica), (3) benzaldehyde in combination with pheromone; and (4) an unbaited control treatment. Release rate of benzaldehyde and pheromone dispensers were ~10 mg/day and ~1 mg/day, respectively. For pyramid, cylinder and circle trap, baits were placed within trap top collection device located at the top of each trap. For panel traps, a single benzaldehyde dispenser was attached to the edge of each panel using a locking plastic cable tie and/or a single pheromone was attached to the upper right-hand corner of the panel with a small binder clip. Benzaldehyde dispensers were replaced weekly and pheromone dispensers were replaced every 5 weeks.

In commercial apple and peach orchards, each orchard plot was divided into four blocks in which each bait combination (benzaldehyde, pheromone, both in combination, unbaited) was evaluated by deploying a baited trap paired directly with an identical unbaited trap for each of the four trap types (8 traps per block and 32 traps per orchard). Within the unmanaged apple and peach orchards, each orchard plot was again divided into four block in which each bait combination was evaluated by deploying each of the four trap types baited with the identical treatment (4 traps per block and 16 traps for entire orchard).

Beginning on 1 April at half inch green in apple and pink bud in peach and weekly for 16 weeks thereafter until 22 July , we sampled each trap for captures of PCs and removed all detritus from traps. After 22 July, we ceased sampling all orchards except the unmanaged apple orchard that we continued to sample until 6 August. At each trap sampling date from petal fall through the close of the study, we also sampled 20 fruit per trapped tree (a total of 480 fruit per orchard plot) for presence of PC oviposition scars. All PCs were brought back to the laboratory, identified to sex (Thomson 1932), and for all females, the stage of ovarian maturity based on descriptions of Smith and Salkeld (1964).

Results and Discussion

We captured 340 PCs through 22 July across all orchards, 183 in apple orchard blocks and 157 in peach orchard blocks. Greatest number of PCs was captured in circle traps (2.61 PCs per trap), followed by cylinder (1.79 PCs per trap), panel (0.91 PCs per trap) and pyramid (0.77 PCs per trap) traps across all orchard blocks and bait treatments. The greatest number of PCs was captured by trap baited with benzaldehyde in combination with pheromone (3.75 PCs per trap), followed by benzaldehyde (2.06 PCs per trap), pheromone (1.97 PCs per trap) and unbaited traps (0.71 PCs per trap) across all orchard blocks and trap treatments. Thus, the combination of a synthetic fruit volatile in combination with the aggregation pheromone increased trap captures over either bait alone by nearly 2-fold, and unbaited traps at greater than 5-fold. These results are similar to those reported by Pinero et al. (2001) for similar bait combinations.

Similar patterns were observed between phenology of trap captures for pyramid, panel and cylinder traps baited with both benzaldehyde and pheromone across commercial orchard blocks and phenology of trap captures for identically baited trap types in unmanaged orchard blocks, but not for circle traps in both apple (Figure 1) and peach (Figure 2) orchards. In this case, our unmanaged orchard blocks, provide a biological baseline of PC activity in the absence of insecticide treatment. Theoretically, then, one should observe similar patterns within a commercial orchard, but to a lesser degree in terms of number of adults captured. Thus, though pyramid, panel and cylinder traps captured fewer adults than circle traps, they provided a better indicator of PC activity in commercial orchards early in the season than did circle traps.

Graphical comparisons of amount and timing of trap captures with amount and timing of fruit injury for each trap type baited with benzaldehyde and pheromone in each apple and peach block are extremely revealing. In general we see a peak in trap captures between bloom and 6 mm fruit in apple blocks (Figure 3) and bloom and shuck fall in peach (Figure 4). The correlation coefficient for each (amount and timing of trap captures with amount and timing of fruit injury) was no greater than 0.621; that is, none of the baited traps tested here provided any strong correlation with oviposition injury and thus, provided little predictive value (Table 1). This is in agreement with work reported by Prokopy et al. (1999, 2000, 2002) in which trap captures do not reflect timing or amount of fruit injury.

Throughout the entire study (including trap captures in the unmanaged apple orchard through 6 August), we captured more males than females, 195 compared to 154, respectively. Of those females that were captured and able to be dissected for mating status and sexual maturity, nearly all females had mature ovaries, and thus could be actively ovipositing eggs in fruit, by 6 May indicating that the overwintering population had become damaging (Figure 5). By mid-June, we observed female specimens with immature ovaries (Figure 5), but fairly close to becoming sexually mature based on descriptions provided by Smith and Salkeld (1964), providing evidence for bivoltine populations in the mid-Atlantic. However, one cannot discount the possibility of univoltine populations as well based on the fact that we had some individuals with no ovarian development (Figure 5) indicating that they may have to undergo an obligatory reproductive diapause or perhaps, they were bivoltine, but had not yet begun development of mature ovaries.

Deploying baited monitoring traps some distance away from the orchard itself (Prokopy et al. 2000, Piñero et al. 2001) may be one method for increasing effective detection of plum curculio immigration into orchards, but our inability to predict potential injury to fruit based on trap captures remains a serious shortcoming. Our traps lost nearly all ability to capture PCs after petal fall. Thus, we were unable to detect increases in PC abundance or activity during or near the time period when PCs began oviposition activity. This is in agreement with other studies (Prokopy et al. 1999, Prokopy et al. 2000, Prokopy et al. 2002) and highlights the need for more competitive baits and traps (Leskey 2002) that will enable us to capture the damaging population of PCs, i.e., ovipositing females and males after fruit set, and thus allow us to develop an effective monitoring tools for use by growers.

Acknowledgements

The authors would like to thank the following growers for their cooperation and participation in these studies, Marr Orr, Orr Bros. Orchard, Arden WV, Ronald Slonaker, Jefferson Orchards, Kearneysville WV, George and Susan Behling, Nob Hill Orchard, Gerrardstown WV, Gordon and Mary Francis Hockman, Twin Ridge Orchard, Shenandoah Junction WV, and Mr and Mrs. Parrott, The Parrott Orchard, Summit Point WV.

References Cited

Hogmire, H. W., Jr., ed. (1995). *Mid-Atlantic orchard monitoring guide,* Publication NRAES-75. Ithaca, NY: Northeast Regional Agricultural Engineering Service.

Leskey, T.C. 2002. Influence of competition from host trees on plum curculio responses to baited traps. pp. 44-52. In Proceedings of the 77 Annual Cumberland-Shenandoah Fruit Worker Meetings. P. Shearer, ed.

Mulder, P. G., B. D. McCraw, W. Reid and R. A. Grantham. 1997. Monitoring adult weevil populations in pecan and fruit trees in Oklahoma. Okla. State Univ. Ext. Facts F-7190: 1-8.

Piñero, J. C., S. E. Wright, and R. J. Prokopy. 2001. Response of plum curculio (Coleoptera: Curculionidae) to odor-baited traps near woods. J. Econ. Entomol. 94: 1386-1397.

Prokopy, R. J. and S. E. Wright. 1998. Plum curculio responses to unbaited pyramid and cone traps. J. Econ. Entomol. 91: 225-234.

Prokopy, R. J., M. Marsello, T. C. Leskey, and S. E. Wright. 1999. Evaluation of unbaited traps for monitoring and controlling plum curculio adults (Coleoptera: Curculionidae) in apple orchards. J. Entomol. Sci. 34: 144-153.

Prokopy, R. J., B. W. Chandler, T. C. Leskey, and S. E. Wright. 2000. Comparison of traps for monitoring plum curculio adults (Coleoptera: Curculionidae) in apple orchards. J. Entomol. Sci. 35: 411-420.

Smith, E. H. and E. H. Salkeld. 1964. Ovary development and oviposition rates in the plum curculio, Conotrachelus nenuphar (Coleoptera: Curculionidae). Ann. Entomol. Soc. Am. 57: 781-787.

Tedders, W. L. and B. W. Wood. 1994. A new technique for monitoring pecan weevil emergence (Coleoptera: Curculionidae). J. Entomol. Sci. 29: 18-30.

Thomson, R. R. 1932. Sex differentiation of adults of *Conotrachelus nenuphar*. J. Econ. Entomol. 25: 807-810.

Table 1. Correlation coefficient (r) for timing and amount of adult plum curculio trap captures and oviposition injury and total trap captures for each trap type in both apple and peach orchards. All traps baited with benzaldehyde and grandisoic acid and monitored from 2 April to 22 July.

Apple Orchards				Peach Orchards			
Orchard	Trap Type	r	Total Trap Captures	Orchard	Trap Type	r	Total Trap Captures
Orr	Pyramid	0.499	4	Orr	Pyramid	0.000	0
	Panel	-0.120	1		Panel	-0.143	1
	Cylinder	0.302	2		Cylinder	0.000	0
	Circle	0.621	2		Circle	0.000	0
Jefferson	Pyramid	0.000	0	Jefferson	Pyramid	0.000	0
	Panel	-0.143	1		Panel	0.000	0
	Cylinder	0.000	0		Cylinder	0.000	0
	Circle	-0.143	2		Circle	0.000	0
Twin Ridge	Pyramid	0.000	0	Nob Hill	Pyramid	0.039	1
	Panel	-0.162	3		Panel	0.000	0
	Cylinder	0.000	0		Cylinder	0.039	1
	Circle	0.173	3		Circle	0.000	0
Parrott	Pyramid	-0.157	12	Parrott	Pyramid	0.057	10
	Panel	-0.003	12		Panel	-0.111	7
	Cylinder	-0.149	14		Cylinder	-0.021	21
	Circle	-0.125	13		Circle	-0.034	10

Figure 1. Comparison of phenology of plum curculio activity based on captures in commercial and unmanaged **apple orchards** from pyramid, panel, cylinder and circle traps baited with a combination of benzaldehyde and grandisoic acid.

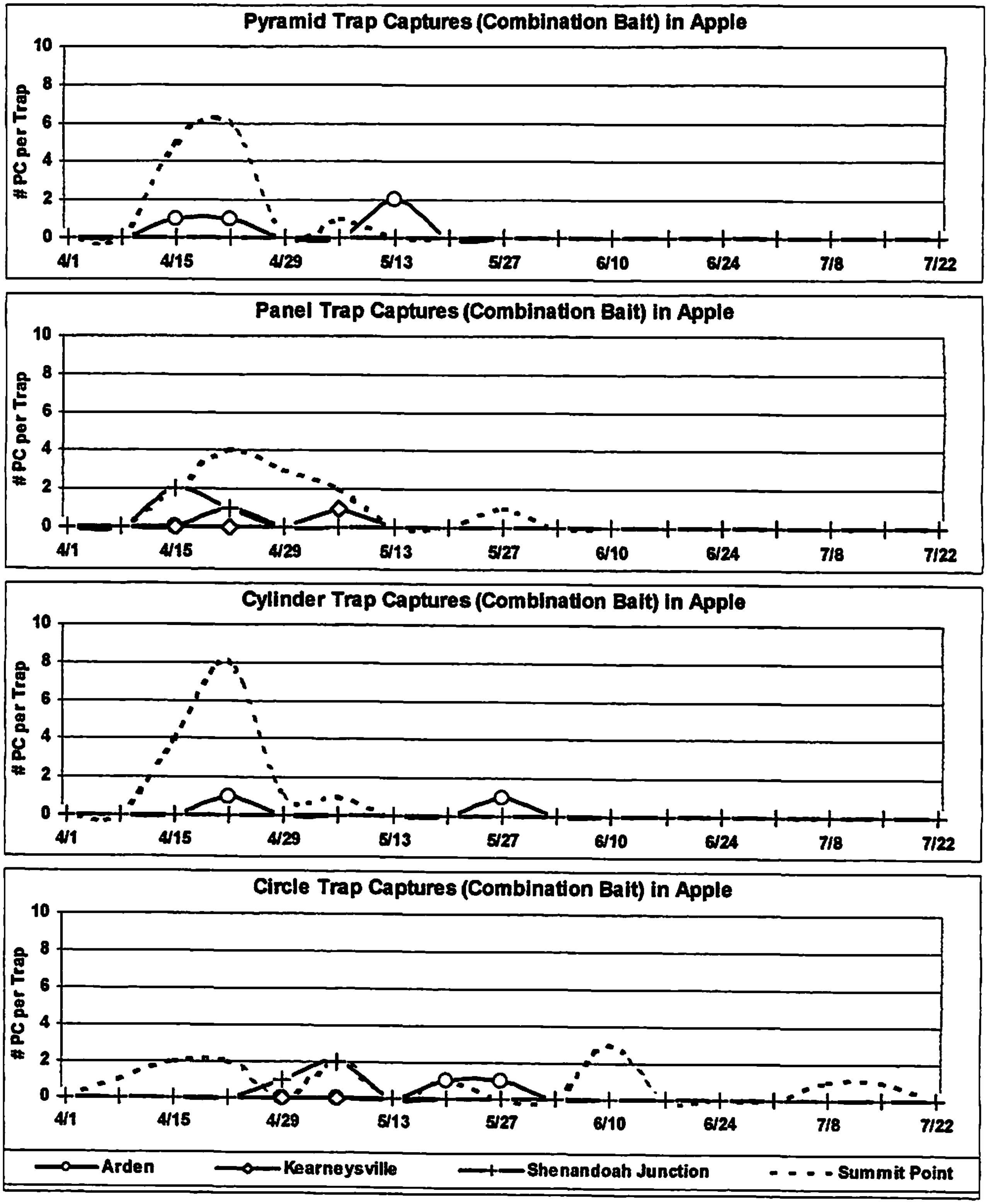


Figure 2. Comparison of phenology of plum curculio activity based on captures in commercial and unmanaged **peach orchards** from pyramid, panel, cylinder and circle traps baited with a combination of benzaldehyde and grandisoic acid.

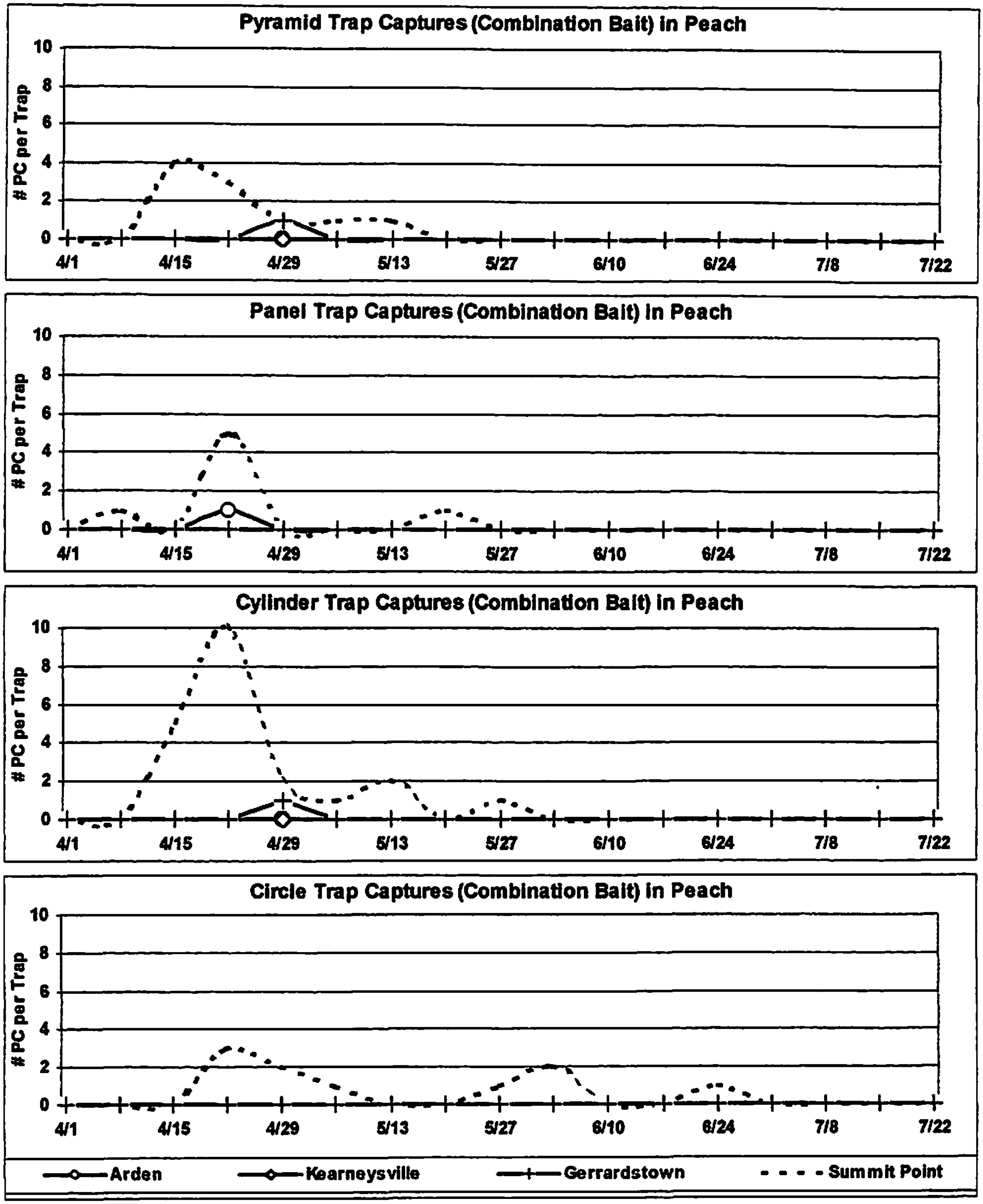


Figure 3. Comparison of phenology of plum curculio trap captures and fruit injury in each **apple orchard** for all trap types baited with a combination of benzaldehyde and grandisoic acid.

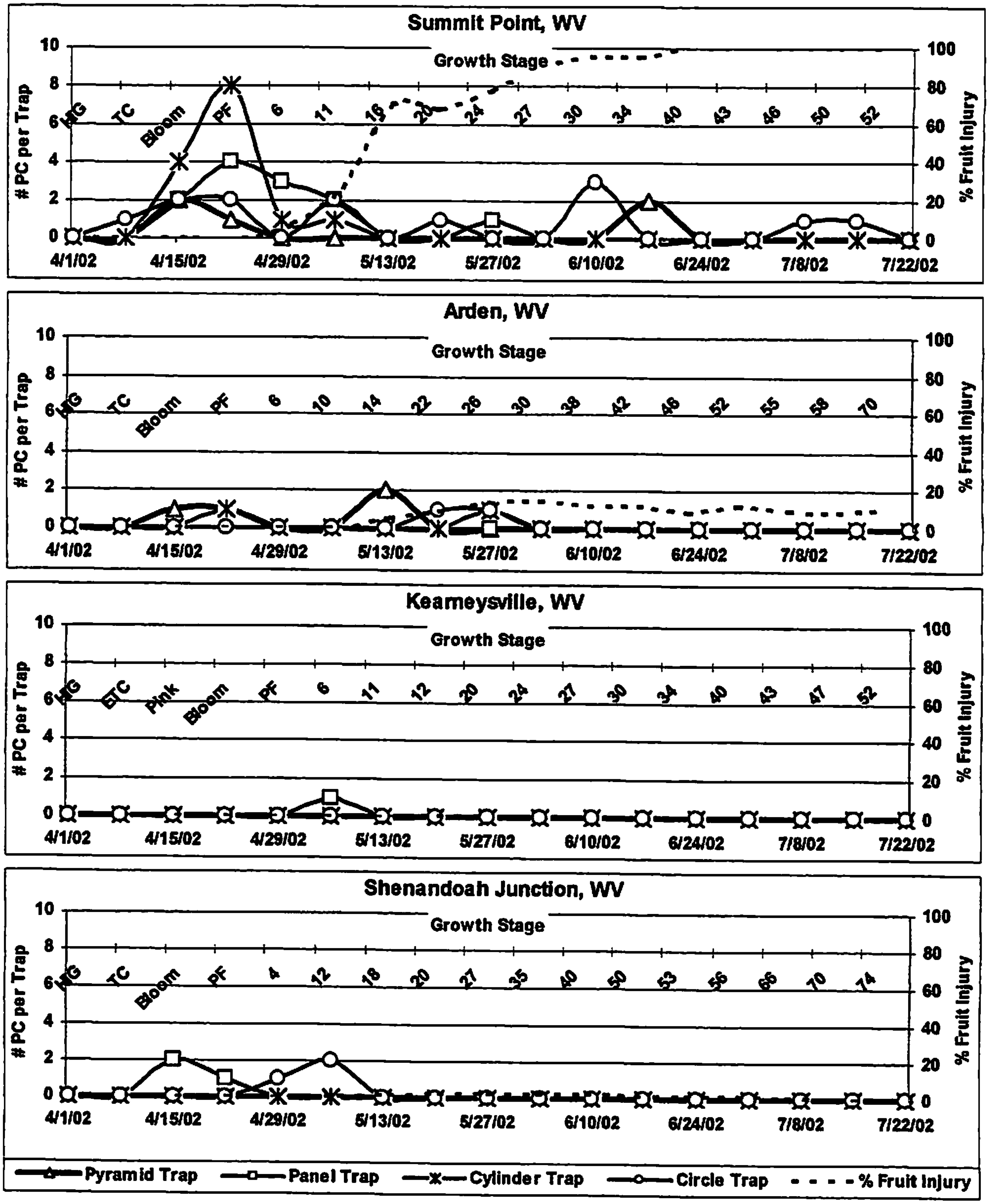


Figure 4. Comparison of phenology of plum curculio trap captures and fruit injury in each **peach orchard** for all trap types baited with a combination of benzaldehyde and grandisoic acid.

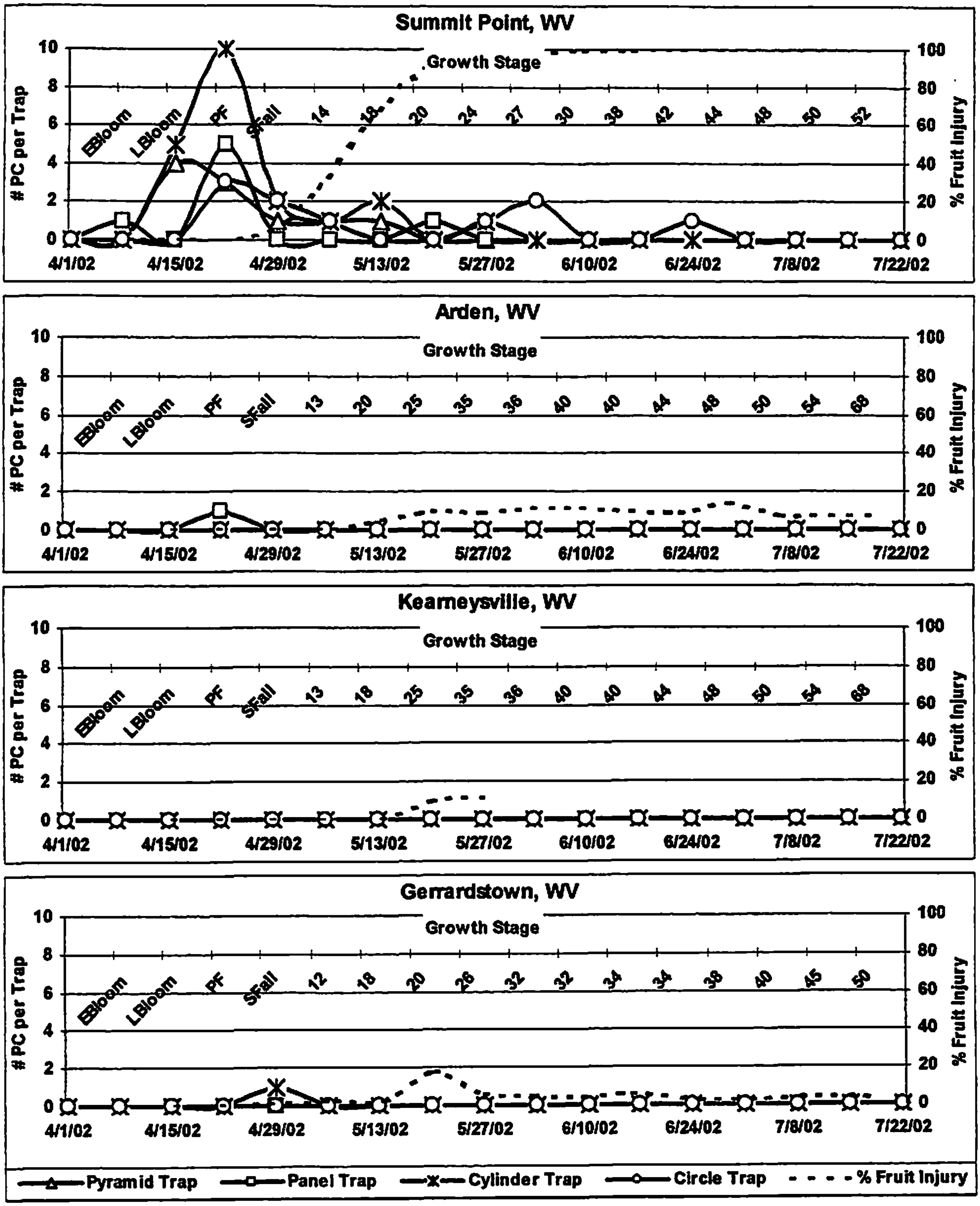
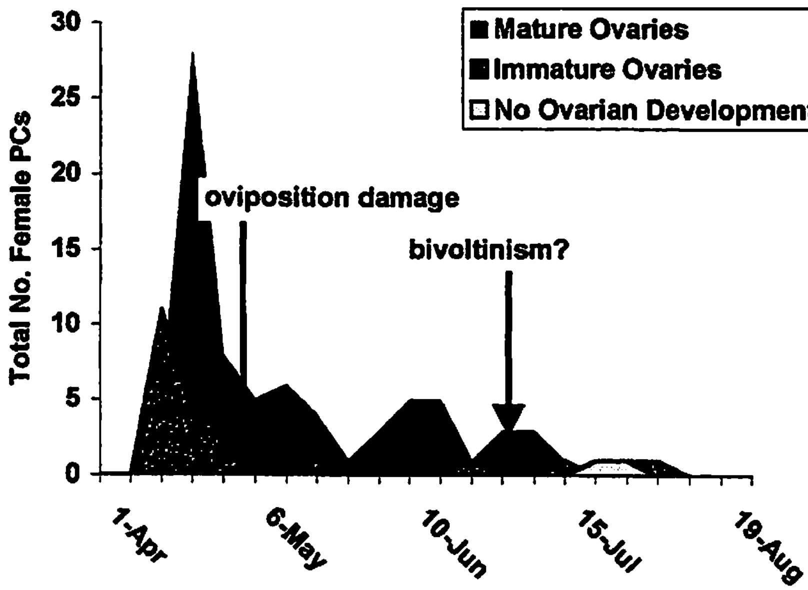


Figure 5. Total number of trapped females with mature ovaries, immature ovaries, and no ovarian development based on laboratory dissections and descriptions by Smith and Salkeld (1964). Arrows indicate when oviposition damage was first detected (and hence, development of a second generation occurring) and when a second generation that may soon become reproductively active, perhaps indicative of bivoltine populations, is detected.



PHENOLOGY AND MANAGEMENT OF THE APPLE MAGGOT IN NORTH CAROLINA

Raul T. Villanueva and James F. Walgenbach

Mountain Horticultural Crops Research and Extension Center – Fletcher
North Carolina State University

The apple maggot (AM), *Rhagoletis pomonella* (Walsh), is a native insect of North America whose original hosts were in the genus *Crataegus* spp. (hawthorns). However, ~ 150 years ago AM switched to introduced plants of the genus *Malus* (i.e. *M. domestica* - domestic apple) (Filchack et al. 2002), and now occurs throughout most apple producing regions of North America (Prokopy 1984, Bush et al. 2000). Adults oviposit eggs into fruit, and damage to apple is the result of tunnels produced by larval feeding in the fruit. The AM has been considered a minor pest in North Carolina, but during the 2001 apple-growing season high percentages of AM-infested fruit were found in western North Carolina. Chen et al. (20002) in Pennsylvania suggested that the increased importance of AM in Pennsylvania may be due to reduced use of broad spectrum organophosphate insecticides in favor of those with a narrow spectrum of pest activity, and/or as to the presence of abandoned orchards that act as reservoirs of AM.

Historically AM has been controlled by broad-spectrum organophosphate insecticides. The uncertain future regulatory statutes of organophosphates has increased the need for alternative insecticides for AM control. In addition, little is known about the life history and phenology of AM in North Carolina, as it has previously not been an important pest in this region. Hence, in 2002 studies were conducted to learn more about the phenology and management of AM in NC. Reported here are the results of studies to 1) monitor the emergence and flight pattern of AM flies, 2) compare the efficiency of the kaolin product Surround and, 3) to compare the efficacy of a diversity of new insectides for control of AM.

Material and Methods

Phenology of Adult Emergence and Flight

Emergence cages and red spheres were used to monitor AM flies in commercial orchards in Henderson County, North Carolina. Emergence cages were placed under the tree canopy in seven apple orchards and monitored from 13 May to 25 October. Orchards selected for these studies were heavily infested by AM in 2001, and 2 – 6 emergence cages per orchard were placed over the soil under trees. Cages were checked twice per week between 27 May to 9 August, and once per week after 9 August. Cages were made of a fine-wire mesh and shaped and folded conically with a piece of wood for support and a clear glass jar on top to collect emerging AM flies. Red spheres were hung on trees in 15 orchards, with 2 to 3 traps hung on the periphery of each orchard. Spheres were coated with tanglefoot (Great Lakes IPM, MI). Non-baited spheres and spheres baited with an apple essence lure consisting of butyl-butanoate, propyl-hexanoate, hexyl-butanoate, butyl-hexanoate and pentyl-hexanoate were placed in each orchard. Traps were checked weekly from 31 May to 1 November.

Evaluation of Surround for Control of Apple Maggot

A 'Golden Delicious' apple orchard in Henderson County, NC, was used to evaluate the kaolin product Surround, Spintor and Guthion for control of the AM. Treatments consisted of one rate of Surround (25 lb) sprayed at two volumes (100 and 200 gpa) and applied at 7- and 14-d intervals, Spintor (5 oz per acre at100) applied at 7- and 14-d intervals, Guthion (2 lb per acre at 100) applied at 14-d intervals, and a non-treated control. All plots were sprayed using an air blast sprayer. Plots consisted of 3 trees each, and each treatment was replicated 3 times in a RCBD. Spray dates were 8, 15, 22, 29 July and 5, 12, 19 and 26 August; 7-d interval applications were made on all dates, and 14-d interval applications made on 8 and 22 July, and 5 and 19 August. Efficacy was evaluated by cutting fruit from the middle tree of each treatment and recording the number of fruit with larval tunnels. Fruit were evaluated on 16 and 30 July and on 16 September; 35 fruit each from the top, lower and inside tree canopy were evaluated. Percentage of fruit infested with AM was transformed using arcsine □(x/100), and then subjected to a two-way ANOVA and means separated by LSD ($P < 0.05$). Results are presented as back transformation (percent damage ± SEM).

Field observations of leaves and fruit after Surround sprays showed that material did not distribute uniformly in the tree canopy. Inner leaves and fruit appeared to have smaller amounts of Surround deposited on their surfaces compared with outer leaves and fruit. To quantify these observations, five apples were collected from the inner and outer portion of trees from three of the following three treatments; Surround at 100 gpa and applied at 7- and 14-d intervals and the non-treated control. Five fruit were also collected from three 'Delicious Golden' trees located approximately 20 miles from the experimental site on the Mountain Horticultural Crops Research and Extension Center (MHCREC) at Fletcher, NC. These latter samples were collected to gauge the amount drift onto non-treated trees at the study site. For non-treated fruit, only outer fruit were sampled on all sample dates, except 19 July when no fruit were sampled at the MHCREC. Fruit were collected 3 h before and 3 h after application on the dates of application, and 4 days after treatment. All fruit were placed in labeled paper bags, placed in a cooler and immediately transported to the laboratory. The area of apples was calculated by assuming that an apple was a sphere. Hence, the height and width of fruit were measured with a caliber to obtain the average radius (r), and the surface (A) of apples was calculating by the formula $A = 4\square r^2$. Each fruit was then brushed and rinsed with methanol into 250 ml plastic containers that were previously weight. The residual methanol was allowed to evaporate overnight and the amount of surround was calculated as the difference between the final and initial weight of the container. Sampling dates were 19, 22, 26, 29 July, and 2, 5, 9,12, 16, 19 August. Data were subjected to a two-way ANOVA, and treatment means were separated by LSD test ($P < 0.05$).

Large Plot Evaluation of Surround for Control of Apple Maggot

To evaluate the utility of Surround in commercial settings, large plot trials were conducted with four growers in Henderson County, NC. At each location a 4-to-5 acre block of 'Golden Delicious' apple was sprayed with Surround and compared with an adjacent block of similar size sprayed with organophosphates (Guthion and/or Imidan). All growers made three applications of Surround (25 lbs per acre) at 14- to 17-d intervals between early July and mid August. Percentage of fruit infested with AM was assessed at various intervals between July and harvest in mid September. To assess efficacy, 5, 10 or 15 apples per tree on 5 to 10 trees per block (number varied with sample date) were removed, cut and examined for presence of larval tunnels. Two orchards consisted of a diversity of tree sizes, and both large (≈20 feet height) and small trees (6-8 feet) were sampled at these locations. Tree height did not vary at the two remaining locations (Marlowe and Coston), and averaged about 15 ft.

Insecticide Efficacy Trials

A trial was conducted in a 'Golden Delicious' orchard to compare the insecticides Avaunt, Spintor, Provado, Actara, Calypso, and Guthion for control of apple maggot. Spray dates were 24, June, 8 and 22 July, and 5 and 19 August. Plots consisted of three trees, and each treatment was replicated three times. The only other insecticide applied in these plants was Actara (4.5 oz/acre) at petal fall (early May) to all treatments. Percentage of AM infested fruit (100 fruit per plot) was assessed on 3 and 20 July, and 9 September. Data were collected from the middle tree of each plot, and transformed using arcsine □(x/100), subjected to a two-way ANOVA, and means were separated by LSD ($P < 0.05$). Data are presented as back transformations.

Results

Phenology of Adult Emergence and Flight

Apple maggot flies in emergence cages and those caught on baited red spheres exhibited a similar phenological pattern (Fig. 1); i.e., high numbers of flies between by mid July to early August. On non-baited red spheres, a single large peak was observed on 7 June; however, 45 out of 54 flies (= 83.3 %) were found in one orchard (Barnwell) and 41 of the flies were males.

Evaluation of Surround for Control of Apple Maggot

Shown in Fig. 2 is the percentage of damage in the small plot Surround study. Control plots had the highest percentage of infested fruit, ranging between 15 to 20 % on all sample dates. All treatments significantly reduce damage below the control on 16 July (df = 7,14; $F = 2.81$ and $P < 0.05$), 30 July (df = 7,14; $F = 3.14$ and $P < 0.05$) and 16 September (df = 7,14; $F = 7.43$ and $P < 0.01$). The lowest percentage of infested fruits was found in the Surround 200 gpa and Guthion treatments, with < 4% infested fruit. Also on 16 September there was a within canopy difference in the percentage of infested fruit, with fruit from the upper canopy having a higher infestation level than fruit from the inner and outer canopy of the lower portion (Fig.3). However, only the non-treated and 14-d Spintor treatments showed differences in the percentage of damage between fruit position. Both treatments showed that the upper and inner fruit had significantly higher damage compared with outer fruit. Mean (± SEM) percentage damage in the control was 7.0 ± 0.7, 1.8 ± 1.3 and 9.8 ± 0.7 for inner, outer and upper fruit, respectively (df = 2,6; $F = 19.47$ and $P < 0.01$). For the 14-d Spintor treatment, damage was 2.8 ± 0.7, 0.4 ± 0.4 and 2.1 ± 0.0 for inner, outer and upper fruit, respectively (df = 2,6; $F = 7.8$ and $P < 0.05$). Although this trend was also observed in the other treatments (i.e., highest damage was observed on either the upper or inner fruits), differences were not significant ($P > 0.05$).

For all dates there were no significant differences ($P > 0.05$) in the amount of Surround on fruits from the control and fruits from the MHCREC, indicating that spray drift to control trees was negligible. However, it was apparent from field observations in the 7- and 14-d Surround

(100 gpa) treatments, outer-canopy fruit had higher amounts of Surround than inner fruit; indicating that Surround coverage was heterogeneous. This observation is confirmed by the significantly higher amounts of Surround found on outer fruit compared with inner fruit on 22 July (df = 7, 14; F = 7.72, P < 0.01), 26 July (5, 10; F = 18.60, P < 0.01), 29 July (9, 18; F = 5.93, P < 0.01), 2 August (5, 10; F = 6.99, P < 0.01), 5 August (df = 7, 14; F = 5.18, P < 0.01), 9 August (df = 5, 10; F = 29.21, P < 0.01), 12 August (df = 9, 18; F = 6.84, P < 0.01), 16 August (df = 5, 10; F = 17.01, P < 0.01) and 19 August (df = 5, 10; F = 6.64, P < 0.01) (Fig.4).

Large Plot Evaluation of Surround for Control of Apple Maggot

High numbers of trees without infested fruit were found in the Surround and Conventional plots in all locations, but more damage was observed on the Surround compare with Conventional plots (Table 1). It was also noted that in Surround plots, small trees had a lower percentage of infested fruit compared with larger trees. The Staton orchard had the highest percentage of infested fruit, and this damage was most abundant in upper canopy fruit, suggesting that Surround was not uniformly sprayed on trees. It was apparent from observations that the upper canopy of large trees received smaller amounts of Surround than the lower canopy, and this may explain the lower AM infestations on small trees that were uniformly covered by the spray. At all locations, damage was generally lower during the final assessment in September compared with assessments in July and August, suggesting that most of the damage occurred early in the season.

Insecticide Efficacy Trials

Apple maggot pressure was very high in this insecticide trial, with >60 % of non-treated fruit infested with AM (Table 2). Among the insecticide treatments, Avaunt and Spintor had the largest percentage of AM infested fruit, while Provado, Guthion and Calypso provided excellent control (□ 10% damage). At this study site (Lancaster orchard), AM flies appeared to emerge later in the season based on the fact that virtually no damage was detected on samples in 3 and 20 July, but on 16 September damage was very high. There were no differences in the level of AM damage from fruit in the upper vs. lower canopy ($P > 0.05$).

Discussion

The unbaited red spheres had peak numbers of AM flies during the first week of June, whereas the baited red spheres and emergence cages peaked between mid-July and early August (Fig. 1). These two different peaks may suggest two distinct emergence patterns of AM flies, one emerging in June and other in July and August. This bimodal emergence is also supported by the timing of fruit damage in the small plot Surround and insecticide trial; there was very little damage in the Surround study after July, whereas in the insecticide study there was virtually no damage until August and September. A bimodal emergence pattern has been reported in other Dipteran pests. Walgenbach et al. (1993) and Biron et al. (1998) studied the cabbage maggot, *Delia radicum* (L.) (Diptera: Anthomyiidae) and reported that the F1 progeny from crosses between early- and later- emerging flies were genetically controlled and that the phenomenon was independent of the diapause period. These apparent differences in the emergence of AM from different orchards warrants further studies on the phenology of AM in North Carolina orchards.

In both small and large plot trials, Surround appeared to be effective in preventing AM infestations. In the small plot Surround trial, none of the Surround treatments significantly differed ($P > 0.05$) from Guthion at harvest, but they were significantly better than the non-treated control (Figs. 2 and 3). Similarly, in large plot studies Surround generally provided comparable control to organophosphate insecticides (Table 1). In the Surround trials, most of the AM damage appeared in upper canopy fruit (Table 1 and Fig 3) where there was poor coverage of Surround. This heterogeneous coverage was noticed on regular visits to study sites, and was corroborated with higher residual amounts of Surround on fruit in the outer compared with inner canopy (Fig. 4). The loss of Surround on the fruit surface between spray intervals was minimal, probably due to the few rainfall events that occurred during this trial in North Carolina. Rain is probably the most important factor in the loss of residual Surround from fruit surfaces.

The neonicotinoids Calypso and Provado provided excellent control of AM in small plot studies (□ 10%). Actara, also a neonicotinoid, along with Avaunt and Spintor all had > 30% infested fruit. These studies have demonstrated that there are a number of alternatives to organophosphate insecticides for managing AM in North Carolina apples, including the use of the kaolin product Surround and a number of reduced-risk neonicotinoids. To develop a cost-effective AM management program, additional studies are needed on the phenology of AM in North Carolina and the efficacy of different rates of products.

Acknowledgement

We thank all cooperating growers for allowing us to use their orchards. We also thank Charles Palmer, Steve Schoof, Tim Leslie, Dan Borchert, Orkum Kovanci, Charles Thayer, Nathan Lyda, Todd Lyda, Ryan Klimstra, and Andrew vun Cannon for help, and data collection. This work was supported, in part by Gerber Products Co. and N.C. Agricultural Research Service

References

Biron, D.G; X. Langlet, G Boivin, and E. Brunel, 1998. Expression of early and late-emerging phenotypes in both diapausing and non-diapausing *Delia radicum* L. pupae Entomol. exp. appl. 87 (2): 119-124

Bush, M. R., M. Klaus, A. Antonelli, and C. Daniels. 2002. Protecting backyard apple trees from Apple Maggots. Cooperative extension,Washington State university and USDA. Extension Bulletin 1928. 6 pp.

Chen, H., C.M. Felland, and B.A. McPheron. 2002. Population dynamics of Apple maggot (Diptera: Tephritidae) in South Central Pennsylvania. Journal of Economic Entomology. 95: 65-71.

Filchack, K. E., J. B. Roethele and J.L. Fedder. 2000. Natural selection and sympatric divergence in the apple maggot *Rhagoletis pomonella*. Nature. 407: 739-742.

Prokopy, R.J. 1984. The pple maggot in Massachusetts, Michigan and west coast states. Fruit Notes. Cooperative Extension Service, University of Massachusetts and USDA. 49:16-18.

Walgenbach, J.F., C.J. Eckenrode, and R.W.Straub. 1993. Emergence patterns of Delia radicum (Diptera: Anthomyiidae) populations from North Carolina and New York. Environmental entomology. 22 (3): 559-566

Table 1. Mean (± SEM) percentage of apples infested with apple maggot in Surround and conventionally sprayed plots. Henderson County, NC. 2002

				% Damage			
Location	Date	Treatment	Tree Size	Inner Canopy	Outer Canopy	Upper Canopy	Total
Staton	15-Jul	Surround	Large	0	2.0 ± 2.0	-	0.7 ± 0.7
		Conventional	Large	0	0	-	0
	31-Jul	Surround	Large	4.0 ± 4.0	0	4.0 ± 4.0	2.7 ± 1.3
			Small	-	-	-	0
		Conventional	Large	0	0	-	0
	14-Aug	Surround	Large	12.0 ± 4.9	4.0 ± 4.0	28.0 ± 14.5	14.6 ± 7.1
			Small	-	-	-	4.0 ± 4.0
		Conventional	Large	0	0	4.0 ± 4.0	1.3 ± 1.3
	21-Aug	Surround	Large	4.0 ± 4.0	8.0 ± 4.9	24.0 ± 11.7	10.7 ± 6.7
			Small	-	-		0
	12-Sep	Surround	Large	1.7 ± 1.0	0	1.7 ± 1.3	1.1 ± 0.6
			Small	-	-		0
		Conventional	Large	-	0	2.0 ± 2.0	1.0 ± 1.0
Mr Ed	15-Jul	Surround	Large	4.0 ± 4.0	4.0 ± 4.0	-	4.0 ± 0
		Conventional	Large	0	0	0	0
	14-Aug	Surround	Large	0	0	0	0
			Small	-	-	-	0
		Conventional	Large	0	0	12.0 ± 8.0	4.0 ± 4.0
	21-Aug	Surround	Large	0	0	0	0
			Small	-	-	-	0
		Conventional	Large	0	0	0	0
	12-Sep	Surround	Large	2.0 ± 1.3	4.0 ± 1.6	3.0 ± 2.1	1.1 ± 0.6
			Small	-	-		0
		Conventional	Large	0	1.0 ± 1.0	0	0.3 ± 0.3
Marlowe	14-Aug	Surround	Large	0	0	0	0
		Conventional	Large	0	0	4.0 ± 4.0	1.3 ± 1.3
	21-Aug	Surround	Large	0	0	0	0
		Conventional	Large	0	0	0	0
Coston	31-Jul	Surround	Large	0	0	0	0
		Conventional	Large	0	0	0	0
	12-Sep	Surround	Large	0	0	2.0 ± 1.3	0.7 ± 0.7
		Conventional	Large	0	0	0	0

Table 2. Insecticide rates and mean (± SEM) percentage of infested fruit with AM.

Insecticide	Rate	3 July	3 July	16 September
Avaunt	6.0 oz/acre	0	0a	43.0 ± 13.0ab
SpinTor	6.0 oz/acre	0	0a	57.0 ± 14.0ab
Provado	6.0 oz/acre	0	0a	10.0 ± 3.5cd
Actara	4.5 oz/acre	0	2.7 ± 1.33a	33.7 ± 5.0bc
Calypso	4.0 oz/acre	0	0a	5.3 ± 2.8d
Guthion	2.0 lb/acre	0	0a	8.0 ± 3.7d
Control	-	0	0a	63.3 ± 9.0a

Means within columns followed by the same letter are not significantly different by LSD (P = 0.05).

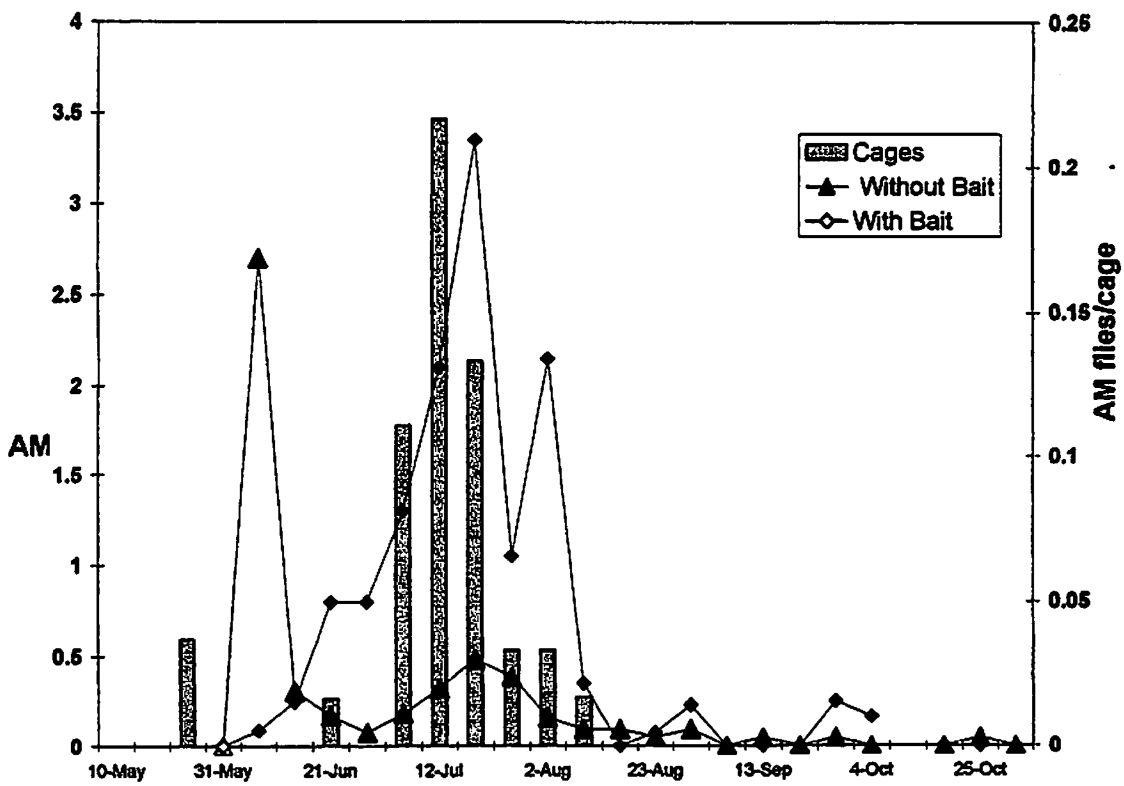


Figure 1. Mean numbers of apple maggot flies on red spheres with and without bait and on cages on 2002.

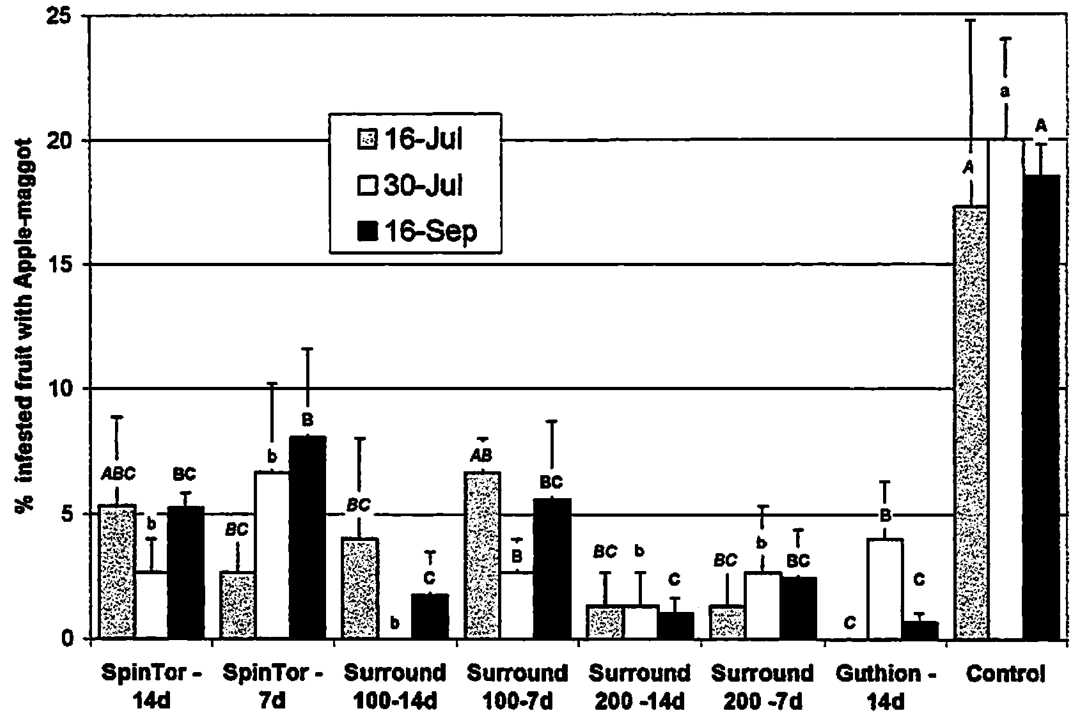


Figure 2. Mean (± MSE) percentage of apples infested with apple maggot. Different letter within each sample date indicates significant differences (LSD test, $P < 0.05$

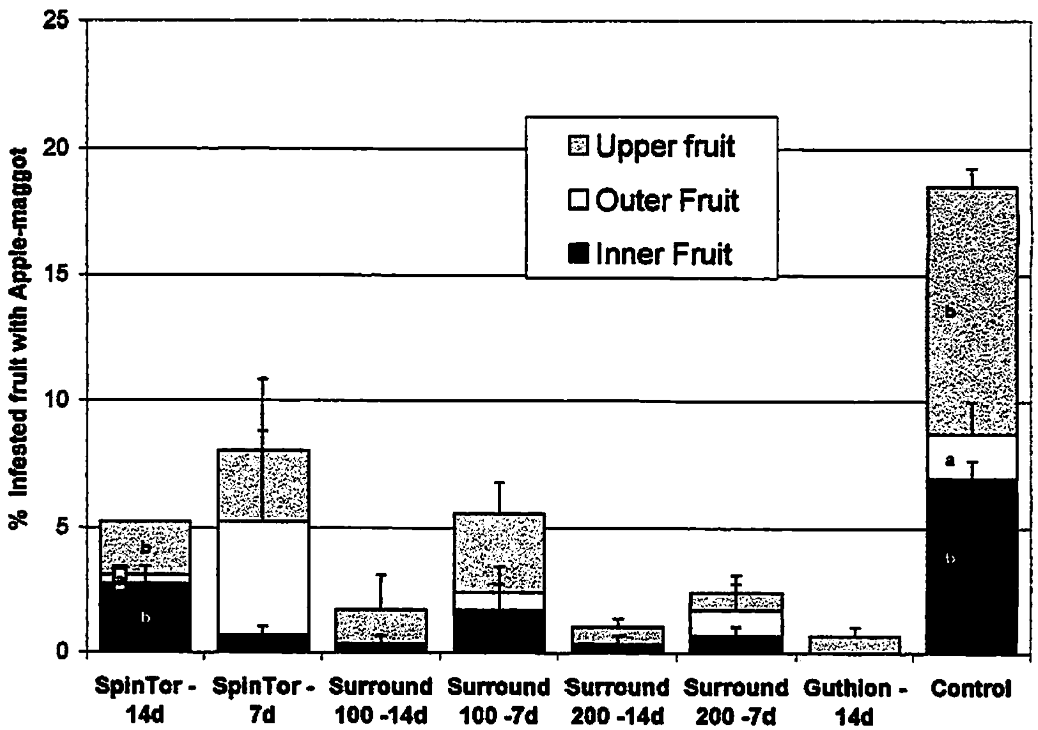


Figure 3. Mean (± MSE) percentage of apples infested with apple maggot on 16 September depending of fruit position in tree canopy. Different letter within each treatment indicates significant differences (LSD test, $P < 0.05$

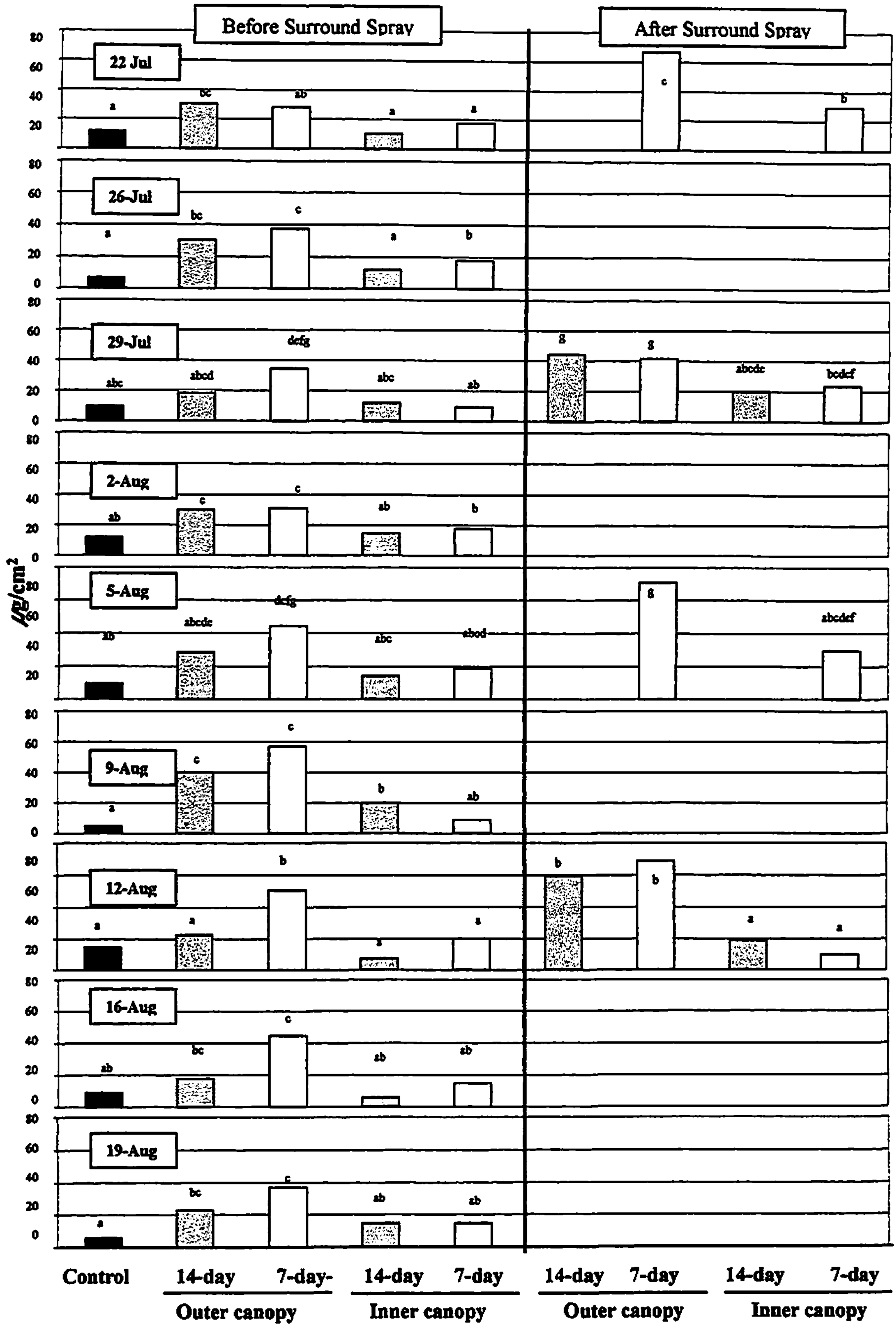


Figure 4. Mean residual of Surround (□g/cm²) on 5 fruit surfaces. Different letter between treatments in the same date indicates significant differences ($P < 0.05$) after LSD test.

Apple (*Malus domestica* 'Rome Beauty')
Fire blight blossom blight; *Erwinia amylovora*

J. W. Travis, K. D. Hickey,
N. O. Halbrendt, E. S. Anderson,
and S. B. Jarjour
PSU Fruit Research and Extension Center
290 University Drive, POB 330
Biglerville, PA 17307-0330

FIRE BLIGHT BLOSSOM BLIGHT INCIDENCE ON 'ROME BEAUTY' APPLE TREATED WITH BACTERICIDES IN 2002: Efficacy of bacterial treatments for blossom protection were evaluated in a mature block of 'Rome Beauty'/seedling trees planted 25 X 30 ft and pruned to a height of 12 ft. Treatment plots were single trees arranged in a randomized complete block design with four replicates. Dilute sprays were applied to the point of run-off with a high pressure sprayer equipped with a nine-nozzle boom and operated at 400 psi. All treatment plots, except the nontreated-1, were sprayed with fixed-copper (COCS 75 WDG 3.0 lb/100 gal) at green-tip and half-inch green growth stages. Treatment applications were made on 23 Apr (90-100% bloom) and 27 Apr (one-day post-inoculation as shown in the table). Following the spray treatments ten blossom clusters per replicate were marked and all blossoms on each inoculated with a suspension of a one-day-old culture of *E. amylovora* (1×10^8 cfu/ml). Blossoms were inoculated by swabbing flower parts with a cotton swab after being dipped in the inoculum suspension. Temperature at the time of inoculation (3:00-4:00 PM) was 59° F. The mean and maximum temperatures for the three days after inoculation were 46° F and 63° F, respectively. Observations for necrosis on flower parts (usually 5 blossoms per cluster) and shoots were made on 20 May. Data obtained were analyzed by analysis of variance using appropriate transformations and the Fisher Protected LSD Test ($P<0.05$) for significance among treatments.

Low temperatures at the time of inoculation and for three days following were unfavorable for rapid development of the fire blight pathogen. Necrosis of the floral parts (anthers and pistils) developed on 90 percent of the nontreated and inoculated blossoms, but shoot blight developed only on a few inoculated blossom clusters (Table 3). The mean maximum temperature of 61° F for the three days following inoculation was high enough for infection of floral parts, but too low for shoot blight development on this moderately susceptible cultivar. The GWN 9200 10W and Agrimycin 17W treatments provided blossom protection significantly better than the nontreated. Serenade WPO (QRD 137) used alone was not significantly different from the nontreated. The combinations with Agrimycin provided significant control which may have been due to the antibiotic. COCS 75WDG 4.0 oz/100 gal did not provide significant protection in this test.

Table 3 . Percent 'Rome Beauty' Blossoms Infected After Treatment With Bactericides and Inoculated with *Erwinia amylovora* in 2002.

Treatment and Rate/100 gal	Application Timing	Fire Blight on Blossoms	
		Avg. no./cluster	Percent inf. Blossoms
1. Nontreated - 1	--	4.5. cd*	89.0 d
2. GWN 9200 10W 2.09 lb (250 ppm)	70- 90% B	3.4 ab	67.4 ab
3. GWN 9200 10W 3.10 lb (375 ppm)	70- 90% B	4.2 bcd	83.0 bcd
4. GWN 9200 10W 4.17 lb (500 ppm)	70- 90% B	3.3 ab	65.8 ab
5. Agrimycin 17W 7.9 oz (100ppm)	70- 90% B	3.6 abc	72.5 abc
6. COCS 75WDG 4.0 oz	70- 90% B	4.6 d	91.8 d
7. Serenade WPO (QRD 137) 2.0 lb	70- 90% B	4.3 cd	86.9 cd
8. Serenade WPO (QRD 137) 2.0 lb Agrimycin 17W 7.9 oz (100 ppm)	70- 90% B 100% B (1 da PI)	3.4 ab	68.5 ab
9. Agrimycin 17W 7.9 oz (100 ppm) Serenade WPO (QRD 137) 2.0 lb	70- 90% B 100% B (1 da PI)	3.2 a	64.0 a
10. Nontreated - 2	--	4.6 d	90.0 d

* Means marked with the same letter(s) are not significantly different according to the Fisher Protected LSD Test ($P < 0.05$).

Not for Publication

Apple: *Malus x domestica* ('Delicious',)
'Golden Delicious', 'Rome Beauty')
Apple scab; *Venturia inaequalis*
Cedar-Apple rust; *Gymnosporangium juniperi-virginianae*
Powdery mildew; *Podosphaera leucotricia*
Flyspeck; *Zygophiala jamaicensis*
Sooty blotch; disease complex
White rot; *Botryosphaeria dothidea*

J. W. Travis, K. D. Hickey,
N. O. Halbrendt, E. S. Anderson,
and S. B. Jarjour
PSU Fruit Res. and Extension Ctr.
290 University Dr., POB 330
Biglerville, PA 17307

EVALUATION OF MANA-131 FOR DISEASE MANAGEMENT ON APPLE IN 2002: The test was conducted in a 27 year-old semi-dwarf experimental orchard planted 15 x 35 ft and pruned to a height of 12 ft. Apple scab inoculum was low due to previous drought conditions and powdery mildew and cedar-apple rust levels were moderate. Inoculum for the summer disease complex (sooty blotch, flyspeck, and fruit rot) was moderately low. Experimental plots consisted of one tree each of three cultivars planted sequentially along the row. The experimental design was a randomized complete block with four replicates. One plot (three trees) on each side of the treated plots was left untreated. Fungicides were applied as dilute sprays to the point of run-off at 3.75 gal /tree (300 gal/A.) with a high pressure sprayer equipped with a 9-nozzle boom and operated at 400 psi. Spray applications were made as follows: 18 Apr (tight-cluster), 30 Apr (petal-fall), first through the seventh cover sprays on 16, 28 May, 12, 25 Jun, 12, 23 Jul, and 12 Aug, respectively. Environmental parameters near the test block were recorded hourly with a Campbell Scientific and Meteos Weather Stations. Disease incidence for apple scab, powdery mildew, and apple rust on 'Rome Beauty' leaves was recorded on 19 Jun by observing all leaves on each of 10 non-fruiting vegetative terminals per replicate. Disease incidence on fruit at harvest (2-3 Oct) was obtained by examining 100-fruit per replicate from 'Delicious' and 'G. Delicious' trees. Data obtained were analyzed by analysis of variance using appropriate transformations and significance among treatment means determined by the Fisher Protected LSD Test ($P<0.05$).

Apple scab incidence in this test was less than 1.0 percent on leaves and fruit of nontreated trees. Mana-131 80WDG treatments provided poor control of powdery mildew, as expected, but the level was significantly different from the nontreated and similar to the Ziram standard (Table 2). Similarly, these treatments significantly reduced the level of apple rust on 'Rome Beauty' leaves, but the level of control was significantly lower than the Ziram standard. The incidence of sooty blotch, flyspeck, and white rot on nontreated fruit of 'Golden Delicious' was 23.5, 65.0, and 8.5 percent, respectively. All treatments provided significant control of these diseases and produced no phytotoxicity to leaves or fruit.

Table 2 . Disease Incidence on Apple Treated with Captan Formulations Applied Dilute in 2002.

Fungicide and Rate/100 gal	Percent Leaves Infected 'Rome Beauty'		Percent Fruit Infected 'Golden Delicious'		
	P. Mildew	A. Rust	S. blotch	Flyspeck	White rot
1. Nontreated	59.7 d*	29.0 d	23.5 b	65.0 b	8.5 b
2. Mana-131 80WDG 20.0 oz	50.1 ab	23.0 c	0.5 a	1.0 a	2.0 a
3. Mana-131 80WDG 10.0 oz	53.6 bc	22.2 b	0.7 a	5.1 a	2.1 a
4. Captan 50W 2.0 lb	48.4 a	22.3 bc	0.0 a	0.3 a	1.5 a
5. Captan 50W 1.0 lb	56.4 cd	24.1 c	0.0 a	0..4 a	1.7 a
6. Ziram Granuflo 75WDG 2.0 lb	53.7 bc	10.9 a	0.5 a	1.9 a	2.4 a

* Means marked with the same letter (s) are not significantly different according to the Fisher Protected LSD Test ($P \leq 0.05$).

Not for Publication

Apple: *Malus x domestica* ('Cortland', 'Delicious', 'Golden Delicious', 'Rome Beauty'
Apple scab; *Venturia inaequalis*
Cedar-Apple rust; *Gymnosporangium juniperi-virginianae*
Powdery mildew; *Podosphaera leucotricia*
Frog-eye leaf spot; *Botryosphaeria obtusa*
Sooty blotch; disease complex
White rot; *Botryosphaeria dothidea*
Fruit finish on 'Golden Delicious'

J. W. Travis, K. D. Hickey,
N. O. Halbrendt, E. S. Anderson,
and S. B. Jarjour
PSU Fruit Research and Extension Ctr.
290 University Dr., POB 330
Biglerville, PA 17307-0330

APPLE DISEASE INCIDENCE ON SEMI-DWARF TREES SPRAYED WITH DILUTE FUNGICIDE SPRAYS IN 2002: Seasonal fungicide spray programs were evaluated for efficacy against early- and late-season diseases. In the test orchard inoculum levels for powdery mildew and the summer disease complex were moderate while apple scab was very low due to drought conditions during the past two years. Dilute sprays were applied seasonally in a 17-year-old semi-dwarf experimental orchard planted 10' X 35'. Experimental plots consisted of one tree each of five cultivars and were separated by a 50 ft space between plots. The experimental plots were arranged in a randomized complete design with four replicates. Adjacent rows to the sprayed trees were nontreated and served as buffers against spray drift. Sprays were applied dilute to complete wetness at 3.75 gal/tree (300 gal/A.) with a high pressure sprayer equipped with a nine-nozzle spray boom and operated at a manifold pressure of 400 psi. Application dates and growth stages were: 17 Apr (tight-cluster), 24 Apr (bloom), 6 May (petal-fall), first through the seventh cover sprays on 16, 29 May,13, 27 Jun, 12, 29 Jul, and 13 Aug, respectively. Orchard environmental conditions were measured hourly with Campbell Scientific and Meteos Weather Stations. Incidence of apple scab, apple rust, and powdery mildew on leaves of 'Rome Beauty' were recorded on 19 Jun by observing all leaves on 10 non-fruiting vegetative shoots per replicate. Incidence of frog-eye leaf spot was recorded similarly on 'Cortland' on 3 Jul. Disease incidence on fruit was recorded at harvest (25 Sep, G. Del. and 4 Oct, Del.) on 100 fruit per replicate. Fruit russeting on 'G. Del'. was determined for the treatment sprayed with copper by the Barratt-Horsfall rating scale on 20 fruit/replicate. Data obtained were analyzed by analysis of variance using appropriate transformations and significance between treatment means determined by the Fisher Protected LSD Test ($P<0.05$).

Scab incidence on leaves of nontreated 'Rome', 'G. Del.', and 'Del' was 2.6, 2.6, and 7.0 percent, respectively. No scab was found on fruit treated with any of the fungicide treatments. Long intervals between rains and high relative humidity between bloom and second cover were favorable for mildew development with 57 and 68 percent incidence on the two non-treated checks, respectively (Table 1). All fungicide treatments provided significant control as compared to the nontreated. Treatments containing Sovran 50W , Flint 50W or BASF 516UD F provided excellent control of mildew and were equal to or better than the Nova standard. Control was significantly improved in treatments where Sovran 50W was used in the tight-cluster and first cover sprays and Procure 4SC/ Dithane used in the bloom and petal fall sprays. Cuprofix Dispess 20DF gave only fair mildew control and produced necrotic spotting on 84 and 54 percent of leaves on 'G. Del.' and 'Del', respectively. Fruit russeting on 'G. Del' was 83 percent at harvest. Incidence of cedar-apple rust on most treatments was similar to the standard. Leaf infections of Frog-eye leaf spot on 'Cortland' leaves occurred between pink and third cover and all fungicide treatments provided significant control compared to the non-treated. BASF 516UD F gave excellent control compared to the Nova 40W / Dithane DF standard. All fungicide treatments, except Ziram Granuflo 75WDG 1.7 lb/100 gal, used alone in the 3rd through 7th cover sprays, provided significant control of the summer disease complex.

Table I . Disease Incidences on Leaves or Fruit of Apple Trees Treated With Fungicide Programs Applied Dilute in 2002.

	Fungicide and Rate/100 Gal	Applic. Timing	Percent Leaves Infected			Percent 'G. Del.' Fruit Infected		
			'Rome Beauty'		'Cortland'			
			P. Mildew	A. Rust	Leaf Spot	S. blotch	Flyspeck	White rot
1.	Nontreated - I	....	68.2 h*	24.6 e	32.9 f	29.0 b	36.8 bc	4.8 de
2.	Scala 40SC 3.4 fl oz	TC						
	Scala 40SC 2.3 fl oz +							
	Nova 40W 0.8 oz	B, PF, 1C						
	Captan 50W 2.0 lb	2C-7C	43.3 ef	0.2 ab	14.6 d	0.3 a	1.3 a	3.8 cde
3.	Rubigan 1E 2.7 fl oz +							
	Dithane DF 75WDG 1.0 lb	TC, B, PF, 1C, 2C						
	Ziram Granuflo 75WDG 1.7 lb	3C-7C	45.2 f	0.2 ab	11.7 cd	1.5 a	5.0 ab	2.5 a-d
4.	Nova 40W 1.7 oz +							
	Dithane DF 75WDG 1.0 lb	TC, B, 1C						
	Flint 50W 0.5 oz +							
	Ziram Granuflo 75WDG 1.0 lb	PF, 2C, 3C						
	Ziram Granuflo 75WDG 1.5 lb	4C, 5C						
	Ziram Granuflo 75WDG 1.0 lb +							
	Topsin-M 70W 4.0 oz	6C, 7C	25.6 ab	0.1 a	10.6 cd	0.0 a	2.0 a	2.3 a-d
5.	Sovran 50W 1.0 oz +							
	Ziram Granuflo 75WDG 1.0 lb	TC, B, 2C, 3C						
	Nova 40W 1.7 oz +							
	Dithane DF 75WDG 1.0 lb	PF, 1C						
	Ziram Granuflo 75WDG 1.5 lb	4C, 5C						
	Ziram Granuflo 75WDG 1.0 lb +							
	Topsin-M 70W 4.0 oz	6C, 7C	21.0 a	0.0 a	5.7 ab	1.0 a	1.3 a	1.0 ab
6.	BASF 516UD F 38W 6.3 oz	TC, B, PF, 1C, 2C						
	Ziram Granuflo 75WDG 1.5 lb	3C, 4C, 5C						
	Ziram Granuflo 75WDG 1.0 lb +							
	Topsin-M 70W 4.0 oz	6C, 7C	20.4 a	0.8 ab	3.0 a	0.0 a	0.8 a	0.5 a

Table 1 (cont.) . Disease Incidences on Leaves or Fruit of Apple Trees Treated With Fungicide Programs Applied Dilute in 2002.

	Fungicide and Rate/100 Gal	Applic. Timing	Percent Leaves Infected: 'Rome Beauty' P. Mildew	Percent Leaves Infected: 'Rome Beauty' A. Rust	Percent Leaves Infected: 'Cortland' Leaf Spot	Percent 'G. Del.' Fruit Infected: S. blotch	Percent 'G. Del.' Fruit Infected: Flyspeck	Percent 'G. Del.' Fruit Infected: w/rot
7.	Sovran 50W 1.33 oz	TC, 1C						
	Procure 50WS 3.33 oz + Dithane DF 75WDG 1.5 lb	B, PF						
	Ziram Granuflo 75WDG 1.5 lb	2C, 3C, 4C, 5C						
	Ziram Granuflo 75WDG 1.0 lb + Topsin-M 70W 4.0 oz	6C, 7C	37.2 cd	4.6 c	10.8 cd	0.5 a	3.3 a	1.5 ab
8.	Sovran 50W 1.33 oz	TC, 1C						
	Procure 4SC 3.33 fl oz + Dithane DF 75WDG 1.0 lb	B, PF						
	Ziram Granuflo 75WDG 1.5 lb	2C, 3C, 4C, 5C						
	Ziram Granuflo 75WDG 1.0 lb + Topsin-M 70W 4.0 oz	6C, 7C	42.3 def	5.6 c	15.1 d	0.3 a	1.8 a	1.3 abc
9. →14	Cuprofix Disperss 20DF 3.33 lb	TC						
	Cuprofix MZ30 42DF 2.0 lb + Microthiol Disperss 80DF 1.0 lb	B, PF, 1C, 2C						
	Cuprofix Disperss 20DF 1.67 lb	3C, 4C, 5C, 6C, 7C ...	37.9 de	2.0 b	20.1 e	0.0 a	0.8 a	6.0 e
10.	Nova 40W 1.33 oz + Dithane DF 75WG 1.0 lb	TC, B, PF, 1C, 2C						
	Sovran 50W 1.0 oz	3C, 4C, 5C						
	Ziram Granuflo 75WDG 1.0 lb + Topsin-M 70W 4.0 oz	6C, 7C	23.9 a	0.0 a	8.6 bc	0.5 a	2.0 a	2.3 a-d
11.	Syllit 65W 10.0 oz	TC						
	Nova 40W 1.33 oz + Dithane DF 75WDG 1.0 lb	B, PF, 1C, 2C						
	Ziram Granuflo 75WDG 1.67 lb	3C, 4C, 5C						
	Ziram Granuflo 75WDG 1.0 lb + Topsin-M 70W 4.0 oz	6C, 7C	31.6 bc	0.2 ab	5.9 ab	0.3 a	0.8 a	2.5 a-d
12.	Nontreated - 2	....	57.4 g	22.2 d	36.0 f	31.0 b	33.5 c	3.3 b-e

• Means marked with the same letter(s) are not significantly different according to the Fisher Protected LSD Test ($P \leq 0.05$).

Not for Publication

SUMMER DISEASE MANAGEMENT WITH NEW FUNGICIDES

Turner B. Sutton, Osama Anas, Jean Harrison, Charles Thayer
Department of Plant Pathology
North Carolina State University
Raleigh, NC 27695

For the past 30 years the control of summer diseases of apples has relied on captan, benzimidazole fungicides, and dithiocarbamate fungicides, often applied in combination with one another. Restrictions on the use of the ethylenebisdithiocarbamtes, withdrawal of products from he marketplace (Benlate, Dikar), and concerns over the use of some fungicides (benzimidazoles, dithiocarbamates, captan) by buyers has provided the opportunity for new chemistries to be developed and used in the summer disease control program. Of the new fungicides that have been evaluated over the past 5 years, the strobilurin or QoI fungicides have the broadest spectrum of activity. Their use is however limited to four applications/year, a limitation that was imposed as a resistance management strategy, primarily for apple scab. They have especially been useful for the control of Alternaria blotch on Delicious, for which there is no alternative, and late season control of sooty blotch and flyspeck. This report focuses on trials established to evaluate the efficacy of two new strobilurin fungicides which are being tested as a prepack combination: BAS516 (pyraclostrobin + boscalid) and KQ667 (fomoxate + mancozeb). Additionally the report summarizes trials with growers who used Cuprofix Disperss for summer disease control on Rome apples destined for processing.

Fungicide trials on Delicious and Golden Delicious, 2002. Fungicide treatments were applied to 12-yr-old Delicious and Golden Delicious trees at the Central Crops Research Station with an airblast sprayer at 225 gpa. Each treatment was applied to two five-tree groups of each cultivar and data were taken from the second and fourth trees within each group. Treatments were applied on 5 (pink), 12, 19, and 26 Apr, 7, 16, and 28 May, 7, 17, and 27 Jun, 8, 18, and 29 Jul and 8 Aug. Only BAS516 and KQ 667 were evaluated for cedar apple rust control. The incidence and severity of cedar apple rust was determined on 30 May by visually examining all leaves on 10 terminals selected arbitrarily from each Golden Delicious record tree. Bitter rot incidence was determined at harvest on 21 Aug by examining all drops and counting the number of fruit with bitter rot symptoms in the tree.

The early part of the growing season was extremely dry with 0.53, 1.16, and 1.03 in. rain in Apr, May, and Jun, respectively. Rainfall was slightly above normal in Jul (6.75 in.) with 3.46 in. occurring from 24 to 26 Jul. Although there was very little rain in Apr and early May, cedar apple rust developed extensively in the orchard. The Nova 40W standard provided excellent control (Table 1). BAS 516 and KQ 667 significantly reduced the amount of cedar apple rust compared to the check, but were significantly less effective than Nova. Extensive bitter rot developed following rains in the latter part of Jul. BAS 516 and KQ 667 showed very good bitter rot activity and were numerically, though not statistically, better than the captan-based standard. Flint, when applied in the last three sprays, provided better bitter rot control on Golden Delicious than Sovran, applied according to the same schedule.

Table 1. Results of fungicide trials on Delicious and Golden Delicious at the Central Crops Research Station, 2002.

Treatment and rate/acre	Cedar apple rust[x] Leaves affected (%)	Cedar apple rust[x] Severity[y]	Bitter rot (fruit affected %) Golden Delicious	Bitter rot (fruit affected %) Red Delicious
BAS 516 UD F 14.2 oz gt-9C	33.2b[z]	2.02b	2.7d	11.2c
KQ 667 68.75 WG 32.0 oz gt-9C	27.2b	1.98b	3.4cd	13.8de
Nova 40W 5.0 oz gt-pf; Captan 50W 6.0 lb + Benlate 50 W 8 oz 1C-9C	5.4c	1.15c	6.1cd	20.9cde
Nova 40W 5.0 oz gt-pf; Captan 50W 6.0 lb 1C-9C	–	–	13.2bc	28.7bc
Nova 40W 5.0 oz gt-pf; Captan 50W 6.0 lb 1C-6C; Flint 50W 3 oz 7C-9C	–	–	6.8cd	26.4bcd
Nova 40W 5.0 oz gt-pf; Captan 50W 6.0 lb 1C-6C; + Sovran 50 W 6.4 oz 7C-9C	–	–	20.9b	39.3b
Mana 131 80W 3.75 lb	–	–	6.6cd	16.7cde
Check	75.3a	2.34a	58.5a	82.7a

[x] Golden Delicious only.
[y] Severity of cedar apple rust: 0 = 0 lesions/leaf; 2 = 6-20 lesions/leaf; 3 = > 20 lesions/leaf.
[z] Means within the same column followed by the same letter are not significantly different at P = 0.05 as determined by the Waller-Duncan k-ratio t-test.

Disease control on Delicious and Golden Delicious in the mountains, 2002. Fungicide treatments were applied with a an airblast sprayer at 225 gpa to 24-yr-old Delicious and Golden Delicious trees located at the Mountain Horticultural Crops Research Station, Fletcher, NC. Each treatment was applied to two groups of five trees and data were taken from the second and fourth trees within each group. Treatments were applied on 27 Mar (green-tip, gt), 2, 11, 18 and 24 (petal fall, pf) Apr, 6 and 20 May, 3 and 17 Jun, 1, 15, and Jul, and 13 and 28 Aug. Data on the incidence of powdery mildew were taken on 24 May by examining the eight youngest expanded leaves on 10 terminals selected arbitrarily from each record tree of Golden Delicious. The incidence and severity of Alternaria blotch was determined by examining all leaves on four terminals, selected arbitrarily, from each Delicious tree on 13 Aug. The percent defoliation associated with necrotic leaf blotch of Golden Delicious was determined on 18 Sept by visually estimating the percent defoliation on each record tree. Data on the incidence and severity of fruit diseases were taken at harvest on 10 Sept by examining 25 fruit selected arbitrarily from each tree.

Although Apr was very dry, conditions were favorable for powdery mildew and 32% of the leaves were infected in the check. BAS 516 and the early-season Nova + mancozeb program provided very good control of powdery mildew (Table 3). KQ 667 did not demonstrate much mildew activity. The summer growing season in general was very dry with only 3.7 in. of rain occurring from 1 Jul-10 Sep. However wet weather in Jun (5.76 in.) was conducive for Brooks spot and black pox and dews in Aug and early Sep were favorable for sooty blotch and flyspeck (Table 2). As a result of the dry weather, Alternaria blotch was light and only 61% of the leaves were affected at harvest (Table 3). BAS 516 and KQ 667 provided very good control. BAS516, KQ 667, and the captan and captan + Benlate standards provided good control of Brooks spot and black pox under high disease pressure. These same treatments, except for the captan alone, provided good sooty blotch and flyspeck control. BAS 516 and KQ 667 provided good suppression of necrotic leaf blotch on Golden Delicious (Table 3). Surprisingly little necrotic leaf blotch developed in the captan-sprayed plots. Captan typically doesn't provide any suppression of the disorder. It is also unusual that a non heavy metal containing fungicide such as BAS516 provided any suppression of necrotic leaf blotch.

Table 2. Results of fungicide trials on Golden Delicious in the mountains, 2002.

	Percent fruit affected (Golden Delicious)				
Treatment and rate/acre	Black pox	Brooks spot	Sooty blotch	Flyspeck	Severity*
BAS 516 UD F 18.9 oz gt-8C	0.0b**	0.0b	23.0d	12.0d	4.5bc
KQ 667 68.75 WG 32.0 oz gt-5C; Captan 50W 6.0 lb + JE 874 WG 6 oz 6-8C	2.0b	1.0b	36.0cd	27.0cd	3.1bc
KQ 667 68.75 WG 40.0 oz gt-5C; Captan 50W 6.0 lb + JE 874 WG 6 oz 6-8C	4.0b	1.0b	58.0bc	45.0c	5.0bc
KQ 667 68.75 WG 48.0 oz gt-5C; Captan 50W 6.0 lb + JE 874 WG6 oz 6-8C	0.0b	0.0b	34.0b	12.0d	2.7bc
Dithane Rainshield 3.0 lb gt-5C; Captan 50W 6-8C	0.0b	0.0b	63.0d	51.0b	6.1b
Nova 40W 5.0 oz + Dithane Rainshield 3.0 lb gt-pf; Captan 50W 6.0 lb + Benlate 50W 8 oz 1C-8C	4.0b	0.0b	13.0d	8.0d	2.5c
Check	70.0a	81.0a	100.0a	100.0a	54.4a

* Percent fruit surface area covered with sooty blotch and flyspeck

** Means within the same column followed by the same letter are not significantly different at P = 0.05 as determined by the Waller-Duncan k-ratio t-test

Table 3. Results of fungicide trials on Delicious and Golden Delicious in the mountains, 2002.

Treatment and rate/acre	Golden Delicious: Powdery mildew leaves affected (%)	Golden Delicious: Necrotic leaf blotch defoliation (%)]	Delicious: Alternaria blotch Leaves affected (%)	Delicious: Alternaria blotch Severity*
BAS 516 UD F 18.9 oz gt-8C	3.1d**	0.0b	5.0b	0.5ab
KQ 667 68.75 WG 32.0 oz oz gt-5C; Captan 50W 6.0 lb + JE 874 WG 6 oz 6-8C	22.2bc	2.5b	4.9b	0.43b
KQ 667 68.75 WG 40.0 oz gt-5C; Captan 50W 6.0 lb + JE 874 WG 6 oz 6-8C	55.9a	7.5b	16.0b	0.81ab
KQ667 68.75 WG 48.0 oz gt-5C; Captan 50W 6.0 lb + JE874 WG 6 oz 6-8C	27.5cd	3.8b	8.7b	0.76ab
Dithane Rainshield 3.0 lb gt-5C; Captan 50W 6-8C	9.1d	6.25b	58.3a	1.19a
Nova 40W 5.0 oz + Dithane Rainshield 3.0 lb gt-pf; Captan 50W 6.0 lb + Benlate 50W 8 oz 1C-8C	4.4d	11.3b	50.2a	0.99ab
Check	32.0b	37.5a	61.0a	1.05ab

* Severity of Alternaria blotch: 0 = 0 lesions/leaf; 1 = 1-3% surface area covered with lesions; 2 = 4-6%; 3 = 7-12%; 4 = 13-25%.

** Means within the same column followed by the same letter are not significantly different at P = 0.05 as determined by the Waller-Duncan k-ratio t-test.

Evaluation of Cuprofix Disperss within the context of a reduced risk IPM program – 2002. In August of 2001 Cuprofix Disperss was registered for use on apples for summer disease control at 4 – 10 lb/acre. If Curofix Disperss could be used safely and provided acceptable disease control, then it would be a low cost alternative for processing growers and would provide the opportunity to reduce residues of some conventional fungicides which are concerns to processors. In 2001 Cuprofix Disperss was evaluated in four blocks of Rome, using either one or two sprays at 6.0 lb/acre beginning in late Jul to early Aug, followed by two sprays of Sovran or Flint. It provided good disease control but, in most blocks there was some speckling of fruit (especially on Law Romes) and there was some leaf spotting and defoliation. The defoliation was most pronounced on weak trees and one block of older weak Romes experienced approximately 25% defoliation.

In 2002 the protocol was revised to lower the rate of Cuprofix Disperss to 2 lb/acre and combine it with Microthiol Disperss at 3.0 lb/acre in either one or two sprays (Table 4).

Table 4. Application schedule for Cuprofix Disperss + Microthiol Disperss, 2002.

Approximate date	one spray	two sprays	grower standard (conventional)
July 1	captan	captan	captan
July 15	captan	Cuprofix	captan
Aug 1	Cuprofix	Cuprofix	captan
Aug 15	Flint	Flint	Flint
Sept 1	Flint	Flint	Flint

Cuprofix Disperss treatments were applied to blocks identified as: Henderson, Marlowe, and Staton/Horse. Because of an application error, only one Cuprofix Disperss treatment was applied in the Staton/Horse block. Very little injury was observed in either the Marlowe or the Staton/Horse block. This injury appeared as a slight leaf purpling and specking and the lenticels on some fruit were prominent. In the Henderson orchard there was pronounced fruit specking and some purple spotting and some marginal necrosis on many leaves. However there wasn't any defoliation. It is not clear why the injury occurred in this block and closer inspection of weather and application records is warranted.

Harvest data were taken on 22-29 Sep by examining 600 fruit/orchard in the Henderson and Staton/Horse blocks and 500 in the Malowe block. Approximately 30 fruit were selected arbitrarily from each of 20 trees/block. Data are reported from blocks receiving either one or two Cuprofix Disperss treatments collectively. Disease control achieved in the Cuprofix/Microthiol Disperss plots was as good as or better than that achieved in the conventionally sprayed plots. One-half percent bot rot was observed in the Henderson Cuprofix Disperss plot and 0.8% was observed in the conventionally sprayed block. Only one fruit with black rot was observed in any blocks and no bitter rot was observed. Similarly no black pox or Brooks spot was observed. Sooty blotch and flyspeck did develop in the blocks with over 60% of the fruit affected in the Staton/Horse conventionally sprayed plot (Table 5)

Table 5. Severity of sooty blotch and flyspeck in blocks of Rome sprayed with Cuprofix Disperss + Microthiol Sulfur or with captan in the 6th and 7th cover sprays.

Block	SB/FS 1* (%fruit affected)	SB/FS 2 (% fruit affected)	SB/FS 3 (% fruit affected)
Henderson Cuprofix	0.7	0	0
Henderson Standard	0	0	0
Marlowe Cuprofix	9.4	0.4	0
Marlowe Standard	34.8	0.4	0
Staton Cuprofix	0.7	0	0
Staton Standard	50.3	10.1	1.8

* Sooty blotch and flyspeck severity. SB/FS1= 1-5% surface area affected; SB/FS2 = 6-10% surface area affected; SB/FS3=11-20% surface area affected.

MANAGEMENT OF FIRE BLIGHT ON APPLE: EFFICACY OF GWN-9200

Norman Lalancette[1], Kathleen Foster[1], and Tom Frieberger[2]
Rutgers Agricultural Research and Extension Center[1], Bridgeton, NJ
Rutgers Fruit Research and Extension Center[2], Cream Ridge, NJ

Successful management of fire blight on susceptible apple cultivars is dependent on the proper integration of three factors: (i) sound orchard management practices; (ii) reduction of inoculum; and (iii) prevention of infection by timely application of bactericides. Available bactericides are the antibiotic streptomycin and copper-based materials. The copper bactericides, however, are phytotoxic to apple, limiting their use to very early season (silver-green tip).

When used properly, streptomycin (Agri-mycin 17) is a very effective disease control agent. Unfortunately, selection for resistant strains of the pathogen, *Erwinia amylovora*, is a major concern and has already occurred in some apple-growing regions. Therefore, the objective of this experiment is to test the efficacy of another antibiotic, gentamycin (GWN-9200), for control of fire blight. If successful, then an integrated program employing both antibiotics should provide both disease control and act as a strategy for resistance management to either material.

MATERIALS AND METHODS

Treatments. The test block, located at the Rutgers Fruit Research and Extension Center in Cream Ridge, NJ, consisted of 4-year old 'Rome Beauty' trees grafted on M7A rootstock. Trees were planted in a rectangular block at 14 ft x 18 ft row spacing. Treatments were replicated four times in a randomized complete block design, each treatment plot consisting of six consecutive trees. A single non-sprayed buffer tree separated plots within the rows; non-sprayed buffer rows separated treatment rows.

An FMC DP 10/3 PT/50F airblast sprayer with 24" fan and pump agitation was used to apply the bactericides. The sprayer was calibrated to deliver 100 gal/A at 100 psi traveling at 2.1 mph. Treatment applications began at first bloom and continued on a 3- to 4-day schedule until bloom ended. Due to cold weather and an extended bloom, a total of 13 sprays were applied on the following dates: 19 Apr, 22 Apr, 25 Apr, 30 Apr, 03 May, 07 May, 10 May, 14 May, 17 May, 21 May, 24 May, 29 May, and 31 May. Insecticides and miticides were applied as needed to the entire block.

Inoculation. *Erwinia amylovora* isolates were streaked on NYDA plates and grown at 25C. After 48 hr incubation, the bacteria were harvested by pouring sterile phosphate buffer in the plates and scraping the plates with a sterile spatula. The suspension was then shaken to disperse any cell clumps. The concentration of bacteria in the suspension was adjusted by adding buffer until its transmittance was 25% at 525 nm using a Bausch and Lomb Spectronic 21; phosphate buffer was the standard. This procedure produced an approximate concentration of 1×10^8 cfu / ml.

On 23 April, treatment trees in replicates 1 and 2 were inoculated with a bacterial suspension at 1 x 10^6 cfu / ml. On 26 April, treatment trees in replicates 3 and 4 were inoculated with a bacterial suspension at 1 x 10^7 cfu / ml. At both times, only one tree per plot (the third tree) was inoculated.

All flowers on designated trees were individually sprayed with the suspension using hand atomizers, applying three "shots" per flower cluster. The total number of inoculated flower clusters on each tree was recorded. Any flower clusters not open at the time of inoculation were removed by pruning so that only inoculated flowers remained. Both inoculations were performed during the evening to allow slow drying.

Environment. Rainfall occurred on 16 days during the extended bloom period from 19 Apr to 31 May (Fig. 1). Eight of these rainfall periods had accumulations of more than 0.50 cm (0.20 in), and the total accumulation for the entire bloom period was 14.35 cm (5.65 in). Thus, in general, rainfall was not limiting to development of fire blight.

Air temperature during bloom, however, was only 14.2C or 57.6F (Fig. 1). Average air temperature only exceeded 18.3C (65F) on nine of the 50 days of bloom. Given that temperatures need to be above 18.3C to favor increase in epiphytic populations of *E. amylovora*, temperature was limiting to [natural] infection. Mean air temperatures on 23 and 26 Apr, the dates of inoculation, were 7.2C (45F) and 7.8C (46F), respectively.

Assessment. The incidence of blighted flower clusters was assessed on 05 June. Assessments were performed on inoculated tree no. 3 in each plot as well as non-inoculated tree no. 5.

On inoculated trees, the total number of diseased clusters was recorded for each tree by examining *all flowers*. On non-inoculated trees, disease incidence was assessed by performing a 1-minute count of blighted clusters using two people. In both cases, blighted clusters were tagged to avoid counting them more than one time. A cluster was considered infected if one or more flowers were blighted.

Disease incidence was expressed for both inoculated and non-inoculated trees as # infected clusters / tree. In addition, since the total number of flower clusters treated with bacteria was known on the inoculated trees, disease incidence on these trees was also expressed as percent infected clusters per tree.

RESULTS AND DISCUSSION

Relative to other cultivars, Rome Beauty tends to bloom over a fairly long period of time. During 2002, cool weather during bloom further extended the time during which flower blossoms were opening. Consequently, an inordinately large number of treatment applications, totaling 13, were required to maintain coverage at a 3-4 day interval. First and last bloom occurred on 19 Apr and 31 May, respectively.

Although weather conditions were cold during bloom, 100% of the flower clusters on the non-sprayed inoculated trees became blighted (Table 1). This success may have been due to the use of fairly high concentrations of bacteria in the inoculum as a means to compensate for the cold weather. Note that although all of these flower clusters became blighted, not very many of these infections advance further into the wood. Perhaps the cold weather following inoculation prevented successful colonization. The standard for comparison, Agri-mycin 17WP, significantly reduced percent infected flower clusters on inoculated trees, achieving approximately 46% control (Table 1). This treatment was also significantly better than any of the GWN-9200 treatments. In comparison, none of the GWN-9200 treatments were significantly different from the non-sprayed control or each other. Their level of control was extremely poor, ranging from about 6 to 8 %.

When disease was assessed as # infected clusters / tree, none of the GWN-9200 treatments were significantly different from each other or the non-sprayed control (Table 1). This pattern was evident on both inoculated and non-inoculated trees. Although the streptomycin treatment had considerably less disease, it too was not significantly different from all others. This lack of separation was most likely due to a greater degree of variability expected in this variable (as opposed to percent infected clusters).

Although statistical separation of the GWN-9200 treatments was not observed, these treatments provided on average about 47% control when inoculum was from natural sources. Similarly, control with the streptomycin treatment increased from 48% (inoculated) to 64% (non-inoculated). This suggests that the high concentration of bacteria applied to the inoculated trees provided an extremely severe test of the materials. Also, it shows that some gentamycin activity was present.

A gradient in disease levels was not observed among the three different concentrations of GWN-9200. Also, no phytotoxicity or effect on fruit finish was evident.

TABLE 1			Fire Blight Blossom Infection (5 June 02)[a]		
			Inoculated		Non-Inoculated
Treatment	Rate / A	Conc. (a.i.)	% Infected Clusters	# Inf Clusters / Tree	# Inf Clusters / Tree
Nonsprayed	———	———	100.0 A	34.0 A	7.0 A
Agri-mycin 17WP + Regulaid	8 oz + 4 fl oz	100 ppm	53.9 B	17.5 A	2.5 A
GWN-9200 10WP + Regulaid	33.4 oz + 4 fl oz	250 ppm	93.5 A	32.8 A	3.5 A
GWN-9200 10WP + Regulaid	50.0 oz + 4 fl oz	375 ppm	92.1 A	30.0 A	3.8 A
GWN-9200 10WP + Regulaid	66.8 oz + 4 fl oz	500 ppm	94.2 A	31.3 A	3.8 A

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

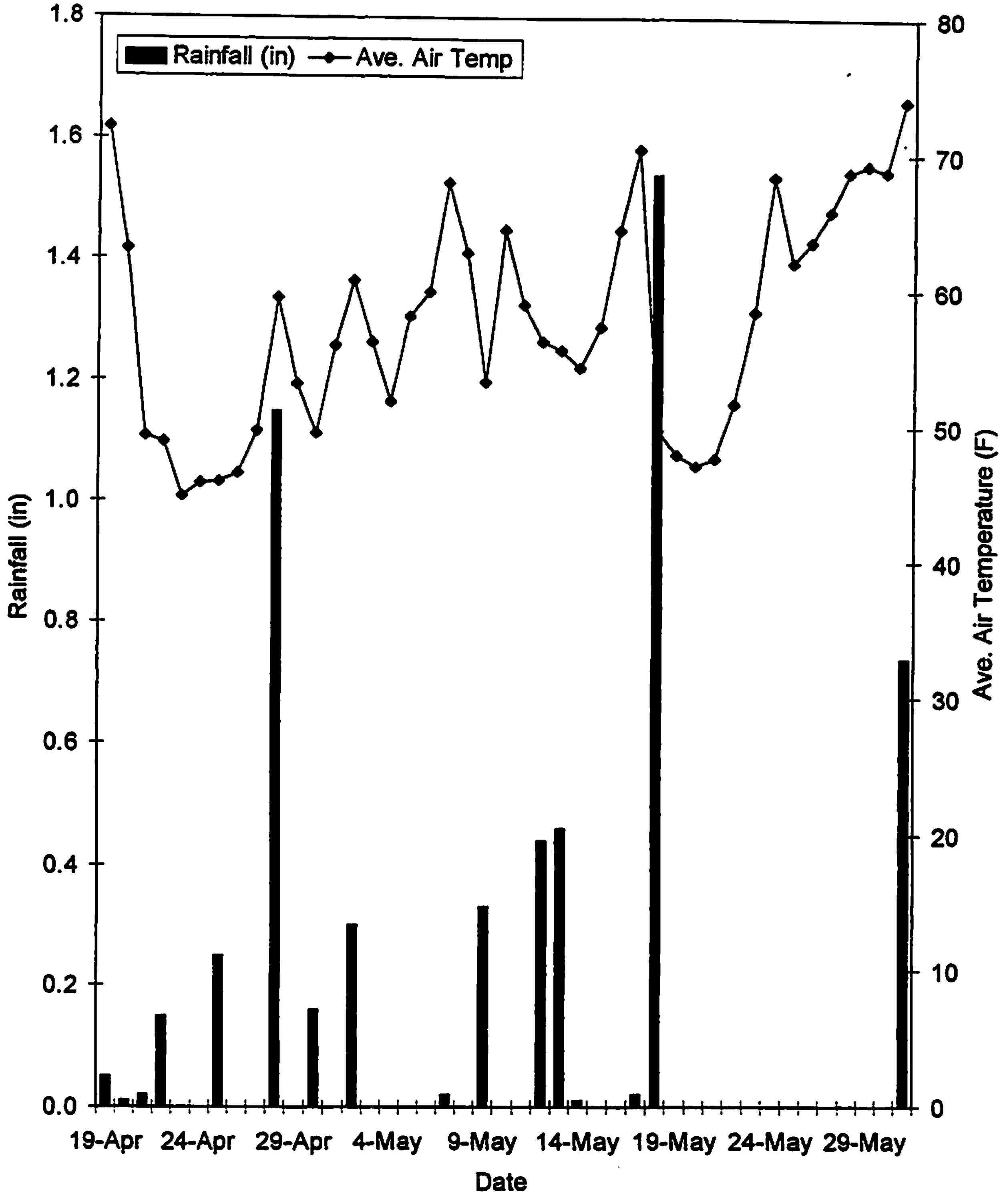


Figure 1. Daily rainfall accumulations and air temperture means during bloom for a 'Rome Beauty' apple orchard during the 2002 growing season, Rutgers Fruit Research and Extension Center, Cream Ridge, NJ

The Hidden Danger of Fire Blight – Apple trees with live cankers may harbor bacteria in symptomless shoots.

T. van der Zwet, USDA-ARS, Appalachian Fruit Research Station, Kearneysville, WV 25430, (retired), **K.D. Hickey,** Pennsylvania State University, Fruit Research and Extension Center, Biglerville, PA 17307 (retired), and **S.S. Miller,** USDA-ARS, AFRS, Kearneysville, WV 25430

External and internal bacteria of *Erwinia amylovora* (Burr.) Winsl. et al. have both been associated with cankers as part of the fire blight (FB) disease cycle for many years. In 1929, Dr. Harry Rosen at the University of Arkansas, first reported the presence of FB bacteria inside the tree vessels of symptomless shoots of 'Kieffer' pear. His work only examined cross sections and did not provide any detailsas to distance along the stem or any other unusual symptomatology of the shoot tip. He also described a second type of primary infection as internal extensions of the previous year's lesions, usually appearing shortly after the first symptoms of blossom blight. This latter symptom description appears similar to the symptoms we have observed for several years in West Virginia and Pennsylvania, as well as to the canker blight symptoms described by the late Dr. Paul Steiner, University of Maryland, for his Maryblyt prediction system.

In 1972, Drs. Keil and van der Zwet, working at the USDA Beltsville Research Laboratory, reported the first isolation of numerous FB bacteria from symptomless shoots that developed near cankers on previously inoculated greenhouse-grown apple and pear trees. Although the systemic nature of the FB bacterium has been reported by numerous investigators since then, van der Zwet and his coworkers in West Virginia were unable to isolate internal bacteria from major scaffold limbs of 17-year-old 'RomeBeauty'/MM.111 apple trees in 1995-1996 (GoodFruit Grower, June 2000). In their study, the trees were severely pruned, using heading cuts into 6-year-old wood, and all cankers were removed. Two of the four experimental trees were enclosed in clear plastic arborspheres. After five months of tree enclosure, no FB symptoms appeared and the bacteria were not isolated from newly developed shoots on the enclosed trees, whereas both unprotected trees had numerous blighted shoots.

In 1997 and 1998, two experiments were performed in Pennsylvania and West Virginia on mature apple trees. Numerous symptomless shoots and branches were collected to attempt isolation of FB bacteria from internal parts of these trees. In **Pennsylvania,** isolations were made from four moderately infected, 23-year-old 'Rome Beauty'/M7 apple trees, located at the Pennsylvania State University Fruit Research and Extension Center in Biglerville. The trees in this orchard had moderate to vigorous shoot growth and many had 50 to 100 blighted shoots in each of the previous three years. Each of the four trees selected for isolations contained five to 12 active, indeterminate (alive with smooth margins) FB cankers and had from 20 to 50 blighted shoots present 7-10 days before isolation attempts on 18 June, 1997. Many of the infected shoots showed characteristic orange-colored tips (Fig. 1A), previously reported by Dr. Steiner to be associated with canker blight. Two symptomless, current-season shoots were selected from each of five locations on each of the four trees including (see Tabel 1): shoots

12 – 18 inches below blighted shoots; shoots 12 – 18 inches above blighted shoots; shoots on branches having no blight; shoots near the top of the tree (without any blight); and shoots (water sprouts) on large scaffold limbs or the central leader. Two shoots showing characteristic shoot blight were selected from each tree to serve as the infected control. Additional isolation attempts were made from approximately the same locations on the same four trees on 11 July, and 15 Oct., 1997, and the following spring on 26 May, 1998.

Mean recovery of FB bacteria from the one inch stem segments from the various locations in the tree (64-113 per location) ranged from 15.7 to 37.5% (Table 1). Considerable variation in recovery occurred among the replicated trees, but mean differences among sample locations were not statistically significant. Symptomless shoots sampled below blighted shoots showed the highest recovery of FB bacteria. At this sampling location, percent recovery varied from 0.0 to 76.9% among the four replicated trees. The second highest recovery was obtained from water sprouts on the scaffold limbs or central leader (trunk) with a range of 7.7 to 64.7% and a mean of 28.7%. The lowest recovery was from shoots above the blighted shoots, with a variation from 0.0 to 30.4% recovery among the replicates. Isolation attempts in July and Oct. 1997, and May 1998, failed to yield additional bacteria. Recovery from infected shoots with FB symptoms ranged from 45.5 to 100% among the replicates, with a mean of 67.7%.

Upon close examination of the otherwise green, actively growing, symptomless 'Rome Beauty' shoots, a unique symptom, not characteristic of shoot or canker blight, was observed on several shoots: a brownish discoloration of the center portion of the stem surface, accompanied by small ooze droplets on it and nearby lower portions of leaf petioles (Fig. 1B). One of the shoots also showed early necrosis along the back midrib of one leaf near the middle of the shoot (Fig.1C). Following plating of the latter shoot, 95% of the 22 shoot pieces contained FB bacteria.

In **West Virginia,** four 18-year-old 'Paulared'/MM.111 apple trees, located at the Appalachian Fruit Research Station in Kearneysville, showed numerous blighted shoots in early June 1998. Upon examination of the trees, the majority of blighted shoots also showed bright orange shoot tips (Fig. 2A). Twenty symptomless shoots, located among numerous blighted shoots, were collected along the tree periphery, about 36-72 inches above the ground. During the next 60 days, additional samples (see Table 2) of symptomless shoots were collected in the top of each tree, as well as from woody branches (1.6 inches diameter), root suckers beneath the trees (Fig 2B), and roots from which the suckers emerged. Also, 20 symptomless shoots (without orange tips) on each of the four trees were tagged on June 15, to determine developmental rate of the orange-colored tips. In addition, 10 shoots (with orange tips) from each of the four trees were plated as positive controls. Because the 'Paulared' trees were scheduled for removal from the orchard, the major scaffold limbs were cut in half with a chain saw, allowing easier sampling at ground level of the shoots in the upper part of the trees. When all major branches were on the orchard floor, numerous live, indeterminate cankers were observed and recorded on these large scaffold limbs (Fig. 2C). At each of the sampling dates, 20 symptomless shoots were also collected from four 'Golden Delicious'/MM.111 apple trees without FB, located in the same orchard row, south and adjacent to the 'Paulared' trees. In total, more than 5400 plant tissue pieces were plated, and all summer sampling was completed by early August. Additional sampling on the 'Paulared' trees of 10 newly developed symptomless shoots and four symptomless rootsuckers were collected in late November 1998, and again in early June 1999.

The FB bacterium was recovered and plated on a culture medium from all the locations where plant tissues were sampled (Table 2). The initial sampling of 80 randomly selected, symptomless shoots along the periphery of the four trees revealed that 36.8% contained internal blight bacteria. A higher percentage recovery from the plated shoot pieces was obtained from the rootsuckers (45.2%) and sections from the roots (45.3%) from which they originated. Sections from the scaffold limbs resulted in 33.8% recovery. Because of a high degree of variability in recovery rates among sampled shoots, differences in the percent recovery among sample locations in the trees were not statistically significant. However, two of the four replicated trees had 67% of the 43 FB cankers and 92% of the blighted shoots. These heavily infected trees also had 43.3% recovery of bacteria from all 140 symptomless shoots, compared to only 1.7% for the other two less blighted trees. Recovery from underground stems of root suckers was 20.4%, while the recovery rate for the water sprouts on the central leaders was 11.7%. Of the 80 symptomless shoots tagged on 15 June, 65% developed orange shoot tips by the time scaffold limbs were removed (one week later). All 40 positive check shoots (with orange tips) tested positive for FB bacteria. All samplings from the four experimental trees in August and November 1998, and in June 1999, as well as from the shoots on the adjacent 'Golden Delicious' check trees, were negative for the bacterium.

Lack of knowledge of the precise location of the bacterial inoculum before, during, and after bloom continues to limit a clear understanding of the infection process for FB on pome fruit trees. The presence of external bacteria in the spring on various apple and pear tissues has been well documented. The exact point of entry of the pathogen directly into the shoots and the role of overwintering of internal bacteria, however, remains unclear. The recovery of the FB bacterium from numerous isolations of symptomless tissues of eight mature apple trees in Pennsylvania and West Virginia supports the contention that the bacterium resides in the stem of apple trees in a latent form, during part of its life cycle, without the production of blight symptoms.

The presence of internal FB bacteria in apple stem, rootsucker, and root tissues of mature apple trees was common in these investigations. The two replicated experiments were performed independently of each other, but produced similar results. Even though the preliminary arborsphere test was performed on only two trees, we believe that the detailed experimental procedure was sufficient to conclude that internal bacteria, as a source of infection, can be eliminated through severe pruning, and removal of all the previous FB cankers.

In the **Pennsylvania** experiment, the distribution of internal FB bacteria in symptomless shoots in five locations on each 'Rome Beauty' apple tree was variable but present in all four trees. The observation of ooze drops and leaf vein necrosis on the central portion of an otherwise symptomless shoot (no necrotic tip), suggested that FB symptoms were initiated by internal bacteria. In the West Virginia experiment, the recovery of bacteria from within shoots around the periphery of the 'Paulared' trees, as well as from rootsuckers near the trees and the connecting roots between the suckers and the tree trunk, suggests that the bacterium moves through the vascular system throughout the tree, more extensively than previously reported.

This is the first time that live cankers in large limbs of 20-year-old apple trees have been investigated to serve as the source of internal bacteria to the rest of the tree. The observations and measurements from the present experiments, combined with the isolations from the preliminary 'Rome Beauty' trees contained in the arborsphere, provide good evidence for an internal inoculum source and may explain the appearance of FB symptoms on apple trees in the early part of the growing season in the absence of blossom blight. The orange shoot tip symptoms, as observed in this study, had been noted three years earlier in West Virginia on mature 'Jonathan'/MM 111 apple trees in the same orchard block with the 'Paulared' trees, as well as on mature 'Empire' apple trees on several rootstocks in a nearby orchard (unpublished data). In all of the above instances, shoot blight developed in June in the absence of blossom blight, and with a recommended streptomycin preventive program. These observations suggest that the bacterial cells produced at the margins of active, live FB cankers move in the stems to distant developing shoots, producing the orange tip symptom.

The characteristic orange shoot tips (origin of color unknown), which loose their brightest color after four to ten days, will later resemble regular shoot blight symptoms. On some apple cultivars, new canker blight symptoms continue appearing as long as the shoots remain succulent. Many growers, who have followed recommended spray schedules completely, often observe and complain about shoot blight occurring without any indication of an infection period. If the FB bacterium is a resident in the tree and moves internally, as we suggest, this might explain the sudden appearance of unexpected shoot blight in June. Since early (soon after petal fall) canker blight symptoms in the upper portion of the tree may go undetected, the Maryblyt prediction system may fail to provide an adequate predictive model for this orange tip shoot blight in June. The result is a sudden outbreak of shoot blight, predominately at the periphery of the tree's canopy. In addition, orange shoot tips can often be observed on succulent bourse shoots that develop from blossom clusters, which became infected during bloom. Under these conditions, the sudden appearance of numerous orange tips are extremely difficult if not impossible to control using preventive chemical sprays. Based on our observations and studies, we recommend that the most effective control method for this shoot blight is to eliminate the presence of overwintering cankers and prevent the annual development of new ones. Growers should be aware that live, indeterminate cankers (Fig. 2C) with smooth margins are often difficult to observe during the dormant season, so diligence is required in the pruning operation.

Table 1. Isolation incidence of *Erwinia amylovora* from two symptomless current-season shoots collected from each of five locations on four 23-year old 'Rome Beauty'/M.7 apple trees. Penn State University FREC, Biglerville, PA. June 1997.

Tissue sample location in tree	No. isolation recoveries/attempts (subsamples) on trees				Total isolation recoveries/ attempts	Mean recovery percent[z]
	1	2	3	4		
Shoots basal to blighted shoots	3/16	0/10	1/22	20/26	24/64	37.5 a
Shoots apical to blighted shoots	3/24	4/15	0/27	7/23	14/89	15.7 a
Shoots at end of scaffold branch without blight	0/24	17/27	4/23	1/24	22/98	22.4 a
Water sprouts on scaffold branch or central leader	11/17	3/25	15/40	2/26	31/108	28.7 a
Shoots in upper portion of tree	14/24	2/24	4/33	1/32	21/113	17.9 a
Blighted shoots (infected control)	21/24	19/19	21/24	15/32	67/99	67.7 a

[z] Means followed by the same letter(s) are not significantly different, Bonferroni and Tukey-Kramer HSD Test ($P \leq 0.05$)

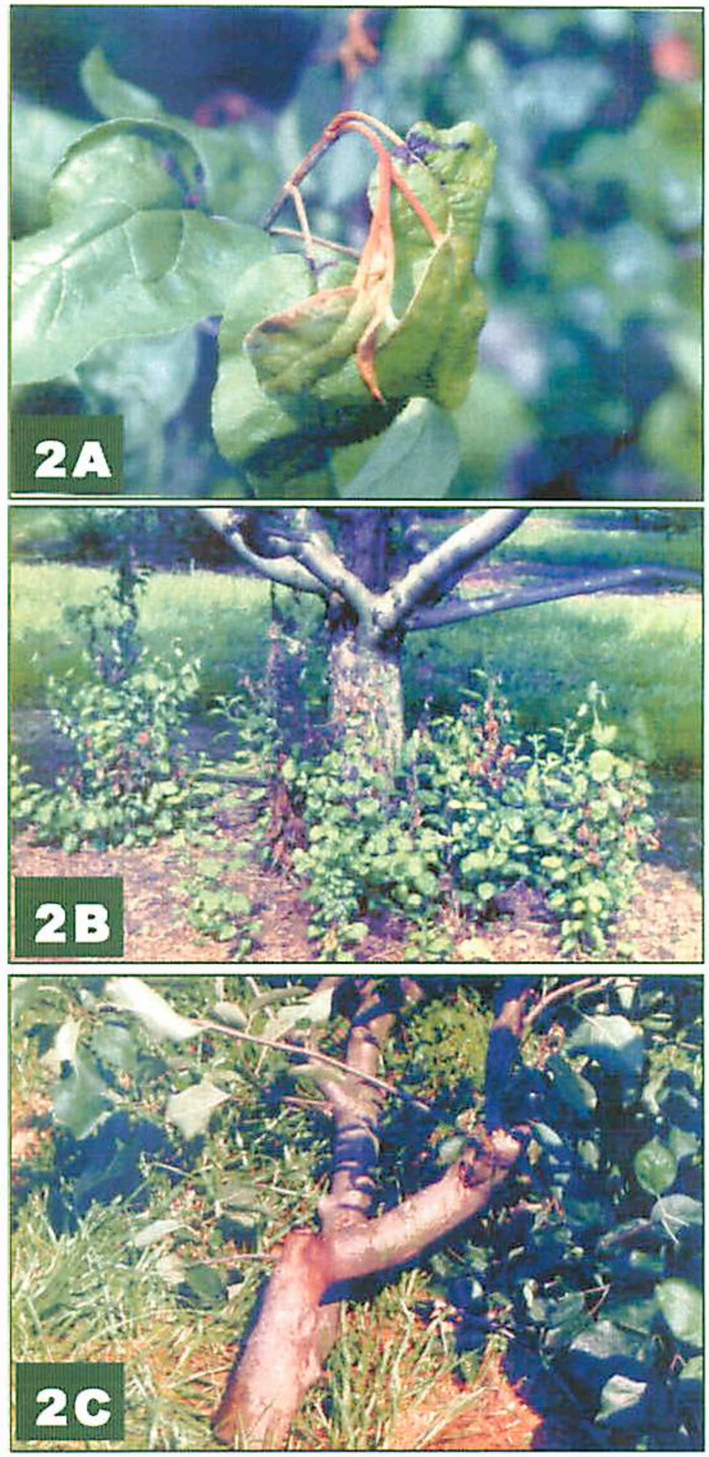


Fig. 1. Symptomatology of fire blight on 'Rome Beauty'/M.7 orchard trees in Pennsylvania: **(A)** characteristic orange shoot tip with advancing blight; **(B)** early necrosis and ooze drops (arrows) in center portion of shoot without orange tip; and **(C)** early necrosis on basal side of leaf mid- vein on otherwise symptomless shoot.

Fig. 2. Symptomology of latent canker blight and methodology to obtain symptomless shoots from 'Paulared'/MM.111 orchard trees in West Virginia: **(A)** close up of characteristic bright orange shoot tip; **(B)** blighted and symptomless rootsuckers beneath a tree; and **(C)** characteristic indeterminate canker on large scaffold limb serving as source for endophytic bacteria.

Table 2. Isolation incidence of *Erwinia amylovora* from symptomless stem and root tissue at different locations on four 18-year old Paulared/MM.111 apple trees. USDA, ARS, Appalachian Fruit Research Station, Kearneysville, WV. June 1998.

Tissue sample location in tree	Total samples	No. isolation recoveries/attempts (subsamples) on trees				Total isolation recoveries/ attempts	Mean recovery percent[z]
		1	2	3	4		
Periphery of tree (1-2 m high)	20	213/259	153/248	7/267	12/265	382/1039	36.8
Scaffold limbs (4) and central leader	50	120/716	88/698	1/849	6/790	215/3053	7.0
Water sprouts on central leader	6	7/77	7/72	9/81	13/77	36/307	11.7
Sections from scaffold limbs (4 cm diam.)	20	12/20	6/20	4/20	5/20	27/80	33.8
Root suckers near tree trunk	12	47/129	104/129	53/143	55/172	259/573	45.2
Underground stems of root suckers	5 - 12	17/121	3/28	33/92	3/34	56/275	20.4
Sections of roots (3-4 cm diam.)	1 - 3	24/34	5/12	10/30	0/12	39/88	45.3
No. tree cankers		15	14	7	7	--	--
No. blighted shoots		151	178	21	6		

[z] Means followed by the same letter(s) are not significantly different, Bonferroni and Tukey-Kramer HSD Test ($P \leq 0.05$)

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

K. S. Yoder, A. E. Cochran II, W. S. Royston, Jr., and S. W. Kilmer
Virginia Tech Agr. Research & Extension Center
595 Laurel Grove Road
Winchester, VA 22602

EVALUATION OF EXPERIMENTAL FUNGICIDE SCHEDULES AND MIXTURES FOR BROAD SPECTRUM DISEASE MANAGEMENT ON STAYMAN, IDARED, AND GRANNY SMITH APPLES, 2002: Ten treatments involving recently experimental fungicides and mixtures were tested for season-long disease management on 16-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 2001 to stabilize mildew inoculum pressure for 2002. 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: 12 Apr (all treatments, Granny Smith- TC, tight cluster; Stayman- TC; Idared- TC-OC);18 Apr (75% bloom, 7-day treatments #2 & 6 only); 22 Apr (petal fall, 10-day treatments, #1, 3-5, & 7-10, only); 25 Apr (7-day treatments only); 1 May (1st cover, all treatments); 8 May (7-day treatments only); 10 May (10-day treatments only); 15 May (7-day treatments only); 7 June, 21 June, 8 July (3rd – 5th covers, all treatments); 31 July (all treatments except #2 and #6). Insecticides, applied separately to the entire test block with the same equipment, included Asana, Lannate LV, Intrepid, Provado, and Imidan 70WSB. Cedar rust galls, quince rust cankers, and bitter rot mummies were placed over each Idared test tree 9 Apr, and wild blackberry canes with the sooty blotch and flyspeck fungi were placed over each Idared test tree 3 May. 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 17 June (Idared), 27 June (Granny Smith) or 17 July (Stayman). Idared trees were sampled 16 Sep, Stayman 2 Oct, and Granny Smith 3 Oct, and the 25-fruit samples were rated after storage at 1C 35 days (Idared), 22 days (Stayman) and 20 days (Granny Smith). Percentage data were converted by the square root arcsin transformation for statistical analysis.

Under heavy mildew pressure, Nova and Bayleton were typically effective as SI fungicide standards. BAS 516 gave mildew control comparable to Nova and Bayleton at the higher rate but significantly less control at the lower rate (Table 1). There was a significant suppression of % leaves and % area infected with mildew by some treatments involving KQ667 on Stayman, but generally less effect on Idared and Granny Smith. However, the 2 lb rate, 10-day interval of KQ667 (treatment #3), gave significant suppression on all three cultivars suggesting an inconsistent result on mildew for rate and interval. Scab pressure was light with infection appearing late in the season on 14% of non-treated Stayman foliage late in the season, and all treatments gave adequate commercial control. All treatments gave significant control of sooty blotch and flyspeck under moderately heavy pressure; BAS 516 was outstanding at the higher rate and commercially acceptable at the lower rate. Late season DPX-JE874 treatments with Captan 3 lb /A were all numerically better than captan 6 lb/A (treatments #1 & 8) for sooty blotch and significantly better for flyspeck suggesting that JE874, 4 oz could replace 3 lb of Captan 50W. All treatments gave good control of Brooks spot. Rot incidence was light. BAS 516 was consistently strong but DPX-JE874 was quite variable. Finish may have been impacted by frosts 4 May, and 20 and 22 May. BAS 516 generally gave the best fruit finish, although not significantly better than several other treatments.

Table 1. Evaluation of experimental fungicide schedules and mixtures on Stayman, Idared and Granny Smith apples

			Mildew, % leaves, % leaf area, or % fruit infected									Scab, % lvs or fruit		
			Stayman			Idared			Granny Smith			Stayman		Granny
	Treatment and rate/A	Timing	% lvs	area	fruit	% lvs	area	fruit	% lvs	area	fruit	% lvs	fruit	fruit
0	No fungicide	—	69f	78e	17c	69f	85e	42e	70d	86d	21c	14c	4b	8c
1	Nova 40W 5 oz + Manzate 200 75DF 3 lb, 10 day Captan 50W 6 lb, 14 day	TC–2C 3C–6C	23ab	3a	4ab	29a	4a	8a-c	34a	6a	9a-c	0a	0a	0a
2	KQ667 68.75WG 2 lb, 7 day DPX-JE874 50WG 4 oz + Captan 50W 3 lb, 14 day	TC–2C 3C–5C	58e	50cd	3ab	65f	72de	11bc	70d	84d	8ab	<1ab	0a	0a
3	KQ667 68.75WG 2 lb, 10 day DPX-JE874 50WG 4 oz + Captan 50W 3 lb, 14 day	TC–2C 3C–6C	46d	19b	6ab	56de	33c	12b-d	57c	54c	12bc	<1b	1a	1ab
4	KQ667 68.75WG 2.5 lb, 10 day DPX-JE874 50WG 5 oz + Captan 50W 3 lb, 14 day	TC–2C 3C–6C	61ef	49cd	3ab	65f	79de	28de	72d	85d	12bc	<1ab	1a	3b
5	KQ667 68.75WG 3 lb, 10 day DPX-JE874 50WG 6 oz + Captan 50W 3 lb, 14 day	TC–2C 3C–6C	57e	50bc	6b	63ef	68d	20cd	70d	84d	7ab	0a	0a	0a
6	Manzate 200 75DF 3 lb, 7 day Captan 50W 6 lb, 14 day	TC–2C 3C–5C	65ef	64d	4b	62ef	75de	16cd	69d	83d	10a-c	0a	0a	0a
7	Sovran 50WG 4 oz + Manzate 200 75DF 3 lb, 10 day Captan 50W 6 lb, 14 day	TC–2C 3C–6C	32c	5a	4ab	47bc	13ab	4ab	51bc	14b	6ab	0a	0a	1ab
8	Bayleton 50DF 2 oz + Manzate 200 75DF 3 lb, 10 day Captan 50W 6 lb, 14 day	TC–2C 3C–6C	28bc	5a	1ab	30a	5a	4ab	39a	12ab	5ab	<1ab	0a	0a
9	BAS 516 UD F 38WG 18.9 oz, 10 day BAS 516 UD F 38WG 18.9 oz, 14 day	TC–2C 3C–6C	18a	3a	0a	41b	7ab	1a	34a	10ab	4a	0a	0a	0a
10	BAS 516 UD F 38WG 8.4 oz, 10 day BAS 516 UD F 38WG 8.4 oz, 14 day	TC–2C 3C–6C	34c	8a	0a	52cd	17b	5ab	48b	15b	5ab	0a	1a	0a

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 17 June (Idared); 27 June (Granny Smith); 17 July (Stayman).

Fruit data based on 25-fruit samples; Idared trees sampled 16 Sep, Stayman 2 Oct, and Granny Smith 3 Oct, and the samples were rated after storage at 1C 35 days (Idared), 22 days (Stayman) and 20 days (Granny Smith).

Fungicide application dates: Fungicide treatments were applied to both sides of the tree on each indicated application date with a Swanson Model DA-400 airblast sprayer at 100 gal/A. as follows: 12 Apr (all treatments, Granny Smith- TC, tight cluster; Stayman- TC; Idared- TC-OC);18 Apr (75% bloom, 7-day treatments #2 & 6 only); 22 Apr (petal fall, 10-day trts, #1, 3-5, & 7-10, only); 25 Apr (7-day treatments only); 1 May (1st cover, all treatments); 8 May (7-day treatments only); 10 May (10-day treatments only); 15 May (7-day treatments only); 7 June, 21 June, 8 July (3rd – 5th covers, all treatments); 31 July (all treatments except #2 and #6).

Maintenance sprays: 4 Apr (Asana XL 14 oz/A); 1 May (Provado 4 fl oz + Imidan WSB 2 lb/A); 7 May NAA 10 ppm + Sevin XLR 3 qt + Regulaid 11 fl oz/A); 16 May (Imidan WSB 2 lb + Provado 4 fl oz + /A); 6 June (Provado 4 fl oz + Intrepid 2F 1 pt/A). 20 June (Imidan WSB 2 lb + Lannate LV 1.5 pt. /A); 3 July, 19 July, 1 Aug, 18 Aug (Imidan WSB 2 lb + Lannate LV 1 qt. /A).

Table 2. Evaluation of sooty blotch and fly speck control on Stayman, Idared and Granny Smith apples, 2002.

			Sooty blotch, % fruit or % fruit area infected						Flyspeck, % fruit or fruit area infected					
			Stayman		Idared		Granny		Stayman		Idared		Granny	
	Treatment and rate/A	Timing	fruit	area	fruit	area	fruit	area	fruit	area	fruit	area	fruit	area
0	No fungicide	—	100e	24f	100d	24d	97f	17f	97g	8g	88d	5 d	90d	7d
1	Nova 40W 5 oz + Manzate 200 75DF 3 lb, 10 day Captan 50W 6 lb, 14 day	TC –2C 3C–6C	59cd	6de	54c	5c	54e	6e	30c-e	2cd	40c	2 c	73cd	5cd
2	KQ667 68.75WG 2 lb, 7 day DPX-JE874 50WG 4 oz + Captan 50W 3 lb, 14 day	TC–2C 3C–5C	45c	4c-e	32bc	3bc	18b-d	1b-e	22b-d	1c	8ab	<1ab	11a	1a
3	KQ667 68.75WG 2 lb, 10 day DPX-JE874 50WG 4 oz + Captan 50W 3 lb, 14 day	TC–2C 3C–6C	15ab	1ab	22ab	1ab	12bc	1a-d	16bc	1bc	9a	<1ab	15ab	1ab
4	KQ667 68.75WG 2.5 lb, 10 day DPX-JE874 50WG 5 oz + Captan 50W 3 lb, 14 day	TC–2C 3C–6C	33bc	3b-d	21bc	2bc	16bc	1b-d	13bc	1bc	6a	<1ab	8a	<1a
5	KQ667 68.75WG 3 lb, 10 day DPX-JE874 50WG 6 oz + Captan 50W 3 lb, 14 day	TC–2C 3C–6C	41bc	4c-e	22bc	1a-c	13bc	1a-c	18bc	1bc	5a	<1a	3a	<1a
6	Manzate 200 75DF 3 lb, 7 day Captan 50W 6 lb, 14 day	TC–2C 3C–5C	52cd	4c-e	38bc	4c	46de	4e	43de	3de	38c	2 a	63cd	4cd
7	Sovran 50WG 4 oz + Manzate 200 75DF 3 lb, 10 day Captan 50W 6 lb, 14 day	TC–2C 3C–6C	39bc	4b-d	30bc	2a-c	30c-e	2c-e	49ef	3e	36bc	1 bc	54bc	3bc
8	Bayleton 50DF 2 oz + Manzate 200 75DF 3 lb, 10 day Captan 50W 6 lb, 14 day	TC–2C 3C–6C	76d	7e	52c	5c	37c-e	4de	72f	5f	48c	2 c	65cd	5cd
9	BAS 516 UD F 38WG 18.9 oz, 10 day BAS 516 UD F 38WG 18.9 oz, 14 day	TC–2C 3C–6C	3a	<1a	2a	<1a	0a	0a	1a	<1a	0a	0 a	0a	0a
10	BAS 516 UD F 38WG 8.4 oz, 10 day BAS 516 UD F 38WG 8.4 oz, 14 day	TC–2C 3C–6C	29bc	2bc	21a-c	1a-c	6ab	<1ab	7ab	<1ab	2a	<1a	9a	<1a

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

Data based on 25-fruit samples; Idared trees sampled 16 Sep, Stayman 2 Oct, and Granny Smith 3 Oct, and the samples were rated after storage at 1C 35 days (Idared), 22 days (Stayman) and 20 days (Granny Smith).

Fungicide application dates: Fungicide treatments were applied to both sides of the tree on each indicated application date with a Swanson Model DA-400 airblast sprayer at 100 gal/A. as follows: 12 Apr (all treatments, Granny Smith- TC, tight cluster; Stayman- TC; Idared- TC-OC);18 Apr (75% bloom, 7-day treatments #2 & 6 only); 22 Apr (petal fall, 10-day trts, #1, 3-5, & 7-10, only); 25 Apr (7-day treatments only); 1 May (1st cover, all treatments); 8 May (7-day treatments only); 10 May (10-day treatments only); 15 May (7-day treatments only); 7 June, 21 June, 8 July (3rd – 5th covers, all treatments); 31 July (all treatments except #2 and #6).

Table 3. Evaluation of experimental fungicide schedules and mixtures on Stayman, Idared and Granny Smith apple fruit

	Treatment ,rate/A, and interval, days	Timing	Brooks spot (% inf.) Stay-man	Idared	Granny	% rot spots, Idared	Russet ratings (0-5) Stay-man	Idared	Granny	Opalescence ratings Stay-man	Idared	Granny
0	No fungicide	—	17b	20c	6b	10c	2.4bc	1.7b	1.3b	2.1a	1.8e	1.3g
1	Nova 40W 5 oz + Manzate 200 75DF 3 lb, 10 day Captan 50W 6 lb, 14 day	TC–2C 3C–6C	0a	1ab	2a	0a	2.3a-c	1.0a	1.1ab	2.2a	0.9ab	1.0de
2	KQ667 68.75WG 2 lb, 7 day DPX-JE874 50WG 4 oz + Captan 50W 3 lb, 14 day	TC–2C 3C–5C	1a	2ab	0a	3b	2.0a-c	1.4ab	0.9a	1.8a	1.4cd	0.8b-d
3	KQ667 68.75WG 2 lb, 10 day DPX-JE874 50WG 4 oz + Captan 50W 3 lb, 14 day	TC–2C 3C–6C	0a	3b	0a	0a	2.0a-c	1.4ab	0.9a	1.8a	1.0bc	0.7a-c
4	KQ667 68.75WG 2.5 lb, 10 day DPX-JE874 50WG 5 oz + Captan 50W 3 lb, 14 day	TC–2C 3C–6C	0a	2ab	0a	7bc	2.4c	1.7b	1.0ab	2.3a	1.3c	1.3fg
5	KQ667 68.75WG 3 lb, 10 day DPX-JE874 50WG 6 oz + Captan 50W 3 lb, 14 day	TC–2C 3C–6C	1a	3b	1a	4b	2.1a-c	1.7b	1.1ab	1.9a	1.7de	0.9c-e
6	Manzate 200 75DF 3 lb, 7 day Captan 50W 6 lb, 14 day	TC–2C 3C–5C	0a	0a	0a	4b	2.3a-c	1.3ab	1.3b	2.4a	1.4cd	1.1ef
7	Sovran 50WG 4 oz + Manzate 200 75DF 3 lb, 10 day Captan 50W 6 lb, 14 day	TC–2C 3C–6C	0a	2ab	0a	0a	2.2a-c	1.3ab	1.0ab	2.0a	1.0bc	0.9c-e
8	Bayleton 50DF 2 oz +Manzate 200 75DF 3 lb, 10 day Captan 50W 6 lb, 14 day	TC–2C 3C–6C	0a	3ab	0a	0a	2.1a-c	1.1a	1.0ab	2.0a	0.6a	0.8b-e
9	BAS 516 UD F 38WG 18.9 oz, 10 day BAS 516 UD F 38WG 18.9 oz, 14 day	TC–2C 3C–6C	0a	0a	0a	0a	2.0ab	1.3ab	0.8a	1.8a	0.7a	0.5a
10	BAS 516 UD F 38WG 8.4 oz, 10 day BAS 516 UD F 38WG 8.4 oz, 14 day	TC–2C 3C–6C	0a	0a	0a	0a	2.0a	1.2a	0.9a	2.1a	0.8ab	0.7ab

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

Data based on 25-fruit samples; Idared trees sampled 16 Sep, Stayman 2 Oct, and Granny Smith 3 Oct, and the samples were rated after storage at 1C 35 days (Idared), 22 days (Stayman) and 20 days (Granny Smith).

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

Fungicide application dates: Fungicide treatments were applied to both sides of the tree on each indicated application date with a Swanson Model DA-400 airblast sprayer at 100 gal/A. as follows: 12 Apr (all treatments, Granny Smith- TC, tight cluster; Stayman- TC; Idared- TC-OC);18 Apr (75% bloom, 7-day treatments #2 & 6 only); 22 Apr (petal fall, 10-day trts, #1, 3-5, & 7-10, only); 25 Apr (7-day treatments only); 1 May (1st cover, all treatments); 8 May (7-day treatments only); 10 May (10-day treatments only); 15 May (7-day treatments only); 7 June, 21 June, 8 July (3rd – 5th covers, all treatments); 31 July (all treatments except #2 and #6).

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*
Rot spots (unidentified)
Fruit finish

K. S. Yoder, A. E. Cochran II,
W. S. Royston, Jr., and S. W. Kilmer
Virginia Tech Agr. Res. & Ext. Center
595 Laurel Grove Road
Winchester, VA 22602

TEST OF AN EXPERIMENTAL FUNGICIDE AND CUPROFIX ON THREE APPLE CULTIVARS, 2002: An experimental fungicide 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 13-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 2001 to allow buildup of powdery mildew inoculum. Treatments were applied dilute to the point of runoff with a single nozzle handgun at 350 psi as follows: 5 Apr (Rome greentip; Red Delicious tight cluster-open cluster; Golden Del. tight cluster); 16 Apr (Rome - pink; Red Delicious full bloom to petal fall; Golden Del. 60% bloom); 26 Apr (Rome pink- petal fall; Red and Golden petal fall; 1st to 6th covers (1C-6C): 8 May, 20 May, 7 June, 21 June, 8 July, and 31 July. Maintenance sprays applied separately with a commercial airblast sprayer included Agri-Mycin 17 (bloom only, 18 Apr), Asana XL, Imidan 70 WSB, Intrepid 2F, Lannate LV, Provado, Pyramite and a dilute application of NAA or Ethrel +Sevin XLR + Regulaid (as thinners). Border Rome trees were treated with Bayleton 1 oz / 100 gal, to reduce 2003 mildew inoculum potential, 7 June, 21 June, 8 July, 31 July, and 23 Aug. Cedar rust galls, quince rust cankers and bitter rot mummies were placed over each Golden Delicious test tree 12 Apr and wild blackberry canes with the sooty blotch and flyspeck fungi were placed over each Golden Delicious test tree 10 May. Other diseases developed from inoculum naturally present in the test area. Foliar counts are based on ten terminal shoots from each of four single-tree reps 4 June (Golden) and 11 June (Rome). Fruit counts are means of 25-fruit samples picked from each of four single-tree reps 16 Sep (Red Delicious), or 24 Sep (Rome) and placed in cold storage at 1C. Golden Delicious was sampled and rated twice to follow progression of summer diseases (16 Sep and 1 Oct). Red Delicious was rated after 51 days' cold storage; and Rome after 41 days' cold storage at 1C. Percentage data were converted by the square root arcsin transformation for statistical analysis.

Under heavy mildew pressure on Rome, no treatment significantly reduced incidence on foliage. The highest rate of TD 2448-1 reduced percent area affected with mildew, and treatments involving Cuprofix/Vangard Cuprofix/Microthiol Disperss reduced percent leaf area affected and percent fruit infected. Under more moderate mildew pressure on Golden Delicious, nearly all treatments significantly suppressed incidence and percent area affected. Microthiol gave the best control of mildew. Scab pressure was light with less than 10% on non-treated fruit. Vangard and treatments involving Cuprofix gave good control; the higher rates of TD 2448-1 gave significant scab suppression but the lower rates were weak. No treatment adequately controlled cedar-apple rust on foliage, although fruit were apparently protected from light incidence of quince and cedar rusts. Cuprofix treatments gave good control of Brooks spot, sooty blotch, fly speck and rots, even with the second sampling of Golden Delicious. TD-2448-1 showed significant activity on sooty blotch, fly speck and rots, but was less active than Cuprofix, with poor activity on Brooks spot, inconsistent rate response on other summer diseases and less residual activity as indicated by disease incidence in the second sampling of Golden Delicious. Cuprofix deleteriously affected fruit finish, as expected, increasing russetting of all cultivars and opalescence on Red Delicious and Rome. Treatments which were switched to Vangard during the pink – 2nd cover were significantly less affected than those which received Cuprofix in each application. The highest rate of TD-2448-1 significantly reduced russetting of Rome.

Table 4. Control of early season diseases on Red Delicious, Golden Delicious and Rome Beauty.

		Mildew infection (%)					% infection						
		Rome			Golden Del.		Scab, fruit		C-apple rust		Quince	Brooks spot,	
Rate per 100 gal dilute	Timing	% lvs	lf. area	% fruit	% lvs	lf. area	R. Del.	Rome	% lvs	fruit	rust	G. Del.	Rome
0 No fungicide	—	62 a-c	80 e	18 c	54 e	45 e	9 d	8 d	7 a	4 b	2 b	7 ab	17 d
1 TD 2448-01 3.36SC 1.11 fl oz	TC-6C	60 a-c	67 c-e	13 bc	44 b-d	12 b-d	7 cd	5 cd	7 a	0 a	0 a	2 ab	5 ab
2 TD 2448-01 3.36SC 1.67 fl oz	TC-6C	64 bc	79 e	8 a-c	48 de	14 cd	6 cd	2 a-c	8 a	0 a	0 a	4 ab	17 cd
3 TD 2448-01 3.36SC 2.22 fl oz	TC-6C	66 c	74 de	6 a-c	47 cd	14 d	3 bc	4 bc	5 a	3 b	0 a	2 ab	7 bc
4 TD 2448-01 3.36SC 3.34 fl oz	TC-6C	64 bc	73 de	6 ab	44 b-d	13 b-d	2 ab	1 ab	9 a	1 a	0 a	10 b	10 b-d
5 TD 2448-01 3.36SC 4.45 fl oz	TC-6C	60 a-c	46 bc	5 ab	41 bc	8 ab	3 bc	2 a-c	7 a	0 a	0 a	2 ab	6 ab
6 Vangard 75WG 1.33 oz	TC-6C	61 a-c	55 b-d	4 a	40 b	12 b-d	1 ab	0 ab	9 a	0 a	1 ab	8 b	10 b-d
7 Vangard 75WG 1.33 oz + Cuprofix Disperss 20DF 2.5 lb Vangard 75WG 1.33 oz Cuprofix Disperss 20DF 2 lb	TC Pk-2C 3C-6C	59 a-c	42 ab	2 a	39 b	8 ab	0 a	0 a	8 a	0 a	0 a	0 a	0 a
8 Cuprofix Disperss 20DF 2.5 lb Vangard 75WG 1.33 oz Cuprofix Disperss 20DF 2 lb	TC Pk-2C 3C-6C	58 ab	49 bc	2 a	42 b-d	8 bc	1 ab	1 a	8 a	0 a	0 a	0 a	0 a
9 Cuprofix Disperss 20DF 2.5 lb Cuprofix MZ30 42DF 1.5 lb + Microthiol Disperss 80DF 1 lb Cuprofix Disperss 20DF 2 lb	TC Pk-2C 3C-6C	57 a	25 a	3 a	28 a	4 a	0 a	0 a	9 a	0 a	0 a	0 a	0 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:
5 Apr (Rome greentip; Red Delicious tight cluster-open cluster; Golden Del. tight cluster); 16 Apr (Rome – pink, Pk; Red Delicious full bloom to petal fall; Golden Del. 60 % bloom); 26 Apr (Rome pink- petal fall; Red and Golden petal fall; 1st to 6th covers (1C-6C): 8 May, 20 May, 7 June, 21 June, 8 July, and 31 July.

Foliar counts based on ten terminal shoots from each of four single-tree reps 4 June (Golden) and 11 June (Rome).

Fruit counts are means of 25-fruit samples picked from each of four single-tree reps 16 Sep (Red Delicious), or 24 Sep (Rome) and placed in cold storage at 1C. Red Delicious was rated after 51 days cold storage; and Rome after 41 days' cold storage. Golden Delicious was sampled twice (16 Sep and 1 Oct) and rated before cold storage.

Table 5. Control of sooty blotch and flyspeck on Red Delicious, Golden Delicious and Rome Beauty.

		Sooty blotch, % fruit and fruit area						Flyspeck, % fruit and fruit area					
		G. Del. 17 Sep		G. Del. 2 Oct				G. Del. 17 Sep		G. Del. 2 Oct		% fruit	
Rate per 100 gal dilute		fruit	area	fruit	area	R. Del.	Rome	fruit	area	fruit	area	R. Del.	Rome
0 No fungicide	—	94d	8e	99f	14e	40e	85d	74d	4d	77cd	5f	35d	48c
1 TD 2448-01 3.36SC 1.11 fl oz	TC-6C	81c	6de	81cd	8cd	24c-e	43b	50c	3c	50b	3cd	16a-c	26b
2 TD 2448-01 3.36SC 1.67 fl oz	TC-6C	63b	5cd	79cd	10cd	36de	62c	47bc	3c	61bc	5ef	24cd	48c
3 TD 2448-01 3.36SC 2.22 fl oz	TC-6C	55b	3b	74c	7c	19bc	42b	28b	1b	48b	3c	13a-c	29b
4 TD 2448-01 3.36SC 3.34 fl oz	TC-6C	68bc	5b-d	88c-e	11de	30c-e	48bc	39bc	2bc	74cd	4d-f	23b-d	32bc
5 TD 2448-01 3.36SC 4.45 fl oz	TC-6C	64b	4bc	89d-f	10c-e	23cd	47bc	30b	1b	72c	4c-e	23b-d	34bc
6 Vangard 75WG 1.33 oz	TC-6C	65bc	5bc	96ef	11de	21cd	53bc	40bc	2bc	90d	4d-f	23b-d	32bc
7 Vangard 75WG 1.33 oz + Cuprofix Disperss 20DF 2.5 lb Vangard 75WG 1.33 oz Cuprofix Disperss 20DF 2 lb	TC Pk-2C 3C-6C	2a	<1a	15b	1b	5a	14a	3a	<1a	13a	1b	7a	11a
8 Cuprofix Disperss 20DF 2.5 lb Vangard 75WG 1.33 oz Cuprofix Disperss 20DF 2 lb	TC Pk-2C 3C-6C	1a	<1a	8ab	<1ab	7ab	12a	2a	<1a	6a	<1a	12ab	4a
9 Cuprofix Disperss 20DF 2.5 lb Cuprofix MZ30 42DF 1.5 lb + Microthiol Disperss 80DF 1 lb Cuprofix Disperss 20DF 2 lb	TC Pk-2C 3C-6C	0a	0a	1a	<1a	7ab	11a	1a	<1a	9a	<1ab	5a	7a

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: 5 Apr (Rome greentip; Red Delicious tight cluster-open cluster; Golden Del. tight cluster); 16 Apr (Rome - pink; Red Delicious full bloom to petal fall; Golden Del. 60 % bloom); 26 Apr (Rome pink- petal fall; Red and Golden petal fall; 1st to 6th covers (1C-6C): 8 May, 20 May, 7 June, 21 June, 8 July, and 31 July.

Fruit counts are means of 25-fruit samples picked from each of four single-tree reps 16 Sep (Red Delicious), or 24 Sep (Rome) and placed in cold storage at 1C. Red Delicious was rated after 51 days cold storage; and Rome after 41 days' cold storage. Golden Delicious was sampled twice (16 Sep and 1 Oct) and rated before cold storage.

Table 6. Treatment effects on rot incidence and fruit finish of Red Delicious, Golden Delicious and Rome Beauty.

		Rots or rot spots (%)			Russet ratings or USDA grade *				Opalescence	
		G. Del sampled			Ratings (0-5)			G. Del. %	Rating (0-5)	
Rate per 100 gal dilute		17 Sep	2 Oct	Rome	R. Del.	Rome	G. Del.	fancy/x-fcy	R. Del.	Rome
0 No fungicide	—	41 d	73 d	4 ab	1.3 a	1.9 de	2.4 a	72 a	0.9 a	1.8 ab
1 TD 2448-01 3.36SC 1.11 fl oz	TC-6C	22 c	46 bc	11 b	1.2 a	1.6 b-d	2.4 a	69 a	1.1 ab	1.8 ab
2 TD 2448-01 3.36SC 1.67 fl oz	TC-6C	29 cd	55 cd	5 ab	1.6 a	1.5 a-c	2.4 a	69 a	1.5 bc	1.7 ab
3 TD 2448-01 3.36SC 2.22 fl oz	TC-6C	25 c	36 b	1 a	1.3 a	1.6 b-d	2.4 a	75 a	1.0 ab	1.7 ab
4 TD 2448-01 3.36SC 3.34 fl oz	TC-6C	23 c	62 cd	1 a	1.5 a	1.3 ab	2.4 a	70 a	1.3 a-c	1.4 a
5 TD 2448-01 3.36SC 4.45 fl oz	TC-6C	28 cd	52 bc	0 a	1.4 a	1.2 a	2.5 a	66 a	1.3 a-c	1.4 a
6 Vangard 75WG 1.33 oz	TC-6C	22 c	53 bc	1 a	1.6 a	1.6 b-d	2.6 a	80 a	1.3 a-c	1.7 ab
7 Vangard 75WG 1.33 oz + Cuprofix Disperss 20DF 2.5 lb Vangard 75WG 1.33 oz Cuprofix Disperss 20DF 2 lb	TC Pk-2C 3C-6C	2 a	9 a	1 a	2.1 b	1.8 c-e	3.6 b	24 b	1.6 c	1.6 a
8 Cuprofix Disperss 20DF 2.5 lb Vangard 75WG 1.33 oz Cuprofix Disperss 20DF 2 lb	TC Pk-2C 3C-6C	7 b	4 a	1 a	2.0 b	2.1 ef	3.3 b	21 b	1.3 a-c	1.6 a
9 Cuprofix Disperss 20DF 2.5 lb Cuprofix MZ30 42DF 1.5 lb + Microthiol Disperss 80DF 1 lb Cuprofix Disperss 20DF 2 lb	TC Pk-2C 3C-6C	1 a	5 a	1 a	3.2 c	2.3 f	4.5 c	0 c	3.1 d	2.4 b

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: 5 Apr (Rome greentip; Red Delicious tight cluster-open cluster; Golden Del. tight cluster); 16 Apr (Rome - pink; Red Delicious full bloom to petal fall; Golden Del. 60 % bloom); 26 Apr (Rome pink- petal fall; Red and Golden petal fall; 1st to 6th covers (1C-6C): 8 May, 20 May, 7 June, 21 June, 8 July, and 31 July.

Fruit counts are means of 25-fruit samples picked from each of four single-tree reps 16 Sep (Red Delicious), or 24 Sep (Rome) and placed in cold storage at 1C. Red Delicious was rated after 51 days' cold storage; and Rome after 41 days' cold storage. Golden Delicious was sampled twice (16 Sep and 1 Oct) and rated before 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* 'Idared')
Scab; *Venturia inaequalis*
Powdery mildew; *Podosphaera leucotricha*
Brooks fruit spot; *Mycosphaerella pomi*
Sooty blotch; disease complex
Flyspeck; *Zygophiala jamaicensis*
Rot spots (unidentified)
Fruit finish

K. S. Yoder, A. E. Cochran II, W. S. Royston, Jr., and S. W. Kilmer
Virginia Tech Agr. Research & Extension Center
595 Laurel Grove Road
Winchester, VA 22602

DISEASE CONTROL BY EXPERIMENTAL FUNGICIDES ON IDARED APPLE, 2002:

Six treatments involving four materials (coded VT), whose source and identity are confidential, were compared to Nova and Flint for control of powdery mildew, and to captan + ziram for summer disease control on 20-yr-old trees. The test was conducted in a randomized block design with four single-tree replicates separated by border trees in the row and by border rows between treatment rows. The test rows were not treated with mildewcides in 2001. 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 indicated application date with a Swanson Model DA-400 airblast sprayer at 100 gal/A as follows: 4 Apr (TC, tight cluster);17 Apr (full bloom); 26 Apr (PF, petal fall); 1st – 6th covers (1C-6C), 8 May, 22 May, 7 June, 21 June, 8 July, and 31 July. Border rows were treated separately with three dilute applications of Bayleton to reduce overall mildew carryover. Other applications applied to the entire test block with the same equipment included Asana XL, Lannate LV, Imidan WSB and Provado. Bitter rot mummies and wild blackberry canes with the sooty blotch and flyspeck fungi were placed over each test tree 6 May. 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 replicate trees 31 May. A 25-fruit sample was harvested from each replicate tree 17 Sep and rated after 28 days storage at 1C. Percentage data were converted by the square root arcsin transformation for statistical analysis.

Under heavy mildew inoculum conditions, Nova gave excellent control and Flint was also good. All treatments reduced mildew incidence on leaves and fruit, and percent foliage area affected compared to non-treated trees. Coded material VT-3 (treatment #5, Table 7) gave the most reduction in mildew incidence among the experimental materials. (Strong control by Treatment #4 is likely attributed to Nova applied through petal fall.) Under light disease pressure, all treatments gave significant suppression of scab, quince rust, and Brooks spot. Under moderate pressure, all treatments gave significant suppression of sooty blotch and flyspeck. Flint, applied alone through third cover, followed with captan + ziram through sixth cover, gave the best control of sooty blotch and flyspeck. Increasing the rate of VT-4 significantly improved control of sooty blotch and flyspeck. No treatment deleteriously affected fruit finish. Several treatments significantly improved finish, possibly by reducing mildew russet. Finish may also have been impacted by frosts 4 May, and 20 and 22 May.

Table 7. 2002 disease control by experimental fungicides on Idared apple
Virginia Tech AREC, Winchester

Treatment and formulated rate/A	Timing	Mildew infection (%) leaves	Mildew infection (%) lf area	Mildew infection (%) fruit	Scab inf., % leaves	Scab inf., % fruit	Quince rust %	Sooty blotch % fruit	Sooty blotch % area	Flyspeck (%) fruit	Flyspeck (%) area	Brooks spot(%)	% rot spots	Finish rating*
0 No fungicide	—	61 d	77 d	64 d	7 b	3 b	3 b	89 f	14 e	48 g	2.5 e	8 b	4 a	1.7 e
1 Nova 40W 5 oz Captan 50W 3 lb +Ziram 76DF 3 lb	TC–3C 4C–6C	3 a	1 a	10 a	0 a	0 a	0 a	21 bc	1 ab	8 bc	0.3 ab	1 a	0 a	0.7 a
2 VT-1 1.25Fl 4.56 fl oz	TC–6C	33 c	10 c	41 c	<1 a	0 a	0 a	37 cd	4 b-d	21 cd	1.0 bc	0 a	1 a	1.3 b-d
3 VT-1 1.25Fl 9.12 fl oz	TC–6C	39 c	15 c	30 c	0 a	1 ab	0 a	53 de	6 cd	28 d-f	1.3 cd	0 a	1 a	1.5 de
4 Nova 40W 5 oz VT-2 1.67EC 3.41 fl oz	TC–PF 2C–6C	5 a	1 ab	13 ab	0 a	0 a	0 a	68 e	7 d	47 fg	2.3 e	1 a	0 a	1.1 bc
5 VT-3 0.41EC 6.96 fl oz	TC–6C	17 b	4 b	24 bc	<1 a	0 a	0 a	33 cd	3 bc	42 e-g	1.9 de	0 a	1 a	1.4 cd
6 VT-4 1.67SC 2.02 fl oz + Induce 0.06% v/v	TC–6C	35 c	10 c	34 c	0 a	0 a	0 a	44 c-e	4 b-d	25 c-e	1.1 cd	1 a	0 a	1.4 cd
7 VT-4 1.67SC 2.48 fl oz + Induce 0.06% v/v	TC–6C	32 c	9 c	38 c	0 a	0 a	0 a	6 ab	<1 a	3 ab	0.2 a	0 a	1 a	1.2 b-d
8 Flint 50WG 2.5 oz Captan 50W 3 lb +Ziram 76DF 3 lb	TC–3C 4C–6C	14 b	3 ab	9 a	0 a	0 a	0 a	3 a	<1 a	0 a	0.0 a	0 a	0 a	1.0 ab

Mean separation by Waller-Duncan K-ratio t-test (p=0.05).
Foliar counts based on ten terminal shoots from each of four single-tree reps 31 May;.fruit counts of 25 fruit from each of four single-tree reps harvested from each replicate tree 17 Sep and rated after 28 days' storage at 1C.

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

Treatments applied to both sides of the tree on each indicated application date with a Swanson Model DA-400 airblast sprayer at 100 gal/A as follows: 4 Apr (TC, tight cluster);17 Apr (full bloom); 26 Apr (PF, petal fall); 1st – 6th covers (1C-6C), 8 May, 22 May, 7 June, 21 June, 8 July, and 31 July. Border rows were treated separately with dilute applications 7 May (Bayleton 1 oz + NAA 10 ppm + Sevin XLR 1 qt + Regulaid 11 fl oz/100 gal), 21 May, 4 and 17 June (Bayleton 1 oz/100 gal).

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

K. S. Yoder, A. E. Cochran II,
W. S. Royston, Jr., and S. W. Kilmer
Virginia Tech Agr. Res. & Ext. Center
595 Laurel Grove Road
Winchester, VA 22602

CONCENTRATE APPLICATIONS OF REGISTERED FUNGICIDES ON GOLDEN DELICIOUS APPLE, 2002: Eight treatments involving mixed schedules of registered compounds, were compared on 30-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: 5 Apr (TC, tight cluster); 16 Apr (Bl, pink-bloom); 26 Apr (PF- late petal fall); 1st – 6th covers (1C-6C): 8 May, 22 May, 7 June, 21 June, 8 July, 31 July. Insecticides applied to the entire test block with the same equipment included Asana XL, Lannate LV, Imidan 70WSB, Intrepid 2F, Provado, and Pyramite. Cedar rust galls, quince rust cankers and bitter rot mummies were placed over each test tree 9 Apr, and wild blackberry canes with the sooty blotch and flyspeck fungi were placed over each test tree 3 May. Foliar data represent averages of counts of all leaves on 10 terminal shoots from each of four replicate trees 22 July. Fire blight blossom cluster strikes per tree were counted 27 Aug. A 25-fruit sample from each replicate tree was harvested 17 Sep and rated after 50 days' storage at 1C.

Under low mildew susceptibility, but relatively high carry-over of inoculum due to mild winter temperatures, the treatments performed as expected (Table 8). Rubigan was less effective than Nova and Flint/Procure schedules. Rotating schedules of Sovran/Nova and Flint/Procure performed well under these conditions. The Cuprofix/Microthiol schedule was the weakest for mildew suppression. With less than 2% non-treated foliage and 7% fruit infected, all treatments gave good scab control. Fire blight blossom strikes resulted primarily from drift from blossom inoculations in an adjacent test area in the evening of 16 Apr, the day of the bloom application in this test block. Treatment #8, which included copper in the bloom spray and throughout the season, most effectively suppressed fire blight strikes. Schedules of captan + ziram, Flint + ziram and Cuprofix generally performed well for control of Brooks spot, sooty blotch, flyspeck and rots which developed late in the season. A schedule involving Sovran at 2nd cover was slightly less effective than one that had Cuprofix MZ (including mancozeb) at 2nd cover (Treatments # 7 and #8). Inclusion of copper (Cuprofix) during bloom – first cover significantly increased the amount of russet and down-grading due to russet. The only other significant fruit finish effect ($p=0.05$), compared to non-treated fruit, was russet which may have been associated with mildew infection on treatment #2. Fruit finish may also have been impacted by frosts 4 May, and 20 and 22 May.

Table 8. Registered fungicide treatments on Golden Delicious apple, 2002

			% leaves inf.		F. blight	% fruit infected					Fruit finish ratings*	
	Treatment and rate/A	Timing	mildew	cedar rust	strikes /tree**	scab, fruit	Brooks spot	sooty blotch	fly speck	rots	russet (0-5)	% x-fancy /fancy
0	No fungicide	—	33d	6b	30c	7b	6c	60b	50c	26c	1.8ab	84ab
1	Nova 40W 5 oz + Dithane RSNT 75DF 3 lb	TC –2C	2a	0a	24bc	0a	0a					
	Captan 50W 3 lb + Ziram 76DF 3 lb	3C–6C						0a	2a	2ab	2.0b	88b
2	Rubigan 9 fl oz + Dithane RSNT 75DF 3 lb	TC –2C	9c	<1a	28bc	0a	0a					
	Captan 50W 3 lb + Ziram 76DF 3 lb	3C–6C						0a	0a	3ab	2.5c	64c
3	Flint 50WG 2 oz	TC, 1C										
	Procure 50WS 10 oz + Dithane RSNT 75DF 3 lb	BI, PF, 2C	3a	0a	14ab	0a	0a					
	Captan 50W 3 lb + Ziram 76DF 3 lb	3C–6C						0a	0a	0ab	1.7ab	93ab
4	Flint 50WG 2 oz	TC, 1C										
	Procure SC 10 fl oz + Dithane RSNT 75DF 3 lb	BI, PF, 2C	4ab	<1a	30bc	0a	0a					
	Captan 50W 3 lb + Ziram 76DF 3 lb	3C–6C						1a	0a	1ab	1.4a	93a
5	Flint 50WG 2 oz + Dithane RSNT 75DF 3 lb	TC, BI										
	Rubigan 9 fl oz + Dithane RSNT 75DF 3 lb	PF–2C	8bc	0a	23bc	0a	0a					
	Captan 50W 3 lb + Ziram 76DF 3 lb	3C–4C										
	Flint 50WG 2 oz + Ziram 76DF 3 lb	5C–6C						0a	0a	0a	1.8ab	93ab
6	Sovran 50WG 4 oz	TC, BI, 2C										
	Nova 40W 5 oz + Polyram 80DF 3.0 lb	PF, 1C	2a	0a	42c	0a	0a					
	Captan 50W 3 lb + Ziram 76DF 3 lb	3C–6C						0a	0a	2ab	2.0b	83b
7	Cuprofix Disperss 20DF 5 lb	TC										
	Sovran 50WG 4 oz	BI, 2C	2a	0a	20bc	0a	2b					
	Nova 40W 5 oz + Polyram 80DF 3.0 lb	PF, 1C										
	Cuprofix Disperss 20DF 6 lb	3C–6C						3A	8b	4b	4.1d	6d
8	Cuprofix Disperss 20DF 10 lb	TC										
	Cuprofix MZ30 42DF 6 lb +											
	Microthiol Disperss 80DF 3 lb	BI–2C	12c	1a	6a	0a	0a					
	Cuprofix Disperss 20DF 6 lb	3C–6C						0a	0a	2ab	4.7e	0d

Mean separation by Waller-Duncan K-ratio t-test (p=0.05).
Foliar counts based on ten terminal shoots from each of four single-tree reps 22 July. **Fire bight blossom cluster strikes were counted 27 Aug.
Counts of 25-fruit samples were harvested 17 Sep and stored at 1 C 50 days until rating 6 Nov.
*Fruit finish: 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* 'Nittany')
Powdery mildew; *Podosphaera leucotricha*
Sooty blotch; disease complex
Fly speck; *Zygophiala jamaicensis*
Rots; unidentified
Fruit finish

K. S. Yoder, A. E. Cochran II, S. W. Kilmer, and W. S. Royston
Virginia Tech Agr. Research & Extension Center
595 Laurel Grove Road
Winchester, VA 22602

COMPARISON OF PROTECTANT FUNGICIDES ON NITTANY APPLE, 2002: Six treatments involving captan formulations, Cuprofix, and an experimental protectant fungicide were evaluated for broad spectrum disease management and fruit russetting potential on 20-yr-old trees. The test was conducted in a randomized block design with four single-tree replicates with treatment rows separated by border rows. Tree-row-volume was determined to require a 400 gal/A dilute base for adequate spray coverage. Treatments applied to both sides of the tree on each indicated application date with a Swanson Model DA-400 airblast sprayer at 100 gal/A as follows: 10 Apr (TC- tight cluster);17 Apr (early bloom); 25 Apr (PF, petal fall); 1st – 7th covers (1C-7C), 8 May, 20 May, 3 June, 17 June, 1 July, 15 July and 1 Aug. Other materials, applied separately to the entire test block with the same equipment, included Agri-Mycin 17, Asana XL, Lannate LV, Provado, and Imidan 70WSB. Bayleton 1 oz/A was applied to selectively suppress mildew 8 May. Bitter rot mummies and wild blackberry canes with the sooty blotch and flyspeck fungi were placed over each Nittany test tree 6 May. 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 replicate trees 11 July. A 25-fruit sample from each replicate tree was harvested 3 Oct and rated after 3 weeks storage at 1C.

The early season favored development of powdery mildew, not wet weather diseases. The treatment with Cuprofix the 3rd-5th cover period reduced mildew infection ratings. Cumulative wetting hours from June through mid-September resulted in moderate summer disease pressure, the appearance of sooty blotch on non-treated trees in August, and a test of residual effectiveness into September. Treatments with Cuprofix and/or captan gave the best control of sooty blotch and flyspeck. In spite of mid-summer wetting and placement of bitter rot mummies in the test trees, rot incidence remained low, and variation among the replications precluded statistical separation of treatments. Also, there was a light incidence of of scab, cedar-apple rust, Brooks spot, and mildew russet, with no significant difference between treated and non-treated fruit. Copper (Cuprofix) although applied as late as the 3rd-5th cover period, significantly increased fruit russet; one or more treatments involving captan significantly reduced russet and opalescence compared to non-treated trees.

Table 9. Comparison of protectant fungicides on Nittany apple

	Mildew		Sooty blotch		Flyspeck		%	Fruit finish *	
Treatment and rate/acre and timing	% lvs	% lf. area	% fruit	% fruit area	% fruit	% fruit area	fruit rots	russet rating	opales-cence
0 No fungicide	30b	5.5c	37c	2.8c	54b	3.4b	2a	1.6b	1.5cd
1 Captan 50W 6 lb, TC-7C	20ab	2.8ab	6b	0.3b	15a	0.8a	0a	1.4ab	1.1a-c
2 Captan 80WDG 3.75 lb, TC-7C	22ab	3.6a-c	3ab	0.2ab	18a	1.0a	0a	1.0a	0.8a
3 MANA 131 80WDG 3.75 lb, TC-7C	25b	4.3bc	2ab	0.1a	16a	0.9a	0a	1.4ab	1.1a-c
4 MANA 131 80WDG 1.88 lb, TC-7C	25b	4.2bc	9ab	0.5ab	31ab	2.1ab	1a	1.5b	1.4bc
5 Captan 50W 6 lb, TC-2C, 6C, 7C Cuprofix Disperss 20DF 6 lb, 3C-5C	13a	2.1a	1a	0.1a	17a	1.1a	1a	2.2c	1.9d
6 Captan 50W 3 lb, TC-7C	22ab	3.2a-c	1ab	0.1a	16a	0.9a	0a	1.3ab	1.0ab

Mean separation by Waller-Duncan K-ratio t-test (p=0.05).
Foliar counts based on ten terminal shoots from each of four single-tree replications 11 July.
A 25-fruit sample from each replicate tree was harvested 3 Oct and rated after 3 weeks storage at 1C.
* Fruit finish rated on a scale of 0-5 (0=perfect finish; 5=severe russet or opalescence).

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

K. S. Yoder, A. E. Cochran II, W. S. Royston, Jr., and S. W. Kilmer
Virginia Tech Ag. Research & Extension Center
595 Laurel Grove Road
Winchester, VA 22602

BLOSSOM BLIGHT TREATMENTS ON GOLDEN DELICIOUS AND ROME BEAUTY APPLES, 2002

A blossom blight control test with new materials was conducted on pairs of adjacent 30 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. Both Golden Delicious and Rome were treated at the same time with a dilute handgun application to run-off in the morning 18 Apr (full bloom), 22 Apr, and 26 Apr. Selected, flagged, branches, each with 30 to 50 blossom clusters, were inoculated by spraying to wet with a bacterial suspension containing $1X10^6$ E. amylovora cells/ml, in the evening of 18 Apr. After inoculation, there were two days warm enough for infection 19-20 April, followed by cool weather after which the next *Maryblyt* infection period occurred 2 May. Counts of infected blossom clusters on the inoculated limbs were conducted after symptoms had progressed beyond individual blossoms. A cluster was rated as infected if it had at least one blossom showing fire blight symptoms 14-16 May (Golden) or 16 May (Rome). Cluster infection was again rated 28 Aug and in these ratings a cluster was rated as infected only if the infection had progressed into the cluster leaves. Because many of the clusters did not set fruit and were no longer present 28 Aug, percent infection was based on the number of clusters present on inoculated branches in the May counts. Maintenance materials, applied throughout the season with a commercial airblast sprayer at 100 gal per acre, included Nova, Captan, Flint, Sovran, Ziram, Asana XL Imidan 70WSB, Lannate LV, and Provado. Harvest ratings of fruit finish were based on a 25-fruit sample from each tree.

Two days of weather favorable for natural infection following inoculation made for a good test of blossom protection by the treatments. Streptomycin (Agri-Mycin 17), applied as the commercial standard, gave good suppression of blossom blight as assessed in both counts (Table 10). The effectiveness of streptomycin appears to have supplemented other materials in combinations or alternating treatments. In combinations with S-0208, QRD 137 or BlightBan, effectiveness appeared to be more related to control by Agri-Mycin 4 oz alone than by the combination partner alone. The importance of the 18 Apr preventive application is shown by treatment #8 where streptomycin was applied first in the alternation sequence as compared to #7 where application of QRD 137 first on 18 Apr resulted in significantly weaker control. S-0208 (Starner) was numerically more effective than QRD 137 or BlightBan when each of these was applied without streptomycin. Compared to non-treated trees, QRD 137 and BlightBan were relatively more effective on Rome, where treatments were first applied earlier in bloom than on Golden, which was more advanced in bloom. QRD 137 and BlightBan, applied without streptomycin, gave significant control only on Rome; the three-application sequence of BlightBan (#10) gave significant control on Rome, but not the two-application treatment (#9). A tank-mix combination of Apogee with Agri-Mycin (treatment #12), applied 18 Apr to test whether Apogee + ammonium sulfate would have any deleterious effect on control of blossom blight by Agri-Mycin, showed that the tank-mix resulted in as good or better control than by Agri-Mycin 4 oz without Apogee. A water spray, applied at the same time as the regular treatments, showed that wetting of the trees by this application did not facilitate infection by epiphytic *E. amylovora.* There was no significant treatment effect (p=0.05) on fruit finish of either cultivar.

Table 10. Fire blight blossom blight treatments on Golden Delicious and Rome apples

Treatment and rate/100 gal dilute	Application dates	% clusters with fireblight symptoms 14-16 May *		% inoc. cluster leaves with blight 28 Aug **	
		Golden Del.	Rome	G. Del.	Rome
0 No treatment	---	64.1 f	76.5 e	41.4 d	46.7 cd
1 Agri-Mycin 17 8 oz + Regulaid 4 fl oz	18 & 22 Apr	17.3 a	30.6 a	8.8 a	14.8 a
2 Agri-Mycin 17 4 oz + Regulaid 4 fl oz	18 & 22 Apr	26.0 a-c	44.8 a-c	18.8 a-c	37.1 b-d
3 S-0208 20W 6.6 oz + Regulaid 4 fl oz	18 & 22 Apr	36.6 b-d	49.4 bc	29.5 b-d	33.9 cd
4 S-0208 20W 10 oz + Regulaid 4 fl oz	18 & 22 Apr	38.4 c-e	37.1 ab	29.0 b-d	21.8 ab
5 S-0208 20W 6.6 oz + Agri-Mycin 4 oz+ Regulaid 4 fl oz	18 & 22 Apr	25.2 a-c	39.0 ab	14.1 ab	23.7 ab
6 QRD 137 10W 2.0 lb	18 & 22 Apr	47.7 d-f	58.5 cd	33.7 cd	48.8 cd
7 QRD 137 10W 2.0 lb Agri-Mycin 17 8 oz + Regulaid 4 fl oz	18 Apr 22 Apr	53.7 ef	46.9 a-c	37.6 d	33.4 bc
8 Agri-Mycin 17 8 oz + Regulaid 4 fl oz QRD 137 10W 2.0 lb	18 Apr 22 Apr	21.9 ab	39.0 ab	14.1 ab	28.4 ab
9 BlightBan 2.5 oz	18 & 22 Apr	48.5 d-f	74.4 de	31.5 cd	53.8 d
10 BlightBan 2.5 oz	18, 22 & 26 Apr	53.2 ef	60.9 cd	38.1 d	52.0 d
11 BlightBan 2.5 oz+ Agri-Mycin 17 4 oz + Regulaid 4 fl oz	18 & 22 Apr	41.1 c-e	37.4 ab	30.3 b-d	25.7 ab
12 Agri-Mycin 17 4 oz+ Regulaid 4 fl oz + Apogee 27.5DF 6 oz + Am. sulfate 6 oz Agri-Mycin 17 4 oz + Regulaid 4 fl oz	18 Apr 22 Apr	16.5 a	37.5 ab	10.5 a	25.2 ab

Means of four replications; mean separation by Waller-Duncan K-ratio t-test (p=0.05).
Treatments applied dilute to run-off on the morning 18 Apr (full bloom), 22 Apr, and 26 Apr. Selected branches were inoculated by spraying to wet with a bacterial suspension containing $1X10^6$ *E. amylovora* cells/ml, in the evening of 18 Apr. After inoculation, there were two days warm enough for infection 19-20 April, followed by cool weather; the next *Maryblyt* infection period occurred 2 May.

* A cluster was rated as infected if any blossoms showed fire blight symptoms 14-16 May.

** Clusters were rated as infected on 28 Aug only if the infection had progressed into the cluster leaves. Percent infection 28 Aug was based on the number of clusters present on inoculated branches in May.

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

K. S. Yoder, A. E. Cochran II, W. S. Royston, Jr.,
and S. W. Kilmer
Virginia Tech Ag. Research & Extension Center
595 Laurel Grove Road
Winchester, VA 22602

EVALUATION OF GENTAMYCIN FOR BLOSSOM BLIGHT CONTROL ON GOLDEN DELICIOUS, 2002:

A blossom blight test of gentamycin (GWN-9200) was established in four randomized blocks on 30 yr-old trees. Treatments were applied to both sides of the tree on the mornings of 16 Apr (full bloom) and 30 Apr with a Swanson Model DA-400 airblast sprayer at the indicated gallons per acre. Four selected branches per tree, each with 30 to 50 blossom clusters, were inoculated by spraying to wet with a bacterial suspension containing $1X10^6$ *E. amylovora* cells/ml, in the evening of 16 Apr. After inoculation, there were four days warm enough for infection 17-20 April, followed by cool weather; after which the next *Maryblyt* infection period occurred 2 May. Counts of infected blossom clusters on the inoculated limbs were conducted after symptoms had progressed beyond individual blossoms. A cluster was rated as infected if it had at least one blossom showing fire blight symptoms 9-10 May. Cluster infection was again rated 27 Aug and in these ratings a cluster was rated as infected only if the infection had progressed into the cluster leaves. Because many of the clusters did not set fruit and were no longer present 27 Aug, percent infection was based on the total number of clusters present on inoculated branches in the May counts. Maintenance materials, applied with the same equipment at 100 gal per acre, included Nova, Captan, Flint, Sovran, Ziram, Asana XL, Imidan 70WSB, Lannate LV, Provado, and Pyramite. Harvest ratings of fruit finish were based on a 25-fruit sample from each tree.

The intent of the treatment schedule was to study the effects of different amounts of water per acre in a single application on blossom blight suppression. However, four days of weather favorable for natural infection following inoculation greatly increased the severity of the test, and apparently overwhelmed any treatment effect. Neither streptomycin (the commercial standard, Agri-Mycin 17), nor GWN-9200 gave any noticeable suppression of blossom blight as assessed in both counts (Table 10). A direct comparison to another test (Table 9) in an adjacent block inoculated two days later from the same stock culture, showed that streptomycin was effective on the inoculum, ruling out the possibility of resistance to streptomycin. Other explanations for the failure of streptomycin and gentamycin in this test: 1) Was the protective interval to short to reach through the fourth infection day? 2) At 19.2 oz/A for 300 gpa trees, based on tree-row-volume, was the streptomycin concentrate rate too low? 3) Should we adjust the test inoculum rate for predicted weather conditions-- lower it from 10^6 to 10^5 for one predicted infection day, or 10^4 for two or three predicted days? There was a significant reduction in russetting by the streptomycin treatment resulting in 95% of fruit grading out as USDA Xtra-fancy & Fancy compared to only 64% in these grades from non-treated trees; there was no significant effect (p=0.05) on fruit finish by GWN-9200. Russetting may also have been affected by frost injury 4 May, and 20 and 22 May.

Table 11. Fire blight blossom test; airblast application of GWN-9200 on Golden Delicious

	Bloom treatment; rate/A and indicated gallons water/A*	% clusters with fire blight symptoms 9 May*	% inoc. cluster leaves with blight 27 Aug **
0	No treatment	48.5 a	44.8 a
1	GWN-9200 10W 33.4 oz/100 gal/A	51.9 a	44.4 a
2	GWN-9200 10W 50.1 oz/100 gal/A	52.2 a	45.7 a
3	GWN-9200 10W 66.8 oz/100 gal/A	51.0 a	47.8 a
4	GWN-9200 10W 33.4 oz /50 gal/A	54.4 a	48.4 a
5	GWN-9200 10W 33.4 oz /200 gal/A	51.5 a	41.9 a
6	Agri-Mycin 17 19.2 oz/100 gal/A	46.2 a	43.6 a

Means of four replications; mean separation by Waller-Duncan K-ratio t-test (p=0.05).
Treatment note: Regulaid 4 fl oz /100 gal of tank mix was included with all treatments.
* A cluster was rated as infected if any blossoms showed fire blight symptoms 9-10 May.
** Clusters were rated infected on 27 Aug if the infection had advanced into the cluster leaves; 27 Aug % infection was based on the total clusters on inoculated branches in the May counts.

Commercial demonstration / test blocks of prohexadione-Ca (Apogee) for shoot blight and growth suppression in commercial apple orchards, 2001-2002.

K. S. Yoder, Virginia Tech AREC, Winchester, VA
J. L. Norelli, USDA-ARS AFRS, Kearneysville, WV
A. R. Biggs, WVU, Kearneysville, WV
R. P. Marini, VPI&SU, Dept. of Horticulture, Blacksburg, VA

With the support of the Virginia Apple Research Program (VARP), 13 Apogee test plots were established in 10 commercial orchards in 2001 and 20 in eight orchards in 2002. Plots were placed where there was some indication of fire blight infection the previous year year, or a planting of highly susceptible cultivars. In the more distant plot areas, the cooperating grower applied the treatment; In the plots summarized here, A. E. Cochran, Virginia Tech AREC, made the applications. In all of these test plots, the base treatment rates were Apogee 6 oz dilute + Choice 1 qt/ 100 gal + LI-700 1 pt /100 gal and the Apogee rate was adjusted by tree row volume calculation for each block. Adjuvant rates were based on the amount of water in the tank. The number of applications was adjusted as deemed necessary to test for an effect on shoot blight, based on growth pressure and evidence of fire blight infection. Reported below are the tabulated results from five plot areas in two orchards in Frederick and Shenandoah counties where blossom blight occurred in 2001 and 2002 and hail favored secondary spread in the month after the initial Apogee application, resulting in a test for shoot blight suppression. In three of these plot areas treatments were applied to the same trees, and the same trees were left non-treated both years. An additional test plot was initiated in each of these orchards in 2002 as reported below.

Blossom blight occurred in nearly all of the total 33 test blocks in the two-year period, but if conditions did not favor spread to shoots, no test for shoot blight control resulted. In nine of the test blocks, hail damage occurred within the month after application, resulting in significant blight spread to shoot tips and a significant comparison of treated versus non-treated replicate tree sets. In those nine test blocks over the 2-yr period (at White Hall, Forestville, and one at Fincastle), the mean reduction by Apogee in the frequency of shoot blight strikes was 85%. Most of the blocks had shoot blight suppression in the 87-96% range. The two blocks with the least control (at Boyles Orchard, White Hall, 2002) had 54 and 71% suppression. Effectiveness there probably was reduced because hail damage occurred less than a week after application, before Apogee would have become effective physiologically.

In the most severely affected plots in 2001 we found significant reductions in the number of potential overwintering cankers on scaffold limbs and trunks, in one case as high as a 96% reduction. By observing different plot areas, we also found that in practice, at least two applications may be needed to reduce susceptibility of growing shoot tips during critical periods of the growing season and that using more applications at lower rates might be a more practical way to achieve the desired effect. The 6 oz dilute rate appeared to be acceptable for our purposes except in one extremely vigorous Ginger Gold block where the grower-applied rate was raised to 9 oz for 2002. Lower shoot blight incidence in some plot areas re-emphasized the importance of other fire blight management practices such as timely streptomycin applications during bloom the and significance of hail damage (for trauma blight) in secondary spread.

Summary

These results demonstrate that Apogee consistently reduces shoot blight spread due to hail injury when applied two to three weeks before injury occurs. Overall, in our research since 1994, Apogee has given a fairly predictable and reliable response for shoot blight suppression. This novel approach, using a plant growth regulator for shoot blight management, has been more consistent and more reliable than the effectiveness of various materials we have tested for blossom blight control. This practice works well for shoot blight (shoot tip protection), and there are synergistic effects when used in our situation with streptomycin at late bloom. With Apogee there is usually a good shoot growth reduction, and with the hardening of the shoot tip comes reduced fire blight susceptibility. The cost and benefit of Apogee usage depends on the location and required rate and number of applications based on tree size, vigor and growing conditions.

In spite of its consistent effect on shoot blight suppression, attractiveness of Apogee usage to processing market apple growers in Virginia has been somewhat limited by cost of the material; however, its value for fire blight management may be enhanced by its usefulness for overall growth suppression and reduced pruning costs to help offset material costs.

Bowman Wunder Orchard, Forestville, VA. York Test Block 1; York/MM.111 (300 gpa base)
Treatments repeated on same trees as 2001. Applied 24 Apr and 2 Jul. Treated with streptomycin during bloom. Tornado weather 28 Apr. Counts 14 June

2001 data, York /MM111, Block 1.

	Mean fire blight strikes per 5-tree replicate set								Shoot length, cm	
	8 June			20 June			shoots	Potential over-		
Treatment	blossom	canker	shoot	blossom	canker	shoot	9 Aug	wintering cankers*	18 May	20 June
Non-treated	8.0	0.2	15.7	7.8	0.2	27.7	95.7	29.8	16.6	36.7
Apogee	6.8 ns	0.0 ns	**1.0*****	7.2 ns	0.5 ns	**3.3*****	**9.8*****	**1.3*****	**10.9*****	**12.4*****
% reduction	15	–	**94**	8	0	**88**	**90**	**96**	**34**	**66**

Averages of six replications. Mean separation by Duncan's Multiple Range Test.
Statistical significance levels: ***= 99.9%; **= 99%; *= 95%; ns= <95%.
* Potential overwintering cankers are shoots with cankers to the base on trunk and limbs > 2-inch diam.

2002 data, York/MM111 block 1, (treatment repeated from 2001).

	Blight strikes* per 5-tree replicate set and severity rating** 14 June				Shoot condition 15 Jul			
Treatment	blossom	canker	shoot	Severity	Length (cm)	% not growing	% still growing	% re-growth
Non-treated	27.4	0.3	26.3	1.8	32.1	87	10	3
Apogee	14.4 ns	0.8 ns	**2.8****	0.7	**12.0*****	100	0	0
% reduction	47.4	–	**89**		**63**			

Averages of six replications. Mean separation by Duncan's Multiple Range Test.
* Type of blight strikes rated in bottom 2.5 m of tree
** Severity rating based on % of total tree area affected; scale: 0 = 0%; 1 =1%;
2= 2-10%; 3=11-25%; 4= 26-50%; 5=51=75%
Statistical significance levels: ***= 99.9%; **= 99%; *= 95%; ns= <95%.
Re-treated 2 July because of some renewed growth of shoot tips and presence of blight in the test area.

Bowman Wunder Orchard. York Test Block 2; York/MM.111 (300 gpa base)
Not treated last year. Applied 24 Apr and 2 Jul. Trees treated with streptomycin during bloom. Tornado weather 28 Apr. Blight counts 14 June

2002 data, York / MM111, Block 2.

	Blight strikes* per 5-tree replicate set and severity rating** 14 June				Shoot condition 15 Jul			
Treatment	blossom	canker	shoot	severity	Length (cm)	% not growing	% still growing	% re-growth
Non-treated	50.4	–	12.3	1.4	26.7	87	10	3
Apogee	22.3 ns	–	**1.4****	0.9 ns	**9.9***	80	13	7
% reduction	55.8	–	**89**		**62**			

* Type of blight strikes rated in bottom 2.5 m of tree, averages of 8 reps
** Severity rating based on % of total tree area affected;
Scale: 0 = 0%; 1 =1%; 2= 2-10%; 3=11-25%; 4= 26-50%; 5=51=75%
Shoot condition averages of 6 reps.
Mean separation by Duncan's Multiple Range Test.
Statistical significance levels: ***= 99.9%; **= 99%; *= 95%; ns= <95%.
Re-treated 2 July because of some renewed growth of shoot tips and presence of fire blight in the test area.

Solenberger Boyles Orchard, White Hall, VA, York and Greening/sdlg (400 gpa base)

Treated 2 May and 2 Jul '01. Not treated with copper or streptomycin during bloom.
Hail damage occurred 26 May.

2001 data; Boyles Orchard, York/seedling root.

Treatment	Mean fire blight strikes per 5-tree replicate set, 9 June: blossom	canker	shoot	Potential over-wintering cankers* 1 Oct	Shoot length, cm: 16 May	26 June
Non-treated	29.3	4.7	134.7	77.0	11.7	25.2
Apogee	26.0 ns	1.7 ns	**8.0***	29.7 ns	**7.4****	**9.8*****
% reduction	11	64	**94**	61	**37**	**61**

Fire blight data means of three reps; shoot length means of six reps.
Mean separation by Duncan's Multiple Range Test (p=0.05).
Statistical significance levels: ***= 99.9%; **= 99%; *= 95%; ns= <95%.
* Potential overwintering cankers are shoots with cankers to the base on trunk and limbs > 2-inch diameter.

2001 data; Boyles Orchard, NW Greening / seedling root.

Treatment	Mean fire blight strikes per 5-tree replicate set, 13 June: blossom	canker	shoot	Potential over-wintering cankers* 1 Oct	Shoot length, cm: 16 May	26 June
Non-treated	7.3	7.5	104.8	74.3	17.4	34.0
Apogee	10.3 ns	**1.8 ***	**4.5****	**22.3***	13.9ns	**19.2*****
% reduction	–	**76**	**96**	**70**	20	**44**

Fire blight data means of four reps; shoot length means of six.
Mean separation by Duncan's Multiple Range Test.
Statistical significance levels: ***= 99.9%; **= 99%; *= 95%; ns= <95%.
* Potential overwintering cankers are shoots with cankers to the base on trunk and limbs > 2-inch diameter.

2002 data, Solenberger Boyles Orchard, White Hall, VA.

York Imperial and NW Greening on seedling rootstock (400 gpa base); Rome/111 (300 gpa base); Treated 26 Apr and 2 Jul. Rome not treated last year. Not treated with copper or streptomycin during bloom. Hail damage 26 May. Counts 18 June

Blight strikes* per 5-tree replicate set and severity rating** 18 June

Treatment*	York Imperial / seedling: blossom	canker	shoot	severity	NW Greening / seedling: blossom	shoot	severity	Rome Beauty/ MM111: blossom	shoot	severity
Non-treated	123.4	0.2	43.1	2.5	168.2	95.8	1.7	117.2	210.6	3.2
Apogee	169.0 ns	0.4 ns	**12.4****	**1.3***	**292.2***	44.4 ns	1.7 ns	122.0 ns	**27.3****	1.8
% reduction	–	–	71		–	54		–	87	

Averages of 6 reps. Statistical significance levels: ***= 99.9%; **= 99%; *= 95%; ns= <95%.
Treatments applied 26 Apr and 2 Jul to same York and Greening trees as last year, 400 gpa base; Treatment not applied to Rome in 2001, 300 gpa dilute base.
* Type of blight strikes rated in bottom 2.5 m of tree.
** Severity rating based on % of total tree area affected; Scale: 0 = 0%; 1 =1%; 2= 2-10%; 3=11-25%; 4= 26-50%; 5=51=75%
All cultivars were re-treated 2 July because of some renewed growth of shoot tips and severity of fire blight in the test area.

MANAGEMENT OF BROWN ROT, SCAB, RUSTY SPOT, AND RHIZOPUS ROT OF PEACH USING FUNGICIDE MIXTURES

Norman Lalancette, Kathleen Foster, and Jody Veler
Rutgers Agricultural Research and Extension Center
Bridgeton, NJ 08302

Mixtures of fungicides of different chemistry (BAS 516; Flint + Elite; Nova + Abound) were examined for their efficacy against one or more important peach diseases. These combinations were compared to each other and to treatments having timings consisting of a single fungicide active against a particular disease (Indar; Elite; Flint; Vangard; Quintec). In addition, peach scab sprays were initiated one growth stage earlier, at petal fall, in order to test anti-sporulant activity against the pathogen.

MATERIALS AND METHODS

Treatments. The experiment was conducted during the spring and summer of the 2002 growing season. The test block consisted of mixed-cultivar orchard of 7-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: 2 Apr (P, pink); 11 Apr (B, bloom); 18 Apr (PF, petal fall); 24 Apr (SS, shuck split); and 1 15 23 May, 3, 17 Jun, 1, 15, 29 Jul (1C-8C, first-eighth cover). Three applications were made for fruit rot control: 12, 21, 30 Aug (22, 13, 4 days preharvest (PH)). Insecticides and miticides were applied as needed to the entire block using a commercial airblast sprayer.

Environment. Weather conditions were highly favorable for scab (Fig.1). A total of 20 days with rain >0.10 in occurred from bloom on 11 Apr to 24 Jul (42 days PH). The number of rain periods following each spray during this time were: B, 2; PF, 1; SS, 2; 1C, 3; 2C, 2; 3C, 1; 4C, 4; 5C, 3; 6C, 1; and 7C, 1. A 40-day drought occurred from mid-July through late August. However, conditions became favorable for brown rot on late-season cultivars during their preharvest period. Seven rain periods >0.10 in and two overhead irrigations occurred during the 21 days prior to harvest. The number of rain / irrigation days following each spray during this time were: 22 PH, 3; 13 PH, 4; and 4 PH, 2.

Assessment. Rusty spot (*Podosphaera leucotricha?*) was evaluated on 10 Jun by examining 40 fruit per tree. Scab (*Cladosporium carpophilum*) was evaluated on 27 Aug by examining 50 fruit per tree. Brown rot (*M. fructicola*) was evaluated at harvest on 3 Sep by examining all fruit on two or more branches per replicate tree; a minimum of 100 fruit / tree was examined. For postharvest evaluations, 40-50 healthy fruit were harvested from each tree on 3 Sep and placed on benches in a shaded greenhouse (ave. air temp. = 70°F). Brown and Rhizopus rot were assessed at 3 and 6 days postharvest (dph).

RESULTS AND DISCUSSION

Rusty Spot. Incidence and severity of rusty spot in the test block, like in commercial orchards, was very severe this season. Non-sprayed control trees had 90% infected fruit and averaged 3.5 lesions per fruit (Table 1). Nevertheless, all treatments during the critical petal fall to second cover period significantly reduced disease levels.

The best treatments were Flint at 3.0 to 3.11 oz/A (alone or in combination with Elite), Nova + Abound alternating with Nova, and BAS 516 at 14.7 oz/A. These treatments, which had incidence levels that were not significantly different from each other, provided disease control ranging from 75% to 86.1%. Differences in disease severity among treatments were less pronounced; all treatments had <1 lesion / fruit.

An increase in the BAS 516 rate from 10.5 to 14.7 oz/A significantly increased the level of disease control from 55.6% to 79.1%. A similar rate response was not statistically significant for increasing concentrations of Elite + Flint, although the highest rate did have the lowest incidence and severity. BAS 516 alternating with Nova did not provide control equivalent to BAS 516 alone. Quintec, a powdery mildew fungicide, was not as effective as the best treatment combinations.

Nova at all four timings is the standard for comparison. However, Abound also provides control of rusty spot. The two sprays of Abound (at PF & 2C) were added to the standard treatments primarily for scab control since Nova provides no activity against this disease.

Scab. A combination of high inoculum (twig lesions) and favorable weather resulted in extremely high disease pressure (Table 2). Control trees had 100% of their fruit with >10 lesions; many fruit were covered by large areas of coalescing lesions. Relative to the nonsprayed control, all fungicide treatments had significantly less disease incidence and severity. Application of fungicide increased the proportion of fruit in the 1-10 lesion category, while reducing the number of fruit with >10 lesions.

The two standard (Abound / Bravo / Captan) and the BAS 516 / Bravo / Captan treatments had the lowest fruit disease incidence and were not significantly different from each other. These treatments provided 67.5 to 82.5% disease control. Flint alone was the next best treatment, differing statistically from only one of the two standards. The least effective treatments were the mixtures BAS 516 and Elite + Flint; neither mixture showed a significant reduction in disease incidence or severity with increasing application rates.

The standard protectant schedule, two applications of Bravo (SS & 1C) followed by six Captan cover sprays, performed poorly under the severe disease pressure. However, addition of Abound at PF, and the substitution of Abound for Captan at 2C, resulted in creation of the best treatments. This difference may be due to anti-sporulant activity exhibited by Abound; lesions on twigs from a separate Abound-only treated block failed to sporulate under favorable conditions in the laboratory. BAS 516 also appeared to exhibit this effect when scheduled with Bravo and Captan. Finally, a similar Flint / protectant fungicide schedule might perform better against scab than Flint + Elite.

Brown Rot. Although a combination of irrigation and rainfall provided sufficient moisture for development of brown rot during the preharvest period (Fig. 1), two other factors most likely limited incidence at harvest (Table 3). First, very few mummies were observed sporulating in spring, possibly due to reduced fungal survival during the preceding warm winter. No blossom blight was observed. Second, the drought occurred during the 40-days prior to 'Autumnglo' ripening. Consequently, much less *M. fructicola* inoculum was available from earlier cultivars.

Under these conditions, only 33% fruit infection occurred at harvest on the control. All fungicide treatments provided > 95% disease control and were significantly different from the nonsprayed treatment. No differences were observed among fungicides, whether they were applied alone, alternated, or in mixture.

Postharvest brown rot development was severe, attaining 66% and 84% of the fruit rotted after 3- and 6-days incubation, respectively (Table 3). This increase was most likely due to the two rain periods that occurred one and two days before harvest. Also, fruit were most susceptible (ripe) at this time. However, any infections that would have occurred would not have exhibited symptoms by harvest. Hence, apparently healthy but infected fruit were chosen for the postharvest study.

This preharvest situation provided an excellent postharvest test of the fungicides. The final spray occurred on 30 Sep, two and three days before the two rains. Under these conditions, all fungicides provided statistically similar control at 3-dph, with all but two treatments maintaining disease below 5%. After 6 days incubation, disease levels increased several fold, but little statistical separation occurred among treatments. The one exception was for Vangard, which had significantly higher % fruit rotted than all other fungicide treatments.

Rhizopus Rot. Approximately 2% of the fruit had Rhizopus rot at harvest, and picked "healthy" fruit became 8% and 27% rotted after 3- and 6-days incubation, respectively, in the postharvest study (Table 4). Except for one Indar standard at harvest, all fungicide treatments had significantly less rot than the non-sprayed treatment. No statistical separation was evident among fungicide treatments.

TABLE 1. Peach Rusty Spot Incidence and Severity[1]				
			% Infected	**# Lesions /**

Treatment[2]	Rate / A	Timing	fruit[3]	fruit[3]
Nontreated Control	----------------	----------------	90.0 a	3.48 a
Orbit 3.6EC **Nova 40W + Abound 2.08SC** **Nova 40W** + Bravo WS 6F Captan 50WP Indar 75WSP + Latron	4.0 fl oz **5.0 oz + 15.4 fl oz** **5.0 oz** + 4.0 pt 6.0 lb 2.0 oz	P, B **PF, 2C** **SS, 1C** 3C-8C 22, 13, 4 PH	22.5 def	0.36 bcd
BAS 516 38WG **BAS 516 38WG** BAS 516 38WG	10.5 oz **10.5 oz** 10.5 oz	P, B **PF, SS, 1C, 2C,** 3C-8C 22, 13, 4 PH	40.0 b	0.81 b
BAS 516 38WG **BAS 516 38WG** BAS 516 38WG	14.7 oz **14.7 oz** 14.7 oz	P, B **PF, SS, 1C, 2C,** 3C-8C 22, 13, 4 PH	18.8 ef	0.39 bcd
Orbit 3.6EC **BAS 516 38WG** **Nova 40W** + Bravo WS 6F Captan 50WP BAS 516 38WG Indar 75WSP + Latron	4.0 fl oz **14.7 oz** **5.0 oz** + 4.0 pt 6.0 lb 14.7 oz 2.0 oz	P **B, PF, 2C** **SS, 1C** 3C-8C 22, 4 PH 13 PH	31.3 bcd	0.47 bcd
Elite 45DF + Induce **Nova 40W + Abound 2.08SC** **Nova 40W** + Bravo WS 6F Captan 50WP Elite 45DF + Induce	7.99 oz **5.0 oz + 15.4 fl oz** **5.0 oz** + 4.0 pt 6.0 lb 7.99 oz	P, B **PF, 2C** **SS, 1C** 3C-8C 22, 13, 4 PH	13.8 f	0.21 d
Orbit 3.6EC **Flint 50WG** Indar 75WSP + Latron	4.0 fl oz **3.0 oz** 2.0 oz	P, B **PF, SS, 1C, 2C,** 3C-8C 22, 13, 4 PH	12.5 f	0.18 d
Elite 45DF + Flint 50WG **Elite 45DF + Flint 50WG** Elite 45DF + Flint 50WG	2.32 oz + 2.08 oz **2.32 oz + 2.08 oz** 2.32 oz + 2.08 oz	P, B **PF, SS, 1C, 2C,** 3C-8C 22, 13, 4 PH	26.3 cde	0.40 bcd
Elite 45DF + Flint 50WG **Elite 45DF + Flint 50WG** Elite 45DF + Flint 50WG	2.89 oz + 2.60 oz **2.89 oz + 2.60 oz** 2.89 oz + 2.60 oz	P, B **PF, SS, 1C, 2C,** 3C-8C 22, 13, 4 PH	26.9 cde	0.46 bcd
Elite 45DF + Flint 50WG **Elite 45DF + Flint 50WG** Elite 45DF + Flint 50WG	3.46 oz + 3.11 oz **3.46 oz + 3.11 oz** 3.46 oz + 3.11 oz	P, B **PF, SS, 1C, 2C,** 3C-8C 22, 13, 4 PH	15.6 ef	0.34 cd
Vangard 75WG **Quintec 2.08SC** **Quintec 2.08SC** + Bravo WS 6F **Quintec 2.08SC** + Captan 50WP Captan 50WP Vangard 75WG	5 oz **8.0 fl oz** **8.0 fl oz** + 4.0 pt **8.0 fl oz** + 6.0 lb 6.0 lb 5.0 oz	P, B **PF** **SS, 1C** **2C** 3C-8C 22, 13, 4 PH	37.5 bc	0.74 bc

[1] Rusty spot treatments, rates, and application timings are indicated in boldface.
[2] Latron B-1956 spreader-sticker and Induce wetter-spreader at .06% v/v ratio, equivalent to 8 fl oz/ 100 gal.
[3] Means in the same column with the same letter do not differ significantly according to the Waller-Duncan K-ratio t-test (*P*□0.05, *K*=100).

TABLE 2. Peach Scab Incidence and Severity[1]			% Fruit[2]		
Treatment[3]	**Rate / A**	**Timing**	**Infected**	**1-10 lesions**	**>10 lesions**
Nontreated Control	----------------	----------------	100.0 a	0.0 e	100.0 a
Orbit 3.6EC Nova 40W + **Abound 2.08SC** Nova 40W + **Bravo WS 6F** **Captan 50WP** Indar 75WSP + Latron	4.0 fl oz 5.0 oz + **15.4 fl oz** 5.0 oz + **4.0 pt** **6.0 lb** 2.0 oz	P, B **PF, 2C** **SS, 1C** 3C-7C, 8C 22, 13, 4 PH	26.0 fg	24.5 cd	1.5 e
BAS 516 38WG **BAS 516 38WG**	10.5 oz **10.5 oz**	P, B **PF, SS, 1C-7C, 8C**			

BAS 516 38WG	10.5 oz	22, 13, 4 PH	88.5 b	38.5 ab	50.0 b
BAS 516 38WG	14.7 oz	P, B			
BAS 516 38WG	**14.7 oz**	**PF, SS, 1C-7C, 8C**			
BAS 516 38WG	14.7 oz	22, 13, 4 PH	82.0 b	25.0 cd	57.0 b
Orbit 3.6EC	4.0 fl oz	P			
BAS 516 38WG	**14.7 oz**	**B, PF, 2C**			
Nova 40W + **Bravo WS 6F**	5.0 oz + **4.0 pt**	**SS, 1C**			
Captan 50WP	**6.0 lb**	3C-7C, 8C			
BAS 516 38WG	14.7 oz	22, 4 PH			
Indar 75WSP + Latron	2.0 oz	13 PH	32.5 efg	27.5 abc	5.0 de
Elite 45DF + Induce	7.99 oz	P, B			
Nova 40W + **Abound 2.08SC**	5.0 oz + **15.4 fl oz**	**PF, 2C**			
Nova 40W + **Bravo WS 6F**	5.0 oz + **4.0 pt**	**SS, 1C**			
Captan 50WP	**6.0 lb**	3C-7C, 8C			
Elite 45DF + Induce	7.99 oz	22, 13, 4 PH	17.5 g	15.5 d	2.0 e
Orbit 3.6EC	4.0 fl oz	P, B			
Flint 50WG	**3.0 oz**	**PF, SS, 1C-7C, 8C**			
Indar 75WSP + Latron	2.0 oz	22, 13, 4 PH	39.0 def	26.0 bcd	13.0 cd
Elite 45DF + Flint 50WG	2.32 oz + 2.08 oz	P, B			
Elite 45DF + **Flint 50WG**	2.32 oz + **2.08 oz**	**PF, SS, 1C-7C, 8C**			
Elite 45DF + Flint 50WG	2.32 oz + 2.08 oz	22, 13, 4 PH	62.0 c	36.5 abc	25.5 c
Elite 45DF + Flint 50WG	2.89 oz + 2.60 oz	P, B			
Elite 45DF + **Flint 50WG**	2.89 oz + **2.60 oz**	**PF, SS, 1C-7C, 8C**			
Elite 45DF + Flint 50WG	2.89 oz + 2.60 oz	22, 13, 4 PH	46.5 cde	31.0 abc	15.5 c
Elite 45DF + Flint 50WG	3.46 oz + 3.11 oz	P, B			
Elite 45DF + **Flint 50WG**	3.46 oz + **3.11 oz**	**PF, SS, 1C-7C, 8C**			
Elite 45DF + Flint 50WG	3.46 oz + 3.11 oz	22, 13, 4 PH	51.5 cd	39.5 ab	12.0 cd
Vangard 75WG	5 oz	P, B			
Quintec 2.08SC	8.0 fl oz	**PF**			
Quintec 2.08SC + **Bravo WS 6F**	8.0 fl oz + **4.0 pt**	**SS, 1C**			
Quintec 2.08SC + **Captan 50WP**	8.0 fl oz + **6.0 lb**	**2C**			
Captan 50WP	**6.0 lb**	3C-7C, 8C			
Vangard 75WG	5.0 oz	22, 13, 4 PH	57.5 cd	40.5 a	17.0 c

[1]Peach scab treatments, rates, and application timings are indicated in boldface; PF spray needs to be anti-sporulant for control at this timing.
[2]Means in the same column with the same letter do not differ significantly according to the Waller-Duncan K-ratio t-test (P□0.05, K=100).
[3]Latron B-1956 spreader-sticker and Induce wetter-spreader at .06% v/v ratio, equivalent to 8 fl oz/ 100 gal.

TABLE 3. Brown Rot Harvest and Post-harvest Incidence [1]			**% Fruit Infected** [2]		
Treatment [3]	**Rate / A**	**Timing**	**Harvest**	**3-dph**	**6-dph**
Nontreated Control	————	————	32.9 a	65.5 a	83.9 a
Orbit 3.6EC	4.0 fl oz	P, B			
Nova 40W + Abound 2.08SC	5.0 oz + 15.4 fl oz	PF, 2C			
Nova 40W + Bravo WS 6F	5.0 oz + 4.0 pt	SS, 1C			
Captan 50WP	6.0 lb	3C-8C			
Indar 75WSP + Latron	**2.0 oz**	**22, 13, 4 PH**	3.7 b	4.7 b	7.3 cd
BAS 516 38WG	10.5 oz	P, B			
BAS 516 38WG	10.5 oz	PF, SS, 1C-8C			
BAS 516 38WG	**10.5 oz**	**22, 13, 4 PH**	3.0 b	2.6 b	9.6 cd
BAS 516 38WG	14.7 oz	P, B			
BAS 516 38WG	14.7 oz	PF, SS, 1C-8C			
BAS 516 38WG	**14.7 oz**	**22, 13, 4 PH**	4.1 b	3.3 b	5.8 cd
Orbit 3.6EC	4.0 fl oz	P			
BAS 516 38WG	14.7 oz	B, PF, 2C			
Nova 40W + Bravo WS 6F	5.0 oz + 4.0 pt	SS, 1C			
Captan 50WP	6.0 lb	3C-8C			
BAS 516 38WG	**14.7 oz**	**22, 4 PH**			

Indar 75WSP + Latron	**2.0 oz**	**13 PH**	2.5 b	3.8 b	10.1 cd
Elite 45DF + Induce	7.99 oz	P, B			
Nova 40W + Abound 2.08SC	5.0 oz + 15.4 fl oz	PF, 2C			
Nova 40W + Bravo WS 6F	5.0 oz + 4.0 pt	SS, 1C			
Captan 50WP	6.0 lb	3C-8C			
Elite 45DF + Induce	**7.99 oz**	**22, 13, 4 PH**	2.0 b	2.4 b	5.0 cd
Orbit 3.6EC	4.0 fl oz	P, B			
Flint 50WG	3.0 oz	PF, SS, 1C-8C			
Indar 75WSP + Latron	**2.0 oz**	**22, 13, 4 PH**	2.2 b	3.3 b	3.3 d
Elite 45DF + Flint 50WG	2.32 oz + 2.08 oz	P, B			
Elite 45DF + Flint 50WG	2.32 oz + 2.08 oz	PF, SS, 1C-8C			
Elite 45DF + Flint 50WG	**2.32 oz + 2.08 oz**	**22, 13, 4 PH**	3.4 b	5.5 b	14.1 c
Elite 45DF + Flint 50WG	2.89 oz + 2.60 oz	P, B			
Elite 45DF + Flint 50WG	2.89 oz + 2.60 oz	PF, SS, 1C-8C			
Elite 45DF + Flint 50WG	**2.89 oz + 2.60 oz**	**22, 13, 4 PH**	1.9 b	3.0 b	10.6 cd
Elite 45DF + Flint 50WG	3.46 oz + 3.11 oz	P, B			
Elite 45DF + Flint 50WG	3.46 oz + 3.11 oz	PF, SS, 1C-8C			
Elite 45DF + Flint 50WG	**3.46 oz + 3.11 oz**	**22, 13, 4 PH**	2.4 b	3.4 b	12.2 cd
Vangard 75WG	5 oz	P, B			
Quintec 2.08SC	8.0 fl oz	PF			
Quintec 2.08SC + Bravo WS 6F	8.0 fl oz + 4.0 pt	SS, 1C			
Quintec 2.08SC + Captan 50WP	8.0 fl oz + 6.0 lb	2C			
Captan 50WP	6.0 lb	3C-8C			
Vangard 75WG	**5.0 oz**	**22, 13, 4 PH**	2.5 b	10.1 b	24.8 b

[1] Brown rot treatments, rates, and application timings in boldface.
[2] Means in the same column with the same letter do not differ significantly according to the Waller-Duncan K-ratio t-test (*P*□0.05, *K*=100).
[3] Latron B-1956 spreader-sticker and Induce wetter-spreader at .06% v/v ratio, equivalent to 8 fl oz/ 100 gal.

TABLE 4. Rhizopus Rot Harvest and Post-harvest Incidence[1]			**% Fruit Infected[2]**		
Treatment[3]	**Rate / A**	**Timing**	**Harvest**	**3-dph**	**6-dph**
Nontreated Control	------------	------------	1.9 a	7.7 a	27.4 a
Orbit 3.6EC	4.0 fl oz	P, B			
Nova 40W + Abound 2.08SC	5.0 oz + 15.4 fl oz	PF, 2C			
Nova 40W + Bravo WS 6F	5.0 oz + 4.0 pt	SS, 1C			
Captan 50WP	6.0 lb	3C-8C			
Indar 75WSP + Latron	**2.0 oz**	**22, 13, 4 PH**	0.8 ab	3.7 b	9.9 b
BAS 516 38WG	10.5 oz	P, B			
BAS 516 38WG	10.5 oz	PF, SS, 1C-8C			
BAS 516 38WG	**10.5 oz**	**22, 13, 4 PH**	0.2 b	0.5 b	1.1 b
BAS 516 38WG	14.7 oz	P, B			
BAS 516 38WG	14.7 oz	PF, SS, 1C-8C			
BAS 516 38WG	**14.7 oz**	**22, 13, 4 PH**	0.2 b	0.0 b	3.5 b
Orbit 3.6EC	4.0 fl oz	P			
BAS 516 38WG	14.7 oz	B, PF, 2C			
Nova 40W + Bravo WS 6F	5.0 oz + 4.0 pt	SS, 1C			
Captan 50WP	6.0 lb	3C-8C			
BAS 516 38WG	**14.7 oz**	**22, 4 PH**			
Indar 75WSP + Latron	**2.0 oz**	**13 PH**	0.0 b	1.9 b	4.9 b
Elite 45DF + Induce	7.99 oz	P, B			
Nova 40W + Abound 2.08SC	5.0 oz + 15.4 fl oz	PF, 2C			
Nova 40W + Bravo WS 6F	5.0 oz + 4.0 pt	SS, 1C			
Captan 50WP	6.0 lb	3C-8C			
Elite 45DF + Induce	**7.99 oz**	**22, 13, 4 PH**	0.0 b	0.0 b	1.8 b
Orbit 3.6EC	4.0 fl oz	P, B			
Flint 50WG	3.0 oz	PF, SS, 1C-8C			
Indar 75WSP + Latron	**2.0 oz**	**22, 13, 4 PH**	0.0 b	0.6 b	1.8 b
Elite 45DF + Flint 50WG	2.32 oz + 2.08 oz	P, B			

Elite 45DF + Flint 50WG **Elite 45DF + Flint 50WG**	2.32 oz + 2.08 oz **2.32 oz + 2.08 oz**	PF, SS, 1C-8C **22, 13, 4 PH**	0.0 b	0.7 b	2.5 b
Elite 45DF + Flint 50WG Elite 45DF + Flint 50WG **Elite 45DF + Flint 50WG**	2.89 oz + 2.60 oz 2.89 oz + 2.60 oz **2.89 oz + 2.60 oz**	P, B PF, SS, 1C-8C **22, 13, 4 PH**	0.0 b	0.0 b	1.9 b
Elite 45DF + Flint 50WG Elite 45DF + Flint 50WG **Elite 45DF + Flint 50WG**	3.46 oz + 3.11 oz 3.46 oz + 3.11 oz **3.46 oz + 3.11 oz**	P, B PF, SS, 1C-8C **22, 13, 4 PH**	0.0 b	0.6 b	1.7 b
Vangard 75WG Quintec 2.08SC Quintec 2.08SC + Bravo WS 6F Quintec 2.08SC + Captan 50WP Captan 50WP **Vangard 75WG**	5 oz 8.0 fl oz 8.0 fl oz + 4.0 pt 8.0 fl oz + 6.0 lb 6.0 lb **5.0 oz**	P, B PF SS, 1C 2C 3C-8C **22, 13, 4 PH**	0.0 b	0.0 b	1.8 b

[1] Rhizopus rot treatments, rates, and application timings in boldface.
[2] Means in the same column with the same letter do not differ significantly according to the Waller-Duncan K-ratio t-test (*P*□0.05, *K*=100).
[3] Latron B-1956 spreader-sticker and Induce wetter-spreader at .06% v/v ratio, equivalent to 8 fl oz/ 100 gal.

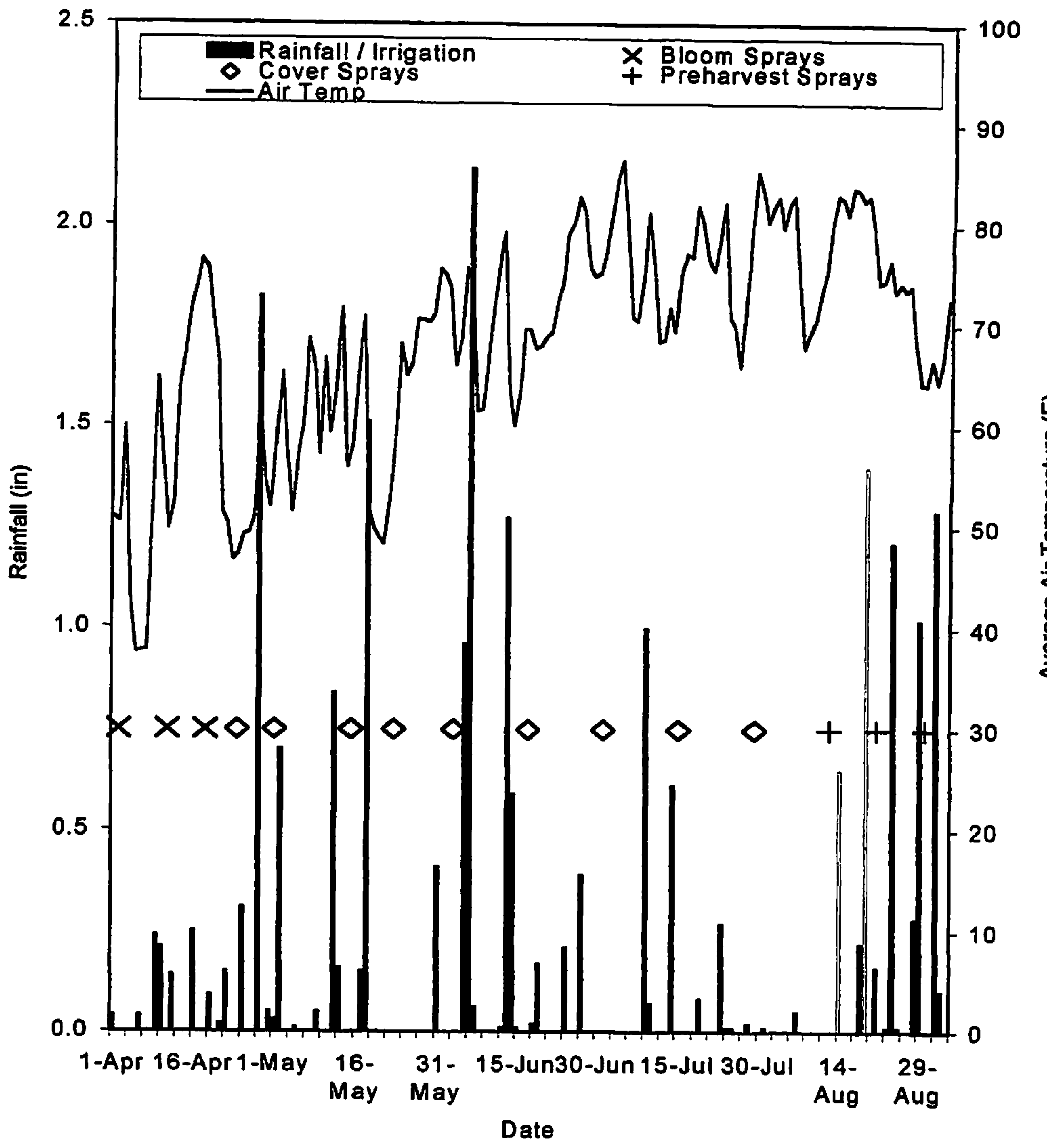


Figure 1. Rainfall, air temperature, and fungicide application timing on 'Suncrest' peach during the 2002 growing season, Rutgers Agricultural Research and Extension Center, Bridgeton, NJ

COMPARISON OF CAPTAN FORMULATIONS FOR MANAGEMENT OF PEACH DISEASES

Norman Lalancette, Kathleen Foster, and Jody Veler
Rutgers Agricultural Research and Extension Center
Bridgeton, NJ 08302

Two rates of a new granular formulation of captan, MANA-131 80WDG, were examined for efficacy at controlling brown rot and scab on *Prunus persica* 'Suncrest'. Comparisons of MANA-131 at the same and reduced rates of active ingredient were made to the standard wettable powder formulation, Captan 50WP.

A late start prevented testing efficacy on blossom blight. However, control of peach rusty spot was examined, although captan has not shown activity against this powdery mildew disease in past studies. The sterol inhibitor fenbuconazole, Indar 75WSP, was also included in the trial at its standard rate, but applied without the usual wetting agent.

MATERIALS AND METHODS

Treatments. The experiment was conducted during the spring and summer of the 2002 growing season. The test block, located at the research center, consisted of 7-year-old 'Suncrest' peach trees grafted on 'Lovell' rootstock. Trees in the block were planted at 25 ft x 25 ft spacing.

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

Fungicide applications were made on the following dates and tree growth stages: 26 Apr (SS, shuck split); 4, 17, 28 May, 11, 24 Jun, 9 Jul (1C-6C, first-sixth cover). Three applications were made for fruit rot control: 21, 30 Jul, 8 Aug (19, 10, 1 days preharvest (PH)). No fungicides were applied during bloom. Insecticides and miticides were applied as needed to the entire block using a commercial airblast sprayer.

Environment. Weather conditions were highly favorable for scab (Fig. 1). A total of 14 days with >0.10 in rain occurred from shuck-split on 26 Apr to 1 Jul (40 days PH). The number of rain periods following each spray during this time was: SS, 2; 1C, 2; 2C, 2; 3C, 3; 4C, 3; and 5C, 2. In contrast, a drought beginning in mid-July and extending into August resulted in unfavorable conditions for brown rot during the preharvest period. A significant amount of rain (0.27 in) only occurred once during this time.

Assessment. Rusty spot (*Podosphaera leucotricha*) was evaluated on 17 Jun by examining 50 fruit per tree. Scab (*Cladosporium carpophilum*) was evaluated on 5 Aug by examining 50 fruit per tree. Brown rot (*Monilinia fructicola*) was evaluated at harvest on 9 Aug by examining all fruit on two or more branches per replicate tree; a minimum of 100 fruit / tree was examined. For postharvest evaluations, 50 healthy fruit were harvested from each tree on 9 Aug and placed on benches at room temperature. Brown and Rhizopus rot were assessed at 3 and 6 days postharvest (dph).

RESULTS AND DISCUSSION

Blossom blight. A late start of the experiment prevented application of the pink, bloom, and petal fall sprays. Nevertheless, subsequent assessment of the control trees revealed no significant development of blossom blight. Cool conditions during bloom (ave. temp. = 58F from 1-20 Apr) and poor survival of the pathogen in mummies most likely contributed to low levels of blossom infection.

Rusty Spot. Rusty spot incidence was moderately severe; control trees had 42% infected fruit (Table 1). Disease levels on fruit receiving either the standard or experimental formulation of captan were not significantly different from that observed on non-sprayed fruit. Indar provided good disease control.

Scab. Scab disease pressure was extremely high; 100% of the nonsprayed fruit had >10 lesions (Table 2). Under these conditions, none of the treatments provided acceptable control. Only the high rate treatment of MANA-131 had significantly less fruit infection than the control. Although incidence of fruit infection for the MANA-131 (1.875 lb/A) and Captan 50WP treatments was not significantly different from the non-sprayed control, application of these fungicides did significantly lower disease severity. Indar did not provide any level of scab control.

Brown Rot. Brown rot disease pressure was low, with only 11% of the non-treated fruit rotted at harvest (Table 3). Under these conditions, all fungicide treatments provided commercially acceptable control of brown rot (< 5% rot). Percent disease control at harvest, relative to the non-sprayed treatment, ranged from 82.7% for Indar to >95% for all captan treatments.

Postharvest Disease. Brown rot development during the post-harvest test was limited, achieving only 20% infection on non-treated fruit after 6-days incubation. Nevertheless, excellent brown rot disease control was maintained by both MANA-131 treatments and Captan 50WP. During this six-day period, disease levels ranged from 0 to 3.0% incidence (Table 3). Disease levels on fruit treated with Indar were not significantly different from that on non-sprayed fruit. At 6-dph, Indar provided only 52.5% control compared to 85.0 to 92.5 % control with the captan formulations. Rhizopus rot at harvest and postharvest was negligible (<1% fruit infection).

CONCLUSIONS

1. Both MANA-131 treatments provided brown rot control equivalent to that of the standard, Captan 50WP. The level of control was excellent and commercially acceptable. However, disease pressure was low due to the drought. Furthermore, these conditions did not test the formulation's ability to maintain adequate residues, an important attribute for protectant fungicides. Therefore, efficacy needs to be examined under pre-harvest conditions that include frequent rainfalls.

2. Peach scab control was poor for all treatments. Unlike the pre-harvest period, all fungicide applications were consistently challenged by rainy periods. Although disease incidence was high, the captan treatments showed significant reductions in severity. Therefore, these materials may have benefited from shorter 10-day spray intervals (test intervals ranged from 11 to 15 days). Indar did not provide any control of peach scab; in past studies, this material has showed good control on nectarine.

3. As expected, the captan formulations did not provide control of peach rusty spot, a powdery mildew disease. Indar provided good disease control, although this treatment may have performed better had the critical petal fall spray been also applied.

4. Indar normally displays excellent brown rot efficacy. Thus, the poor control of rot in this study, particularly in post-harvest results, may have been due to absence of a wetting agent or, more likely, lack of control of peach scab. Scab severity (# fruit with >10 lesions) for the Indar treatment was about twice the value observed on the three captan treatments. A high level of scabbed fruit surface results in fruit cracking during the final swell prior to harvest. Prevention of brown rot on exposed fruit flesh is difficult, if not next to impossible, for any fungicide.

TABLE 1. Peach Rusty Spot Incidence and Severity[1]				
Treatment	Rate / A	Timing	% Infected fruit[2]	# Lesions / fruit[2]
Nontreated Control	------	------	42.0 a	0.8 a
Indar 75WSP[3]	2 oz	SS, 1C, 2C, 3C, 4C, 5C, 6C, PH1, PH2, PH3	14.0 b	0.2 b
Captan 50WP	6 lb	SS, 1C, 2C, 3C, 4C, 5C, 6C, PH1, PH2, PH3	43.5 a	0.6 a
MANA-131 80WDG	1.875 lb	SS, 1C, 2C, 3C, 4C, 5C, 6C, PH1, PH2, PH3	42.0 a	0.7 a
MANA-131 80WDG	3.75 lb	SS, 1C, 2C, 3C, 4C, 5C, 6C, PH1, PH2, PH3	45.5 a	0.8 a

[1] Rusty spot application timings are indicated 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<0.05, K=100).
[3] Indar applied without a wetting agent.

TABLE 2. Peach Scab Incidence and Severity[1]			% Fruit[2]		
Treatment[3]	Rate / A	Timing	Infected	1-10 lesions	>10 lesions
Nontreated Control	------	------	100.0 a	0.0 c	100.0 a
Indar 75WSP[3]	2 oz	SS, 1C, 2C, 3C, 4C, 5C, 6C, PH1, PH2, PH3	99.0 a	3.0 c	96.0 a
Captan 50WP	6 lb	SS, 1C, 2C, 3C, 4C, 5C, 6C, PH1, PH2, PH3	92.0 a	41.0 ab	51.0 b
MANA-131 80WDG	1.875 lb	SS, 1C, 2C, 3C, 4C, 5C, 6C, PH1, PH2, PH3	89.5 a	32.5 b	57.0 b
MANA-131 80WDG	3.75 lb	SS, 1C, 2C, 3C, 4C, 5C, 6C, PH1, PH2, PH3	69.0 b	46.0 a	23.0 c

[1] Peach scab application timings are indicated 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<0.05, K=100).
[3] Indar applied without a wetting agent.

TABLE 3. Brown Rot Harvest and Post-harvest Incidence[1]			% Fruit Infected[2]		
Treatment	Rate / A	Timing	Harvest	3-dph[3]	6-dph[3]
Nontreated Control	------	------	11.0 a	8.0 a	20.0 a
Indar 75WSP[4]	2 oz	*SS, 1C, 2C*, 3C, 4C, 5C, 6C, **PH1, PH2, PH3**	1.9 b	2.5 ab	9.5 ab
Captan 50WP	6 lb	*SS, 1C, 2C*, 3C, 4C, 5C, 6C, **PH1, PH2, PH3**	0.4 b	0.0 b	1.5 b
MANA-131 80WDG	1.875 lb	*SS, 1C, 2C*, 3C, 4C, 5C, 6C, **PH1, PH2, PH3**	0.5 b	1.0 b	3.0 b
MANA-131 80WDG	3.75 lb	*SS, 1C, 2C*, 3C, 4C, 5C, 6C, **PH1, PH2, PH3**	0.5 b	0.0 b	2.5 b

[1] Application timings for brown rot development during pre-harvest (PH) ripening in boldface; timings for potential latent infection in italics.
[2] Means in the same column with the same letter do not differ significantly according to the Waller-Duncan K-ratio T test (p<0.05, K=100).
[3] dph = days post-harvest.
[4] Indar applied without a wetting agent.

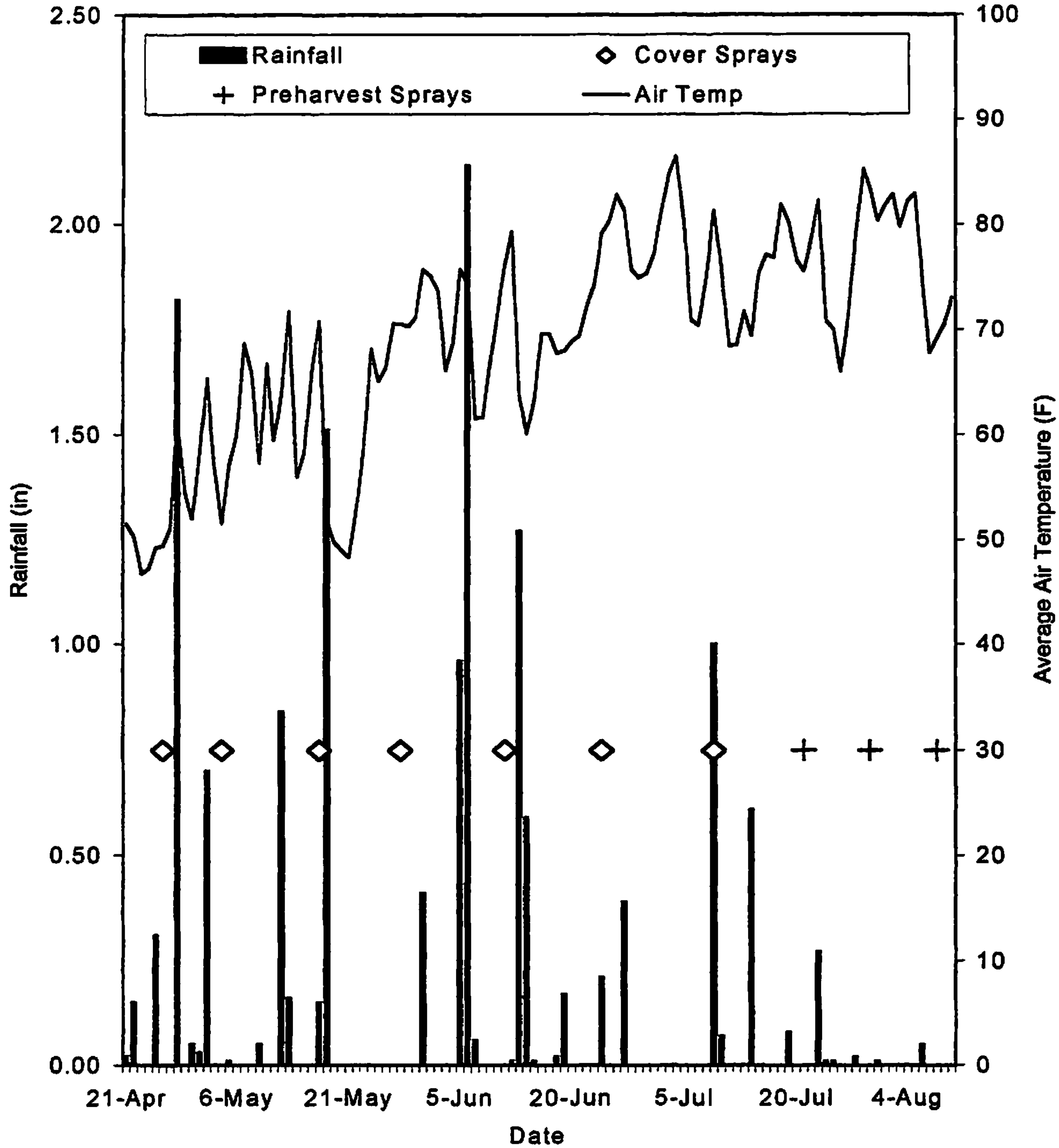


Figure 1. Rainfall, air temperature, and fungicide application timings on 'Suncrest' peach during the 2002 growing season, Rutgers Agricultural Research and Extension Center, Bridgeton, NJ

EFFICACY OF PLANT ACTIVATOR, BIOCONTROL, AND EXPERIMENTAL MATERIALS FOR MANAGEMENT OF BACTERIAL SPOT OF PEACH

Norman Lalancette, Kathleen Foster, and Jody Veler
Rutgers Agricultural Research and Extension Center
Bridgeton, NJ 08302

Bacterial spot of stone fruit is caused by *Xanthomonas arboricola* pv. *pruni*. Control of this pathogen on peach and nectarine is currently dependent on the antibiotic oxytetracycline (Mycoshield) and copper materials. Management with Mycoshield can be highly effective, but application timing is critical for maximum efficacy, preferably within 24 hr before an infection period. Furthermore, antibiotic bactericides have residuals that are relatively short-lived, require high spray volumes for best coverage, and are prone to resistance development. Copper materials are highly effective against bacteria, but readily cause phytotoxicity.

Plant activators that infer disease resistance, such as Actigard and Messenger, and biocontrol agents, such as Serenade, offer new possibilities for disease management. Even if these materials don't provide complete control, their integration with Mycoshield and copper materials may enhance overall management. Of particular concern is prevention of sporadic, but major outbreaks that cause considerable crop loss.

The main objective of this study was to determine efficacy of these newer materials in relation to the antibiotic and copper standards. Any moderate or better level of efficacy would be justification for testing in an integrated program. To increase the likelihood of success, these compounds would be applied at relatively high rates and at short application intervals; if found effective, proper rates / intervals could be determined later. In addition, an experimental bactericide was included for comparison.

MATERIALS AND METHODS

Treatments. The test block consisted of 7-year old 'Suncrest' trees planted at 25 ft x 25 ft row spacing. Treatments were replicated four times in a randomized complete block design with single tree plots. Non-sprayed buffer trees on all sides surrounded treatment trees. A Rears Pak-Blast-Plot airblast sprayer calibrated to deliver 100 gal/A at 100 psi traveling at 2.1 mph was used to apply the bactericides.

A total of 12 bactericide applications were made from petal fall on 18 Apr through 10th cover in mid-July (Fig. 1). Application intervals ranged from 5 to 10 days in length, with a mean interval of 7.7 days. Treatments were applied on the following dates and tree growth stages: 18 Apr (PF, petal fall); 24 Apr (SS, shuck split); 1, 11, 20, 28 May, 3, 11, 19, 28 Jun, 3, 12 Jul (1C-10C, first-tenth cover). Insecticides and miticides were applied as needed to the entire block using a commercial airblast sprayer.

Environment. Frequent rainfalls occurred during April, May, June, and early July (Fig. 1). A total of 19 days having significant rainfall (> 0.10 in) occurred from SS to 10C.

During this period, all but two treatment applications were challenged by at least one rainfall. The experiment ended in mid-July, at which time a 40-day drought began. Weather data were observed every minute and recorded hourly using a Campbell Scientific 21X datalogger and associated sensors.

The 4-week period following SS is when fruit are most susceptible to infection. For 'Suncrest', moisture was present at this time, but temperatures during late April and throughout May were not conducive to infection (Fig. 1). During this period, the mean, minimum, and maximum daily air temperatures were 58.6°F, 47.3°F, and 69.7°F, respectively. These temperatures were well below the optimum 75°F to 84°F growth range of the pathogen.

Temperatures during June and July increased sufficiently to provide moderate levels of foliar infection on 'Suncrest'. Mean, minimum, and maximum temperatures during these two months were 74.1°F, 64.1°F, and 84.6°F, respectively. Later maturing cultivars, such as 'Autumnglo', were observed to sustain some fruit infection, most likely during the warm, wet weather in early June.

Assessment. On each treatment tree, 10 shoots were arbitrarily selected and tagged around the periphery of the canopy. During each assessment, the total number of leaves present and missing (abscised) on these shoots was recorded. Of those leaves present, the number of leaves with bacterial spot lesions and shot-holes were recorded. Trees were monitored for fruit infection by examining 50 fruit per tree, selected arbitrarily from the canopy.

A total of four disease assessments were conducted during the growing season on the following dates: 4 Jun, 17 Jun, 2 Jul, and 19 July. From the data collected, three dependent variables were calculated: % infected leaves, % shot-holed leaves, and % leaves abscised. Disease incidence on fruit was estimated as % infected fruit.

Statistical Analysis. Separate analyses of variance (ANOVA) and mean comparisons were conducted for each assessment date using the GLM procedure of the Statistical Analysis System v8.0 (SAS Institute, Inc., Cary NC). Since multiple observations were made for each dependent variable, additional ANOVA's were performed on areas under disease progress (AUDPC), shot-hole (AUSHC), and defoliation (AUDFC) curves. All mean comparisons were conducted using the Waller-Duncan K-ratio T-test (*P*□0.05, K=100)

RESULTS & DISCUSSION

Fruit Infection. Bacterial spot was not observed on non-treated fruit at any time during the growing season. Fruit are believed to be most susceptible during the four-week period following SS. Adequate wetting periods but cool temperatures during this time, which occurred from late April through the end of May, most likely inhibited disease development on fruit.

Foliar Infection. Once infected, leaves progress through a range of symptoms that have been captured by the different types of observations conducted in this study. The first symptom consists of water-soaked angular lesions that turn brown to black in color. These lesions are often found along the leaf edges or near the tip. Eventually, the lesion centers "drop out", creating the second type of symptom, called shot-holing. Finally, if enough lesions occur on a leaf, the leaf will become chlorotic and abscise, resulting in defoliation.

Percent Infected Leaves. Examination of the disease progress curves revealed that trees treated with the two plant activators, Messenger and Actigard, and the biocontrol Serenade, had foliar incidence levels very similar to that of the nonsprayed control (Fig. 2). Except for Serenade at the first assessment, these materials had disease levels that were not significantly different from the control for each of the four disease assessments (Table 1). As would be expected, their AUDPC's were also not significantly different from each other and from the control.

In contrast, the lowest disease incidence was observed on trees receiving the Mycoshield, Labs 128, and Tenn-Cop bactericides (Fig. 2). For both June assessments, these three treatments were not significantly different from each other (Table 1). On 17 Jun, Mycoshield, Labs 128, and Tenn-Cop provided 73%, 47%, and 56% disease control. However, in July the level of disease on Mycoshield-treated trees increased substantially (Fig. 2). By the final assessment on 19 Jul, trees treated with Tenn-Cop had significantly less disease than all other treatments except for Labs 128.

Percent Shot-Holed Leaves. During the entire disease assessment period, the nonsprayed control trees and those treated with Messenger, Actigard, and Serenade had the least amount of shot-holed foliage (Fig. 3). The percentage of shot-holed leaves was not significantly different among these four treatments at any of the four assessment times (Table 2). Similarly, their AUSHC's were also not different.

In general, trees receiving Mycoshield, Labs 128, and Tenn-Cop tended to have significantly higher percentages of shot-holed leaves than those trees treated with most other materials during each of the four disease assessments (Table 2). The Tenn-Cop AUSHC was significantly greater than all other treatments. Materials containing copper are known to cause shot-holing, which is often difficult to distinguish from that caused by bacterial spot. Thus, the different behavior of the Tenn-Cop shot-holing curve, relative to all other treatments, is most likely due to this phytotoxicity.

Percent Abscised Leaves. The amount of defoliation observed on the control, Messenger, Actigard, and Serenade treated trees was very similar throughout the test period (Fig. 4). Trees sprayed with these materials, plus the nonsprayed trees, had statistically identical levels of defoliation at each assessment as well as for their AUDFC's (Table 3).

The Mycoshield, Labs 128, and Tenn-Cop defoliation curves showed much less increase in leaf abscission over time relative to the other treatments (Fig. 4). However, the degree of defoliation on trees treated with these three materials was often not significantly different from that observed on most other treatment trees (Table 3). One exception to this generalization was for the Mycoshield AUDFC, which was significantly less than AUDFC's for Messenger, Actigard, Serenade, and the nonsprayed control.

CONCLUSIONS

1. Due to lack of infection, no conclusions could be made concerning efficacy of Actigard, Messenger, Serenade, or Labs 128 for controlling bacterial spot on fruit.

2. Actigard, Messenger, and Serenade failed to provide any significant foliar disease control. Disease progression and defoliation on trees treated with these materials were not significantly different from that observed on nonsprayed trees.

3. Mycoshield, Labs 128, and Tenn-Cop provided the best overall foliar disease control under the conditions of the study. These materials reduced disease incidence measured as the number of leaves with identifiable lesions. Although disease severity was not assessed, these bactericides most likely reduced the number of lesions per leaf as well (assuming a typical relationship between disease incidence and severity). This severity reduction would in turn decrease the likelihood of leaf abscission. Consequently, higher numbers of shot-holed leaves would remain attached to the trees, and lower levels of defoliation would occur - two phenomena observed in this experiment for these treatments.

4. The treatment application schedule was geared towards the plant activators, which require regular "immunizations" to maintain plant disease resistance. Consequently, sprays were applied on a 7-day calendar schedule regardless of weather patterns. Thus, infection periods occurred when materials were at their lowest concentrations. This situation would not normally be problematic, as most fungicides and insecticides have residuals that can provide control during such a short interval. However, antibiotics such as Mycoshield, as well as the biological control agent Serenade, may have benefited from applications timed according to infection events.

5. The copper compound Tenn-Cop most likely increased shot-holing as a result of phytotoxicity. But, unlike bacterial spot, these shot-holed leaves did not abscise. Hence, Tenn-Cop treated trees had significantly lower disease levels and significantly higher shot-holing than on trees receiving most other treatments, yet the level of defoliation was the same. However, the rate of actual copper applied is relatively low, and increased defoliation might occur with increased concentration.

TABLE 1. Foliar Disease Incidence			% Infected Leaves [a]				
Treatment	Rate / A	Timing	4 Jun	17 Jun	2 Jul	19 Jul	AUDPC [b]
Nonsprayed	-----	-----	14.0 ab	33.3 ab	34.7 ab	25.8 ab	1332 ab
Messenger 3WDG	9 oz	PF, SS, 1C-10C	14.2 ab	30.2 abc	36.1 a	23.6 ab	1295 abc
Actigard 50WG	6 oz	PF, SS, 1C-10C	15.2 a	37.5 a	40.7 a	30.5 a	1534 a
Serenade 10WP	8 lb	PF, SS, 1C-10C	6.1 bc	28.3 abc	34.5 ab	24.8 ab	1198 abc
Mycoshield 17WP	1.5 lb	SS, 1C-10C	2.9 c	9.1 d	30.3 ab	28.9 ab	877 cd
LABS 128-F02 WP	1.5 lb	SS, 1C-10C	5.9 bc	17.8 bcd	29.2 ab	18.6 bc	913 bcd
Tenn-Cop 5E	8 fl oz	SS, 1C-10C	6.5 abc	14.7 cd	21.4 b	11.9 c	692 d

[a] Leaves were considered infected if at least one lesion was observed, regardless of number of shot-holes. Means in the same column with the same letter do not differ significantly according to the Waller-Duncan K-ratio t-test ($P \leq 0.05$, $K=100$).
[b] Area under the disease progress curve; see Fig. 2.

TABLE 2. Foliar Shot-holing			% Shot-holed Leaves [a]				
Treatment	Rate / A	Timing	4 Jun	17 Jun	2 Jul	19 Jul	AUSHC [b]
Nonsprayed	-----	-----	23.7 b	15.8 b	8.1 d	8.6 c	577 d
Messenger 3WDG	9 oz	PF, SS, 1C-10C	28.2 ab	16.6 b	8.6 d	8.2 c	622 d
Actigard 50WG	6 oz	PF, SS, 1C-10C	23.7 b	16.1 b	9.1 cd	9.0 c	602 d
Serenade 10WP	8 lb	PF, SS, 1C-10C	31.5 ab	20.1 b	10.5 cd	8.5 c	726 cd
Mycoshield 17WP	1.5 lb	SS, 1C-10C	33.5 a	33.8 a	20.3 ab	16.1 b	1152 ab
LABS 128-F02 WP	1.5 lb	SS, 1C-10C	34.6 a	27.8 a	14.9 bc	11.0 bc	945 bc
Tenn-Cop 5E	8 fl oz	SS, 1C-10C	26.9 ab	30.0 a	23.8 a	28.2 a	1216 a

[a] Only those leaves with shot-holes were counted; leaves with shot-holes + lesions were counted as infected (see Table 1, Fig. 2). Means in the same column with the same letter do not differ significantly according to the Waller-Duncan K-ratio t-test ($P \leq 0.05$, $K=100$).
[b] Area under the shot-hole curve; see Fig. 3.

TABLE 3. Defoliation			% Abscised Leaves [a]				
Treatment	Rate / A	Timing	4 Jun	17 Jun	2 Jul	19 Jul	AUDFC [b]
Nonsprayed	-----	-----	1.7 a	7.5 a	28.9 a	30.2 a	836 ab
Messenger 3WDG	9 oz	PF, SS, 1C-10C	4.5 a	10.1 a	31.7 a	30.5 a	938 a
Actigard 50WG	6 oz	PF, SS, 1C-10C	5.7 a	9.3 a	29.8 a	32.8 a	924 a
Serenade 10WP	8 lb	PF, SS, 1C-10C	5.0 a	10.7 a	31.0 a	31.9 a	948 a
Mycoshield 17WP	1.5 lb	SS, 1C-10C	1.6 a	2.8 a	11.9 b	20.9 a	418 b
LABS 128-F02 WP	1.5 lb	SS, 1C-10C	1.3 a	6.0 a	17.8 ab	20.7 a	553 ab
Tenn-Cop 5E	8 fl oz	SS, 1C-10C	2.7 a	5.9 a	21.5 ab	25.2 a	659 ab

[a] Means in the same column with the same letter do not differ significantly according to the Waller-Duncan K-ratio t-test ($P \leq 0.05$, $K=100$).
[b] Area under defoliation curve; see Fig. 4.

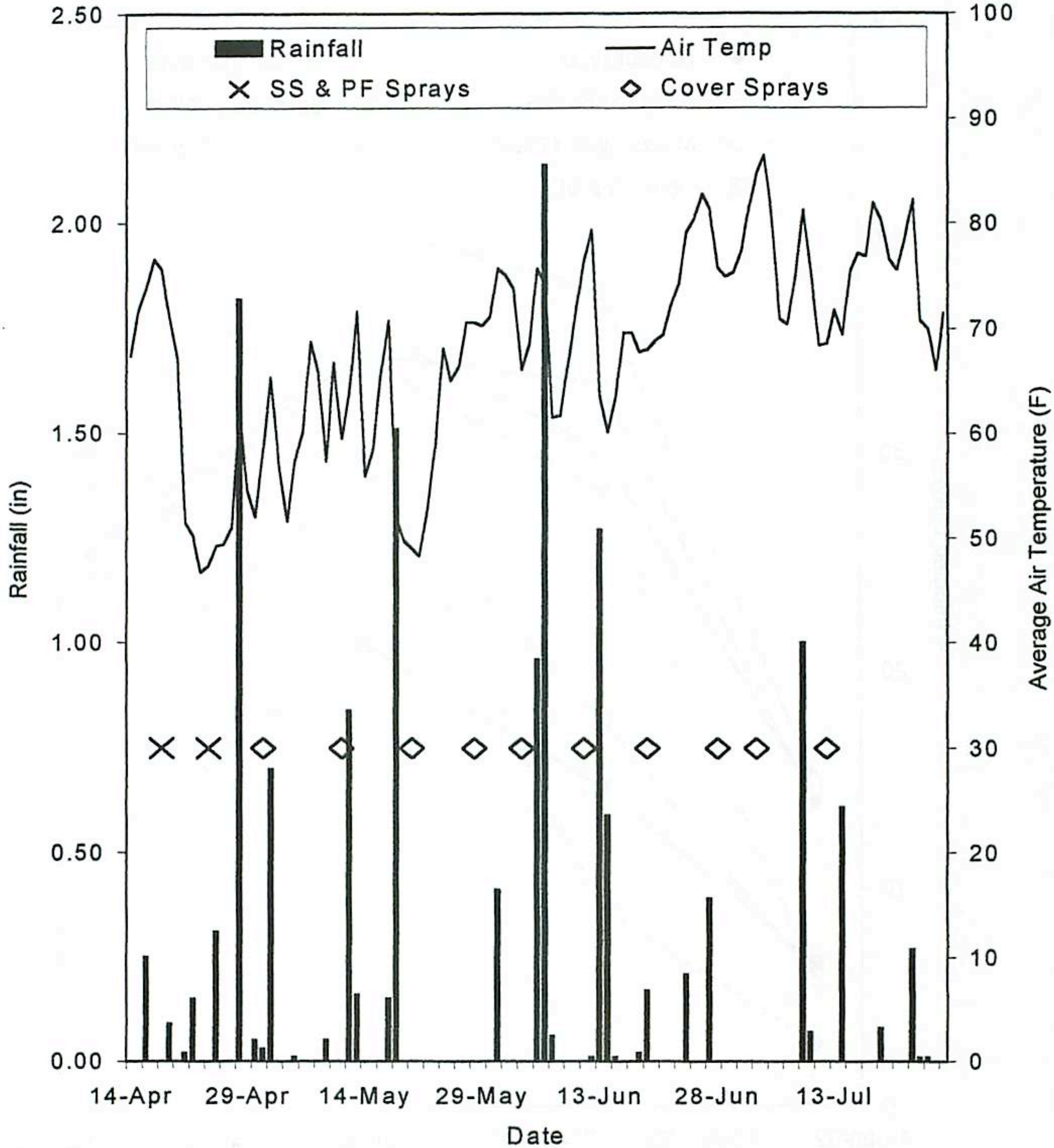


Figure 1. Rainfall, air temperature, and bactericide application timings on 'Suncrest' peach during the 2002 growing season, Rutgers Agricultural Research and Extension Center, Bridgeton, NJ

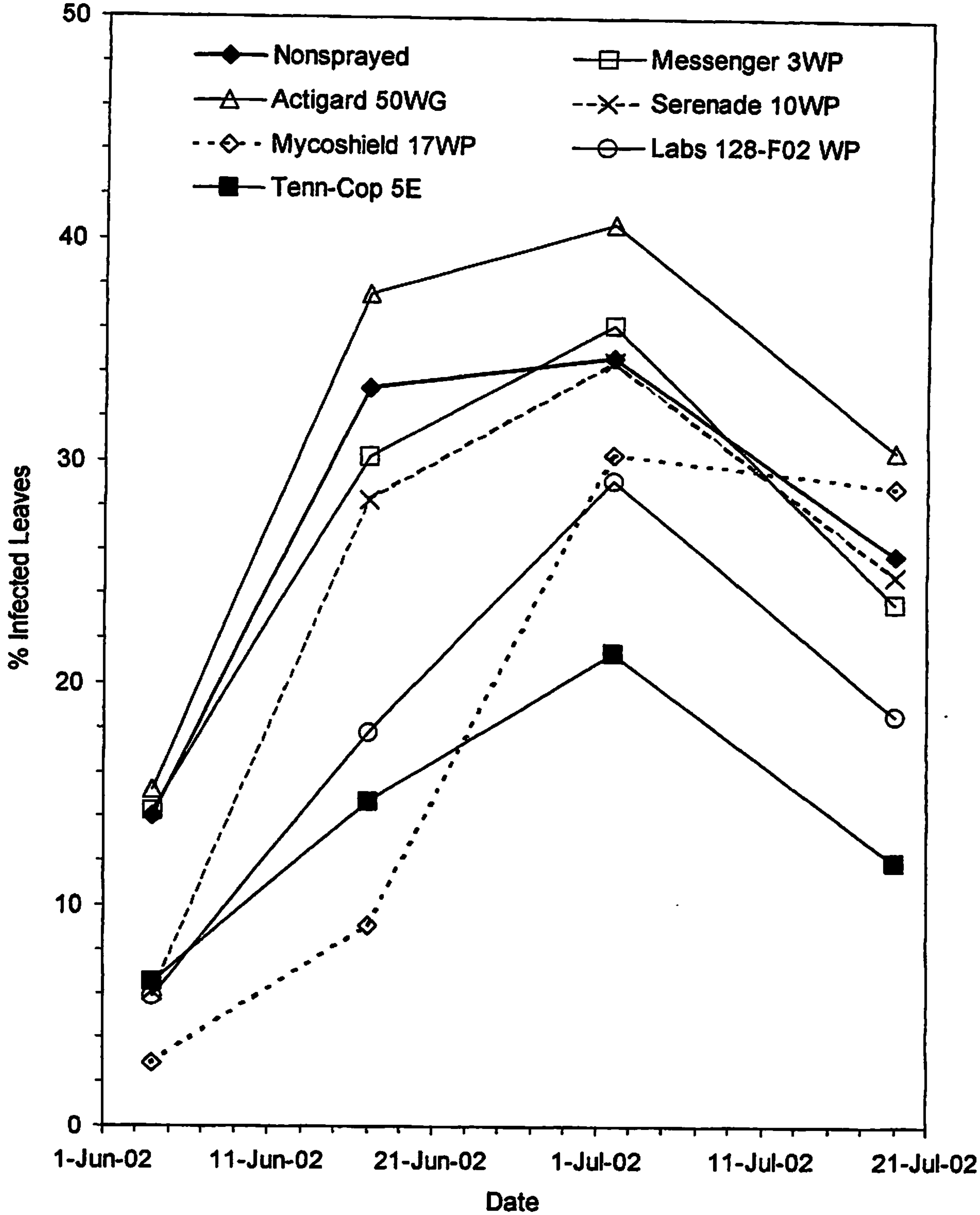


Figure 2. Progression of bacterial leaf spot on 'Suncrest' peach trees treated with six bactericides during 2002. Leaves were counted as "infected" if at least one lesion was present.

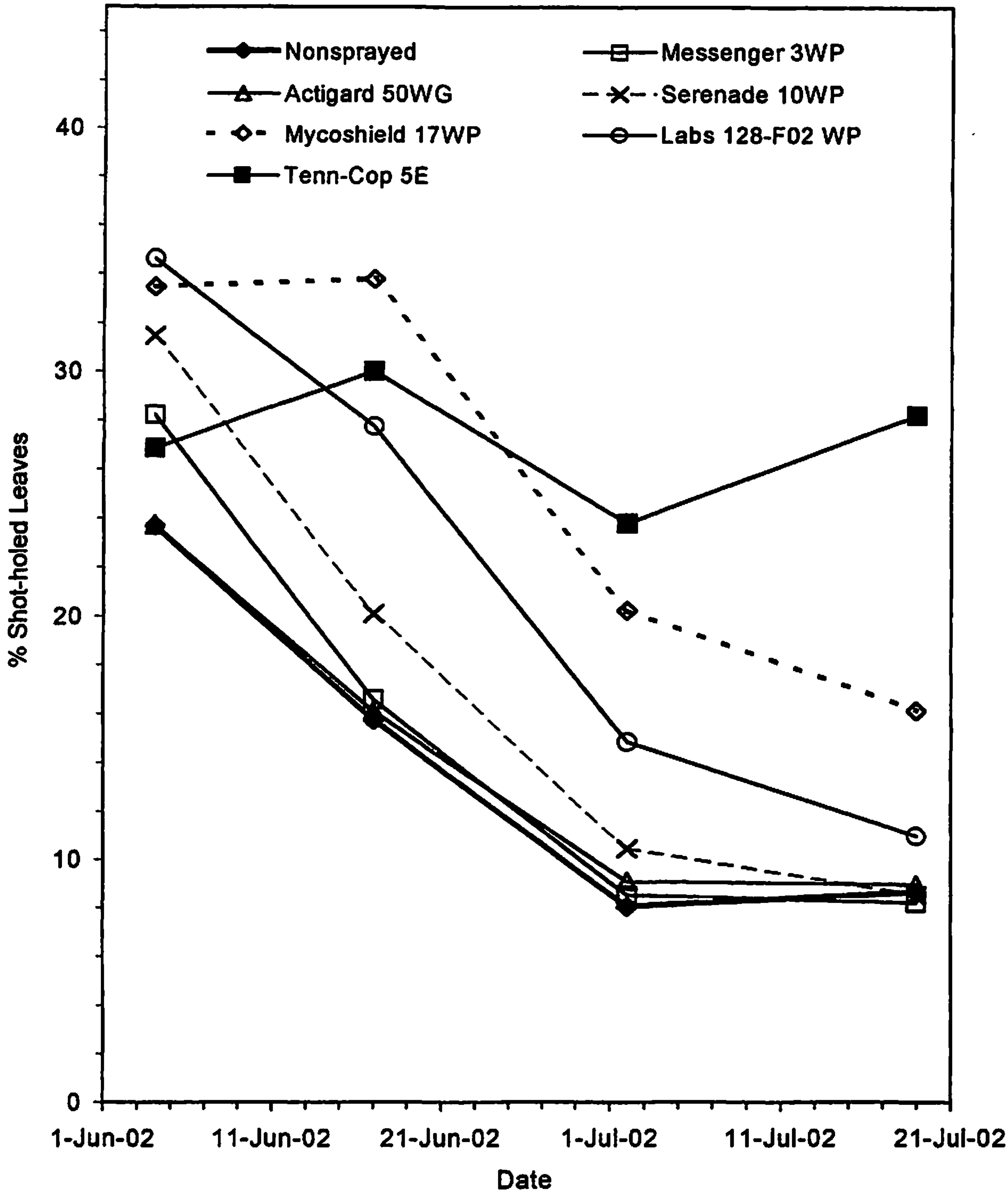


Figure 3. Progression of foliar shot-holing on 'Suncrest' peach trees treated with six bactericides during 2002. Data consist of leaves having only shot-holes; leaves having both shot-holes and lesions were assessed as "infected"(see Fig. 2).

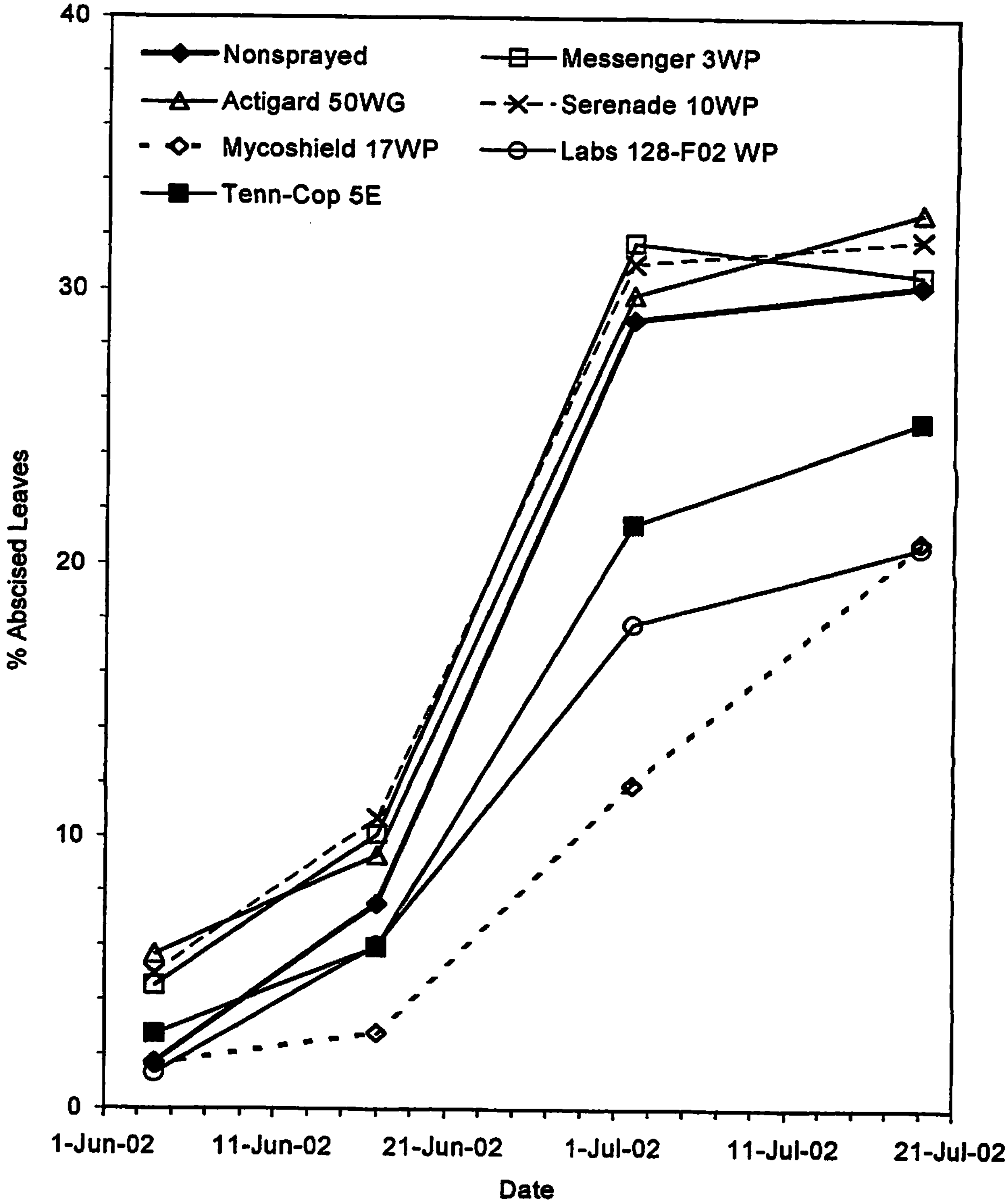


Figure 4. Progression of defoliation on 'Suncrest' peach trees treated with six bactericides during 2002. Data were calculated from counts of # leaves and # leaf scars on 10 shoots / tree.

PEACH RUSTY SPOT EPIDEMICS: TEMPORAL ANALYSIS, OPTIMIZING MANAGEMENT, AND EFFECT ON FRUIT GROWTH

Laura Furman[1], Norman Lalancette[1], and James F. White[2]

Rutgers University
Agricultural Research and Extension Center[1], Bridgeton, NJ
Department of Plant Biology and Pathology[2], New Brunswick, NJ

Abstract – Temporal Analysis. Incidence and severity of peach rusty spot were monitored throughout the growing seasons of 1999-2001. Graphical and statistical analysis revealed that disease increased from the shuck-off stage of fruit development until 60 days after full bloom; epidemics typically lasted from 17 to 30 days. An analysis of fruit growth indicated that the early-season epidemic coincided with the first stage of stone fruit development, physiologically characterized as the period of cell division. During this period, as fruit growth slowed and approached initiation of pit-hardening, the rate of disease increase slowed. Since fruit infection was greatest during the period of fruit growth, disease progression was modeled as a function of plant growth instead of time. Temporal analysis revealed that the logistic function was appropriate for describing both growth processes, and a synchronous logistic / logistic composite disease progression / fruit growth model was fit to all data sets. No change in disease levels occurred during mid-season, which coincided with the second stage of fruit development, a period of slow growth. Subsequently, disease incidence and severity significantly declined on average by 26% and 1.3 lesions/fruit, respectively, during the 20 to 30 days prior to harvest. This decline phase coincided with the third stage of fruit growth, the period of cell enlargement and coloration. These disease reductions may be related to physical changes in fruit size and pigmentation, as opposed to resistance development, causing younger, less established lesions to become undetectable.

Abstract – Optimizing Management. Different numbers of consecutive fungicide applications, beginning at petal fall and continuing into the summer, were examined for their effect on rusty spot epidemics. Disease progressions for each fungicide level were quantified by fitting either the logistic or monomolecular models. When the weighted absolute infection rate (ρ) and maximum disease level (K_{max}) parameters were expressed as functions of the number of applications, the logistic decline model provided the best fit for five of six data sets. This model described a gradual decrease in ρ and K_{max} in response to the initial fungicide application; a rapid decline in parameter values with the addition of one or two applications; and a diminished parameter

response as fungicide applications continued toward the end of the epidemic. Based on examination of model behavior across all three years of the study, optimal management was achieved with a total of three to five fungicide applications. Additional empirical analyses supported these results and indicated that further reduction in fungicide usage may be possible. Unlike earlier findings, rusty spot did not significantly decrease fruit volume or weight at mid-season or at harvest; as disease severity increased, fruit volume remained constant. Although the exponential model provided an excellent fit to the disease incidence – severity data within each year, comparison of model parameters across years revealed significant seasonal variation. Nevertheless, data were fairly uniform at incidence values below 0.5, where severity increased gradually and in a near-linear fashion.

PEACH (*Prunus persica* 'Redhaven')
Leaf curl; *Taphrina deformans*)
Scab; *Cladosporium carpophilum*
Brown rot; *Monilinia fructicola*

K. S. Yoder, A. E. Cochran II,
W. S. Royston, Jr., and S. W. Kilmer
Va. Tech Ag. Res. and Ext. Center
595 Laurel Grove Road
Winchester, VA 22602

Evaluation of fungicides for disease control on Redhaven peach, 2002:

Several registered fungicides and Flint were compared for broad spectrum disease control on 10-yr-old trees. The test planting is composed of 3-tree sets, each including Redhaven peach, which was not treated with fungicides in 2001 to allow the buildup of scab inoculum, and Loring peach and Redgold nectarine which were not used in the test in 2002. Brown rot inoculum was standardized in the orchard by placing three mummified fruit in each test tree before bloom. Dilute treatments were applied to the point of run-off (approximately 200 gal/A) with a single nozzle handgun at 300 psi in a randomized block design with five replications. Applications were as follows: 26 Mar (BS, bud swell, treatments #7 & 8 only); 2 Apr (P, pink); 8 Apr (early bloom); 16 Apr (PF, petal fall); 26 Apr (SS, shuck split); 1st-4th covers, (1C-4C), 10 May, 24 May, 7 June, and 21 June; Pre-harvest sprays (3PH, 3 July and 1PH, 16 July) were aimed at 3 weeks and 1 week before harvest. Actual harvest date for Redhaven was 23 July, 7 days after the last application. 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 and Sevin XLR. Samples of 40 apparently rot-free fruit per replicate tree were harvested 23 Jul, rated for scab and split into 20-fruit subsamples. Fruit were selected for uniform ripeness and placed on fiber trays. One set was misted with de-ionized water, and the other subsample was inoculated with a suspension containing 30,000 M. fructicola conidia/ml which had been recently isolated from freshly sporulating fruit and grown on potato dextrose agar plates. All were incubated in polyethylene bags at ambient temperature 23-31C (mean 27.2C) for the indicated interval before assessing rot development at the indicated intervals.

Following a year without fungicides, leaf curl infection was moderately heavy on non-treated trees. All treatments, including Bravo, Ziram, and Elite and/or Flint, first applied at pink, gave excellent control (Table 12). Weather during the early cover spray period was favorable for scab infection. Under strong test conditions, with 94% of untreated fruit infected, Flint + Elite and Flint alone through petal fall followed by sulfur in the cover sprays gave the best scab control. Schedules that included Ziram Granuflo from petal fall to first cover (Trts. 6 and 7) gave scab control that was as good or better than those including Bravo during those applications. Inoculation of test fruit with *Monilinia* conidia increased the overall severity of the brown rot test (Table 13). The effect of the pre-harvest applications on brown rot control was more residual with Indar (Trt. #4) than with Elite (Trt. #1), and resulted in significantly better control at the 5-, 7- and 8-day incubation intervals after harvest. Supplementing Elite with Flint (Trts. #2 & 3) improved residual control on inoculated fruit 8 days post-harvest compared to Elite alone. Although treatments with Ziram as the mid-season cover spray and Indar pre-harvest generally had less brown rot than those involving sulfur in the covers and Flint + Elite pre-harvest, there was no treatment which compared sulfur and Ziram directly in the cover spray. *Gilbertella*, appeared sporadically from natural infection without inoculation on test fruit, and all treatments gave significant suppression of Gilbertella

Table 12. Leaf curl and scab control on Redhaven peach

	Treatment and rate/100 gal dilute	Timing	Leaf curl strikes / tree*	Scab infection** % fruit infected	Scab infection** lesions / fruit
0	No fungicide	—	59 b	94 e	31.7 b
1	Elite 45DF 3.0 oz + Induce 8 fl oz	P-PF, 3 & 1PH	1 a		
	Microfine Sulfur 90W 3 lb	SS-4C		18 a-d	1.0 a
2	Flint 50WG 1.0 oz + Elite 45DF 1.2 oz	P-PF, 3 & 1PH	0 a		
	Microfine Sulfur 90W 3 lb	SS-4C		8 a	0.8 a
3	Flint 50WG 1.3 oz + Elite 45DF 1.4 oz	P-PF, 3 & 1PH	0 a		
	Microfine Sulfur 90W 3 lb	SS-4C		5 a	0.2 a
4	Indar 75W 1 oz + Induce 8 fl oz	P-PF, 3 & 1PH	<1 a		
	Microfine Sulfur 90W 3 lb	SS-4C		15 a-d	1.1 a
5	Flint 50WG 1.3 oz	P-PF, 3 & 1PH	0 a		
	Microfine Sulfur 90W 3 lb	SS-4C		11 ab	0.5 a
6	Ziram Granuflo 76WDG 2 lb	Pink-4C	0 a	13 a-c	1.0 a
	Indar 75W 1 oz + Induce 8 fl oz	3PH, 1PH			
7	Ziram Granuflo 76WDG 2 lb	BS-4C	0 a	29 cd	3.3 a
	Indar 75W 1 oz + Induce 8 fl oz	3PH, 1PH			
8	Bravo Weather Stik 6F 1 pt	BS - 1C	0 a		
	Ziram Granuflo 76WDG 2 lb	2C-4C		35 d	5.8 a
	Indar 75W 1 oz + Induce 8 fl oz	3PH, 1PH			
9	Bravo Weather Stik 6F 1 pt	Pink - SS	0 a		
	Ziram Granuflo 76WDG 2 lb	1C-4C		14 a-c	2.0 a
	Indar 75W 1 oz + Induce 8 fl oz	3PH, 1PH			
10	Bravo Weather Stik 6F 1 pt	Pink- 1C	<1 a		
	Ziram Granuflo 76WDG 2 lb	2C-4C		25 b-d	1.9 a
	Indar 75W 1 oz + Induce 8 fl oz	3PH, 1PH			

Averages of five single tree replications.
Mean separation by Waller-Duncan K-ratio t-test (p=0.05).
* Leaf curl was counted 29 May;
** Scab was rated on 40 fruit per rep at harvest 23 Jul.

Table 13. Treatment effects on postharvest rot development on Redhaven peach

		Non-inoculated fruit inf. / days incubation: % fruit with brown rot				Non-inoculated: *Gilbertella*	Inoculated fruit inf. with brown rot after days incubation				*Gilbertella*
	Treatment, rate/100 gal dilute, and timing	3 days	5 days	7 days	8 days	7 days	3 days	5 days	7 days	8 days	7 days
0	No fungicide	1a	13b	40c	55d	23d	14c	92e	100b	100e	20b
1	Elite 45DF 3.0 oz + Induce 8 fl oz, P- PF, 3 & 1PH Microfine Sulfur 90W 3 lb, SS- 4C	1a	2a	6b	6bc	10bc	3b	29d	50e	54d	5a
2	Flint 50WG 1.0 oz + Elite 45DF 1.2 oz, P- PF, 3 & 1PH Microfine Sulfur 90W 3 lb, SS- 4C	0a	1a	4ab	5a-c	6a-c	0a	12bc	33c-e	35bc	3a
3	Flint 50WG 1.3 oz + Elite 45DF 1.4 oz, P- PF, 3 & 1PH Microfine Sulfur 90W 3 lb, SS- 4C	0a	0a	1ab	2a-c	1ab	0a	21cd	27b-d	36bc	0a
4	Indar 75W 1 oz + Induce 8 fl oz, P- PF, 3 & 1PH Microfine Sulfur 90W 3 lb, SS- 4C	0a	3a	4ab	4a-c	5a-c	1ab	13bc	30b-d	33bc	2a
5	Flint 50WG 1.3 oz, P- PF, 3 & 1PH Microfine Sulfur 90W 3 lb, SS- 4C	1a	0a	3ab	6c	5bc	1ab	22cd	44de	47cd	3a
6	Ziram Granuflo 76WDG 2 lb, P-4C Indar 75W 1 oz + Induce 8 fl oz, 3PH, 1PH	0a	0a	0a	0a	0a	0a	4ab	13a	18a	0a
7	Ziram Granuflo 76WDG 2 lb, BS-4C Indar 75W 1 oz + Induce 8 fl oz, 3PH, 1PH	0a	0a	0a	0a	0a	0a	5ab	14ab	22ab	1a
8	Bravo Weather Stik 6F 1 pt, BS-1C Ziram Granuflo 76WDG 2 lb, 2C-4C Indar 75W 1 oz + Induce 8 fl oz, 3PH, 1PH	0a	0a	1ab	1ab	1ab	0a	12bc	22a-c	23ab	1a
9	Bravo Weather Stik 6F 1 pt, P-SS Ziram Granuflo 76WDG 2 lb, 1C-4C Indar 75W 1 oz + Induce 8 fl oz, 3PH, 1PH	1a	2a	4ab	5bc	10c	1ab	18cd	28cd	31bc	3a
10	Bravo Weather Stik 6F 1 pt, P-1C Ziram Granuflo 76WDG 2 lb, 2C-4C Indar 75W 1 oz + Induce 8 fl oz, 3PH, 1PH	0a	1a	1ab	3a-c	0a	0a	3a	13ab	15a	0a

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

Treatments applied dilute to runoff at 300 psi as follows: 26 Mar (BS, bud swell, treatments #7 & 8 only); 2 Apr (P, pink); 8 Apr (early bloom); 16 Apr (PF, petal fall); 26 Apr (SS, shuck split); 1st-4th covers, 1C-4C, 10 May, 24 May, 7 June, and 21 June; Pre-harvest sprays (3PH, 3 July and 1PH, 16 July) were aimed at 3 weeks and 1 week before harvest. Actual harvest date was 23 July, 7 days after the last application.

ROTATION CROPS FOR CONTROL OF NEMATODES PATHOGENIC TO TREE AND SMALL FRUITS (A PROGRESS REPORT)

James A. LaMondia and John M. Halbrendt
The Connecticut Agricultural Experiment Station
Windsor CT 06095 and The Fruit Research and Extension Center
Biglerville PA 17307

Soil fumigation and nematicides are effective tools for the management of plant parasitic nematodes in fruit crops. However, the decision to control nematodes with chemicals has become increasingly difficult in recent years since many products have been banned due to environmental concerns and the few remaining compounds have become more expensive and regulated.

Alternatives to nematicides exist and involve a number of different tactics including alternative soil fumigant chemistry, nematode resistant cultivars, solarization and heat, disease suppressive composts, flooding and integrated management. While not listed under the EPA alternatives, nematode suppressive rotation or cover crops are important potential alternatives to chemicals. A number of rotation or cover crops have been identified in the literature, but success under commercial conditions has been elusive and widespread utilization of these crops has not occurred.

Part of the problem stems from the fact that growers often assume that a nematode suppressive crop will control all plant pathogenic nematodes but crop rotation is not a one-size-fits-all answer to nematode management. In many cases, crops or cultivars suppressive to one nematode genus may in fact be good hosts for other nematode genera. We have determined for example that sudangrass which is suppressive to lesion nematodes, is actually one of the best host plants upon which to raise dagger nematodes in the greenhouse (unpubl.). Additionally, canola, used to reduce root-knot nematode populations in soil, is an excellent host of lesion nematodes. Research is needed to clarify the effects of reported suppressive plants on a range of important nematode genera.

This paper summarizes the first in a series of experiments to evaluate the host status and suppressive effects of selected nematode suppressive rotation crops against three nematodes, the lesion nematode, *Pratylenchus penetrans*; the root-knot nematode, *Meloidogyne hapla*; and the dagger nematode, *Xiphinema americanum*. These three nematodes represent model systems as economically important examples of each of the major host-parasite interactions: migratory endoparasites, sedentary endoparasites, and migratory ectoparasites. Plant resistance is not available for any of the nematode species that will be evaluated. In addition, these nematodes are the most important, widespread and damaging nematodes in the northern temperate United States.

With regard to fruit production *Pratylenchus* is an important pathogen and component of strawberry black root rot in conjunction with the fungi *Rhizoctonia fragariae*; the northern root-knot nematode, *Meloidogyne hapla*, is a widespread pathogen of small fruit crops; and *Xiphinema* has great economic impact on small fruit and tree fruit as a vector of tomato ringspot virus.

Greenhouse, microplot and laboratory bioassay experiments were conducted to determine the host status and suppressive effects of potential rotation crops including *Avena strigosa* (Saia oat); *Brassica napus* (Dwarf Essex or Humus canola); *Pennisetum glaucum* (forage pearl millet); *Rudbeckia hirta* (small black-eyed-Susan); *Sorghum sudanense* (Trudan 8 or Haychow sudangrass); and *Tagetes minuta* (Polynema marigold).

Greenhouse experiments

The host status of Piper sorgho-sudangrass, *Rudbeckia hirta*, Saia oat, Dwarf Essex canola, Polynema marigold, Haychow sorgho-sudangrass, Pearl Millet 101, Trudan 8 sudangrass, winter rye, and 'Rutgers' tomato was evaluated against *P. penetrans* and *M. hapla* in a greenhouse experiment. Nematodes were extracted from roots and soil of five replicate pots inoculated with either nematode species after 10 weeks (Table 1). The total number of lesion nematodes per pot was less for all rotation crops compared with rye. *M. hapla* did not reproduce on five of the rotation crops.

Microplot experiments

The same rotation crops were evaluated against lesion and root-knot nematodes in two sets of field microplots. Root-knot nematodes were extracted from 150 cm^3 soil by means of a tomato bioassay, and lesion nematodes were extracted from strawberry plants grown for three months after each rotation crop. The host status of rotation crops to *M. hapla* in microplots was similar to the previous greenhouse experiment (Table 2). Populations were highest after Dwarf Essex canola and tomato. Fallow was ineffective at reducing root-knot densities. Lesion nematode extraction from strawberry roots was highest for Dwarf Essex canola, and oats, and high for continuous strawberry (Table 3). The incorporation or removal of crop shoots had a large effect on lesion nematode numbers, indicating that plant breakdown products may be nematicidal.

Bioassays

Healthy leaf and root tissue of ten plants including Sesame (*Sesamum indicum*), Nasturtium (*Tropaeolum majus*), Edible Mum (*Chrysanthemum coronarium*), Foxglove (*Digitalis purpurea*), Sunn-hemp (*Crotalaria juncea*), Black-eyed Susan (*Rubeckia hirta*), Marigold (*Tagetes minuta* 'polynema'), Rapeseed (*Brassica napus* 'Humus'), Castor bean (*Ricinus communis*) and Oat (*Avena sativa* 'Saia') was quick frozen and freeze-dried. The dried tissue was pulverized and mixed with dry sterile sand in concentrations that ranged from 0.5 – 5.0 mg/cc for roots and 5.0 – 20.0 mg/cc for leaves. Dagger nematodes (*Xiphinema americanum*) were hand picked into 2-ml sample cups containing 250 µl sterile distilled water This was followed by the addition of 1.5 cc of the plant tissue / sand mix. The cups were sealed and incubated for 24 hours at 24 C. All nematodes (alive and dead) were recovered and the numbers analyzed for nematicidal activity by probit analysis. Data are the means of four replicates.

Nematodes were not killed in sterile sand and water. Nematode mortality increased with increasing amounts of leaf tissue for every plant tested (Fig. 1). The concentration required to kill 50% of the nematodes (LC50) ranged from 0.6 mg (Nasturtium) to 13.2 mg (Sunn hemp) per cc of sand. A conversion of dry weights to fresh weight equivalents showed that except for Nasturtium, the LC50 of leaf tissue was typically greater than 1.0 gm per cc sand (Fig. 3). Nematode mortality at high tissue concentrations may be due a weak toxin or more likely some other general effect such as increased osmotic strength of the soil solution or both. It should be noted that freeze-dried material allows for the testing of concentrations that would be impossible to prepare with fresh tissue because the ratio of plant material to sand could not be physically combined in a meaningful way for the bioassay. Nasturtium leaves showed potent nematicidal activity with an LC50 of 0.6 mg or the equivalent of only 0.1 gm of fresh tissue (Fig. 3).

Root tissue was only tested at concentrations up to 5 mg / cc sand (Fig.2). At these concentrations six plants including Sesame, Foxglove, Sunn hemp, Marigold, Castor bean, and Oat showed little or no nematicidal activity. Three plants showed strong nematicidal activity with LC50 values ranging between 0.8 for Nasturtium and Rapeseed and 1.0 mg / cc for Chrysanthemum while Black-eyed Susan was slightly less toxic with an LC50 of 3.5 mg / cc sand. Interestingly, Black-eyed Susan roots were determined to be more toxic than Chrysanthemum on a fresh weight basis (Fig. 3).

These data suggest the presence of a relatively potent nematicidal compound in the roots of Nasturtium and Rapeseed and a slightly less toxic substance in Black-eyed Susan and Chrysanthemum roots. Nasturtium was the only plant to show relatively strong nematicidal activity in leaf tissue.

Table 1. Greenhouse evaluation of rotation crops for host status against *Pratylenchus* and *Meloidogyne hapla*. Total number of nematodes per pot in roots and soil.

Crop	*Pratylenchus*	*M. hapla*
Saia oat	0.0 A	0 A
Polynema marigold	35.5 A	252 A
Rudbeckia hirta	50.7 A	3019 AB
Triple S sorghosudangrass	63.4 A	0 A
Pearl millet 101	132.0 A	0 A
Piper sudangrass	187.2 A	0 A
Trudan 8 sudangrass	190.4 A	0 A
Dwarf Essex canola	198.3 A	5185 AB
Rye	1110.5 B	
Tomato		230653 B
P =	0.002	0.001

Table 2. Microplot evaluation of rotation crops against *Meloidogyne hapla*. Number of galls on tomato bioassay plants grown in 150 cm^3 microplot soil.

Rotation Crop	*M. hapla*
Saia oat	5.0 A
Polynema marigold	9.3 A
Pearl millet 101	9.8 A
Trudan 8 sudangrass	9.3 A
Oat	11.0 A
Rudbeckia hirta	20.0 A
Fallow	21.9 AB
Dwarf Essex canola	27.0 AB
Rutgers tomato	44.8 B
P =	0.047

Table 3. Microplot evaluation of rotation crops against *Pratylenchus penetrans*. Nematodes extracted from strawberry crowns following a one-year rotation with or without shoot incorporation.

Rotation Crop	Mean	Shoot incorporation	Shoot removal
Rudbeckia hirta	0 A	0	0
Polynema marigold	4 A	0	7
Pearl Millet 101	60 AB	0	120
Trudan 8 Sudangrass	212 AB	4	525
Saia oat	297 AB	15	391
Dwarf Essex canola	327 BC	14	536
Garry oat	507 C	255	885
Strawberry	240 AB	269	210

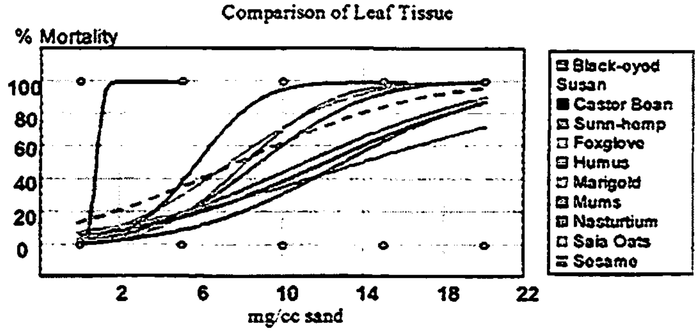


Figure 1.
Nematicidal activity of freeze-dried leaf tissue against dagger nematodes, *Xiphinema americanum.*

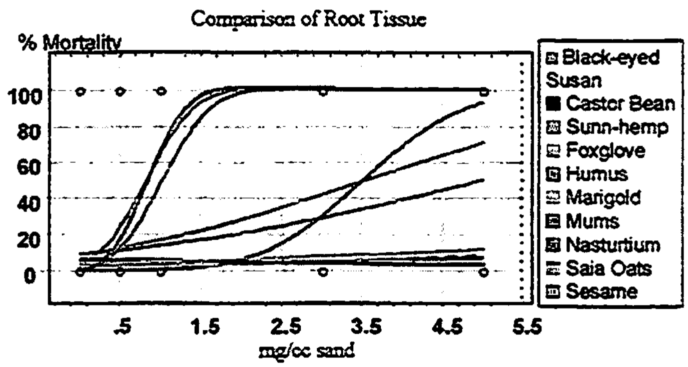
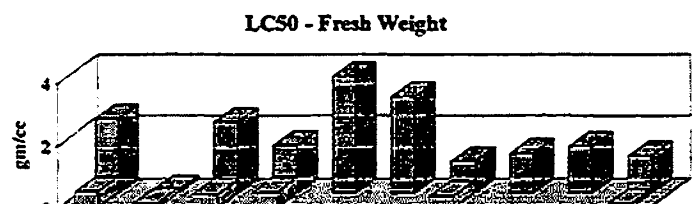


Figure 2.
Nematicidal activity of freeze-dried root tissue against dagger nematodes, *Xiphinema americanum.*



	Seme	Nstm	Mum	Foxgl	Snhmp	Castor	Blk Sue	Mgold	Oat	Humus
Root	0.55	0.15	0.44	0.52			0.39			0.14
Leaf	2.4	0.1	2.28	1.54	3.75	3.1	1.02	1.27	1.5	1.21

Plant tissue

*NA= Not toxic at the levels tested.

Key: Seme = Sesame, Nstm = Nasturtium, Oat = Oat, Mum = Chrysanthemum, Foxgl = Foxglove, Snhmp = Sunn hemp, Castor = Castor bean, Mgold = Marigold, Humus = Rapeseed, Blk Sue = Black-eyed Susan

Figure 3.
LC 50 concentrations converted to fresh weight equivalents.

Not for citation or publication without consent of the authors

Overwintering Sites of *Colletotrichum Acutatum* in Highbush Blueberry

Anne DeMarsay and Peter V. Oudemans
Department of Plant Biology and Pathology, Rutgers University
Phillip E. Marucci Center for Blueberry and Cranberry Research and Extension
Chatsworth, NJ 08019

Introduction. Anthracnose fruit rot of highbush blueberry (*Vaccinium corymbosum* L.) is a serious postharvest disease in New Jersey, the nation's top producer of fresh market blueberries (value of the 2001 crop = $37 million). The disease is incited by the fungal pathogen *Colletotrichum acutatum* J.H. Simmonds. Green fruit are infected in the field, but infections remain latent until ripening (Daykin and Milholland, 1984). Acervuli develop on ripening fruit and exude sticky masses of salmon- to orange-colored conidia. Infection by *C. acutatum* can drastically reduce marketability and shelf life, as symptom development in storage renders fruit unsalable. Growers currently apply 8 to 14 fungicidal sprays per season to control anthracnose.

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. Our objective is to develop and validate a sampling method to assess the risk of infection in a field early in the season. Proper risk assessment will allow growers to: (1) optimize the timing and targeting of sprays; and (2) reduce the number of fungicide applications per season in some fields, without sacrificing the quality of fresh fruit.

Identification of the overwintering sites of *C. acutatum* is crucial to risk assessment. According to published studies, the fungus overwinters as mycelium in and on blighted twigs, particularly fruit spurs (Hartung et al., 1981), which are colonized by infections originating in the fruit. In early April 2001, we sampled 30-cm distal sections (twigs) of 100 dormant canes of 'Bluecrop', a cultivar highly susceptible to anthracnose. Sections from two canes were taken from each of 50 bushes along a diagonal transect in a commercial field in New Jersey. The twigs were incubated in moist chambers and the emerging spore masses tallied to determine the incidence and proportion of *C. acutatum* infection in various tissue types, including fruit spurs, other blighted twigs, flower buds, and vegetative buds. While blighted twigs did harbor the fungus in significantly higher proportions than other types of tissue, we found more than twice as many infected flower and vegetative buds as blighted twigs. These results provide evidence that: (1) the overwintering sites for *C. acutatum* include living as well as dead tissue; (2) infected buds may be the major source of primary inoculum for the following season's infection.

Materials and methods. Two cultivars of commercial importance were chosen for sampling: 'Bluecrop', which is highly susceptible to anthracnose, and 'Elliott', which is resistant. We chose these cultivars to determine whether our findings on overwintering sites and spatial pattern of infection in 'Bluecrop' would be supported by a second year's data, and whether they would apply to a cultivar at the other end of the resistance continuum. Based on 2001 data, the spatial pattern of *C. acutatum* infection in a field appears to be highly aggregated, and the frequency of infections per cane section fits a negative binomial distribution. Using the maximum-likelihood estimate of k, the negative binomial exponent ($k = 1.112$), 2002 sample size was set at 150 cane sections per cultivar (sample mean within 20% of the true mean, 95% confidence level). Each sampling plot was divided into 10 strata. In each stratum, a distal 10- to 15-cm section of one cane was taken from each of 15 randomly selected bushes.

Dormant cane samples were collected in early April from plots in two commercial fields containing mature bushes (age > 20 years) that had not been treated with fungicides more than two years. Samples were incubated and spore masses tallied as in the 2001 experiments. To correlate fruit infection with overwintering infections, random samples of ripe fruit were taken by stratum in each plot before each commercial picking. Three samples of 'Bluecrop' fruit were taken in June and July, and two samples of 'Elliott' fruit in July and August. Fruit were incubated in sealed boxes (88 fruit per stratum) at ambient temperature, similarly to cane samples, and examined for anthracnose infection after 7 days.

Results and discussion. As shown in Table 1, our 2002 data confirmed our 2001 findings that *C. acutatum* can overwinter in or on both living buds and blighted tissue of highbush blueberry. Buds, especially flower buds, were the primary source of overwintering inoculum in both cultivars. In 'Bluecrop', buds accounted for 72% of overwintering infections in the 2002 sample, compared with 73% in the 2001 sample. In 'Elliott', whose berries are resistant to anthracnose, 95% of infections in dormant canes were found in the buds. No 'Elliott' fruit spurs were infected.

Table 1. Incidence of infection by cultivar and tissue type
(N=150 cane sections per cultivar)

	Bluecrop			Elliott		
	Total	Infected	Uninfected	Total	Infected	Uninfected
Fruit spurs	257	40	217	185	0	185
Other blighted tips	122	10	112	115	3	112
Total, dead tips	379	50	329	300	3	297
Flower buds	850	111	739	1185	56	1129
Vegetative buds	1943	24	1919	1333	3	1330
Total, buds	2793	135	2658	2518	59	2459

'Bluecrop' twigs in the 2001 and 2002 samples were more likely both to be infected and to have higher numbers of mean infections than 'Elliott' twigs, as shown in Table 2. These results suggest a greater carryover of inoculum in the more susceptible cultivar.

Table 2. Incidence of infection in dormant cane sections by cultivar

	Bluecrop		Elliott
	2001 (N=100)	2002 (N=150)	2002 (N=150)
Number of infections	115	185	62
Mean percentage of twigs infected (%N)	59.0%	50.7%	24.7%
Mean number of infections per twig	1.15	1.23	0.41

The spatial pattern of *C. acutatum* was highly aggregated in sampling plots for both cultivars, though slightly less so for 'Bluecrop' than in 2001. 'Bluecrop' samples were taken in different fields in 2001 and 2002, using somewhat different sample sizes and sampling designs, which may account for some of the variation. Infections in the 'Elliott' sampling plot were even more tightly clustered, though the apparent degree of aggregation may be exaggerated by the low infection rate, as 2/3 of the bushes sampled had no infections. The frequency of infections per cane section in both cultivars fitted a negative binomial distribution, though a beta-binomial distribution may be a better descriptor.

The percentage of fruit with anthracnose rot is shown in Table 3. As expected, a higher proportion of 'Bluecrop' fruit was infected seasonally and at each picking. Analysis of fruit rot data and correlation with dormant twig infections is still underway. By visual inspection, the relative incidence of infection in all dormant twig parts, flower buds, and ripe fruit appears to exhibit a similar pattern in both cultivars, except that 'Elliott' berries are relatively more resistant to infection than dormant flower buds. Blighted twigs showed a dissimilar pattern due to the lack of infection in 'Elliott' fruit spurs.

Table 3. Incidence of fruit rot by cultivar and picking

	Bluecrop (%)	Elliott (%)
Picking:		
First	3.19	–
Second	1.93	0.23
Third	18.64	1.93
Season average*	7.92	1.08

*Unweighted; may need to be adjusted for differences in the yield for each picking.

Acknowledgments. The authors thank Vera Kyryczenko-Roth, Rebecca Gleason, Erin O'Brien, Jennifer Vaiciunas, Donna Larsen, Micah Torres, Aaron Starr, Chris Constantelos, and Lusike Wasilwa for their technical assistance.

Literature Cited

1. Daykin, M.E., and Milholland, R.D. 1984. Infection of blueberry fruit by *Colletotrichum gloeosporioides*. Plant Dis. 68:948-950.

2. Hartung, J.S., Burton, C.L., and Ramsdell, D.C. 1981. Epidemiological studies of blueberry anthracnose disease caused by *Colletotrichum gloeosporioides*. Phytopathology 71: 449-453.

Calcium, Boron, and Stink Bugs: What is Causing Cork Spot?

M. W. Brown
USDA, ARS, Appalachian Fruit Research Station
45 Wiltshire Road, Kearneysville, WV 25430

Definitions:

Bitter pit—begins as slight depressions in skin, then localized discoloration, and finally small brown desiccated pits. Condition begins in field but most obvious after storage. Flesh has a "soft corky" texture beneath the pit. Typically many numerous pits on fruit, but may occur as a single pit and pits may be more common around calyx. (Faust & Shear 1968)

Cork spot—develops during growing season, blushed area on skin developing a depressed area, corking anywhere in flesh from the skin to the core. In most varieties, the cork spot is separated from skin by healthy tissue. (Faust & Shear 1968)

Stink bug—approximately circular discolored depression on fruit skin with corky flesh immediately below skin, but some recently damaged fruit can show a discoloration and corking without a depression. Feeding puncture site may be obvious due to secondary decay or may be visible only with magnification, but is always present. Damage may be anywhere on fruit with single or multiple damage sites, where multiple sites occur they are often clustered on one region of the fruit. (Brown 2002)

Cage Study Summary

Cage studies in 2001 were inconclusive due to a trap design flaw that allowed stink bug feeding through the cage mesh. These cage studies did show that damage could be caused from July until harvest with most damage coming 1-2 months prior to harvest. In 2002 cages were redesigned to avoid contact of the fruit with the cage material. Data showed that stink bugs caged with fruit for a 2-week period caused more damage than fruit exposed to natural stink bug populations. Fruit caged in early July without stink bugs showed no cork spot-like damage.

Mineral Analysis

In 2001 fruit were harvested from orchards receiving no foliar calcium sprays versus 39-47 pounds calcium chloride per acre; there were no differences in occurrence of cork-spot-like damage between the orchards. Analysis of the fruit flesh showed no difference in calcium levels between the two orchards, however, indicating the trees may not have absorbed calcium during the dry 2001 summer. Analysis of the fruit flesh just below the fruit skin from damaged versus undamaged fruit showed no differences in either calcium or boron concentration.

Conclusion

Stink bugs are causing considerable damage to apples by late season feeding in some eastern orchards. Conclusive identification of damage by stink bug compared with cork spot is by the presence of a feeding puncture on the skin and the location of corking immediately under the skin. Calcium related problems and other causes of corking damage, including other insects, continue to cause damage similar to that caused by stink bugs.

References

Faust, M. and C. B. Shear. 1968. Corking disorders of apples: a physiological and biochemical review. Botanical Review 34: 441-469.

Horticultural Performance of Apple Cultivars in the NE-183 Planting in West Virginia [1]

Stephen S. Miller
USDA-ARS, Appalachian Fruit Research Station
Kearneysville, West Virginia 25430

Fruit growers and consumers continue to show a high level of interest in growing and marketing new, high quality apple cultivars (Gelski, 2002; Stern, 2000). Miller (1998) noted several factors that contribute to this heightened interest. In addition, there has been a shift from wholesale to more local retail marketing for apples in the eastern U.S. Success with this marketing strategy generally requires a wide range in apple cultivar selection (Greene, 1999). Since new cultivars often command higher prices, growers also see an opportunity to increase profit margins (Burnham, 1998) by planting new and unique cultivars. At the same time, consumers are interested in a wider selection of high quality apples that offer improved sensory qualities in such characteristics as crispness, juiciness, texture, and flavor (Harker, 2002). Selecting the right cultivar to plant is one of the most important decisions for a grower. To make this decision, growers need reliable performance data developed from replicated trials (Greene, 1998).

A regional project (NE-183) was initiated in 1994, involving 26 cooperators located in 18 states and two Canadian provinces, to systematically evaluate the performance of new apple cultivars in replicated trials under a wide range of climatic and edaphic conditions. The initial planting was made in 1995 and consisted of 22 cultivars. A second planting was made in 1999 with 20 additional cultivars. The Appalachian Fruit Research Station (AFRS), as a cooperator in this project, has two plantings dedicated to evaluating the horticultural characteristics of these apple cultivars and one for use in evaluating pest susceptibility. Reports on the performance of the selected apple cultivars in the 1995 plantings over the first five growing seasons have been presented (Miller, 1998, 1999).

The present report provides an update on the yield of cultivars in the 1995 plantings. In addition, information is presented on the growth, yield, and fruit quality of the 20 cultivars in the 1999 planting.

Materials and Methods

1995 Plantings: Two separate replicated plantings in a randomized complete block were made with the 1995 cultivars. The pest (P) planting contained 22 cultivars plus 'Pioneer McIntosh' as the scab indicator, each cultivar with five single-tree replicates. The horticultural (H) planting contained only 19 cultivars, since bud failures in the nursery resulted in a deficit of some cultivars. In addition, not all cultivars had five replicate trees in the H planting. The H and P plantings were separated from each other by about 0.4 km. Details concerning the cultivars planted, planting methods, and cultural management has been presented (Miller, 1998, 1999). Containment pruning to restrict growth into the drive middles and between adjacent trees in the row was practiced in both the H and P plantings beginning in 1999. Containment pruning consisted of only thinning type cuts. Beginning in 2000 and continuing through 2002 the P planting was treated with the local recommended disease control spray schedule (Va. Coop. Ext., 2002) and a reduced insecticide schedule. A complete pest control schedule, based on local recommendations for commercial orchards (Va. Coop. Ext., 2002), was followed in the H planting throughout the study, except no calcium sprays were applied. Chemical thinner (carbaryl as Sevin XLR Plus) at the recommended rate was applied to all trees each year when fruit were about 10 mm in diameter. Hand thinning was used in late June to further adjust crop load and space fruit on limbs. Details on harvesting and data collection have been previously presented (Miller, 1998, 1999). Percent fruit drop and cracking for 'GoldRush' were computed as a percentage of total fruit number on the tree prior to the initial fruit drop.

1999 Planting: The 20 cultivars selected for this planting and their parentage (origin) are presented in Table 1. In 1999 only an H planting was made and this was located adjacent to the 1995 H planting. Planting methods, training, and cultural management were identical to that for the 1995 planting. Bloom that appeared in the first and second leaf was removed by hand; trees were allowed to fruit beginning in the third leaf. Five trees lost (4 test cultivar trees and 1 filler tree) at the end of the first growing season were replaced in 2000 with a new selection, 'NY 428'. No data is presented on 'NY 428' at this time. Fruit quality was determined for each cultivar from a 10-apple sample chosen at random from the total yield of fruit harvested from each replicated tree in the planting. Greene (1998) and Miller (1998) provide details in the methods used for fruit analysis. Sensory evaluation was performed on a 5-apple sample selected from each replicated tree as described above. Miller (1999) provides additional details on sensory evaluation. The overall sensory rating was based on the mean of a minimum of three 5-apple samples.

Results and Discussion

Tree mortality: The total number of trees in each planting, the number lost and the percent loss is given in Table 2. Fire blight was responsible for the major portion of the tree losses in the 1995 H planting. The fire blight infection followed a hailstorm in June 1995, about 2 months after planting. Several of the trees in the 1995 plantings died from collar rot (*Phytophthora* spp.) infection and several from unknown causes. In the 1999 planting 3 trees succumbed to a herbicide overdose and one tree died from a dogwood borer (*Synanthedon scitula*) infestation. Plastic tree guards were placed around trees at the time of planting, which may have encouraged the dogwood borer infestation.

1995 Planting: Low temperatures during bloom reduced the potential crop in 2000 and 2002, especially in the P planting in 2002 when frost protection was not available. The cumulative yield (kg/tree) from 1996 thru 2002 (2^{nd} thru 8^{th} leaf) for comparable varieties was greater in the H planting (Table 3) than the P planting (Table 4) except for 'Orin'. Fruit damage from pests was greater in the P planting resulting in greater preharvest fruit drop (data not shown). The lower yields in the P planting are probably related to the greater fruit drop, since dropped fruit was not included in the cumulative yield. 'Enterprise', 'GoldRush', 'Golden Delicious'/M.9, 'Fortune', and 'Fuji Red Sport # 2' had the highest cumulative yield per tree averaged over the H and P plantings. 'Shizuka', which had the highest cumulative yield of all cultivars in the P planting, was not represented in the H planting. 'Enterprise' and 'GoldRush', both "disease resistant cultivars", have shown good annual production. 'Golden Delicious', a cultivar noted for alternate bearing, demonstrated some of this characteristic in these two plantings. 'Fuji Red Sport #2', 'Yataka', 'Golden Supreme', and 'Suncrisp' have shown a somewhat stronger tendency toward biennial bearing than 'Golden Delicious' in the 1995 plantings. Miller (1999) identified 11 cultivars from the 1995 planting with above average potential. Based on cumulative yields and fruit quality and sensory evaluation (data not shown), four cultivars are identified as showing the best potential for wider planting in West Virginia and the mid-Atlantic region: 'Enterprise', 'GoldRush', 'Cameo', and 'Golden Supreme'. 'Golden Delicious' and 'Fuji', which scored well in these test plots, are not identified since they are already widely planted and generally proven in this region. 'Golden Supreme' is an early apple that resembles 'Golden Delicious' in appearance except it is generally free of russet. 'Golden Supreme' has demonstrated a high level of preharvest fruit drop (Table 5), which could be problematic. Among the four selected cutivars, 'GoldRush' may be considered the best all around performer, with 'Enterprise' a close second. Both apples appear to have potential as processing cultivars. In preliminary evaluations, 'GoldRush' has shown better storage potential and sensory quality following storage than 'Enterprise' (data not shown). One significant problem observed with 'GoldRush' grown at this site has been preharvest fruit cracking (Fig. 1). Initially this was thought to be a problem associated with young trees. Data was collected on cracking of 'GoldRush' in the H and P plantings in 1999, 2000, and 2002 (Table 6). No data was collected in 2001 since cracking was not observed. Because the presence of cracking was low in 2000 (Table 6) and not observed in 2001 (data not taken), it was believed that cracking may be associated with younger trees. However, significant cracking appeared again in 2002 (Table 6). Observations suggest that cracking is related to excess late season moisture and is somewhat similar to traditional 'Stayman' apple cracking, although cracking in 'GoldRush' does appear to be initiated closer to harvest than with 'Stayman' cracking. Additional studies are being planned to examine this problem and methods to reduce the incidence of 'GoldRush' cracking.

1999 Planting: Trunk size is a good indicator of overall tree size and vigor (Westwood and Roberts, 1970). After four growing seasons, average trunk circumference ranged from a low of 16.1 cm for 'Zestar!' to 23.6 cm for 'CQR10T17' among the 20 cultivars in the planting. 'NJ109' and 'Autumn Gold' were the next largest trees with a trunk circumference of 23.0 cm and 22.6 cm, respectively. Six other cultivars had trunk circumferences between 20 and 22 cm after the fourth leaf (data not shown).

The average number of days from full bloom (FB) to harvest for the first two cropping seasons (2001-2002) is given in Table 7. 'Zestar!' was the first cultivar to mature, at 110 days after FB, which in West Virginia occurs in early August. The last cultivar to mature was Cripps Pink', which matures about 187 days after FB or late October to early November. Fourteen of the 21 cultivars represented in this planting mature in September or between 135 and 162 days after FB.

Three cultivars, 'Autumn Gold', 'Golden Delicious', and 'Runkel', produced cumulative yields of 32 kg per tree or greater after two cropping seasons (Table 8). Seven cultivars had cumulative yields between 20 and 27 kg per tree. Four cultivars, 'Zestar!', 'Ambrosia', 'NJ 109', and 'NY79507-72', produced cumulative yields of less than 10 kg per tree through the first two cropping seasons. All cultivars produced greater yields in the second compared to the first cropping year, except 'Hampshire', 'Chinook', and 'Delblush'. After two cropping years, no cultivar in the 1999 planting has shown a strong tendency toward biennial bearing. 'Golden Delicious' was the most yield efficient cultivar in 2002 followed by 'Runkel' and 'NY 79507-49'. 'Ambrosia', 'NJ 109', and 'NY 79507-72' have demonstrated a very low yield efficiency.

Preharvest fruit drop can be a significant problem for apple growers. Plant growth regulators may provide some control of preharvest fruit drop, but these materials are costly and they may hasten maturity. Weather conditions during the latter part of the 2002 growing season were conducive to a high preharvest fruit drop. Cultivars showing 10 % fruit drop or greater in 2002 are listed in Table 9; percent fruit drop for the same cultivar in 2001 is also presented. 'NJ 90' has shown excessive preharvest drop in the first two cropping years. Based on the data, preharvest fruit drop is a potential problem for several other cultivars particularly 'Hampshire', Autumn Gold' and 'Delblush'. Studies to evaluate drop control methods appear warranted for these cultivars that have promise as commercial varities in the mid-Atlantic region.

Mean quality data for selected fruit quality attributes for fruit harvested in 2002 are presented in Table 10. Flesh firmness for most cultivars was at or above 15 lbs force (lbf). The 'CQR10T17' selection had the highest (25.6 lbf) flesh firmness and 'Zestar!' had the lowest (13.7 lbf) firmness at harvest. 'Crimson Crisp' fruit showed good flesh firmness, however this cultivar has rather small size fruit (Table 11), which may contribute to the higher flesh firmness. Soluble solids concentration (SSC) was generally above 13.0. The lack of moisture for about 6 weeks before harvest may have contributed to the elevated SSC levels. All cultivars were harvested within the established starch index (S.I.) rating range of 3.5 to 6.5 except 'CQR12T50', which was harvest slightly over mature, and 'Sundance' and 'Zestar!', that were somewhat immature when harvested. Based on length:diameter (L/D) ratio, 'Silken' is the most elongated fruit among these 20 cultivars while 'NY 79507-72' and 'NJ 90' are rather truncated or "flat". Among the red skinned cultivars, 'NJ 90' and 'Crimson Crisp' have the highest percent surface red color. Red color on 'Zestar!' is rather disappointing in this warmer climate region, in contrast to that found in its native Minnesota. Surface russet formation appears to be a problem on two of the yellow skinned cultivars, 'Delblush' and ''Sundance'. Russet formation was also rather prominent on 'BC 8S-26-50', a red skin cultivar. 'Hampshire' and 'Runkel' have consistently produced the largest fruit while 'Chinook' has consistently had the smallest fruit (Table 11).'Cripps Pink' and 'Crimson Crisp', two cultivars that may have potential for the West Virginia growing region, also appear to be rather small sized, although observations indicate that heavy fruit thinning may improve the size of 'Cripps Pink'.

Results of selected sensory attribute evaluations are presented in Table 12. Based on the author's observations and the two years of data, only those cultivars that appear to have significant potential for the West Virginia growing region are listed. 'Golden Delicious' is the standard for comparison. A rating of 3.0 is considered acceptable or "average" for any given attribute, and a rating above 3.0 indicates a more robust character for that sensory attribute. No cultivar received a maximum rating of "5" for the selected attributes. 'September Wonder Fuji' and 'NJ 90' received the highest average rating (4.0 and 3.9, respectively) for desirability, flavor, and crispness combined over all years. 'September Wonder Fuji' is a sweet apple and 'NJ 90' can be characterized as subacid, with similarities to 'McIntosh'. 'Crimson Crisp', which rated higher in flavor in 2002, is a subacid apple that looks and tastes similar to 'Jonathan'. Interestingly, 'Golden Delicious' had the lowest average rating for the combined three attributes. Ratings between years were generally consistent, but with a few exceptions. Ratings for 'Crimson Crisp' were noticeably higher in 2002 than in 2001. In contrast, ratings for 'Hampshire' decreased for desirability, flavor, and crispness in 2002 compared to 2001.

Evaluation of cultivars in the 1999 planting will continue in order to obtain a more complete picture of yield potential and consistency in fruit quality. The present data does not provide sufficient data to make a judgment on the acceptability of any one cultivar.

Literature Cited

Biggs, A.R. and S.S. Miller. 2001. Relative susceptibility of selected apple cultivars to *Colletotrichum acutatum*. Plant Dis. 85:657-660.

Biggs, A.R. and S.S. Miller. 2003. Relative susceptibility of selected apple cultivars to *Botryosphaeria dothidea*. HortScience 38:(in press).

Burnham, T.J. 1998. A new spin in orchards. New varieties, planting methods offer apple growers quicker returns. The Grower 31(11):14-15.

Gelski, J. 2002. Five year plan. Research growing conditions, market trends before planting new apple cultivars. The Grower 35(10):30-31.

Greene, D.W. 1998. Promising high quality apples evaluated in New England. Fruit Var. J. 52:190-199.

Greene, D.W. 1999. Apple variety evaluation in New England. Proc. 95th Wash. State Hort. Assoc. pp. 16-19.

Harker, R. 2002. How people respond to apples Part 2: Eating quality. Good Fruit Grower 53(4):20.

Miller, S.S. 1998. Early performance of apple cultivars in the NE-183 planting in West Virginia. Proc. 74th Cumb.-Shen. Fruit Workers Conf. 12 pp.

Miller, S.S. 1999. Yield and quality attributes of promising apple cultivars in West Virginia. Proc. 75th Cumb.-Shen. Fruit Workers Conf. 13 pp.

Stern, R. 2000. New apple varieties spark grower interest. The Grower 33(2):40-41.

Virginia Cooperative Extension. 2002. Virginia-West Virginia-Maryland Commercial Tree Fruit Spray Bulletin, Va. Tech. Coop. Ext. Publ. 456-419.

Westwood, M.N. and A.N. Roberts. 1970. The relationship between trunk cross-sectional area and weight of apple trees. J. Amer. Soc. Hort. Sci. 95:28-30.

Table 1. Apple cultivars and their parentage growing in the 1999 NE-183 horticultural (H) planting at the Appalachian Fruit Research Station.

Cultivar	Parentage	Cultivar	Parentage
Ambrosia	Chance seedling	Hampshire	Chance seedling
Autumn Gold	Chance seedling	September Wonder Fuji	Mutation of Fuji
BC 8S-26-50	Gala x Splendour	NJ 101	Golden Delicious x NJ88
Chinook	Splendour x Gala	NJ 90	136055 x Spartan
Crimson Crisp (Coop 39)	PCFW2-134 x PRI 669-205	NY 79507-40	Empire x Redfree
CQR10T17	DIR102T198 x PWR37T133	NY 79507-72	Empire x Redfree
CQR12T50 (Princess)	NJ75 x DIR101T117	Runkel	Chance seedling
Cripp's Pink (Pink Lady®)	Lady Williams x Golden Delicious	Silken	Honeygold x 8C-27-96
Delblush	Golden Delicious x Blushing Golden	Sundance (Coop 29)	Golden Delicious x PRI 1050-201
Golden Delicious (Gibson strain)	Mutation of Golden Delicious	Zestar!™	State Fair x MN 1691

Table 2. Tree losses in the NE-183 plantings at the Appalachian Fruit Research Station from 1999 through 2002.

Planting		Original	Trees lost	
Year	Type	No. trees planted	Number	%
1995	Horticulture	93	39	41.9
1995	Pest	130	7	5.4
1999	Horticulture	100	4	4.0

Table 3. Mean yield per tree, cumulative yield, and cumulative yield rank for the 1995 horticultural (H) NE-183 planting at the Appalachian Fruit Research Station, Kearneysville, WV for the 2nd thru 8th leaf.

Cultivar/Rootstock	Mean Yield, (kg per tree): 1996	1997	1998	1999	2000	2001	2002	Cumulative Yield (kg/tree)	Cultivar's Rank of Cumul. Yield 1999	2000	2001	2002
Enterprise/M.9	0	3.9	32.6	(2)* 63.9	31.1	67.7	105.2	304.5	1	1	2	1
GoldRush/M.9	0.3	11.2	0.1	(3) 52.2	46.6	87.6	60.3	258.3	8	2	3	2
Golden Del/M.9	0.3	2.9	3.3	(4) 67.2	15.5	97.4	54.0	240.6	5	7	4	3
Fuji Red Sport #2/M.9	0	5.2	9.3	(4) 64.8	2.6	101.6	56.4	239.9	2	11	5	4
Fortune/M.9	0	0.4	10.9	(1) 58.2	38.1	92.7	34.2	234.5	7	3	1	5
Gala Supreme/M.9	0	2.0	28.6	(1) 47.6	21.3	78.7	53.7	231.9	3	4	6	6
Cameo/M.9	0.3	1.5	9.6	(2) 39.6	32.3	75.3	69.2	227.8	13	9	8	7
Arlet/M.9	0.1	7.6	16.4	(2) 36.0	38.2	56.3	58.8	213.4	11	5	9	8
Golden Del/Mark	0	9.4	8.2	(3) 42.8	27.4	72.1	36.3	196.1	9	8	7	9
Golden Supreme/M.9	0	3.9	1.2	(2) 70.6	6.4	52	52.4	186.5	4	10	11	10
Ginger Gold/M.9	0	0.1	13.9	(1) 38.3	37.4	41.5	48.8	180.0	12	6	12	11
Yataka/M.9	0	7.2	0.1	(4) 53.0	0.1	75.4	39.1	174.9	10	15	10	12
Sunrise/M.9	0.2	1.0	5.2	(4) 31.0	22.3	43	58.4	160.9	18	16	16	13
NY75414-1/M.9	0	1.8	12.2	(4) 28.4	29.8	40.9	29.5	142.6	16	12	15	14
Braeburn/M.9	0	1.5	15.0	(3) 28.2	26.2	42.9	23.4	137.2	14	13	14	15
Suncrisp/M.9	0.3	6.3	3.3	(2) 59.8	0	51.4	(1) 8.5	129.6	6	14	13	16
Pristine/M.9	0	0.5	3.2	(1) 20.9	23.9	21.6	57.3	127.4	21	17	20	17
Yataka/Mark	0	4.7	1.7	(3) 37.9	1.6	55.1	25.8	126.8	15	18	17	18
Orin/M.9	0	4.3	1.5	(3) 27.8	4.7	51.3	27.9	117.5	19	21	18	19
Honeycrisp/M.9	0	2.9	0.6	(2) 23.3	18	43.1	8.0	95.9	20	19	19	20
Sansa/M.9	0	1.2	0.8	(5) 13.8	15.3	33.4	21.4	85.9	22	22	21	21
Braeburn/Mark	0	1.7	18.2	(1) 21.3	3.2	19.1	10.9	74.4	17	20	22	22
Overall mean yield(kg/tr)	--	3.7	8.9	42.1	20.1	59.1	42.7					

* (#) indicates number of trees in mean yield for cultivar

Table 4. Mean yield per tree, cumulative yield, and cumulative yield rank for the 1995 pest (P) NE-183 planting at the Appalachian Fruit Research Station, Kearneysville, WV for the 2[nd] thru 8[th] leaf.

Cultivar/Rootstock	Mean Yield, (kg per tree): 1996	1997	1998	1999	2000	2001	2002	Cumulative Yield (kg/tree)	Cultivar's Rank of Cumul. Yield 1999	2000	2001	2002
Shizuka/M.9	0.1	1.2	3.8	(5)* 44.9	80.5	41.2	27.1	198.9	6	1	1	1
Enterprise/M.9	0	1.8	14.9	(4) 27.8	37.7	47.1	65.8	195.0	13	7	8	2
Fortune/M.9	0	3.0	22.9	(4) 41.0	33.7	61.1	16.3	178.1	2	2	3	3
Cameo/M.9	0	3.9	8.9	(5) 48.3	39.0	66.2	11.2	177.5	4	3	2	4
Golden Del/M.9	0	4.3	8.4	(5) 48.5	37.4	54.7	21.1	174.3	3	5	4	5
Fuji Red Sport#2/M.9	0.1	4.4	0.2	(4) 45.5	8.5	87.5	23.8	169.9	5	16	5	6
GoldRush/M.9	0.6	7.7	1.8	(5) 35.4	42.9	50	24.2	162.6	10	6	6	7
Arlet/M.9	0.1	1.2	7.9	(5) 29.4	60.6	39.1	20.6	158.9	17	4	7	8
Ginger Gold/M.9	0.1	4.2	13.4	(5) 27.0	34.9	43	15.5	138.1	11	9	9	9
Sunrise/M.9	0.2	3.0	7.7	(4) 22.1	30.3	35.3	30.6	129.2	19	14	16	10
Gala Supreme/M.9	0	3.6	6.3	(5) 33.1	15.1	37.1	26.7	121.9	14	17	18	11
Golden Supreme/M.9	0	0.4	3.5	(5) 44.2	20.1	49.9	3.5	121.6	7	13	11	12
Orin/M.9	0.1	1.6	9.4	(5) 33.6	25.2	49.2	1.2	120.3	12	12	10	13
Golden Del/Mark	0	5.4	5.2	(5) 29.8	38.7	29.5	9.2	117.8	15	10	13	14
Suncrisp/M.9	0	13.2	0	(4) 55.4	11.6	34.2	3.2	117.7	1	8	12	15
Creston/M.9	0.1	3.1	9.1	(5) 34.2	14.0	42.8	13.6	116.9	8	15	14	16
Braeburn/M.9	0.2	1.8	22.5	(5) 21.1	30.4	23.7	10.8	110.5	9	11	15	17
NY75414-1/M.9	0	0.9	8.7	(5) 15.4	29.0	37.6	13.7	105.3	23	18	19	18
Yataka/M.9	0	2.1	2.6	(5) 35.2	4.0	53	3.0	99.9	16	22	17	19
PioneerMac/M.9	0	3.7	1.8	(5) 19.6	6.5	38.6	23.6	93.9	22	25	23	20
Yataka/Mark	0	2.6	2.0	(4) 32.7	16.5	28.3	10.1	92.2	18	19	20	21
Senshu/M.9	0	0.6	3.1	(5) 22.1	15.2	39.9	10.5	91.4	21	23	21	22
Pristine/M.9	0	2.1	3.9	(4) 26.4	19.2	24	14.0	89.6	20	20	22	23
Braeburn/Mark	0.1	0.6	7.3	(5) 13.7	26.4	14.4	7.0	69.4	24	21	24	24
Honeycrisp/M.9	0	0.1	2.5	(5) 8.6	20.9	25.9	5.6	63.6	26	24	25	25
Sansa/M.9	0.1	1.2	3.0	(5) 8.0	12.9	24.9	9.4	59.4	25	26	26	26
Overall Mean Yield (kg/tr)	–	3.0	7.0	30.9	27.4	41.4	16.2					

* (#) indicates number of trees in mean yield for cultivar

Table 5. Mean percent pre-harvest fruit drop for selected cultivars in the 1995 NE-183 plantings for the 1999 and 2000 growing seasons at the Appalachian Fruit Research Station, Kearneysville, WV. No materials were applied to retard pre-harvest fruit drop.

Cultivar/rootstock	Mean fruit drop/tree (%) [z]
Golden Supreme/M.9	29.1
PioneerMac/M.9	20.7
Pristine/M.9	19.0
Braeburn/MARK	11.9
Shizuka/M.9	10.0
Suncrisp/M.9	8.6
Enterprise/M.9	6.3
Cameo/M.9	6.2
GoldRush/M.9	5.7
Gala Supreme/M.9	2.7

[z] Mean fruit drop averaged over two growing seasons, 1999-2000. Data combined from Pest and Horticulture plantings.

Table 6. Fruit cracking in 'GoldRush' apples during three growing seasons in the 1995 NE-183 plantings at the Appalachian Fruit Research Station, Kearneysville, WV.

	% fruit cracked in the:	
Year	Horticulture planting	Pest planting
1999	19.5	25.1
2000	1.0	1.4
2001	DNR*	DNR
2002	19.3	24.4

* DNR = data not recorded

Fig 1. Minor to severe symptoms characteristic of 'GoldRush' fruit cracking.

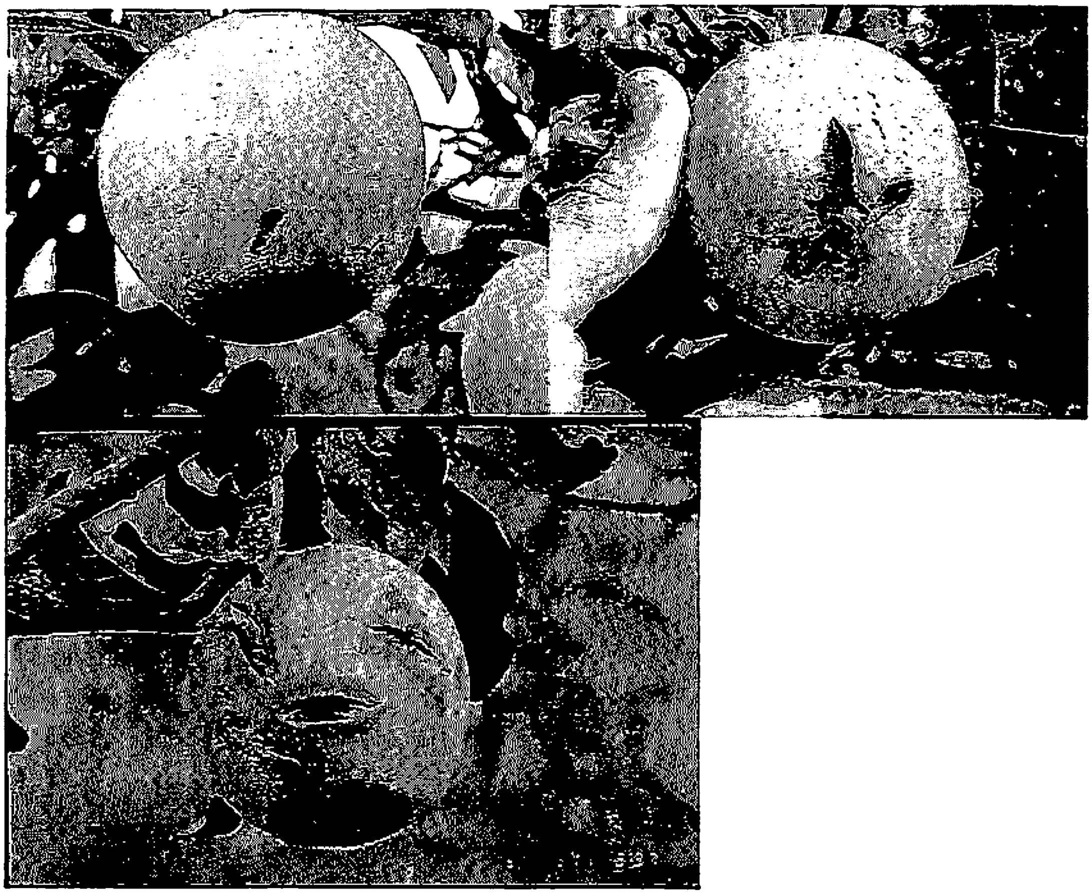


Table 7. Cultivars grown in the 1999 NE-183 planting at the Appalachian Fruit Research Station and the average number of days from full bloom (FB) to harvest (H) calculated from the 2001 and 2002 growing seasons.

Cultivar	days, FB – H	Cultivar	days, FB - H
Zestar!™	- 110	BC 8S-26-50	- 144
NJ 109	- 120	Ambrosia	- 148
CQR12T50	- 126	Golden Delicious	- 150
NY 79507-72	- 128	NJ 90	- 151
Silken	- 132	Delblush	- 156
NY 79507-49	- 135	Autumn Gold	- 158
September Wonder Fuji	- 136	Hampshire	- 159
Runkel	- 137	Sundance (Coop 29)	- 162
CQR10T17	- 138	Chinook	- 165
Crimson Crisp (Coop 39)	- 139	Cripps Pink	- 187
NY 428	- 144		

Table 8. Mean yield per tree, cumulative yield, yield rank, and yield efficiency in 2001 and 2002 for apple cultivars planted in the 1999 NE-183 evaluation planting at the Appalachian Fruit Research Station, Kearneysville, WV.

Cultivar	Mean Yield (kg/tree) 2001	Mean Yield (kg/tree) 2002	Cumulative yield (kg/tree)	Cumulative Yield Rank 2001	Cumulative Yield Rank 2002	Efficiency (kg/TCSA*) 2002
Autumn Gold	11.50	23.93	35.43	3	1	0.59
Golden Delicious	10.45	23.38	33.83	5	2	0.83
Runkel	10.87	21.26	32.14	4	3	0.65
Hampshire (4 trees)	14.88	11.30	26.18	1	4	0.29
NY79507-49	9.47	16.37	25.84	8	5	0.59
BC 8S-26-50	10.08	14.15	24.23	7	6	0.63
September Wonder Fuji	5.46	18.04	23.50	15	7	0.56
CQR12T50	8.35	12.98	23.35	9	8	0.59
Chinook	11.67	11.40	23.07	2	9	0.39
Silken (3 trees)	7.82	13.06	20.88	10	10	0.36
NJ 90	6.64	11.75	18.39	12	11	0.44
Delblush	10.42	7.15	17.57	6	12	0.22
CQR10T17	5.94	9.76	15.70	14	13	0.24
Crimson Crisp (Coop 39)	7.14	8.27	15.40	11	14	0.27
Cripps Pink	6.07	8.62	14.68	13	15	0.25
Sundance (Coop 29)	2.00	11.78	13.78	17	16	0.41
Zestar!	2.51	5.84	8.35	16	17	0.26
Ambrosia (4 trees)	1.19	6.28	7.47	19	18	0.19
NJ 109	1.40	3.34	4.74	18	19	0.08
NY 79507-72	0.41	2.11	2.51	20	20	0.08

Trees planted April 1999. Bloom removed in 2000
* TCSA = trunk cross-sectional area

Table 9. Apple cultivars growing in the 1999 NE-183 planting with fruit drop of 10% or higher in 2002 and the corresponding fruit drop in 2001.

Cultivar	% Fruit drop/tree in: 2001	2002
NJ 90	44.0	53.7
Hampshire	22.2	34.6
NY79507-72	47.8*	27.3
NY 79507-49	11.8	26.3
Autumn Gold	15.7	25.9
Delblush	21.0	25.4
Zestar!	10.6	20.2
Ambrosia	7.7	15.0
Sundance (Coop 29)	4.3	13.2
BC 8S-26-50	0.4	11.2

* fruit drop percent based on less than 5 fruit per tree

Table 10. Various fruit quality attributes at the time of harvest in 2002 for apple cultivars growing in the 1999 NE-183 planting at the Appalachian Fruit Research Station, Kearneysville, WV.

Cultivar	Firmness (lbs.)	SSC[z] (%)	S.I.[y] rating	L/D[x] ratio	Red surface color (%)	Russet (%)
Ambrosia	17.7	15.3	4.5	0.86	62.5	2.1
Autumn Gold	15.7	13.2	5.8	0.90	-[w]	2.4
BC 8S-26-50	16.9	16.2	4.7	0.88	61.8	10.3
Chinook	18.9	16.2	4.1	0.82	80.6	2.7
CQR10T17	25.6	13.4	4.1	0.91	56.8	0.9
CQR12T50	17.6	13.1	7.2	0.80	0.5	0.9
Crimson Crisp (Coop 39)	20.6	14.6	6.5	0.87	81.0	1.7
Cripps Pink	18.4	15.1	4.5	0.90	61.6	0.8
Delblush	19.3	17.5	4.1	0.90	-	16.1
Golden Delicious	16.8	16.4	3.7	0.88	-	10.1
Hampshire	16.9	13.9	5.3	0.81	89.3	0.8
September Wonder Fuji	14.9	13.1	5.7	0.81	44.2	0.7
NJ 90	15.1	13.8	3.8	0.77	91.9	0.9
NJ 109	16.7	14.0	3.5	0.91	-	3.6
NY 79507-49	17.2	13.3	4.5	0.79	64.0	1.0
NY 79507-72	19.5	13.4	4.3	0.72	62.6	0.2
Runkel	15.6	12.8	3.9	0.81	52.4	1.6
Silken	17.0	14.1	4.3	0.94	-	5.2
Sundance (Coop 29)	18.6	13.5	2.8	0.86	-	13.7
Zestar!	13.7	14.9	3.0	0.83	41.4	3.4

[z] SSC = soluble solids concentration
[y] S.I. rating = starch index rating at harvest on a scale of 1 to 8 where 1 is fully immature and 8 is fully overmature; attempted to harvest at S.I. rating of 4 to 6.
[x] L/D ratio = length/diameter ratio
[w] - indicates a yellow or green skinned cultivar

Table 11. Average per fruit weight (grams) for fruit harvested in 2001 and 2002 from the 1999 NE-183 planting at the Appalachian Fruit Research Station, Kearneysville, WV.

Cultivars - largest	Fruit wt. (g)	Cultivars - smallest	Fruit wt. (g)
Hampshire	247	Chinook	125
Runkel	234	NJ 109	162
NY 79507-49	226	Cripps Pink	163
Autumn Gold	222	NY 79507-72	168
Sundance (Coop 29)	218	Crimson Crisp (Coop 39)	171
CQR10T17	215	Delblush	175

Table 12. Sensory quality evaluation ratings for the most promising apple cultivars tested in the 1999 NE-183 planting at the Appalachian Fruit Research Station, Kearneysville, WV. Data presented for the first two cropping years, 2001 - 2002.[z]

	Sensory attribute					
	Desirability [y]		Flavor [x]		Crispness [w]	
Cultivar	2001	2002	2001	2002	2001	2002
Silken	3.2	2.8	3.7	3.6	4.2	4.2
September Wonder Fuji	4.5	4.0	4.5	4.0	3.7	3.0
Crimson Crisp (Coop 39)	2.2	4.0	2.7	4.2	3.5	4.2
Ambrosia	1.0	4.0	2.8	4.2	4.0	3.8
Golden Delicious	3.0	3.2	3.3	3.2	1.8	2.1
NJ 90	3.8	4.0	3.7	4.0	4.0	4.1
Autumn Gold	3.5	3.8	3.8	3.7	2.8	2.8
Hampshire	4.3	3.5	4.2	3.3	3.8	2.8
Cripps Pink	3.5	3.7	3.3	3.7	3.0	3.5

[z] 'Golden Delicious' included for comparison. Evaluations conducted on day of harvest with starch index (S.I.) rating between 3.5 and 6.5 (scale of 1 = fully immature to 8 = fully over mature). All sensory evaluations conducted by the author. Rating on 1 to 5 scale

[y] Desirability: 1 = dislike, 3 = acceptable, 5 = excellent

[x] Flavor: 1 = dislike, 3 = acceptable, 5 = like very much

[w] Crispness: 1 = not crisp, 3 = crisp, 5 = extremely crisp

(Not for publication or distribution, CSFWC 2002)

Chemical Sprays for Control of Apple Fruit Drop and Inhibition of Apple Maturity

R. E. Byers, D. H. Carbaugh, and L. D. Combs
Professor of Horticulture and Research Specialists
Virginia Polytechnic Institute and State University,
Alson H. Smith, Jr. Agricultural Research and Extension Center,
595 Laurel Grove Road
Winchester, VA 22602

Abstract. In 2002, NAA + Silwet + superior oil inhibited fruit drop of 'Golden Supreme'/MM.111, but neither Agri-Mek nor GA4+7 provided an additional benefit when applied 1 month before harvest. ReTain + NAA + Silwet + superior oil provided no better control of fruit drop than NAA + Silwet + superior oil. The addition of Agri-Mek + GA_{4+7} to NAA + Silwet + superior oil or ReTain + NAA + Silwet + superior oil did not provide an additional benefit. Additional experiments should be conducted earlier in the season (within 60 days after bloom) to determine if additional control of fruit drop could be found without affecting fruit size.

In 2001, ReTain and/or NAA inhibited fruit drop of 'Golden Supreme'/MM.111. EthylBloc when used alone or when combined with ReTain did not affect fruit drop alone. Cyclanilide increase the rate of fruit drop and when combined with ReTain. Cyclanilide inhibited the influence ReTain on fruit drop. The combination of ReTain + NAA + EthylBloc provided superior control of fruit drop. A delay in harvest date allowed ReTain fruit to increase in fruit diameter without loss of fruit quality until at least Sept 29. ReTain delayed fruit softening, NAA hastened softening, and EthylBloc had no effect. ReTain maintained starch but NAA, EthylBloc, and Cyclanilide did not. ReTain delayed the starch:sugar conversion as indicated by lower soluble solids and higher starch levels. ReTain delayed the development of background color, fruit shriveling, and fruit cracking.

In 2001, ethephon nor its combination with ReTain or NAA+ReTain affected the rate of fruit drop of 'Gala'/M.9 trees; however, little drop occurred by Sept 18. A delay in harvest from 22 Aug to 5 Sept allowed fruit to increase in diameter without loss of fruit quality. Ethephon caused fruit to have about the same firmness, less starch, and more color than control fruit. ReTain delayed fruit maturity, soluble solids, red color development, loss of starch, and loss of firmness. Ethephon+ ReTain sprayed trees had higher firmness and more starch than the control on 5 Sept and better red color than ReTain alone on 5 Sept and 19 Sept.

In 2001, ReTain and/or NAA inhibited fruit drop, 10-year-old 'Law Rome'/MM.111 trees. On 18 Oct NAA, EthylBloc, Kinetin, or Cyclanilide when used alone did not affect fruit drop, firmness, starch, soluble solids, or red color. ReTain delayed fruit drop loss of fruit firmness, and starch. The combination of ReTain + NAA + EthylBloc provided superior control of fruit drop.

Introduction

Fruits of many apple cultivars may abscise before adequate color or maturity develops. Because adequate labor often is unavailable to harvest large orchards of a single cultivar, growers may begin to harvest earlier than the optimum maturity date. Early harvest may lead to poorer fresh and processed fruit quality and poorer fruit storability. In addition, early and short harvest periods may present several practical problems such as inadequate numbers of picking bins, trucks, and cold storage equipment to handle more fruit in a short period of time. Early harvest can also result in lower yields, because fruit that remains on the tree may continue to increase in size (Shallenberger et al., 1961; Curtis, 1961). Chemical sprays that delay pre-harvest fruit drop and maturity for an additional 2 to 4 weeks may increase crop value by increasing yield, fruit size, quality, and price by as much as 20% (Byers, unpublished).

Chemical control of pre-harvest fruit drop has been studied for many years (Batjer and Moon, 1945; Batjer, L. P. and A. H. Thompson, 1946; Batjer and Thompson, 1947; Edgerton and Hoffman, 1948; Edgerton, 1947; Gardner et al., 1940; Harley et al., 1946; Mattus and Moore, 1954; Mattus et al., 1956; Smock et al., 1954; Southwick et al., 1953; Thompson 1952).

NAA, 2,4,5-TP, and daminozide (Alar) have been registered to delay pre-harvest abscission of apples. The registration of daminozide was withdrawn in 1989. This compound hastened red color development, delayed fruit maturity and fruit drop (Batjer and Williams et al., 1966; Edgerton and Blanpied; 1970; Pollard, 1974). When daminozide (Alar) + NAA or 2,4,5-TP was used to control preharvest drop, a 2- to 4-week extension of the harvest period was possible for many red cultivars.

The registration of 2,4,5-TP was cancelled in 1986. This material controlled fruit drop better than daminozide or NAA, but it caused a hastening of maturity (Mattus and Moore, 1954; Mattus et al., 1956; Smock et al., 1954; Southwick et al., 1953). The optimum harvest period was shortened by 2,4,5-TP even though fruit were held on the tree adequately. Combinations of daminozide and 2,4,5-TP minimized fruit drop, caused negligible fruit ripening (Batjer and Williams, 1966; Edgerton and Blanpied, 1970; Pollard, 1974; Schomer et al., 1971; Smock et al., 1954), increased fruit color, and extended the harvest season substantially. A survey of Virginia apple growers in 1989 (after the cancellation of 2,4,5-TP but before the cancellation of daminozide (Alar)), indicated 5 to 25% of the total crop was lost to preharvest drop.

NAA was considered to be less effective than 2,4,5-TP or daminozide (Looney and Cochrane, 1981; Southwick, et al 1953; Thompson 1952). More recent studies indicate that NAA is more effective when applied 3 to 4 weeks before the optimum harvest date followed by a second application 14 to 21 days afterward for cultivars grown in Virginia (Marini, et al., 1993).

A wider harvest window (over a 2 – 4 week period) is needed to allow each cultivar to be harvested without loss of yield or fruit quality. Ideally, fruit of each cultivar should be harvested in a 3 to 5 day picking window for maximum fruit quality; however, a shortage of labor, bins, poor picking weather, as well as early ripening or coloring sequence of cultivars may frequently alter the anticipated harvest window.

Other chemicals that have auxin-like activity will also delay pre-harvest fruit drop. They include: 1) phenoxys (fenoprop, 2,4-DP), chloroxuron (Looney and Cochrane, 1981; Looney and Hogue, 1987; Marini and Byers, 1988a; Marini et al., 1988b; Marini et al., 1989), 2) benzoic acides (dicamba) (Marini and Byers, 1988a; Marini et al., 1988c; Marini et al., 1989), and pyridines (triclopyr, lontrel, and fluroxypyr). Among these 2,4-DP and dicamba appeared be superior to NAA because they are longer lasting and have little negative affects on fruit ripening (Marini and Byers, 1988a; Marini et al., 1988b; Marini et al., 1988c)

Aminoethoxyvinylglycine (AVG, ReTain) is an ethylene-biosynthesis inhibitor (Yu and Yang, 1979, Shafer et al., 1995) that suppresses ethylene production in apple fruit and other plant tissues (Autio and Bramlage, 1982; Bangerth, 1978). When applied within 1 month of harvest, AVG delays fruit ripening, suppresses preharvest and postharvest flesh softening, reduces watercore, reduces pre-harvest fruit drop, and increases fruit removal force (Autio and Bramlage, 1982; Bangerth, 1978; Williams, 1980; Byers, 1997a,b,c).

Due to the temporary lack of transportation and/or cold storage facilities at harvest, apple growers, packers, and processors need methods to store large quantities of apples for short periods in outside non-refrigerated storage shelters, or as a pre-treatment for long term regular cold or CA storage. At harvest, rapidly cooling large quantities of fruit is both expensive and/or requires additional refrigeration capacity to cool fruit to 32°F rapidly. In addition, during peak loading of cold storages, core temperatures may not reach 32°F for a week or more due to inadequate refrigeration capacity. Occasionally, if cold storages are full, some fruit may set for several weeks at temperatures of 50°F to 75°F before processing. During these periods, fruit may deteriorate rapidly due to the loss of firmness, starch, fruit rots, and/or insect damage.

Since short-term cold storage before processing can be expensive, any treatment that would dramatically maintain fruit firmness and eating quality (shelf-life) at 75°F could be of great importance for both fresh and processed apple marketability. A chemical drench that would inhibit fruit maturity, fruit rots, and insect damage could be useful in many certain circumstances. Many cold storages and processors have quick fruit dip or drench capacity for treating trucks loads of fruit.

In 1997, AVG (ReTain) was registered for control of fruit drop. Orchard sprays or fruit dips of AVG were found to inhibit loss of firmness, ethylene evolution, and starch degradation (Byers, 1997abc; and Byers, unpublished). In 1995, ethylene production of York and Rome fruit dipped in AVG was greatly inhibited during the 21 days after harvest when compared to untreated control fruit. In another AVG dip experiment, fruit rots were inhibited to 9% by AVG vs 27% in the control when apples were stored at 70°F for 26 days. AVG is not known to inhibit fruit rot organisms, but the rot inhibition may be a result of AVG maintenance of fruit firmness and condition. Dipping peach and nectarine fruit (Byers, 1997) with ReTain maintained fruit firmness when held at 70°F for

12 days. In addition, ethylene production was completely inhibited by dipping fruit in AVG for 30 seconds or less.

1-Methylcyclopropene (MCP) is an inhibitor of ethylene action that has been found to block ethylene responses in plants (Fan et al. 1999; Sisler and M. Serek, 1997). MCP is a gas which has been formulated as a powder with the trade name EthylBloc. EthylBloc releases the MCP gas when mixed with a base. MCP is currently being used commercially in the cut flower industry, and has potential for use in apple cold storages to prolong the post-harvest quality of apples and peaches (Fan et al., 1999). On September 24 1999, we gassed 'Golden Delicious' trees in the field with MCP using 300 cubic foot bags. At this time the control fruit averaged 18.5 lbs. firmness. Fruit drop was not controlled by MCP, but 30 days after gassing whole trees, fruit were still 18.3 lbs on Oct 24 1999 (control was 14.0 lbs). In addition, we also were partially successful in making a sprayable formulation. The MCP spray was not as effective as the gas, but fruit from sprayed trees were 15.9 lbs. firmness compared to the control at 14.0 lbs.

The objectives of these experiments were to investigate 1) sprays of ReTain, NAA, dicamba, 2,4-DP, tryclopyr, fluroxypyr, their combinations, and adjuvants for maximum control of pre-harvest fruit drop and maintenance of "on tree" fruit quality, 2) fruit dips to provide short-term room temperature storage of apples, 3) fruit dips for long term regular storage, and 4) dips to promote shelf life of fruit after removal to room temperature from cold storage.

Materials and Methods

Trees were selected for uniformity and blocked according to row and terrain into six or more blocks for the number of treatments listed in each table. Specific information about spray application dates, tree size, chemical rates, maturity at harvests, and storage temperatures are reported in each table when appropriate. Experimental procedures will follow previous work on fruit drop and fruit quality (Byers, 1997abc; Marini et al., 1988ab; Marini et al.,1989).

Five to 10 limbs/tree (with a minimum of approximately 50 fruit/tree) were selected and tagged to monitor fruit drop . At 7-day intervals, fruit remaining on these limbs were counted and the percentage of fruit drop was calculated. Fruit samples were taken at intervals for testing.

In several experiments, a 10 fruit sample was collected near fruit maturity from each tree for quality evaluations (flesh firmness, soluble solids concentration, starch staining, percentage red color, fruit scaring and/or russet, and incidence of water core). Flesh firmness of was measured on two sides of each fruit with an Effegi penetrometer (Model FT327: McCormick Fruit Tech, Yakima, Wash.) fitted with an 11.1-mm tip. Soluble solids concentration (SSC) was estimated with an Atago hand-held refractometer (Model N1, McCormick Fruit Tech, Yakima, Wash.), utilizing a composite sample of juice resulting from penetrometer testing of all replicates of each treatment. Each apple fruit was cut in half transversely, and severity of water core was rated on a scale of 0 to 5 (0= none, 5 = severe). Flesh starch was evaluated by dipping half of each apple in iodine solution for approximately 15 s. The degree of staining was rated on a scale of 0 to 8 where 0 = staining of the entire cut surface and 8 = absence of starch (Poapst et al., 1959). Stem-end and side russet were rated as 0=no russet to 5= severe russet.

Unfortunately a sample of 2,4-DP was not available for testing. Past results indicated this compound will inhibit fruit drop without promoting fruit ripening (Marini and Byers 1988a).

Expt. 1. In 2002, forty 5-year-old 'Golden Supreme'/M9 trees (5 blocks) were used for 8 treatments (Tables 1). Treatments were applied on 17 July 02 at an estimated 4 weeks before the optimum harvest date (19 Aug.). Since combinations of GA_4+_7 and NAA are known to cause pigmy fruit , and since Agri Mek and NAA has caused similar responses with Golden Delicious (Unrath, personal communication) if applied during the thinning period (about 10 mm to 20 mm fruit diameter), various combinations of these were used to inhibit fruit drop.

Expt. 2. In 2001, forty 5-year-old 'Golden Supreme'/MM.111 trees (5 blocks) were used for 8 treatments (Tables 2A, 2B, 2C). Treatments were applied on 25 July at an estimated 4 weeks before the optimum harvest date (24 Aug.). In 2002, trees were observed for tree injury, and return bloom was visually estimated as the % of spurs flowering on 22 Apr 02.

Expt. 3. In 2001, forty nine 5-year-old 'Gala'/M.9 trees (7 blocks) were used for 7 treatments (Tables 3A, 3B, 3C). Treatments were applied on 8 August at an estimated 3 weeks before the optimum harvest date (29 Aug.), except for ethephon which was applied on 22 Aug. Fruit drop and maturity data were taken at various intervals of time. In 2002, trees were observed for tree injury, and return bloom was visually estimated as the % of spurs flowering on 19 Apr 02.

Expt. 4. In 2001, fifty four 13-year-old 'Law Rome'/MM.111 trees (6 blocks) were used for 9 treatments (Tables 4A, 4B, 4C). Treatments were applied on 27 September at an estimated 2 weeks before the optimum harvest date (11 Oct.). Fruit drop and maturity data at various intervals of time. In 2002, trees were observed for tree injury, and return bloom was visually estimated as the % of spurs flowering on 24 Apr 02.

Results and Discussion

Expt. 1. In 2002, NAA + Silwet + superior oil inhibited fruit drop of 'Golden Supreme'/MM.111 (Table 1, trt# 3), but neither Agri-Mek (trt# 4) nor GA_4+_7 (trt#5) provided an additional benefit (Tables 1A, 1B, 1C). ReTain + NAA + Silwet + superior oil (trt# 8) provided no better control of fruit drop than NAA + Silwet + superior oil (trt# 3). The addition of Agri-Mek + GA_4+_7 (trt#s 6,7) to NAA + Silwet + superior oil or ReTain + NAA + Silwet + superior oil did not provide an additional benefit.

Even though NAA + GA_4+_7 (Byers, unpublished) or NAA + Agri-Mek (Unrath, personal communication) are known to cause pigmy fruit and stick them on the tree if applied during the thinning period (about 10 mm to 20 mm fruit diameter), they did not provide *additional benefit* when applied about 1 month before harvest (Table 1).

Additional experiments should be conducted earlier in the season (within 60 days after bloom) to determine if additional control of fruit drop could be found without affecting fruit size.

Expt. 2. In 2001, ReTain and/or NAA inhibited fruit drop, 5-year-old 'Golden Supreme'/MM.111. EthylBloc did not affect fruit drop alone or when combined with ReTain. Cyclanilide increase the rate of fruit drop and when combined with ReTain. Cyclanilide inhibited the influence ReTain on fruit drop (Tables 2A, 2B, 2C). The combination of ReTain + NAA + EthylBloc provided superior control of fruit drop (Table 2A).

A delay in harvest date allowed ReTain fruit to increase in fruit diameter without loss of fruit quality until at least Sept 25 (Table 2B). ReTain delayed fruit softening, NAA hastened softening, and EthylBloc had no effect. ReTain maintained starch but NAA, EthylBloc, and Cyclanilide did not. ReTain delayed the starch:sugar conversion as indicated by lower soluble solids and higher starch levels. ReTain delayed the development of background color, fruit shriveling, and fruit cracking (Table 2C). In 2002, trees were not injured by the treatments, and return bloom may have been promoted by ReTain + NAA + EthylBloc (trt#7).

Expt. 3. In 2001, Ethephon nor its combination with ReTain or NAA+ReTain affected the rate of fruit drop of 'Gala'/M.9 trees (Table 3A); however, little drop occurred by Sept 18. A delay in harvest from 22 Aug to 5 Sept allowed fruit to increase in diameter without loss of fruit quality (Table 3B). Ethephon caused fruit to have about the same firmness, less starch, and more color than control fruit. ReTain delayed fruit maturity, soluble solids, red color development, loss of starch, and loss of firmness. Ethephon+ ReTain sprayed trees had higher firmness and more starch than the control on 5 Sept and better red color than ReTain alone on 5 Sept and 19 Sept (Table 3B). In 2002, trees were not injured by the treatments, and return bloom may have been promoted by ReTain + Ethephon (trt# 4) and/or ReTain + NAA + Ethephon (trt# 6).

Expt. 4. ReTain and/or NAA inhibited fruit drop, 10-year-old 'Law Rome'/MM.111 trees. On 18 Oct NAA, EthylBloc, Kinetin, or Cycilinalid did not affect fruit drop, firmness, starch, soluble solids, or red color alone. ReTain delayed fruit drop loss of fruit firmness, and starch (Tables 4A, 4B, 4C). The combination of ReTain + NAA + EthylBloc provided superior control of fruit drop (Table 4A). In 2002, trees were not injured by the treatments, and return bloom was not promoted by the treatments.

Expected Significance to the Apple Industry

These experiments demonstrated that one spray ReTain + NAA + EthylBloc + Silwet L-77 can delay maturity, preharvest fruit drop, and increase fruit size more than other combinations which may provide a wider window of harvest possible without the loss of fruit firmness.

Acknowledgements

Appreciation to Jean Engelman, Tim Stern, Maurice Keeler, Harriet Keeler for data collection, analysis, and technical assistance.

References

Byers, R. E. 1997a. Peach and nectarine fruit softening following aminoethoxyvinylglucine (AVG) sprays and dips. HortScience 32:86-88.

Byers, R. E. 1997b. Effects of Aminoethoxyvinylglycine (AVG) on Preharvest Fruit Drop, Maturity, and Cracking of Several Apple Cultivars. Journal of Tree Fruit Production. 2:77-97.

Byers, R. E. 1997c. Effects of Aminoethoxyvinylglycine (AVG) on Preharvest Fruit Drop and Maturity of 'Delicious' Apples. Journal of Tree Fruit Production. 2:53-75.

Fan X., S. M. Blankensip, and J. P. Pattheis 1999. 1-Methylcyclopropene inhibits apple ripening. J. Amer. Soc. Hort. Sci. 124:690-695.

Marini, R. P., R. E. Byers, and D. L. Sowers. 1989. Growth regulators and herbicides for delaying apple fruit abscission. HortScience 24:957-959.

Marini, R. P. and R. E. Byers. 1988a. Fruit abscission, fruit quality, and residue levels of dichloroprop used to control preharvest drop of apple. HortScience 23:717-719.

Marini, R. P. and R. E. Byers. 1988b. Methods for evaluating chemical inhibitors of apple abscission. HortScience 23:849-851.

Serek, M. E. C. Sisler and M. S. Reid. 1995. Effects of 1-MCP on the vase life and ethylene response of cut flowers. Plant Growth Regulation 16:93-97.

Sisler E. C. and M. Serek. 1997 Inhibitors of ethylene responses in plants at the receptor level: Recent developments. Physiologia Plantarium 100:577-582.

Yoder, K. S., A. E. Cochran, W. S. Royston, and S. W. Kilmer. 1996. Control of Penicillium blue mold by Aspire biofungicide on Golden Delicious apples, 1995. Fungic. Nematic. Tests. Vol. 51:39.

Additional reference available on request.

Autio, W. R. and W. J. Bramlage. 1982. Effects of AVG on maturation, ripening, and storage of apples.

Bangerth F. 1978. The effect of a substituted amino acid on ethylene biosyntheses, respiration, ripening and pre-harvest drop of apple fruits. J. Amer. Soc. Hort. Sci. 103:401-404.

Batjer, L. P. and H. H. Moon. 1945. Effect of naphthaleneacetic acid spray on maturity of apples. Proc. Amer. Soc. Hort. Sci. 46:113-117.

Batjer, L. P. and A. H. Thompson. 1946. Effects of 2,4-dichlorophenoxyacetic acid sprays in controlling the harvest drop of several apple varities. Proc. Amer. Soc. Hort. Sci. 47:35-38.

Batjer, L. P. and A. H. Thompson. 1947. Further studies with 2,4-dichlorophenoxyacetic acid sprays in retarding fruit drop of Winesap apples. Proc. Amer. Soc. Hort. Sci. 49:45-48.

Batjer, L. P. and M. W. Williams. 1966. Effects of N-dimethyl amino succinamic acid (Alar) on watercore and harvest drop of apples. Proc. Amer. Soc. Hort. Sci. 88:76-79.

Curtis, O. F. Jr. 1961. Upgrading commercial packs of Rhode Island Greening apple slices II. Crop gain from delayed harvest. Proceeding 1961, Annual Meeting, New York State Horticultural Society. Pp 72-85.

Edgerton, L. J. 1947. A method for evaluating the effectiveness of growth substances in delaying apple abscission. Proc. Amer. Soc. Hort. Sci. 49:42-44.

Edgerton, L. J. and G. D. Blanpied. 1970. Interaction of succinic acid 2,2-dimethyl hydrazide, 2-chloroethylphosphonic acid and auxins on maturity, quality and abscission of apples. J. Amer. Soc. Hort. Sci. 95:664-666.

Edgerton, L. J. and M. B. Hoffman. 1948. Tests with 2,4-dichlorophenoxyacetic acid for delaying fruit drop of McIntosh. Proc. Amer. Soc. Hort. Sci. 51:67-70.

Gardner, F. E., P. C. Marth, and L. P. Batjer. 1940. Spraying with plant growth substances for control of the pre-harvest drop of apples. Proc. Amer. Soc. Hort. Sci. 37:415-428.

Harley, C. P., H. H. Moon, L. O. Regeimbal, and E. L. Green. 1946. 2,4-dichlorophenoxyacetic acid as a spray to reduce harvest fruit drop of apples. Proc. Amer. Soc. Hort. Sci. 47:39-43.

Looney, N. E. and E. J. Hogue. 1987. Chemical control of pre-harvest fruit drop on 'McIntosh' apple: A comparison of mecoprop chloride, dichlorprop, fenoprop, NAA, and lactidichlor ethyl. HortScience 22:1036. (Abstr.)

Looney, N. E. and W. P. Cochrane. 1981. Relative effectiveness of and residue declination values for dichloroprop, fenoprop and napthaleneacetic acid used to control pre-harvest drop of McIntosh apples. Can. J. Plant Sci. 61:87-91.

Marini, R. P. and R. E. Byers. 1988a. Methods for evaluating chemical inhibitors of apple abscission. HortScience 23:849-851.

Marini, R. P., R. E. Byers, D. Sowers, M. E. Marini, and R. W. Young. 1988b. Fruit abscission, fruit quality, and residue levels of dichlorprop used to control pre-harvest drop of apple. HortScience 23:717-719.

Marini, R. P. and R. E. Byers, D. Sowers, and R. W. Young. 1988c. Fruit abscission and fruit quality of apples following use of dicamba to control pre-harvest drop. J. Amer. Soc. Hort. Sci. 115:390-394.

Marini, R. P., R. E. Byers, and D. L. Sowers. 1989. Growth regulators and herbicides for delaying apple fruit abscission. HortScience 24:957-959.

Marini, R. P. and R. E. Byers, D. Sowers. 1993. Repeated applications of NAA control pre-harvest drop of 'Delicious' apples. J. Hort. Sci. 68:247-253.

Mattus, G. E. and R. C. Moore. 1954. Pre-harvest growth regulator sprays on apples. I. Drop and maturity 1952 and 1953. Proc. Amer. Soc. Hort. Sci. 64:199-208.

Mattus, G. E., R. C. Moore, and H. A. Rollins, Jr. 1956. Pre-harvest growth regulator sprays on apples. II. Drop and maturity for 1954 and 1955. Proc. Amer. Soc. Hort. Sci. 67:63-67.

Pollard, J. E. 1974. Effects of SADH, ethephon and 2,4,5-T on color and storage quality of 'McIntosh' apples. J. Amer. Soc. Hort. Sci. 99:341-343.

Poapst, P. A., G. M. Ward, W. R. Phillips. 1959. Maturation of McIntosh apples in relation to starch loss and abscission. Canadan J. of Plant Science. 39:257-263.

SAS Institute. 1985. SAS User's guide and SAS statistical procedures. SAS Institute, Cary N. C.

Schupp, J.R. D. C. Ferree. 1988. Effects of root pruning at four levels of severity on growth and yield of 'Melrose'/M.26 apple trees. J. Amer. Soc. Hort. Sci. 113:194-198

Schomer, H., M. W. Williams, and H. D. Billingsley. 1971. Effect of combinations of growth regulators on maturity and quality of 'Tydeman's Red' apples. HortScience 6:453-455.

Shafer, W. E., G. Clarke, J. Hansen, D. Woolard, B N. Defisetty, and R. Fritts. 1995a. Practical applications of Aminoethoxyvinylglycine. Proc. 22nd Ann. Mtg. Plant Growth Regulator Soc. Amer. p11-15.

Shafer, W. E., R. Fritts, and B N. Defisetty. 1995b. A Commercial formulation of Aminoethoxyvinylglycine (AVG) for use on apples. Proc. 91st Ann. Mtg. Wash. State Hort. Assoc. (in press).

Shallenberger, R. S., R. L. Labelle, and J. C. Moyer. 1961. Upgrading commercial packs of RhodeIsland Greening apple slices – . Maturity and Processing Studies. Proc. Ann. New York State Horticultural Society, p 72-85.

Smock, R. M., L. J. Edgerton, and M. B. Hoffman. 1954. Some effects of stop drop auxins and respiratory inhibitors on the maturity of apples. Proc. Amer. Soc. Hort. Sci. 63:211-219.

Southwick, F. W., I. E. Demoranville, and J. F. Anderson. 1953. The influence of some growth regulating substances on pre-harvest drop, color, and maturity of apples. Proc. Amer. Soc. Hort. Sci. 61:155-162.

Thompson, A. H. 1952. Further experiments with 2,4,5-trichlorophenoxypropionic acid sprays for control of the pre-harvest drop of apples. Proc. Amer. Soc. Hort. Sci. 60:175-183.

Williams, M. W. 1980. Retention of fruit firmness and increase in vegetative growth and fruit set of apples with aminoethoxyvinylglycine. HortScience 15:76-77.

Yu, Y. B. and S. F. Yang. 1979. Auxin-induced ethylene production and its inhibitors by aminoethoxyvinylglycine and cobalt ion. Plant Physiol. 64:1074-1077.

(Not for publication or distribution, CSFWC 2002)

Influence of Adjuvants and Temperature on Apple Fruit Set and Chemical Thinning and Peach Bloom Thinning

R. E. Byers, D. H. Carbaugh, L. D. Combs
Professor of Horticulture and Research Specialists
Virginia Polytechnic Institute and State University,
Alson H. Smith, Jr. Agricultural Research and Extension Center,
595 Laurel Grove Road
Winchester, VA 22602

Abstract. The thinning activity of 6-BA alone was marginal but its combination with Sevin + Oil made for a potent thinner. Oil was found to be the best potentiator of 6-BA and its combinations with Sevin; and Oil was more effective at increasing rates in the 6-BA + Sevin combination. Shading trees for 3 days effectively defruited trees, which showed that reduced photosynthesis alone can have a major influence on fruit retention. The influence of shade could not be overcome by sorbitol sprays. Trees temporarily brought into darkness at 40F vs 70F in growth chambers for 2 to 5 days also showed that temperatures during photosynthetic stress periods were important to fruit retention/loss. In addition, some data indicated that sorbitol in combination with 6-BA+Sevin+Oil may increase thinning; thus, the possibility that increased energy supplied by sorbitol increased absorption of the thinners.

Chemicals used: Sodium salt of napthalene acetic acid (NAA, Fruitone-N); 2-chloroethylphosphonic acid (ethephon, Ethrel); 1-naphthy N-methylcarbamate (carbaryl, Sevin XLR); 6-BA (6-benzyladinine); mixture of 6-benzyladinine and gibberellin A_{4+7} (Accel). Regulaid® (a surfactant mixture, polyoxyethylenepolypropoxypropanol, alkyl 2-ethoxethanol, and dihydroxy propane; Silwet L-77 (polyalkyleneoxide modified heptametyltrisiloxane, silicon surfactant), LI-700 (80%, phosphatidylcholine, methylacetic acid and alkyl polyoxyethylene ether), Choice (commercial product containing proprioitory water conditioners); Superior Oil (Drexel Damoil 70 sec delayed dormant spray oil), $CaCl_2$, NH_4SO_4 ; 2,6,8-trimethyl-4-nonyloxypolyethyleneoxyethanol (Tergitol TMN-6 surfactant).

Introduction

The objectives of the experiments reported here were to: 1) investigate hormone-type chemical combinations for apple fruit thinning, 2) observe injuries to fruit and foliage caused by chemical thinners, 3) compare the effectiveness of chemical thinner and adjuvant combinations, 4) determine the influence of temperatures (40^{O}F and 70^{O}F) alone or after chemical thinner application on fruit retention and low light stress, and 5) determine the influence of multiple applications of a pollination/fertilization inhibitor (Tergitol) on peach flower thinning, fruit set, foliage, and twig injury.

Materials and Methods

Chemicals were applied to whole trees with a Swanson 3-point-hitch airblast sprayer (Durand Wayland, Inc., LaGrange, Georgia; both fans adjusted to one side to double air output) or with a hand wand sprayer, or a low-pressure hand-wand sprayer. Specific information about tree size, spray application dates, chemical and water rates, stage of development, and temperatures are reported in each table. All apple tests were randomized complete block experiments. Trees were selected for uniform flowering at bloom and were blocked according to row and terrain into replicate blocks for the number of treatments listed in each table.

Apple crop density (fruit/cm^2 limb cross sectional area, CD) was determined by counting fruit on 3 pre-selected limbs per tree; or on whole trees (fruit/cm^2 trunk cross sectional area, CD). Three limbs per tree were tagged during the late pink stage; at the point where limbs were tagged, limb circumferences were measured. The number of fruit on each limb were counted 50 to 55 days (following bloom and after unfertilized fruit had dropped). Crop density (CD) on sample limbs was expressed as fruit•cm^2 limb cross-sectional area (LCSA). In the event that all the fruit on a tree were counted, crop density (CD) was expressed as fruit•cm^2 trunk cross-sectional area (TCSA). Past experience has indicated that when using these techniques the desirable crop load is approximately 4 to 6 fruit•cm^2 limb (or trunk) cross-sectional area after thinning (Byers and Lyons 1984, 1985; Byers, et. al. 1985; Byers; Byers and Carbaugh, 1991; Byers, 1997).

In several experiments, a 10 fruit sample was collected from each tree near harvest. Fruit diameter and length, percentage red color, fruit scarring, and/or russet was determined for each sample. Fruit diameter and length was determined by alignment of all 10 fruit on a right angle board for measurement. Percentage red color was visually rated from 0 to 100%. Stem-end and side russet were rated as 0=no russet to 5= severe russet.

Data for apple and peach crop density, fruit diameter, and vegetative injury were analyzed with SAS (SAS Institute, Cary, N. C.), general linear model (GLM procedures) to evaluate the linear and quadratic effects, pre-planned single-degree of freedom contrasts of interest, and/or Duncan's New Multiple Range Test depending upon the experimental design. The experimental designs for all apple experiments were randomized complete block designs (RCBD) and were blocked by location within rows.

Expt. 1. Thirty-six 27-year-old 'Redspur Delicious'/MM.111 trees were selected for uniformity and blocked according to row and terrain into 5 blocks for 6 treatments (Table 1). Treatments were applied with Swanson 3-point-hitch airblast sprayer at 100 gal/acre on May 6 when fruit were 9.4 mm in diameter. Trees were considered 80% TRV; thus, the dilute rate of 100 mg•L^{-1}/300gal/acre was equivalent to 300 mg•L^{-1}/100gal/acre.

Expt. 2. Sixty 27-year-old 'Law Rome'/MM.111 trees were selected for uniformity and blocked according to row and terrain into 10 blocks for 6 treatments (Table 2). Treatments were applied with Swanson 3-point-hitch airblast sprayer at 100 gal/acre on May 8 when fruit were 12.8 mm in diameter. Trees were considered 50% TRV; thus, the dilute rate of 200 mg•L^{-1}/200gal/acre was equivalent to 200 mg•L^{-1}/100gal/acre.

Expt. 3. Twelve 27-year-old 'Virginia Gold'/MM.111 were selected for uniformity and blocked according to row and terrain into 2 blocks for 2 treatments (Table 3). Treatments were applied with airblast sprayer at 100 gal/acre on May 6 when fruit were 11.2 mm in diameter.

Expt. 4. Twelve 27-year-old 'Redspur Delicious'/MM.111 were selected for uniformity and blocked according to row and terrain into 2 blocks for 2 treatments (Table 4). Treatments were applied with airblast sprayer at 100 gal/acre on May 10 when fruit were 12.8 mm in diameter and then sprayed on May 30 with ethrel when fruit were 24.6 mm.

Expt. 5. Fifty-two 12-year-old 'Gala'/M.27 were selected for uniformity and blocked according to row and terrain into 4 blocks 13 treatments (Table 5). Treatments were applied with a low pressure hand-wand sprayer on May 6 when fruit were 12.4 mm in diameter.

Expt. 6. Sixty-six 3-year-old 'York'/M.9 were selected for uniformity and blocked according to row and terrain into 6 blocks for 11 treatments (Table 6). Treatments were applied with a low pressure hand-wand sprayer on May 23 when fruit were 23.4 mm in diameter.

Expt. 7. One hundred twelve 3-year-old 'Gala'/M.9 were selected for uniformity and blocked according to row and terrain into 8 blocks for 14 treatments (Table 7). Treatments were applied with a low pressure hand-wand sprayer on May 8 when fruit were 10.8 mm in diameter.

Expt. 8. Seventy-seven 3-year-old 'Golden Delicious'/M.9 were selected for uniformity and blocked according to row and terrain into 7 blocks for 11 treatments (Table 8). Treatments were applied with a low pressure hand-wand sprayer on May 17 when fruit were 18.6 mm in diameter.

Expt. 9. One hundred thirty 3-year-old 'Pink Lady'/M.9 were selected for uniformity and blocked according to row and terrain into 13 blocks for 10 treatments (Table 9). Treatments were applied with a low pressure hand-wand sprayer on May 9 when fruit were 13.5 mm in diameter.

Expt. 10. One hundred thirty ??-year-old 'Red Chief Delicious'/M.111 were selected for uniformity and blocked according to row and terrain into 10 blocks for 13 treatments (Table 10). Treatments were applied with a low pressure hand-wand sprayer on May 23, 24, 25 when fruit were 10.9 mm in diameter.

Expt. 11. One hundred eight 6-year-old 'Golden Delicious'/M.27 were selected for uniformity and blocked according to row and terrain into 6 blocks for 18 treatments (Table 11ABCD). Treatments were applied with a low pressure hand-wand sprayer on May 10 when fruit were 12.4 mm in diameter.

Expt. 12. Sixty 6-year-old 'Golden Delicious'/M.27 were selected for uniformity and blocked according to row and terrain into 5 blocks for 12 treatments (Table 12AB). Treatments were applied with a low pressure hand-wand sprayer on May 17 when fruit were 18.2 mm in diameter.

<u>Expt. 13.</u> Twenty eight 10-year-old 'Cresthaven' were selected for uniformity and blocked according to row and terrain into 7 blocks for 4 treatments (Table 13). Treatments were applied with an airblast sprayer on Apr 10 (trt#2), Apr 16 (trt#3), and Apr 24, 27 (trt#4), when trees were at 80% open flowers (trt#2), petal fall (trt#3), and shuck split (trt#4).

<u>Expt. 14.</u> Twenty eight 10-year-old 'Redhaven' were selected for uniformity and blocked according to row and terrain into 7 blocks for 4 treatments (Table 14). Treatments were applied with an airblast sprayer on Apr 10 (trt#2), Apr 16 (trt#3), and Apr 24, 27 (trt#4), when trees were at 80% open flowers (trt#2), petal fall (trt#3), and shuck split (trt#4).

Results and Discussion

<u>Expt. 1.</u> The Valent 30001 formulation of 6-BA at 300 mg•L^{-1} alone was not a very effective thinner for 'Redspur' Delicious'/M.111, but the addition of Oil potentiated 6-BA thinning; the addition of Sevin + Oil to 6-BA cause further thinning. Half the rate of 6-BA (Valent or Fine Agro) at 150 mg•L^{-1} + Sevin + Oil was more effective than 6-BA (300 mg•L^{-1})+ Oil (Table 1).

<u>Expt. 2.</u> The Valent 30001 formulation of 6-BA at 50, 100, 200 mg•L^{-1} alone was not a very effective thinner (trt#s 2,3,4) for 'Law Rome'/M.111, and the addition of Oil did not potentiated 6-BA thinning (trt#s 5,6,7); the addition of NH4SO4 or CaCl2 to 6-BA at 100 mg•L^{-1} had no effect on 6-BA thinning (trt#s 8,9,10) (Table 2).

<u>Expt. 3.</u> The Valent 30001 formulation of 6-BA at 300 mg•L^{-1} + Sevin XLR + Oil at 100gal/acre was a very effective thinner (trt# 2) for 'Virginia Gold'/M.111.

<u>Expt. 4.</u> The Accel formulation of 6-BA + GA4+7 at 300 mg•L^{-1} + Sevin XLR + Oil at 100gal/acre did not cause thinning (trt# 2) of Redspur Delicious'/M.111.

<u>Expt. 5.</u> The Valent 30001 formulation of 6-BA at 50, 100, 200 mg•L^{-1} alone did not cause fruit thinning (trt#s 2,3,4) of 'Gala'/M.27, and the addition of Oil did not potentiated 6-BA thinning (trt#s 5,6,7); however, the addition of Sevin + Oil to 6-BA caused substantial thinning leaving an adequate crop (trt#s 8,9,10). Increasing oil rates from 1pt to 1 gal/100 gal increased thinning (P=0.059) of the 50 mg•L^{-1} 6-BA + 1pt/100gal Sevin XLR combination. Fruit diameter or length were not affected by the treatments (Table 5).

<u>Expt. 6.</u> The Valent 30001 or Fine Agro formulations of 6-BA were ineffective alone or in combination with Oil, NH4SO4 or CaCl2 (trt# 4,5,6,7,8,9,10) for 'York'/M.9. The only treatment that may have caused thinning was Valent 30001 6-BA + Oil (trt#3).

Expt. 7. T he Valent 30001 formulation of 6-BA at 0, 50, 100, 150, 200 mg•L^{-1} alone cause increased fruit thinning as concentration increased (regression trt#s 1,2,3,4,5) on 'Gala'/M.9. The addition of Li-700 did not potentiated 6-BA thinning(trt#s 6); however, the addition of Silwet L-77 did. Oil was the best single adjuvant for 6-BA (trt#s 8,12) leaving an adequate crop. NH4SO4, CaCl2, or NH4SO4 + CaCl2 to 6-BA did not potentiate thinning (trt#s 9,10,11). The best thinning was obtained by 50 mg•L^{-1} 6-BA + 1pt/100gal Sevin XLR + Oil (trt#s 13,14). These treatments (trt#s 13,14) also gave the best L/D ratio (Table 7).

Expt. 8. The Valent 30001 formulation of 6-BA at 50 mg•L^{-1} alone caused some fruit thinning (trt#s 2) on 'Golden Delicious'/M.9. The addition of Sevin XLR + Oil substantially potentiated 6-BA thinning (trt#s 3). Increasing oil rate did not provided increased thinning of 6-BA + Sevin XLR (trt#s 3,4,5,7) but the numbers indicate a trend to increased thinning. The best thinning was obtained by 100 mg•L^{-1} 6-BA + 2qt/100gal Sevin XLR + Oil (trt#s 6). Increasing oil rate provided increased thinning of Sevin XLR (trt#s 8,9,10) leaving an adequate crop on most treatments. Oil alone did not cause thinning (trt#11).

Expt. 9. The Fruittone-N formulation of NAA alone or + Regulaid or Choice did not cause fruit thinning (trt#s 2,3,4) of 'Gala'/M.27, but several other combinations of NAA with NH4SO4, Sorbitol, Ca Cl2 (trt#s 5,6,7,8,9,10) did cause thinning.

Expt. 10. Sevin XLR + Oil did not cause fruit thinning (trt# 2) of 'Red Chief Delicious'/MM.111. However, trees were almost defruited by Sevin XLR + Oil + 3 days + shade (trt# 3). If Sorbitol was sprayed on trees each day during the shade event, fruit were not retained (trt# 4). The addition of Sorbitol to Sevin + Oil (no shade) caused more thinning (trt#6) than without the Sorbitol (trt# 2). Sorbitol alone did not cause thinning (trt #6); and sorbitol sprays did not hold fruit on shaded trees.

6-BA + Oil did not cause fruit thinning (trt# 8) of 'Red Chief Delicious'/MM.111. However, trees were substantially thinned by 6-BA + Oil + 3 days + shade (trt# 9). If Sorbitol was sprayed on trees each day during the shade event, fruit were thinned to approximately the same level (trt# 11). The addition of Sorbitol to 6-BA + Oil (no shade) had no thinning effect (trt#10) than without the Sorbitol (trt#8) or the control (trt#1). Sorbitol alone did not cause thinning (trt #6). Sevin + 6-BA + Oil caused substantial thinning (trt#12) and the addition of Sorbitol to this combination may have slightly increased thinning (trt#13) but not statistically. The use of sorbitol with thinners caused increased thinning (contrast trt#s 4,5,6,10,11 vs 1,2,3,8,9,12).

Expt. 11. After a 68 hour period of darkness at 40F or 75F, more fruit were retained on 'Golden Delicious'/M.27 trees at 40F than at 75F (trt 2 vs 3) (Figure?). Trees sprayed with NAA, Carbaryl + NAA, and 6-BA retained more smaller fruit (<23 mm) on trees held at 40F than at 75F, but not for 6BA + Carbaryl + Oil. The proportion of fruit sizes and fruit numbers retained by trees were related to chemical treatment an temperature in the dark period.

Expt. 12. After periods of darkness from 44 to 140 hours at 40F or 75F, more fruit were retained on 'Golden Delicious'/M.27 trees at 40F than at 75F (trt 3,5,7,9,11 vs 4,6,8,10,12). In addition more smaller fruit (<23 mm) were retained on trees held at 40F than at 75F. The average single fruit weight increased with darkness at 75F but decreased at 40F since more thinning occurred at 75F than at 40F; and more fruit of smaller sizes were retained at 40F than at 75F(Figure?).

Expected Significance to the Apple Industry

The thinning activity of 6-BA alone was marginal but its combination with Sevin + Oil made for a potent thinner. Oil was found to be the best potentiator of 6-BA and its combinations with Sevin; and Oil was more effective at increasing rates in the 6-BA + Sevin combination. Shading trees for 3 days effectively defruited trees, which showed that reduced photosynthesis alone can have a major influence on fruit retention. The influence of shade could not be overcome by sorbitol sprays. Trees temporarily brought into darkness at 40F vs 70F in growth chambers for 2 to 5 days also showed that temperatures during photosynthetic stress periods were important to fruit retention/loss. In addition, some data indicated that sorbitol in combination with 6-BA+Sevin+Oil may increase thinning; thus, the possibility that increased energy supplied by sorbitol increased absorption of the thinners.

Acknowledgements

Appreciation to David Carbaugh, Leon Combs, Heath Combs, Jean Engelman, Tim Stern, Maurice Keeler, Harriet Keeler for data collection, analysis, and technical assistance.

References

Byers, R. E. and C. G. Lyons, Jr. 1984. Flower thinning of peach with desiccating chemicals. HortScience 19:545-546.

Byers, R. E. and C. G. Lyons, Jr. 1985. Peach flower thinning and possible sites of action of desiccating chemicals. J. Amer. Soc. Hort. Sci. 110:662-667.

Byers, R. E. ,C. G. Lyons, Jr., S. J. Donohue. 1985. Effect of spray chemical deposits from spraying adjacent rows on efficacy of peach bloom thinners. HortScience 20:1076-1078.

Byers, R. E. and D. H. Carbaugh. 1991. Effect of chemical thinning sprays on apple fruit set. HortTechnology 1:41-48.

Byers, R. E. 1997. Effects of Bloom-Thinning Chemicals on apple fruit set. J. Tree Fruit Production. 2:13-31.

Byers, R. E. 1999. Effect of bloom-thinning on peach fruit set. J. of Tree Fruit Production 2:59-78.

Poapst, P. A., G. M. Ward and W. R. Phillips. 1959. Maturation of McIntosh apples in relation to starch loss and abscission. Can. J. Plant Sci. 39:257-263.

SAS Institute, Inc. 1985. SAS user's guide:Statistics. SAS Inst., Cary, N. C.

More references are available on request.

The Influence of Apogee and Its Combinations with Ethephon, Cations, Water Source, and/or Adjuvants on Apple Tree Growth Control and/or Return Bloom

R. E. Byers, D. H. Carbaugh, and L. D. Combs
Professor of Horticulture and Research Specialists
Virginia Polytechnic Institute and State University,
Alson H. Smith, Jr. Agricultural Research and Extension Center,
595 Laurel Grove Road
Winchester, VA 22602

Abstract. In 2002, Prohexadione-calcium technical grade 90.1% (PHCA) applied to 'Fuji'/M.9 trees in 3 applications suppressed tree growth; but the addition of NH_4SO_4 further suppressed growth. PHCA + $CaCl_2$ in deionized water suppressed the effect of P-Ca. PHCA + $CaCl_2$ + NH_4SO_4 gave equivalent control of shoot growth as if no $CaCl_2$ had been added to the tank mix. NH_4NO_3 or Na_2SO_4 was as effective as NH_4SO_4. These data suggest that both the NH_4 and SO_4 ions were potentiating PHCA. These data indicate that regardless of the water source that NH_4SO_4 or NH_4N0_3 is needed to obtain maximum effectiveness from the technical P-Ca. Technical P-Ca added to well water was completely inhibited by hard well water, but the addition of NH_4SO_4 completely restored the activity of PHCA in well water. P-Ca (Apogee) + NH_4SO_4 in well water improved efficacy from P-Ca (Apogee). The addition of Regulaid to P-Ca (Apogee) + NH_4SO_4 did not improve efficacy further. P-Ca (Apogee) + $CaCl_2$ substantially inhibited efficacy of P-Ca (Apogee). NH_4SO_4 + Regulaid restored efficacy of P-Ca (Apogee) at + $CaCl_2$. Li 700 + Choice + P-Ca (Apogee) was as effective as NH_4SO_4 + Regulaid + P-Ca (Apogee). Three applications of Li 700 + Choice + P-Ca (Apogee) at 63 ppm or Quest + P-Ca (Apogee) at 63 ppm provided equivalent shoot growth suppression as 3 applications of Li 700 + Choice + P-Ca (Apogee) at 125 ppm or 3 applications of NH_4SO_4 + Regulaid + P-Ca (Apogee) at 63 ppm by 22 Jun. Only 3 of the 6 applications of the 63 ppm had been applied on 22 June. If regrowth in 2002 is substantial in the late summer, our expectations are that the 6 application treatments will provide more shoot growth suppression. Additional measurements will be taken in Dec 2002 after the summer growth period is complete to determine the amount of re-growth after 22 Jun 02.

In 2001, Prohexadione-calcium technical grade 93.2% (PHCA) applied to 'Fuji'/M.9 trees in 3 applications in deionized water reduced tree growth somewhat. The addition of NH_4SO_4 to PHCA further suppressed tree growth. However, if PHCA was mixed in well water, PHCA did not suppress tree growth. Apogee + Regulaid in well water was not as effective as simply adding more NH_4SO_4; however, Regulaid may have had some additional influence but not statistically. If $CaCl_2$ (frequently used to reduce bitter pit and corkspot disorders) was added to Apogee + Regulaid, the calcium completely inhibited the growth suppression of Apogee. If NH_4SO_4 is added at the same rate as $CaCl_2$ (w/w) the growth suppression was completely restored. If Solubor was added to Apogee + Regulaid, the effectiveness in of Apogee is compromised but $MgSO_4$ did not. Apogee + Li-

700 + Choice, a commercial water conditioner, provided the most effective growth suppression. Choice, among other ingredients, has NH_4SO_4 in the formulation. In one of three treatments, Apogee decreased the number of apples harvested on 11 Oct; even though the Apogee treated trees appeared to have more apples due to the inhibition of tree growth. The Apogee treatment that had the fewest fruit per tree, numerically, also had the largest fruit.

In 2001, prohexadione-calcium [formulated as 27.5% BAS-125 (Apogee™) or the technical 93.2% prohexadione-calcium (PHCA) applied to 'Empire'/Mark trees in deionized water did not reduced tree growth. Only the combination of Apogee+NH4SO4+Regulaid caused fruit cracking (21%) as compared to 7% in the control.

Chemicals used: Prohexadione-calcium (P-Ca) formulated as Apogee™, (27.5% P-Ca), or Technical 3-oxido-4-propionyl-5-oxo-3-cyclohexenecarboxylate, (93.5% P-Ca), Regulaid® (a surfactant mixture, polyoxyethylenepolypropoxypropanol, alkyl 2-ethoxethanol, and dihydroxy propane; Silwet L-77 (polyalkyleneoxide modified heptametyltrisiloxane, silicon surfactant), LI-700 (80%, phosphatidylcholine, methylacetic acid and alkyl polyoxyethylene ether), Choice (commercial product containing proprioitory water conditioners); Superior Oil (Drexel Damoil, 70 sec delayed dormant spray oil), ethephon (2-chloroethyl phosphonic acid), NaOH, HCl, KCl, NaCl, $CaCl_2$, $MgSO_4$, $(NH_4)_2SO_4$, Urea, Solubor (20.5%, Boron equivalent), and Captan (N-Trichloromethylthio-4-cyclohenene-1,2-dicarboximide).

Introduction

In northern Virginia, over 80% of the apple crop is grown for processing. Many trees are propagated on vigorous rootstocks and require much pruning, especially in the tops. To reduce costs and labor needs, many growers prune every second or third year. When trees are not pruned, shading caused by tree growth in the current season is detrimental to pest control, fruit quality, and yield.

Several plant growth regulators have been evaluated for their potential to reduce vegetative growth of tree fruits, thereby reducing pruning costs and improving fruit quality. Several reviews (Faust, 1984; Looney, 1983; Luckwill, 1970; Miller, 1988; Williams, 1984) indicate that many of these regulators have effects of greater commercial value than control of vegetative growth.

The objectives of the experiments reported here were to evaluate the effectiveness of prohexadione-calcium [formulated as 27.5% BAS-125 (Apogee™) or the technical 93.2% or 90.1% prohexadione-calcium (PHCA), alone or in combinations with deionized water, well water high in calcium, calcium chloride, ammonium sulfate, spray-adjuvants, Ethrel for additional tree-growth control, and GA_3 for flower bud inhibition.

Materials and Methods

Data were analyzed by ANOVA and GLM procedures using SAS software (SAS Institute, 1985). Means were compared by single-degree-of-freedom contrasts, by linear and polynomial regressions, or Duncan's New Multiple Range Test depending upon the experimental design.

Expt. 1. In 2002, one hundred thirty three 7-year-old 'Fuji'/M.9 trees (7 blocks) were selected for 19 treatments (Table 1). In 2002, Prohexadione-calcium technical grade 90.1% (PHCA) was applied at 125 ppm to 'Fuji'/M.9 trees (dilute to drip) in 3 applications at FB+7, FB+29, FB+48, or 6 applications at 63ppm P-CA + 135 ppm ethephon on FB+7, FB+29, FB+48, FB+69, FB+90, FB+113 days. In addition, Regulaid, NH_4SO_4, NH_4NO_3, Na_2SO_4, Choice, LI-700, $CaCl_2$, Ethrel, and Quest were applied in various combinations with Apogee (formulated as 27.5% ai) or technical pro-hexadione-calcium (90.1% ai; PHCA) in deionized water or "hard" well water as indicated in Table 1.

Ten of the longest scaffold shoots were tagged around the periphery of each tree and their lengths were measured on June 22. During dormancy, the 10 scaffold shoots will be pruned and the basal diameters and lengths of the and terminal shoots recorded. In addition, the nodes/cm of the basal 40 cm and nodes/cm of the upper 30 cm of shoots will be recorded. Trees will be pruned and the total length of the shoots longer than 30 cm, the weight and time required to prune, the number of cuts, and the pruning weights/cm^2 trunk cross-sectional area (TCSA) per tree will be recorded.

Expt. 2. In 2001, seventy-eight 6-year-old 'Fuji'/M.9 trees (6 blocks) were selected for 13 treatments (Table 2). Prohexadione-calcium (Apogee) was applied at 125 ppm (to drip) in 3 applications to the same trees at FB+7, FB+28, and FB+59 days. In addition, Regulaid, NH_4SO_4, Choice, LI-700, Quest, $MgSO_4$, $CaCl_2$, were applied in various combinations with Apogee (formulated as 27.5% ai) or technical pro-hexadione-calcium (93.2% ai; PHCA) in deionized water or "hard" well water as potential adjuvants, or water conditioners as indicated in Table 1. Ten of the longest scaffold shoots were tagged around the periphery of each tree and their lengths were measured on July 13. During dormancy, the 10 scaffold shoots were pruned and the basal diameters and lengths of the terminal shoots recorded. In addition, the nodes/cm of the basal 40 cm and nodes/cm of the upper 30 cm of shoots were recorded. Trees were pruned and the total length of the shoots longer than 30 cm, the weight and time required to prune, the number of cuts, and the pruning weights/cm^2 trunk cross-sectional area (TCSA) per tree were be recorded.

Expt. 3. In 2001, twenty-four 10-year-old 'Empire'/Mark trees (6 blocks) were selected for 4 treatments (Table 3A). Prohexadione-calcium (PHCA, 93.2% ai) or Apogee (27.5% ai) was applied at 125 ppm (to drip) in 3 applications to the same trees at FB+9, FB+30 and FB+64 days. In addition Regulaid, NH_4SO_4, and/or Solubor, were applied in various combinations to determine if fruit cracking would occur as indicated in Table 3B. On July 19, ten of the longest scaffold shoots were tagged around the periphery of each tree and their lengths were measured. In 2002, return bloom for each tree was visually estimated as % of spurs flowering.

Results and Discussion

Expt. 1. In 2002, Prohexadione-calcium technical grade 90.1% (PHCA) applied at 125 ppm to 'Fuji'/M.9 trees (dilute to drip) in 3 applications at FB+7, FB+29, FB+48 suppressed tree growth (trt#2); but the addition of NH_4SO_4 further suppressed growth (trt#3) (Table 1). PHCA + $CaCl_2$ in deionized water suppressed the effect of P-Ca (trt#4). PHCA + $CaCl_2$ + NH_4SO_4 gave equivalent control of shoot growth (trt#5) as if no $CaCl_2$ had been added to the tank mix (trt#3). NH_4NO_3 (trt# 6) or Na_2SO_4 (trt# 7) was as effective as NH_4SO_4 (trt# 3). These data suggest that both the NH_4 and SO_4 ions were potentiating PHCA. These data indicate that regardless of the water source that NH_4SO_4 or NH_4N0_3 is needed to obtain maximum effectiveness from the technical P-Ca. Technical P-Ca added to well water was completely inhibited by hard well water (trt#8) but the addition of NH_4SO_4 completely restored the activity of PHCA (trt#9) in well water. P-Ca (Apogee) at 125 ppm + NH_4SO_4 at either rate (trt#10, 11) in well water improved efficacy from P-Ca (Apogee) at 125 ppm alone. The addition of Regulaid to P-Ca (Apogee) at 125 ppm + NH_4SO_4 (trt#12) did not improve efficacy further. P-Ca (Apogee) at 125 ppm + $CaCl_2$ (trt#13) substantially inhibited efficacy of P-Ca (Apogee). NH_4SO_4 (trt#14) + Regulaid restored efficacy of P-Ca (Apogee) at 125 ppm + $CaCl_2$. Li 700 + Choice + P-Ca (Apogee) at 125 ppm (trt#15) was as effective as NH_4SO_4 + Regulaid + P-Ca (Apogee) (trt#12). Three applications of Li 700 + Choice + P-Ca (Apogee) at 63 ppm (trt#16) or Quest + P-Ca (Apogee) at 63 ppm (trt#18) provided equivalent shoot growth suppression as 3 applications of Li 700 + Choice + P-Ca (Apogee) at 125 ppm (trt#15) or 3 applications of NH_4SO_4 + Regulaid + P-Ca (Apogee) at 63 ppm (trt#19) by 22 June. Only 3 of the 6 applications of the 63 ppm had been applied by 22 June,. If regrowth is substantial in the late season our expectations are that the 6 application treatments will provide more shoot growth suppression.

Additional measurements will be taken in Dec 2002 after the summer growth period is complete to determine the amount of re-growth after 22 Jun 02.

Expt. 2. In 2001, Prohexadione-calcium technical grade 93.2% (PHCA) applied at 125 ppm to 'Fuji'/M.9 trees (dilute to drip) in 3 applications at FB+7, FB+28, and FB+59 days in deionized water reduced tree growth somewhat (trt#2), and the addition of NH_4SO_4 to PHCA further suppressed tree growth (trt#3)(Table 2). However, if PHCA was mixed in well water (250ppm hardness), PHCA did not suppress tree growth (trt#4). Apogee (27.5% ai + some NH_4SO_4 in the formulation) + Regulaid (trt#6) in well water was not as effective as simply adding more NH_4SO_4 (trt#7); however, the Regulaid may have had some additional influence but not statistically (trt#8). If $CaCl_2$ was added to trt#6, the calcium completely inhibited the effect of the Apogee + Regulaid (trt#9); but if NH_4SO_4 was added at the same rate (w/w), the effectiveness was completely restored (trt#10). If Solubor is added the effectiveness of Apogee was compromised (trt#11), but $MgS0_4$ did not (trt#12). Apogee + Li-700 + Choice, a commercial water conditioner, was the most effective treatment (trt#13). Choice among other ingredients has NH_4SO_4 in the formulation (trt#13). Additional measurements taken 4 Dec 01 after the summer growth period was complete indicated that re-growth after 13 July was substantially greater for treatments that suppressed growth the greatest before 13 July 01.

Expt. 3. In 2001, prohexadione-calcium [formulated as 27.5% BAS-125 (Apogee™) or the technical 93.2% prohexadione-calcium (PHCA)] applied at 125 ppm to 'Empire'/Mark in 3 applications at FB+9, FB+30, and FB+64 days in deionized water did not reduced tree growth (Table 3A). Only the combination of Apogee+NH_4SO_4+Regulaid caused fruit cracking (21%) as compared to 7% in the control (Table 3B). Data from other experiments suggest that this combination is more effective as a result of increase absorption or activation of prohexadione-calcium; thus the cracking may be related to a higher concentration of prohexadione-calcium in the fruit or tree.

Summary

The past two seasons' experiments suggest, the benefit of additional NH_4SO_4 on Prohexadione-calcium response may not be due to an adjustment of pH or counter acting hardness (as defined by high Ca concentration); but a direct effect on uptake and/or activity of the molecule. The possibility exists that NH_4SO_4 may provide sufficient inorganic energy to a proton pump that may increase the loading of Prohexadione-calcium into the plant, or that the equilibrium of the Prohexadione-calcium with the NH_4 ion is critical during the absorption and action of this biosynthetic inhibitor of gibberellin.

The use of ethephon with Apogee provided some additional suppression of tree growth; but since ethephon will cause fruit thinning, a low rate must be chosen (Table1). The commercial water conditioners, Choice or Quest, were as effective as NH_4SO_4 + Regulaid for counteracting the effect of Calcium (Tables 1,2). Solubor also inhibited the activity of Apogee (Table 2). Three applications of Apogee at 63 ppm was not as good as 3 applications at 125 ppm by 22 June, but data for the full season has not been taken (Table 1). The expectation is that the six applications at approximately 3 week intervals will be superior to 3 applications; and the addition of ethephon will add substantially to the suppression of shoot growth.

Acknowledgements

Appreciation to Seth Combs, Heath Combs, Jean Engleman, Tim Stern, Maurice Keeler, and Harriet Keeler for data collection, analysis, and technical assistance.

References

Faust, M. (ed.). 1984 International workshop on controlling vigor in fruit trees. Acta Hort. 146.

Franklin M. H. 1986. The vital force: A study of bioenergetics. W. H. Freeman and Company. 574p.

Looney, N. E. 1983. Growth regulator usage in apple and pear production, p. 27-40 In: L. G. Nickell (ed.). Plant growth regulating chemicals, Vol. I. CRC Press, Boca Raton, Fla.

Luckwill, L. C. 1970. The control of growth and fruitfulness of apple trees. p. 237-254 In: L. C. Luckwill and C. V. Cutting (eds.). Physiology of tree crops. Academic Press, London.

Miller, S. S. 1988. Plant bioregulators in apple and pear culture. Hort. Rev. 10:309-401.

Poapst, P. A., G. M. Ward and W. R. Phillips. 1959. Maturation of McIntosh apples in relation to starch loss and abscission. Can. J. Plant Sci. 39:257-263.

SAS Institute, Inc. 1985. SAS user's guide:Statistics. SAS Inst., Cary, N. C.

Williams, M. W. 1984. Use of bioregulators to control vegetative growth of fruit trees and improve fruit efficiency, p.93-99. In: R. L. Orydn and F. R. Rittig (eds.). Bioregulators: Chemistry and uses. Amer. Chem. Soc. Washington, D. C.

(Not for publication or distribution, CSFWC 2002)

Root Restriction, an Alternative to Rootstocks, for Control of Flowering, Fruiting, Tree Growth, Yield Efficiency, and Fruit Quality of Apple Trees

R. E. Byers, D. H. Carbaugh, and L. D. Combs [1]
Virginia Polytechnic Institute and State University,
Alson H. Smith, Jr. Agricultural Research and Extension Center,
595 Laurel Grove Road
Winchester, VA 22602

Abstract. Trees planted in root restriction bags provided an alternative to dwarfing rootstocks for control of tree vigor. Root restriction suppressed tree growth, reduced the need for pruning, and increased tree flowering, yield efficiency, fruit color, and firmness and soluble solids. Root bags, with hole sizes of less than 2 mm in diameter restricted tree growth and root development more than desirable.

Apples wrapped in various root bag materials and presented to singly-caged voles (*Microtus spp.*) did not inhibit root bag penetration or damage to the apple. Only galvanized wire mesh (hardware cloth) and/or screen wire excluded voles from apples. Galvanized wire mesh was toxic to roots, limited root and tree growth, and caused significant leaf yellowing.

Introduction

Even though dwarfing rootstocks are widely used for control of apple tree size and increased fruiting efficiency, they have many problems associated with scion/rootstock compatibility, rootstock brittleness, poor anchorage, disease and insect susceptibility, hardiness, and requires costly tree support systems (Ferree and Carlson, 1987). In addition, rootstocks seldom provide an ideal tree size for each scion cultivar, soil, and climatic condition. Other methods (trunk scoring, plant growth retardents, root pruning, high density planting, and pruning) for controlling tree size, flowering, and fruiting have been marginally satisfactory.

In the early 1980's, Whitcomb (Whitcomb, 1986; Reiger and Whitcomb, 1982) experimented with the use of fabric containers, "root bags", to reduce nursery transplant shock. Trees grown in fabric bags result in denser, shorter, and more fibrous root systems (Whitcomb, 1986; Reiger and Whitcomb, 1982). Observations of roots penetrating the fabric "root bag" showed root girdling, restricted root diameter, and

---

[1] Professor of Horticulture and Director, Alson H. Smith, Jr. Agricultural Research and Extension Center, Virginia Polytechnic Institute and State University,595 Laurel Grove Road, Winchester, VA 22602 USA, and the author extends his appreciation to David Carbaugh, Leon Combs, Maurice and Harriet Keeler, for assistance in conducting these experiments.

This project was partially supported by the Virginia Agricultural Council.

secondary root branching (Whitcomb and Reiger, 1983; Threadgill, 1987; Cole et. al. 1998). According to Chong (1987), the altered flow of nutrients, in particular, carbohydrates, resulted in decreased tree growth which varied with the species. Several studies have shown that the shoot growth is related to root system vigór. Artificial or natural barriers in the soil can limit the spread and penetration of roots, soil volume accessibility to water, and competition from neighboring plants. Myers (1992) found root restriction with fabric bags resulted in smaller tree sizes, higher flower bud number and fruit set per tree for both apple and peach trees. Previously used fabric bags or lined trenches confined of the root system mostly to inside the fabric bag thus causing a water supply deficit which required supplemental irrigation (Williamson, et al., 1992). Boland et al. (2000) also reported on the combined effects of root/soil volumes and regulated deficit irrigation in peach trees restricted by impervious plastic liners.

The objective of this research was to compare several different types of root restrictive bags on apple tree flowering, tree growth, pruning, yield efficiency, fruit quality, etc. Bags were made from a variety of materials with different weaves and hole sizes with specific intent to allow a portion of the root system to penetrate the bag so that supplemental irrigation would not be required. Since root bags could provide an exclusion of voles from trunk and roots, an apple enclosed by various bag materials were presented to caged pine voles for 24 hours and evaluated for penetration or damage to the apple.

Materials and Methods

Trees in all experiments were pruned to remove annual shoot growth over 75 cm; and a small number of narrow angled limbs. Vigorous, non-bearing trees were pruned more severely than trees with less vigorous shoot growth. Trees were not fertilized for the first 5 years. Several bagged materials significantly dwarfed trees and could have benefited by some fertilizer since their foliage was a lighter green in comparison to non-bagged (control) trees that were non-fruiting and too vigorous.

Statistical analysis. Data were analyzed with ANOV using SAS (SAS Institute, Cary, N. C.) software and mean differences were determined by Duncan's New Multiple Range Test.

Expt. 1 In 1995, 48 'Fuji'/MM.111 apple trees bought from a commercial nursery were individually planted in 7 different types of knit or woven bags, or galvanized wire mesh (hardware cloth) or none in the field. Trees were planted in single tree plots in a randomized complete block design having six blocks of 8 treatments. Trees were planted in 6.1 m wide rows, at 3 meter intervals within each row. Holes were dug with a 45 cm auger, and trees were planted in bags placed in the holes. Trees were not fertilized during the experiment. Bag types were of different diameters: 1) Control (no *bag);* 2,3,4,5) Root Control™ 10-inch, 12-inch, 14-inch, 16-inch; 6) Knitted (DeWitt Company, Sikeston, Missouri) 14-inch; 7) Insect screen (Dewitt) 14-inch; and 8) Hardware cloth (6.4cm) 14-inch. Each year during the dormant season trunk circumference, shoot growth of the 5 longest terminals on the tree, number of pruning cuts per tree, and pruning weights were determined. During the growing season flower clusters, fruit numbers, and fruit weight per tree; and a 10-fruit sample per tree was collected near harvest for quality evaluations (flesh firmness, soluble solids concentration, starch staining, percentage red color, fruit scaring and/or russet, and incidence of watercore). In 2000, one tree of each treatment was excavated on one side with a high-pressure water stream to remove soil 20 cm deep for root observation.

Flesh firmness was measured on two sides of each fruit with an Effegi penetrometer (Model FT327: McCormick Fruit Tech, Yakima, Wash.) fitted with an 11.1-mm tip. Soluble solids concentration (SSC) was estimated with an Atago hand-held refractometer (Model N1, McCormick Fruit Tech, Yakima, Wash.), utilizing a composite sample of juice resulting from penetrometer testing of all replicates of each treatment. Each apple fruit was cut in half transversely, and severity of water core was rated on a scale of 0 to 5 (0= none, 5 = severe). Flesh starch was evaluated by dipping half of each apple in iodine solution for approximately 15 seconds. The degree of staining was rated on a scale of 0 to 8 where 1 = heavy starch (cut surface entirely stained); and 8 = no starch (absence of stain on the cut surface) (Poapst et al., 1959). Stem-end and side russet were rated as 0 = no russet to 5 = severe russet.

<u>Expt. 2.</u> To determine the susceptibility of potential root bag materials to penetration by pine voles, 10 apples were individually wrapped in each material and placed with 10 singly-caged animals. After 24 hours, each apple and root bag material was examined for vole damage.

Expt. 3. In 1995, 5 'Pink Lady'/M.7A trees were planted in the 10-inch "Root Control" bag (Root Control, Inc., 7505 North Broadway, Oklahoma City, OK.) and compared to 5 non-bagged trees. Data were collected similarly to Expt. 1.

Expt. 4. In 1995, 5 'Summerfield'/M.7A were planted in the 10-inch "Root Control" bag (address) and compared to 5 non-bagged trees. Data were collected similarly to Expt. 1.

Results and Discussion

<u>Expt 1.</u> In 2000, after removal of soil from one side of each bag, examination of 'Fugi'/MM.111 root systems revealed that all bag materials confined the development of large roots to within the bag. Roots that penetrated the bags resulted in smaller branched roots and inhibited development of any large roots beyond the bag exterior (Figure 1). As the roots enlarged, roots penetrating the bags were restricted in diameter by the fabric hole size (Figure 1). Roots enlarged on both sides of the fabric holes but were not killed by girdling within the first few years (Figure 2). Root restriction bags inhibited trunk circumference (Figure 3A), shoot growth (Figure 3B), pruning weights (Figure 3C), number of cuts per tree(Figure 3D), and next season's flowering, fruit numbers before (Figure 3E) and after thinning (Figure 3F), and yields/cm^2 trunk cross sectional area (Figure 3G). Fruit firmness, soluble solids and color was increased and starch was unchanged in comparison with the non-bagged controls (Table 1). Quality

differences may have been the result of smaller fruit size in response to higher crop loads and/or reduced canopy leaf density of trees planted in root bags.

The Root Control bags confined both large and small roots to a greater extent than the Knitted (Dewitt) 14-inch, Insect screen (Dewitt) 14-inch; and Hardware cloth (6.4cm) 14-inch. The Root Control bag was a heavy cloth fabric that was more impervious to root growth and soil contact across the bag. The other bags had whole sizes of approximately 1 mm or so that allowed soil contact inside and outside the bag and greater penetration of small roots (Figure 1). Foliage of trees planted in root restrictive bags caused leaves to be noticeably more yellow-green in color when compared to trees not grown in root bags. Trees planted in hardware cloth bags were more yellow than trees in other bag types as a result of metal toxicities.

<u>Expt. 2.</u> In cage and tank trials, pine and/or meadow voles easily penetrated all 10 of the fabric and polypropylene bags within 24 hours (Figure 4), except for those made of screen wire or galvanize wire mesh (hardware cloth) (data not presented).

<u>Expt 3.</u> The root restrictive bags confined the development of large roots of 'Pink Lady'/MM. 7A trees to within the bag. The bags inhibited trunk circumference (Figure 5A), shoot growth (Figure 5B), pruning weights (Figure 5C), number of cuts per tree(Figure 5D), and increased next season's flowering, fruit numbers before (Figure 5E) and after thinning (Figure 5F), and yields/cm^2 trunk cross sectional area (Figure 5G). Fruit firmness, soluble solids and color was increased and starch was unchanged in comparison with the non-bagged controls (Table 2); however quality differences may have been the result of reduced canopy density and/or smaller fruit size in response to higher crop loads on trees planted in root bags.

Expt. 4 The root restrictive bags confined the development of large roots of 'Smmerfield'/MM. 7A trees to within the bag. The bags inhibited trunk circumference (Figure 6A), shoot growth (Figure 6B), pruning weights (Figure 6C), number of cuts per tree(Figure 6D), and increased next season's flowering, fruit numbers before (Figure 6E) and after thinning (Figure 6F), and yields/cm^2 trunk cross sectional area (Figure 6G). Fruit firmness, soluble solids and color was increased and starch was unchanged in comparison with the non-bagged controls (Table 3); however quality differences may have been the result of reduced canopy density and/or smaller fruit size in response to higher crop loads on trees planted in root bags.

<u>Discussion:</u>

Root restriction bags provided an alternative to dwarfing rootstocks for control of tree size, early flowering, and early fruiting. Root bags with hole diameters of < 2 mm in diameter used in these experiments, restricted roots more than desirable. Subsequent experiments have been initiated with larger hole sizes, 0.25 to 1.27 cm diameter, to allow for unrestricted root growth in the first 3 growing seasons. Unrestricted root growth in the first few seasons could allow for rapid filling of the tree space, reduction or elimination of supplemental irrigation need, and with increasing tree age increasingly influence apple tree flowering, tree growth suppression, reduce pruning, increase yield efficiency, and increase fruit color and quality.

Further research is needed to evaluate root bag materials with more vigorous rootstocks (Rootstocks that have more desirable disease and insect resistance and less brittle scion/root stock characteristics, ie. "No Vole" or MM.111) and larger hole diameters with various cultivars, soils, planting distance, and climatic conditions and to reduce or eliminate vole (*Microtus spp.)* damage to tree trunk and roots. The galvanized wire mesh (hardware cloth) was toxic to roots, limited root development, and caused significant leaf yellowing; but it completely excluded vole damage.

References

Boland, A. M. P. H. Jeri, P. D Mitchell and I. Goodwin. 2000. Long-term effects of restricted root volume and regulated deficit irrigation on peach: II. Productivity and water use. J. Amer. Soc. Hort. Sci. 125:143-148.

Byers, R. E., D. H. Carbaugh, and L. D. Combs. 2000. The Influence of Root Restriction on Flowering, Fruiting, Tree Growth, Yields, and Fruit Quality of Apple Trees. HortScience 35:418 (Abstract: #162).

Chong, C., G.P. Lumis and R. A. Cline. (1989). Effects of fabric containers. Nurseryman 170: 51-55.

Cole, J. C., R. Kjelgren and D. L. Hensley. (1998). In-ground fabric containers as an alternative nursery crop production system. HortTechnology 8(2): 159-163.

Cummins, J. N., H. S. Aldwinckle, and R. E. Byers. 1983. 'Novole' apple. HortScience 18:772-774.

Ferree, D. C. and R. F. Carlson. 1987. Apple Rootstocks. Pp. Pp. 107-143In: Rootstocks for Fruit Crops, John Wiley & Sons, Inc., New York, N.Y. 494p.

Myers, S.C. (1992) Root restriction of apple and peach with in-ground fabric containers. Acta Horticulturae 322: 215-219.

Reiger, R. and C. E. Whitcomb. (1983) A root control system for growing trees in the field. SNA Research Conference: 100-102.

Threadgill, C. (1987) Plant production using a root control fabric container. Comb. Proc. Int. Plant Propagators Soc.: 367-369.

Tilt, K., C. Gilliam, J. Olive and E. Carden. (1992) Growth of container-grown trees transplanted from the field or grow bags. HortTechnology 2(3); 415-417.

Whitcomb, C.E. (1984) Root development of trees grown in field-grown fabric containers following transplanting. Res. Rep. P. Agric. Exp. Stn. Okla. State. Univ. 855:27.

Whitcomb, C. E. 1986. Fabric field-grow containers enhance root growth. American Nurseryman. 49-52.

Williamson, D. C. Coston, J. A. Cornell. 1992. Root restriction affects shoot development of peach in a high-density orchard. J. Amer. Soc. Hort. Sci. 17:362-367.

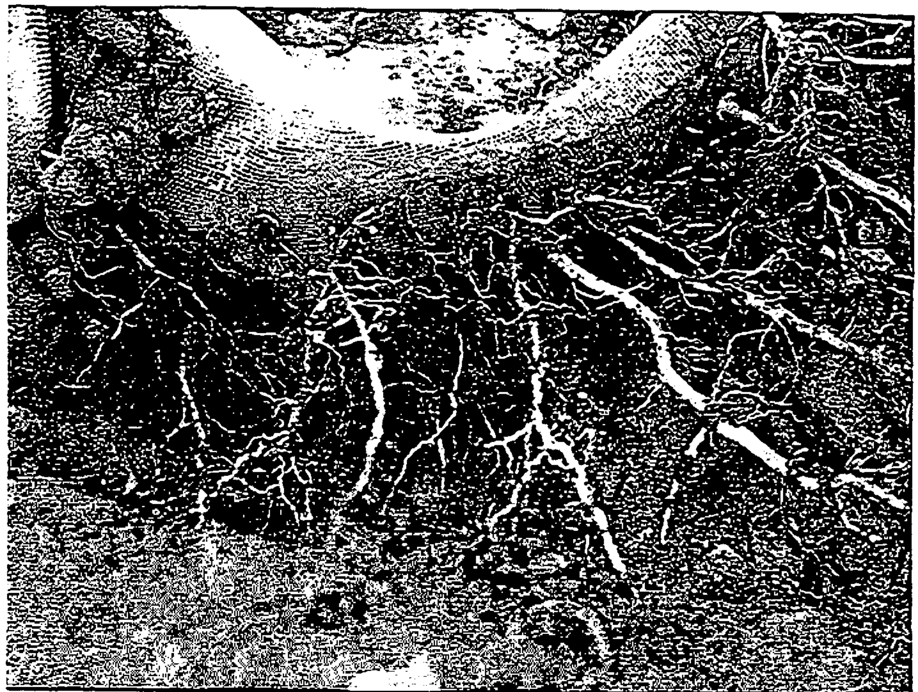


Figure 1. Penetration of Fuji/MM.111 roots through Knitted root bag (Dewitt).

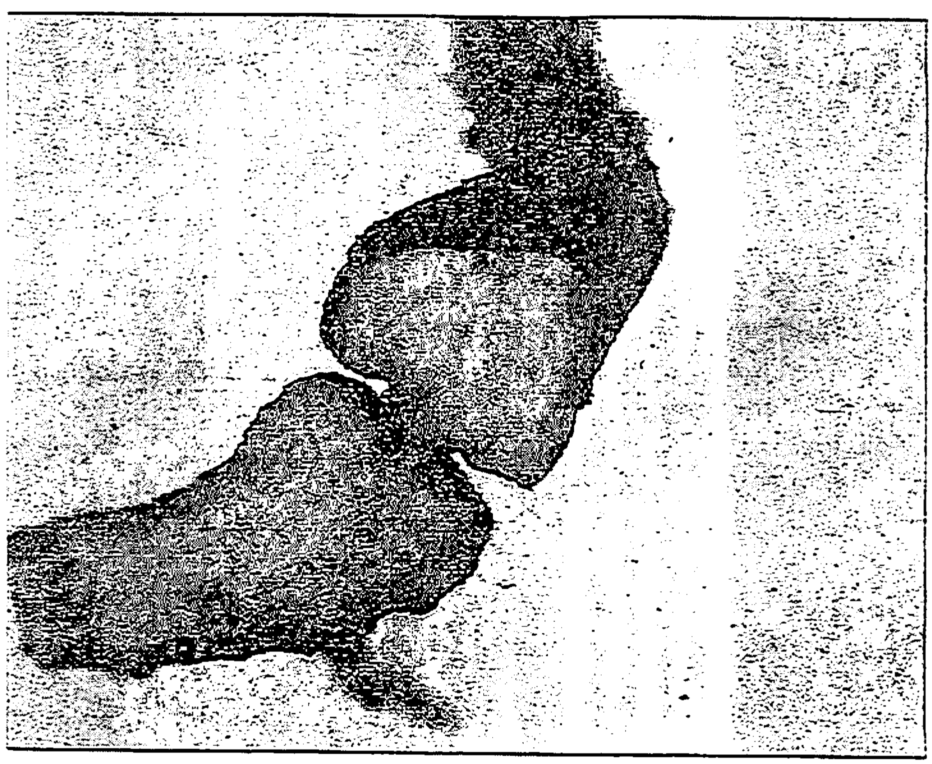


Figure 2. Root which penetrated bag showing restriction and enlargement on both sides of the fabric restriction.

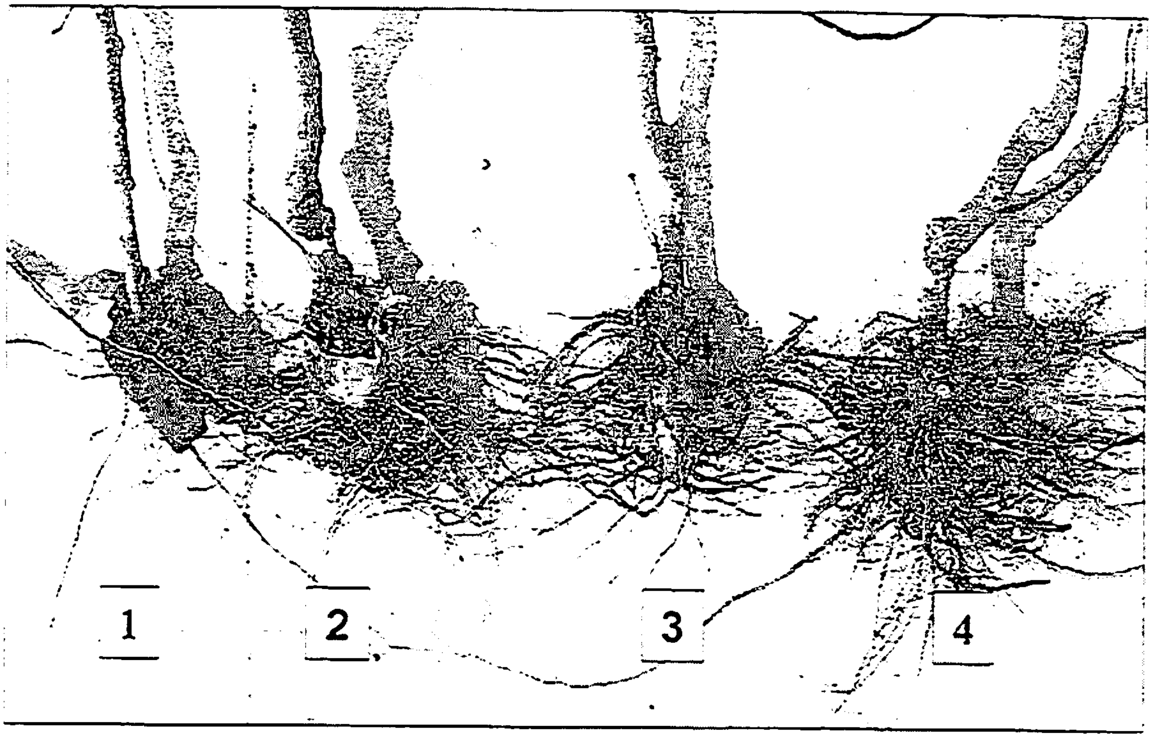


Figure 3. Penetration of Idared/MM. 111 apple roots through 1.5 liter volume root bags grown for one season in the field: 1) Root Control, 2) Knitted (Dewitt), 3) Insect Screen (Dewitt), and 4) Control (no bag).

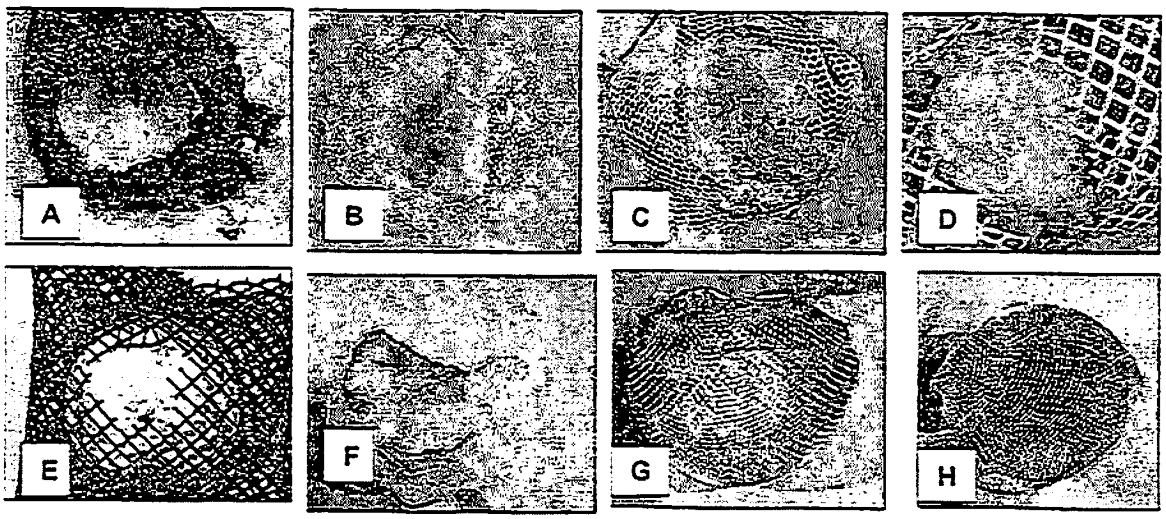
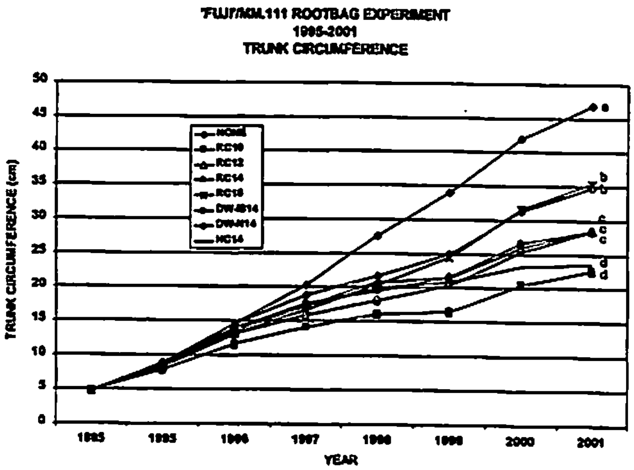
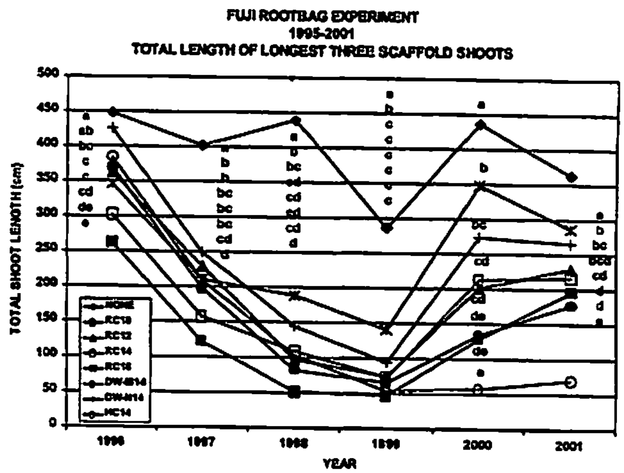
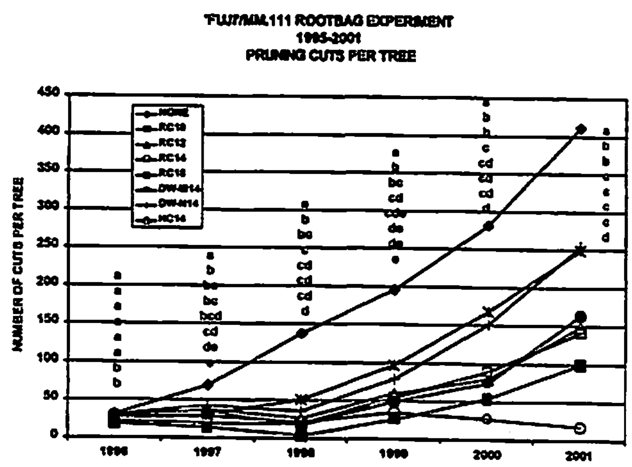
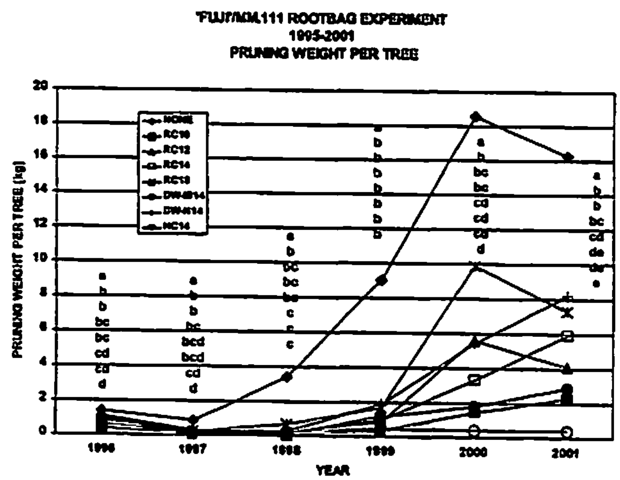


Figure 4. Vole Damage to an apple in bags made from various materials and caged with pine voles for 24 hours (A, B, C, D, E, F). Only wire bags excluded voles from the apple (G, H).

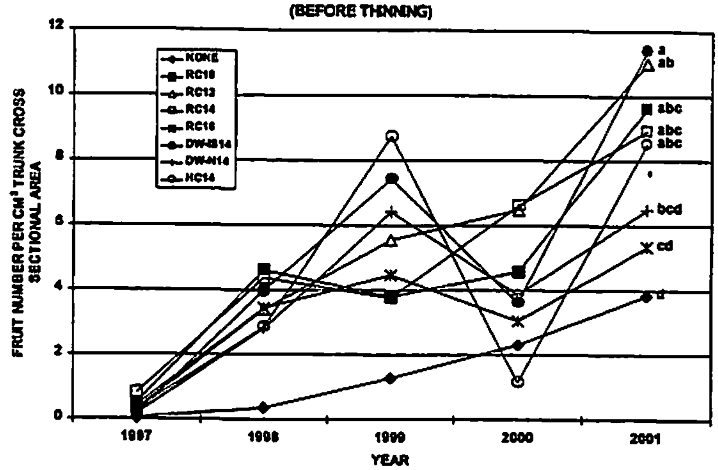

'FUJI'/MM.111 ROOTBAG EXPERIMENT
1995-2001
TRUNK CIRCUMFERENCE
TRUNK CIRCUMFERENCE (cm)
YEAR
NONE
RC10
RC12
RC14
RC18
DW-B14
DW-N14
HC14


FUJI ROOTBAG EXPERIMENT
1995-2001
TOTAL LENGTH OF LONGEST THREE SCAFFOLD SHOOTS
TOTAL SHOOT LENGTH (cm)
YEAR
NONE
RC10
RC12
RC14
RC18
DW-B14
DW-N14
HC14

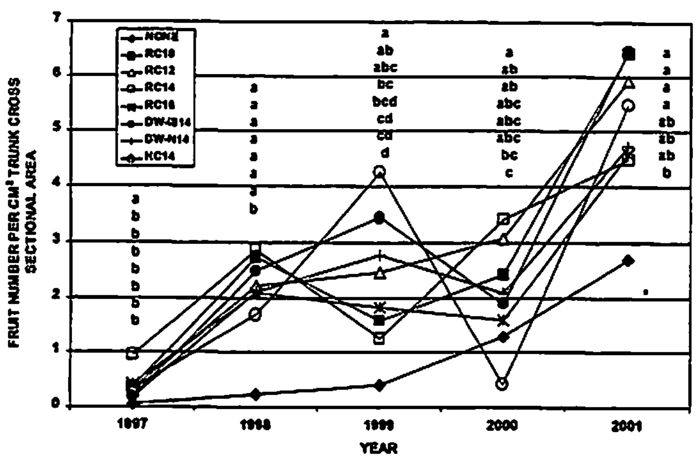

'FUJI'/MM.111 ROOTBAG EXPERIMENT
1995-2001
PRUNING CUTS PER TREE
NUMBER OF CUTS PER TREE
YEAR
NONE
RC10
RC12
RC14
RC18
DW-B14
DW-N14
HC14


'FUJI'/MM.111 ROOTBAG EXPERIMENT
1995-2001
PRUNING WEIGHT PER TREE
PRUNING WEIGHT PER TREE (kg)
YEAR
NONE
RC10
RC12
RC14
RC18
DW-B14
DW-N14
HC14

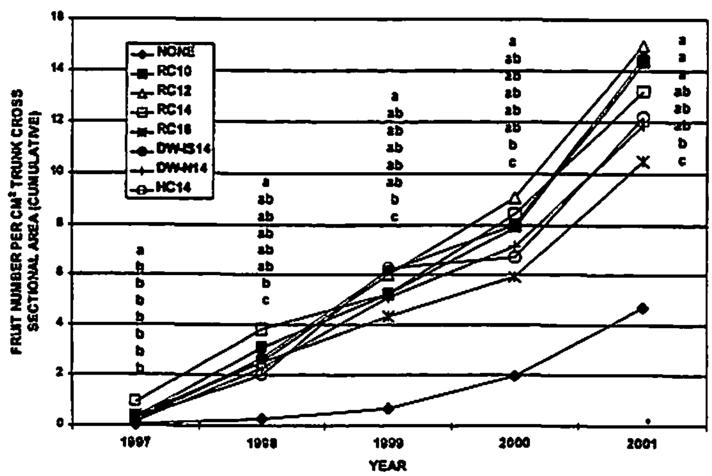
'FUJI'/MM.111 ROOTBAG EXPERIMENT
1995-2001
FRUIT NUMBER PER CM² TRUNK CROSS SECTIONAL AREA
(BEFORE THINNING)



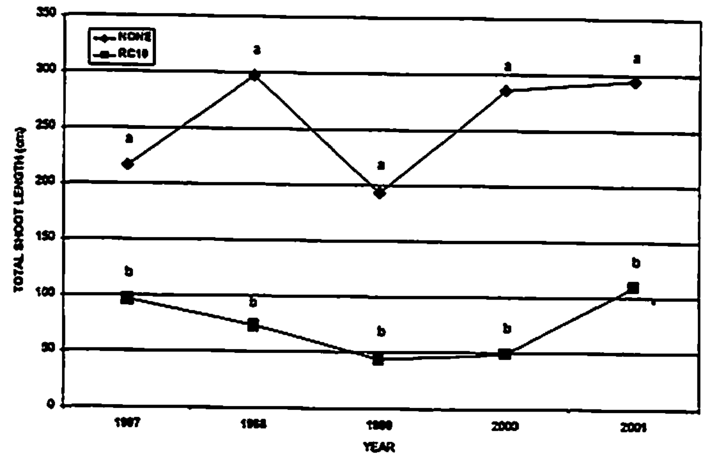
'FUJI'/MM.111 ROOTBAG EXPERIMENT
1995-2001
FRUIT NUMBER PER CM² TRUNK CROSS SECTIONAL AREA (AT HARVEST)



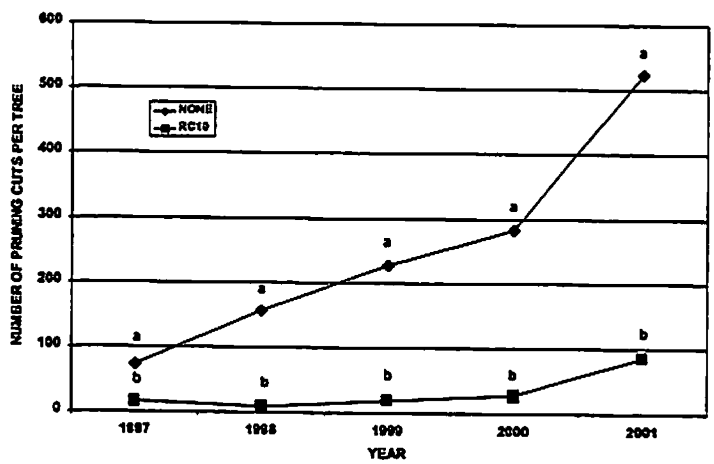
'FUJI'/MM.111 ROOTBAG EXPERIMENT
CUMULATIVE FRUIT NUMBER PER CM² TRUNK CROSS SECTIONAL AREA (AT HARVEST) 1995-2001



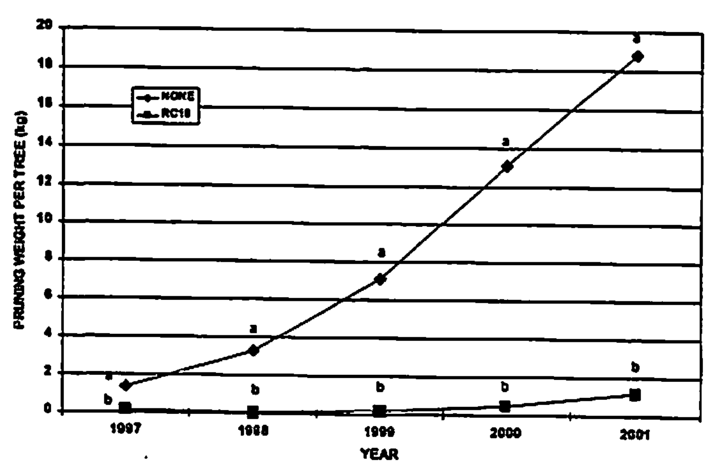
'PINK LADY'/M.7A ROOTBAG EXPERIMENT
1995-2001
TOTAL SHOOT LENGTH OF 3 LONGEST SHOOTS

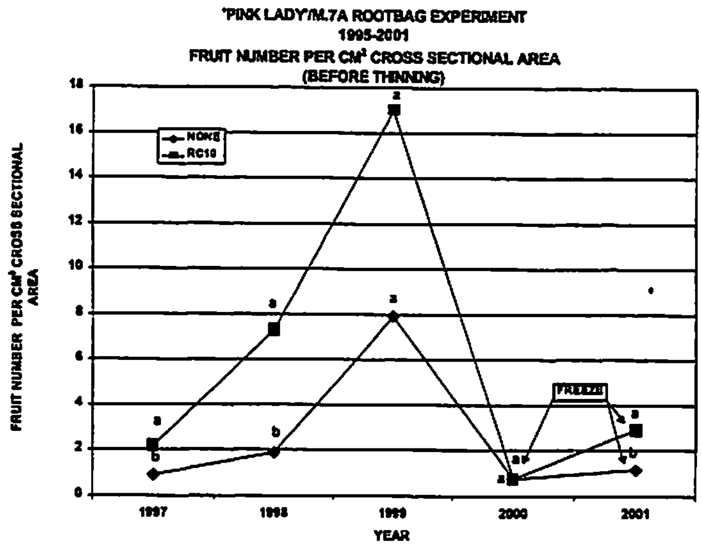


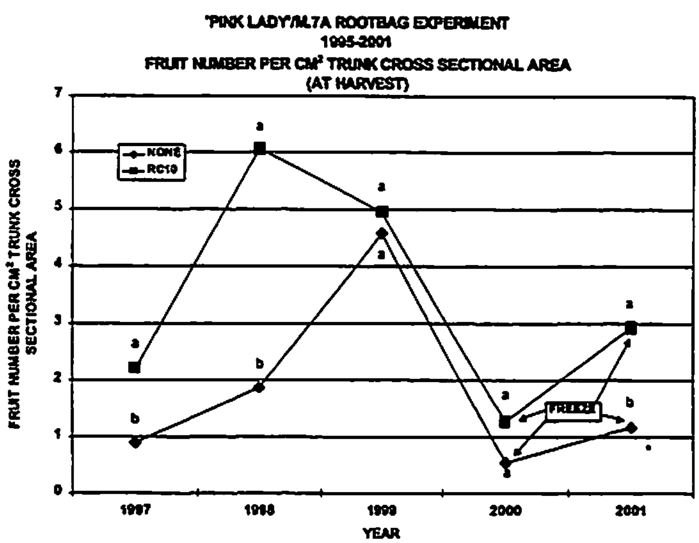
'PINK LADY'/M.7A ROOTBAG EXPERIMENT
1995-2001
NUMBER OF PRUNING CUTS PER TREE

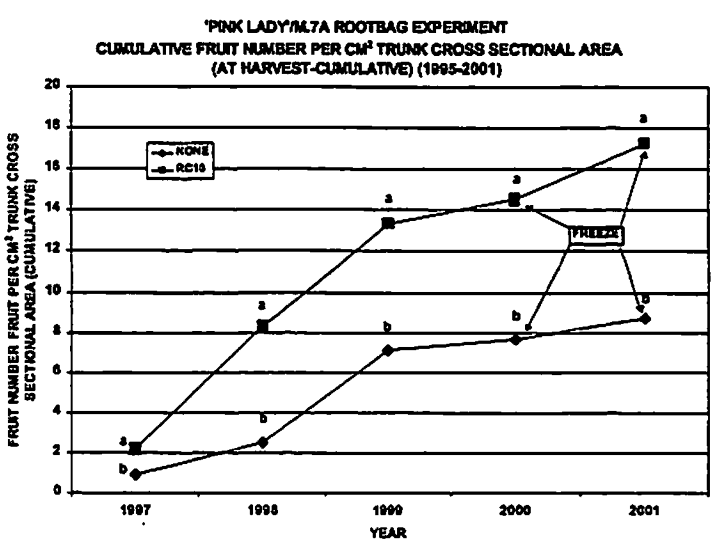


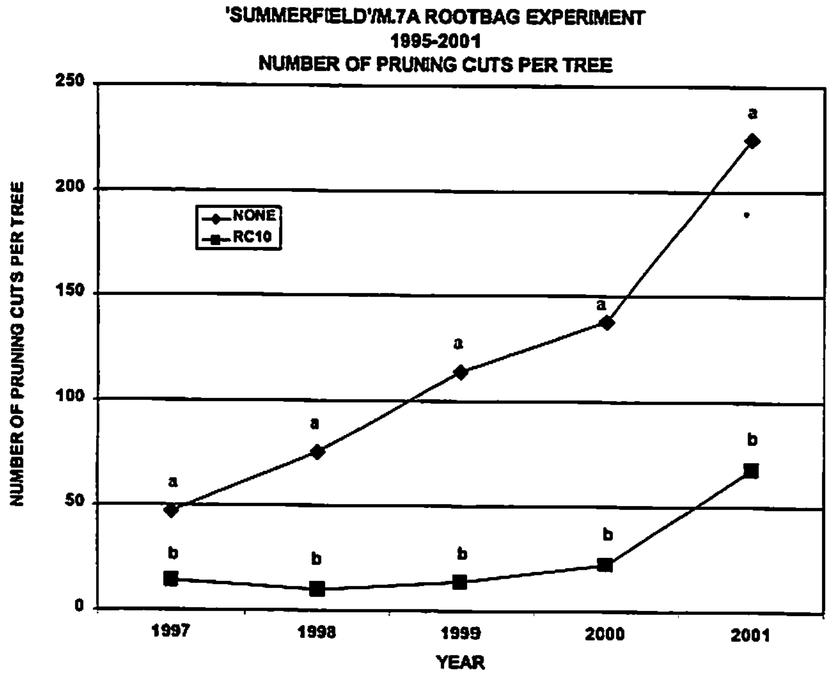
'PINK LADY'/M.7A ROOTBAG EXPERIMENT
1995-2001
PRUNING WEIGHT PER TREE

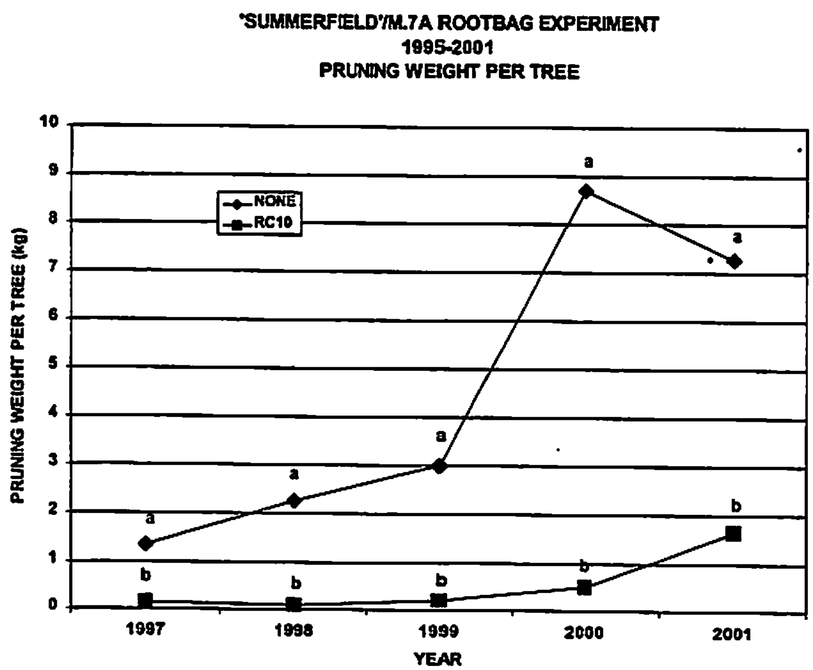



'PINK LADY'/M.7A ROOTBAG EXPERIMENT
1995-2001
FRUIT NUMBER PER CM² CROSS SECTIONAL AREA
(BEFORE THINNING)
NONE
RC10
FRUIT NUMBER PER CM² CROSS SECTIONAL AREA
FREEZE
YEAR

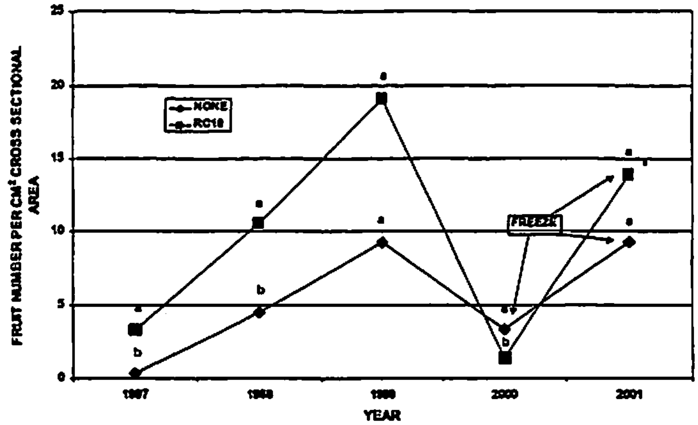

'PINK LADY'/M.7A ROOTBAG EXPERIMENT
1995-2001
FRUIT NUMBER PER CM² TRUNK CROSS SECTIONAL AREA
(AT HARVEST)
NONE
RC10
FRUIT NUMBER PER CM² TRUNK CROSS SECTIONAL AREA
FREEZE
YEAR


'PINK LADY'/M.7A ROOTBAG EXPERIMENT
CUMULATIVE FRUIT NUMBER PER CM² TRUNK CROSS SECTIONAL AREA
(AT HARVEST-CUMULATIVE) (1995-2001)
NONE
RC10
FRUIT NUMBER FRUIT PER CM² TRUNK CROSS SECTIONAL AREA (CUMULATIVE)
FREEZE
YEAR

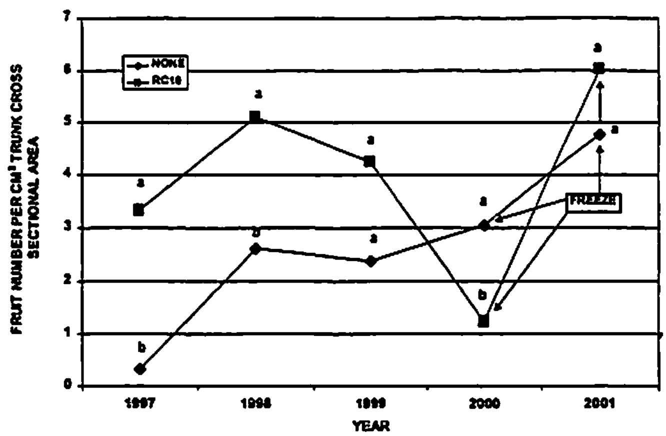

'SUMMERFIELD'/M.7A ROOTBAG EXPERIMENT
1995-2001
NUMBER OF PRUNING CUTS PER TREE
NUMBER OF PRUNING CUTS PER TREE
250
200
150
100
50
0
NONE
RC10
a
b
1997
1998
1999
2000
2001
YEAR


'SUMMERFIELD'/M.7A ROOTBAG EXPERIMENT
1995-2001
PRUNING WEIGHT PER TREE
PRUNING WEIGHT PER TREE (kg)
10
9
8
7
6
5
4
3
2
1
0
NONE
RC10
a
b
1997
1998
1999
2000
2001
YEAR

'SUMMERFIELD'/M.7A ROOTBAG EXPERIMENT
1995-2001
FRUIT NUMBER PER CM^2 TRUNK CROSS SECTIONAL AREA
(BEFORE THINNING)



'SUMMERFIELD'/M.7A ROOTBAG EXPERIMENT
1995-2001
FRUIT NUMBER PER CM^2 TRUNK CROSS SECTIONAL AREA
(AT HARVEST)



'SUMMERFIELD'/M.7A ROOTBAG EXPERIMENT
1995-2001
FRUIT NUMBER PER CM^2 TRUNK CROSS SECTIONAL AREA
(AT HARVEST-CUMULATIVE)

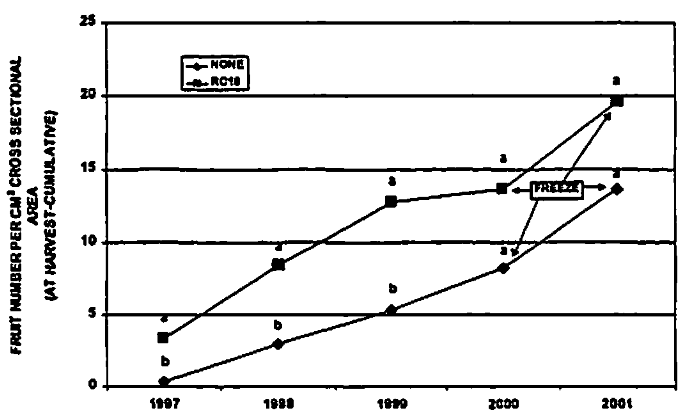


Table 1. Effect of root restriction on Fuji/MM 111 planted in April 1995 (2002).

No.	Color	Treatment	Bag diameter (inches)	Fruit diameter (cm)	Fruit firmness (neutons)	Soluble solids (%)	Starch (0-8)	Color (0-100%)
				20 Sept 99	20 Sept 99	20 Sept 99	20 Sept 99	20 Sept 99
1.	W	No bag	0	7.52 a[z]	83.2 d	13.4 bc	3.60 a	36 b
2.	R	RC Fabric	10	6.60 de	93.4 a	14.3 ab	3.34 a	65 a
3.	B	RC Fabric	12	7.04 bc	89.4 bc	14.2 abc	3.35 a	64 a
4.	G	RC Fabric	14	6.86 bcd	91.2 ab	14.7 a	3.21 a	67 a
5.	FO	RC Fabric	16	7.11 b	88.1 bc	13.3 c	3.37 a	49 ab
6.	Y	DW (insect screen--fine)	14	6.71 cde	88.5 bc	14.6 a	3.70 a	60 a
7.	RS	DW (netted--fine)	14	7.05 bc	87.2 c	13.7 abc	3.68 a	64 a
8.	BS	Hardware cloth 1/4in	14	6.49 e	90.7 ab	14.7 a	3.42 a	63 a
				26 Sept 00	26 Sept 00	26 Sept 00	26 Sept 00	26 Sept 00
1.	W	No bag	0	7.57 a	75.6 d	13.3 e	5.43 a	47 d
2.	R	RC Fabric	10	7.07 b	84.0 b	14.4 bc	4.45 b	75 b
3.	B	RC Fabric	12	7.10 b	77.8 cd	14.0 cd	5.20 a	71 b
4.	G	RC Fabric	14	7.01 b	80.5 bc	14.1 cd	5.33 a	73 b
5.	FO	RC Fabric	16	7.49 a	77.4 cd	13.5 de	5.28 a	57 c
6.	Y	DW (insect screen--fine)	14	7.10 b	80.9 bc	14.9 b	5.58 a	72 b
7.	RS	DW (netted--fine)	14	7.30 ab	79.2 cd	14.1 cd	5.48 a	68 b
8.	BS	Hardware cloth 1/4in	14	7.10 b	88.1 a	16.2 a	5.12 ab	86 a
				10 Oct 01	10 Oct 01	10 Oct 01	10 Oct 01	10 Oct 01
1.	W	No bag	0	7.56 a	79.6 c	13.5 c	5.5 bc	55 b
2.	R	RC Fabric	10	6.94 b	91.6 b	14.8 b	5.5 bc	78 a
3.	B	RC Fabric	12	7.31 ab	82.7 c	14.8 b	5.4 bc	72 a
4.	G	RC Fabric	14	7.30 ab	86.7 bc	15.0 b	5.2 c	73 a
5.	FO	RC Fabric	16	7.37 ab	82.7 c	14.0 bc	5.2 c	72 a
6.	Y	DW (insect screen--fine)	14	7.13 ab	83.2 c	14.5 bc	6.1 b	77 a
7.	RS	DW (netted--fine)	14	7.33 ab	83.6 c	14.2 bc	5.2 c	75 a
8.	BS	Hardware cloth 1/4in	14	5.67 c	109.8 a	16.4 a	7.2 a	73 a
				4 Oct 02	4 Oct 02	4 Oct 02	4 Oct 02	4 Oct 02
1.	W	No bag	0	7.66 a	76.9 c	14.3 ab	5.5 c	19 d
2.	R	RC Fabric	10	7.38 a	83.2 b	16.2 a	6.3 ab	53 ab
3.	B	RC Fabric	12	7.71 a	80.5 bc	15.7 a	6.0 abc	43 bc
4.	G	RC Fabric	14	7.20 a	81.8 bc	15.2 ab	5.5 c	44 bc
5.	FO	RC Fabric	16	7.65 a	77.4 c	15.1 ab	5.7 bc	29 cd
6.	Y	DW (insect screen--fine)	14	7.53 a	80.9 bc	13.3 b	6.0 abc	41 bc
7.	RS	DW (netted--fine)	14	7.71 a	78.7 bc	15.3 ab	6.0 abc	26 cd
8.	BS	Hardware cloth 1/4in	14	5.91 b	101.8 a	16.0 a	6.6 a	68a

[z]Mean separation within columns by Duncan's New Multiple Range Test, ($P \leq 0.05$).

Table 2. Effect of root restriction on 'Pink Lady'/7A planted in April 1995 (2002).

No.	Treatment	Bag diameter (inches)	Fruit diameter (cm)	Fruit firmness (neutons)	Soluble solids (%)	Starch (0-8)	Red color (%)
			7 Nov 99	7 Nov 99	7 Nov 99	7 Nov 99	7 Nov 99
1.	No bag	0	7.02 a[z]	81.8 b	15.4 b	4.1 a	82 b
2.	RC Fabric	10	6.74 a	88.5 a	17.2 a	4.0 a	92 a
			31 Oct 00	31 Oct 00	31 Oct 00	31 Oct 00	31 Oct 00
1.	No bag	0	7.29 a	90.3 b	14.8 b	5.0 a	76 b
2.	RC Fabric	10	6.85 b	100.1 a	16.2 a	4.4 b	92 a
			24 Oct 01	24 Oct 01	24 Oct 01	24 Oct 01	24 Oct 01
1.	No bag	0	7.12 a	97.4 b	14.9 b	2.9 a	53 b
2.	RC Fabric	10	7.14 a	109.0 a	16.6 a	3.4 a	76 a
			26 Oct 02	26 Oct 02	26 Oct 02	26 Oct 02	26 Oct 02
1.	No bag	0	7.22 a	88.9 b	14.2 b	2.9 a	52 b
2.	RC Fabric	10	7.23 a	95.7 b	15.7 a	2.6 a	76 a

[z]Mean separation within columns by t test,($P \leq 0.05$).

Table 3. Effect of root restriction on 'Summer Field'/7A planted in April 1995 (2002).

No.	Treatment	Bag diameter (inches)	Fruit diameter (cm)	Fruit firmness (neutons)	Soluble solids (%)	Starch (0-8)	Red color (%)
			13 Sep 99	13 Sep 99	13 Sep 99	13 Sep 99	13 Sep 99
1.	No bag	0	7.37 a[z]	77.4 a	14.4 b	4.5 a	49 b
2.	RC Fabric	10	6.86 a	79.6 a	15.1 a	4.2 a	73 a
			4 Sep 00	4 Sep 00	4 Sep 00	4 Sep 00	4 Sep 00
1.	No bag	0	7.37 a	66.3 b	14.1 b	6.9 a	57 a
2.	RC Fabric	10	7.32 a	73.4 a	15.9 a	6.3 b	72 a
			17 Sep 01	17 Sep 01	17 Sep 01	17 Sep 01	17 Sep 01
1.	No bag	0	7.38 a	77.4 b	13.4 b	6.4 a	53 b
2.	RC Fabric	10	7.25 a	83.6 a	13.9 a	6.2 a	68 a
			17 Sep 02	17 Sep 02	17 Sep 02	17 Sep 02	17 Sep 02
1.	No bag	0	7.21 a	77.4 b	14.7 a	7.0 a	33 a
2.	RC Fabric	10	7.06 a	81.4 a	15.6 b	6.7 b	43 a

[z]Mean separation within columns by t test,($P \leq 0.05$).

(Not for publication or distribution, CSFWC 2002)

Maximizing Apple Crop Value by Reducing the Influence of Return Bloom with Gibberellin, Pruning, Chemical Fruit Thinning, and/or Apogee

R. E. Byers, D. H. Carbaugh, and L. D. Combs
Professor of Horticulture and Research Specialists
Virginia Polytechnic Institute and State University,
Alson H. Smith, Jr. Agricultural Research and Extension Center,
595 Laurel Grove Road
Winchester, VA 22602

Abstract. Sprays of GA_3 provided some control of alternate bearing of 'York'/M.7 trees when applied in the "off year" (1997) of the biennial bearing cycle. Trees sprayed with 160 mg/liter GA_3 or 320 mg/liter GA_3 had significantly less return bloom in the 1998 ("on year") with 61% and 46% spurs flowering, respectively, compared to control trees that had 99% of spurs flowering. Trees sprayed with GA_3 in the "off year" in 1997 returned bloom and cropped again in 1999, 2000, 2001, and 2002. Trees in the "off year" in 1997 that were not sprayed with GA_3, heavily cropped in 1998 and 2000, and 2002, but not in 1999 and 2001. These data show that 'York'/M.7 trees sprayed with GA_3 to in the "off year" of the biennial bearing cycle continued to bear on a more annual cycle for 4 years after a single spray.

In 2002, pruning by removal of 50% or 80% of the spurs reduced the crop load from 4.04, to 2.75 fruit/cm2 truck cross sectional area. The average single fruit weight of fruit on trees at harvest was increased. An analysis of % of fruit by size category indicated that pruning at either level increased the % of fruit in size catagories above 3.25 inches, 3.50 inches, and 3.75 inches.

Hand Thinning and Ethephon Return Bloom Trials (2001-2002)

In 2001, 'Fuji'/M.27 trees defruited or sprayed with ethephon at various times were evaluated for return bloom in 2002. Ethephon did not cause intended fruit drop when applied Aug 8 or Aug 22. In 2001, defruiting trees by hand during the period of 13 Jun to 4 July provided an adequate return bloom in 2002 (65 to 48% spurs flowering in 2002) for a crop; but neither defruiting by hand from 11 Jul 01 to 4 Oct 01, or spraying with ethephon on Aug 8 or Aug 22 promoted return bloom in 2002.

In 2001, 'Starkrimson'/Mark trees defruited or sprayed with ethephon at various times were evaluated for return bloom in 2002. As expected, the late ethephon application on 22 Aug more effectively removed fruit than the 8 August application. In 2002, neither defruiting trees by hand during or spraying with ethephon on Aug 8 or Aug 22 promoted return bloom.

In 2001, 'York'/M.27 trees defruited or sprayed with ethephon at various times were evaluated for return bloom in 2002. Ethephon application on 8 Aug or 22 Aug was equally effective for fruit removal (approx. 50%). In 2002, neither defruiting trees by hand during or spraying with ethephon on Aug 8 or Aug 22 promoted return bloom.

Chemical Thinning Trials (2001-2002)

When applied to 'Starkrimson Delicious'/MM.106 & MM.111, NAA alone or in combination with 6-BA or Accel caused an undesirable increase in the numbers of small fruit < 25mm on 6 June and decreased the numbers of large fruit > 25 mm when compared to the untreated controls. At harvest on 11 Sept., NAA alone or in combinations with 6-BA (45g/acre) or Accel (45g/acre) increase the numbers of fruit below 2.25 inches and decreased the fruit numbers above 2.50 and 2.75 inches. NAA+Accel+Li-700 increase the total number of fruit/cm^2 limb cross sectional area and NAA+6-BA+Li-700 numerically was greater but was not significantly. In 2002, all of the treatments caused increased return bloom.

'Starkrimson Delicious'/MM.106 and MM.111 trees having a high percentage of pigmy fruit were sprayed with ethephon + Sevin + Oil to determine if small fruit could be preferentially removed. More small fruit were removed than large fruit. There was a greater percentage of fruit above 2.25 and 2.75 in the sprayed trees.

In 2001, sprays on 14-year-old .'Ace Delicious'/MM.111 trees 6-BA (90g/acre) + Li-700 or Oil provided more thinning than Accel (90g/acre) + Li-700 or Oil. Oil was a superior adjuvant for thinning with 6-BA and Accel based on single degree of freedom contrasts. In 2002, none of the treatments caused increased return bloom. However when each treatment is compared to the control, none of the treatments individually caused thinning based on Duncan's multible range test ($P=\leq 0.05$). In 2002, none of the treatments caused increased return bloom.

Thinning sprays of ethephon applied at 5 pt/acre to 'Rome'/MM.106 trees when fruit were 13 mm in diameter caused more fruit thinning than at 2.5 pt/acre regardless of water volume. While keeping the chemical rate/acre constant, the water rates of 100 gal/acre or 400gal/acre were equally effective. With the greater fruit thinning of ethephon, the greater was the fruit length and diameter at harvest; however, greater thinning did not affect the L/D ratio. In 2002, all of the treatments caused increased return bloom.

None of the spray treatments caused significant fruit thinning of 'Starkrimson Delicious'/Mark (young) when applied with a hand-wand sprayer to trees on 22 May at 23.5 mm fruit diameter. Over all combinations, Sevin XLR caused more fruit injury than Sevin 50WP, but this difference was small. Sevin XLR caused slightly more fruit injury in lenticles than Sevin 50WP. The addition of Accel or Accel+Oil caused more injury than Sevin alone. Oil did not increase injury to fruit. Sevin + Accel + Oil or Sevin + 6-BA + Oil caused more injury than no treatment. Pigmy fruit development <32 mm on 26 June was increased by Accel more than by 6-BA even when combined with Sevin+Oil. Sevin XLR, Sevin 50WP, or ethephon did not influence pigmy fruit development. Fruit larger than 32mm was not affected by treatment. In 2002, none of the treatments caused increased return bloom.

None of the Accel treatments caused fruit thinning of 26-year-old 'Empire'/MM.111 trees; but did increase the % of pigmy fruit when compared to the untreated control. In 2002, none of the treatments caused increased return bloom.

At a 9X registration rate, Nova 40 W (45 oz/acre) reduced fruit length, fruit weight and length diameter ratio, but fruit diameter was not affected. No differences were found between the treatments regarding firmness, soluble solids, starch, or red color. When the whole 'Gala' tree's fruit sample was sized and placed into 0.25-inch fruit diameter categories, the highest Nova 40 W rate (45 oz/acre) fruit were smaller than the control as indicated by the percentage of fruit <and> 2.5 inches, <and> 2.75 inches, % fruit 2.00 to 2.25 inches, and % fruit 2.75 to 3.00 inches. No difference in fruit numbers/tree were noticed. In 2002, none of the treatments affected return bloom.

In 2001, Prohexadione-calcium technical grade 93.2% (PHCA) applied to 'Fuji'/M.9 trees in 3 applications in deionized water reduced tree growth somewhat. The addition of NH_4SO_4 to PHCA further suppressed tree growth. However, if PHCA was mixed in well water, PHCA did not suppress tree growth. Apogee + Regulaid in well water was not as effective as simply adding more NH_4SO_4; however, Regulaid may have had some additional influence but not statistically. If $CaCl_2$ (frequently used to reduce bitter pit and corkspot disorders) was added to Apogee + Regulaid, the calcium completely inhibited the growth suppression of Apogee. If NH_4SO_4 is added at the same rate as $CaCl_2$ (w/w) the growth suppression was completely restored. If Solubor was added to Apogee + Regulaid, the effectiveness in of Apogee is compromised but $MgS0_4$ did not. Apogee + Li-700 + Choice, a commercial water conditioner, provided the most effective growth suppression. Choice, among other ingredients, has NH_4SO_4 in the formulation. In one of three treatments, Apogee decreased the number of apples harvested on 11 Oct; even though the Apogee treated trees appeared to have more apples due to the inhibition of tree growth. The Apogee treatment that had the fewest fruit per tree, numerically, also had the largest fruit. Some of the Apogee treatments may have increased return bloom; but no trend was found related to shoot growth suppression.

Introduction

<u>Effect of crop reduction on Growth and Fruiting of Bearing Trees</u>

The timing and severity of thinning in one year may strongly influence cropping for several subsequent years. Singh (1948) reviewed several studies suggesting *that fruit* thinning practiced 30 or more days after bloom was rarely successful for control of alternate bearing. As in the past, strongly biennial bearing cultivars may routinely be over-thinning in order to achieve return bloom, even though greater yields of adequate fruit size could be realized with an earlier thinning time (Singh, 1948 and Harley *et al.,* 1934, 1942). Comparison studies of bloom vs 30 days AFB thinning on subsequent season's return bloom, yield, and fruit size were not conducted in the 1940s because hand thinning at bloom or petal fall was commercially impractical.

Fruit thinning, if sufficiently severe as late as 60 days after full bloom (AFB), has been shown to increase blossom-bud differentiation (Haller and Magness, 1933). However, for some strongly biennial bearing cultivars when bloom thinned may not result in an adequate return bloom if the trees carry a full crop to harvest, (*ie.* 'York Imperial'/M.26 and 'Golden Delicious'/M.26) (Byers et al., 2000b). McArtney *et al.* (1996) found that if Royal Gala (an annual bearing cultivar) was fruit thinned three to four weeks after bloom, fruit weight was 16% less at harvest and leaf area per tree was depressed by 17%.

Fruit size, quality, colour, and pest control

Typically with alternate bearing cultivars, thinning in the "on year" increases yields of the more valuable fruit sizes (Preston, 1958). In the "off year", fruit in the larger size catagories (over 75 mm) frequently command a lower price because they are too large, have more physiological disorders, and shorter storage life. In the "on year", a significant portion of the fruit are in the smaller, low priced categories. In large fruited cultivars, early thinning of may result in oversized fruit at harvest; for this reason, thinning may be deliberately delayed in order to reduce fruit size. This delay may improve fruit firmness but have a negative impact on return bloom (Johnson, 1992; 1995). Johnson (1995) reported earlier fruit maturation of when trees were thinned at full bloom (FB) + 5 days, but not later (at FB +27 days or FB +39 days as determined by internal ethylene, respiration rates, and colour). Also larger fruit that matured earlier more susceptible to rotting by Gloeosporilum perennans. Large fruit from thinned trees were more susceptible to bitter pit and internal breakdown, had lower calcium and higher potassium concentrations than did small fruit from non-thinned trees. Fruits from thinned trees were higher in firmness and soluble solids than from unthinned trees (Volz *et al.* 1993; Sharples, 1964; 1968). Lafer et al. (1999) determined that the optimum crop load should range between 1 to 1.5 kg cm^{-2} (6-9 fruits cm^{-2}) for several cultivars. Crops below 0.5 kg cm^{-2} dramatically increased bitter pit, senescent breakdown, low temperature breakdown, and spoilage. Over-cropped trees had fruit with depressed firmness, green background colour, reduced starch and soluble solids, poorer internal quality and storability. Johnson (1992) suggested that growers should be cautioned against long-term storage of fruit from light or over-thinned trees and that additional calcium sprays may be needed to reduce storage disorders in some cultivars.

Volz and Ferguson (1999) found that bloom thinning trees to a single fruit/spur greatly increased fruit size (65%); and had no effect on calcium concentration. However, in contrast, thinning alternate clusters only slightly increased fruit size (21%) and reduced calcium concentration by up to 22%. The reduced calcium concentration was caused by an increase in multi-fruited clusters and by lower leaf areas on bearing spurs. For cultivars that suffer from calcium disorders, 1-naphthy N-methylcarbamate (carbaryl) may be a more desirable thinner since it is a more selective thinner for removal of smaller fruit from the cluster than is napthaleneacetic acid (NAA), ethephon, or 6-benzyladinine (6-BA).

In "regular bearing" cultivars, total yields over a two year cycle may be reduced by thinning, but the increased fruit size improves crop value (Preston, 1954; Quinlan and Preston, 1968). If one assigns a theoretical value to each fruit size, the total crop value is disproportionally influenced by the larger fruit (Table 1, from Quinlan and Preston, 1968). In this case, crop value was higher even though fruit yields were lower due to over thinning at FB + 1 week. For these reasons, the objectives of thinning should be to 1) eliminate the smallest fruit, 2) maximize the production of the most valuable fruit sizes, and 3) to prevent biennial bearing.

Since cell division ceases four to six weeks after bloom, trees thinned near bloom are larger at harvest and have more cells than fruit from trees thinned progressively later after bloom (Goffinet, *et al.*, 1995; Denne 1960; 1963; 1970; Sharples, 1968). The greater cortical cell number appears to be the result of an increase rate of cell division, and not an extended period of cell division by increased cell enlargement, or by intercellular spaces. Even though fruit size is more correlated with increased cortex cell number than increased cell enlargement,. Sharples (1964) demonstrated that severe thinning to less than the optimum cropping five weeks after bloom (after the cell division stage) led to doubling of fruit weight due primarily to cell enlargement, and cell division was only slightly stimulated.

Seed development is essential for apple fruit set in most apple cultivars; but the number of seeds per fruit is considered to have only a minor positive influence on fruit growth. The leaf to fruit ratio is by far of the greatest importance. The "king" fruit have a greater seed number than side fruit and seed are uniformly distributed in the core, thus fruit shape is more typical of the cultivar (Westwood, 1978). Fletcher (1932) showed that hand thinning of fruit to one fruit per 50 or 100 leaves increased fruit red colour and size; but when trees were fertilized, red colour was not promoted by thinning. Preston (1954) showed substantial increases in yellow and red colour of 'Duchess Favorite' apples by thinning to 20 or 30 leaves/fruit, but thinning to 10 leaves/fruit only slightly affected fruit colour.

Lawson *et al.*, (1998) found that hand thinning fruit to single-fruit clusters reduced oblique-banded leafroller damage to apple fruit. Possible explanations were that a single larvae would more likely damage two fruit hanging in a cluster than a single fruit, and/or better pesticide coverage of a single than a multi-fruit cluster.

Chemical thinners, or selective hand thinning, that select for the "king" fruit, typically improves the L/D ratio, colour, symmetry, and allows for better exposure to pest control chemicals of the remaining fruit. Even though fruit shape is generally not correlated with fruit density, plant growth regulating chemicals (ie 6-BA) used for thinning may directly increase fruit weight and elongation of 'McIntosh'-type cultivars (Greene et al, 1990), but not in others ('Golden Delicious', 'Red Delicious', 'Rome', 'York Imperial', etc. (Greene and Autio, 1994).

Yields

Since total crop value is comprised of the sum of fruit values for each size category averaged over two or more years, in the future multi-year studies should determine the economic impact of thinning on each size category. Even though convincing data are not available from multi-year studies, annual-bearing trees from a biennial bearing cultivar would likely average greater yields of optimum fruit sizes than trees showing a strong biennial bearing habit since fruit would be large in the "off year" and small in the "on year". When trees of a biennial cultivar were thinned annually with

Elgetol over a four year period; Elegtol increased the average total yields and fruit size for the four years. In the non-thinned trees, high yields of small fruit in the "on year" were followed by low yields of large fruit in the "off year" (Hoffman, 1947).

Parry (1974) demonstrated that "half-tree" defruitation was a more reliable method to avoid biennality of 'Laxton Superb' trees than "whole-tree" cluster reduction, and Preston (1954) showed that trees that were "half-tree" defruited had a larger percentage of marketable fruit over the two year bearing cycle. Forshey and Elfving (1977) found that 'McIntosh' apple yields were positively related to fruit numbers, but the increase in fruit size as a result of thinning was proportionally less than the decrease in fruit numbers. Consequently, the total yield per hectare of large, higher valued fruit was either unchanged or reduced by thinning. In the year of fruit thinning, the point of diminishing returns may be quickly reached.

Defruiting young trees for tree growth

Trees grown on dwarfing rootstocks typically flower and fruit in the second or third season; where as, trees of similar age grown on semi-dwarf and seedling rootstocks seldom adequately flower at 4 to 6 years of age. Early flowering and fruiting may seriously inhibit tree growth, and cause long-term stunting of the tree that may contribute to reduced tree size, poor tree structure, and reduced yields for several years thereafter. For this reason, defruiting of young, dwarf trees with chemical thinners or by hand has become a routine commercial practice.

Bedford and Pickering (1916) showed that deblossoming young apple trees for the first two crop years caused trees to bear more heavily for up to 14 years after treatment. The trees were larger and stronger than trees that were allowed to bear in the first two seasons. Maggs (1963) showed that deblossoming caused a three-fold increase in new root growth and a two-fold increase in trunk cross sectional area when compared to thinned?? trees. Deflowering spur 'Rome' trees increased terminal shoot growth by 52% and trunk circumference by 47% (R. E. Byers, 1992, unpublished results). The application of gibberellins soon after bloom will partially, but not consistently, inhibit flower bud formation for the subsequent season and will stimulate tree growth in the current season independently of cropping (Unrath and Whitworth, 1991).

Growth Regulators (Gibberellin & Ethephon)

Since heavy flowering in one year inhibits the growth and development of the bourse flowers in the subsequent season, partial inhibition of flowering with gibberellin sprays may promote fewer and larger flowers. McArtney (1994) demonstrated that a single spray of GA_3 or GA_{4+7} at full bloom reduced the subsequent season's flowering and the severity of biennial bearing of 'Braeburn' trees. Increasing concentrations of a gibberellin spray linearly decreased flowering the following year and promoted flowering two years after application. Several experiments have shown GA_7 to be more effective than GA_3, and that GA_4 is ineffective for inhibition of flower bud formation (Dennis and Edgerton, 1966; Tromp, 1982; McArtney and Shao-Hua Li, 1998; Tromp, 1982). Tromp (1982) found that GA_{4+7} more effectively reduced flowering than did GA_3 on both spurs and one-year-old shoots. However, Marino and Greene (1981) found that GA_3 was more effective on one-year-old shoots, and GA_{4+7} was more effective on spurs to decrease flower bud formation. Applications of gibberellins must be made at bloom or shortly thereafter to be effective on spurs; but applications up to 60 days AFB are effective on one-year-old shoots (Tromp, 1982). Gibberellins used to reduce russeting of 'Golden Delicious' fruit has also shown some inhibition of flower bud formation (Meador and Taylor, 1987; Greene, 1993). It is believed that gibberellins interfere with the early phases of bud primordia development long before flower buds are microscopically visible. Although less effective for flower bud inhibition, GA_3 may be a better choice economically since the price of GA_{4+7} may be five times that of GA_3.

To maximize tree growth, Unrath and Whitworth (1991) attempted to completely inhibit flowering of young non-bearing 'Red Chief Delicious' trees. In one experiment, multiple applications GA_{4+7} at rates of 250 mg liter^{-1} or 500 mg liter^{-1} reduced flowering by 95% to 99%, respectively. In two other experiments, similar treatments gave very little or no suppression of return bloom; however, the timing of GA_{4+7} applications may have been too late.

Ethephon has been used in the apple industry as a thinning agent, flower promoter, and color enhancer (Abeles 1992). Multiple low dose applications of ethephon during the thinning period have been used to promote return bloom of apple while avoiding fruit abscission from higher rates (Byers 1993). Olien and Bukovac (1978) have reported that temperature may greatly influence ethylene evolution in cherry leaves. Jones and Koen (1985) found that, in growth chambers, application and post application temperatures greatly contribute to increased fruit abscission. Our data from 1999, indicated that low levels of ethylene evolved from trees for more than 14 days after application; and that the rate of ethylene evolution was temperature dependent (Byers, unpublished). In addition, Jones et al. (1991) found that ethephon thinning was greater when an increased spray water volume was used while keeping the chemical rate constant/hectar.

Dormant pruning

Dormant pruning reduces the number of flower and vegetative buds resulting in a greater supply of organic carbon reserves for fruit set and fruit growth for the remaining vegetative and floral buds. Pruning may easily remove 30 to 80% of the flower buds before growth has started in the spring. In addition, pruning restricts of tree height, spread, and density, reduces canopy density, increases spray penetration, helps maintain tree structure, promotes regular bearing, stimulates shoot growth, inhibits flower bud formation, but increases spur vigour and flower bud size, increases the percentage of flowers setting fruit, fruit size, quality, and colour, and results in a reduction of the current season's yield; but may promote yields over the 2-year bearing cycle (Mika 1986). Forsythe (1802, reviewed by Davis, 1958) made detailed recommendations for pruning and training systems designed to "keep trees in a constant state of bearing; which if left to nature would produce a crop only once in two or three years". Roberts (1952) showed that fruit set, fruit size, leaf size, shoot length, and subsequent season's return bloom could be substantially increased by detailed removal of 70% of the growing points by heading cuts in the dormant season even after flower bud size had been determined. He demonstrated that heavy pruning in the "on year" could decrease the number of flower buds

Chemical or Hand Thinning

Thinning of bearing trees soon after bloom results in greater tree growth and a greater number of spurs with growing bourse shoots when compared to progressively later thinning times (Preston, 1954). In the year following thinning, larger dormant buds have been correlated with larger flowers, greater spur leaf area, longer bourse shoots, and greater fruit size on trees thinned shortly after bloom (Denne, 1963). Maggs (1963) demonstrated that deblossoming trees resulted in more and larger leaves, longer shoot growth, increased trunk thickening, and greater root growth; however, cropping trees produced more total dry matter (vegetative growth plus crop) per unit leaf area. In addition, deblossoming trees stimulated tree growth more than defruiting trees 36 days after bloom. Barlow (1966) demonstrated that thinning promoted an increase in the total number of longer shoots that grow, and to a lesser extent an increase in shoot length. Llewelyn (1968) demonstrated that flower bud removal from every other limb at the "mouse ear" stage caused a greater number of bourse shoots than limbs bearing flowers at bloom.

By thinning 18-year-old 'Sunset'/M.9 trees trees at progressively later times at Pink Bud, FB +7 days, FB +14 days and FB +21 days, Quinlan and Preston (1968) recorded a 4-year incremental increase in trunk cross sectional area of 198%, 198%, 193%, 155%, respectively. In addition, total bourse shoot length/100 flowering clusters, was greatest for the earliest thinning time, and over the four year period was 324%, 221%, 151%, and 149% of the control, respectively. Thus the increase in shoot growth per tree was due to the increase in the number of bourse shoots produced not their length. These data suggest early thinning allows for a greater number of fruiting spurs and leaves within the whole tree. Thinning after bloom decreased spur leaf size and number (McArtney, 1996) and decreased flower bud size and subsequent fruit size the next season.

The objectives of the experiments reported here were: 1) to follow the return bloom and fruiting of biennial bearing 'York'/M.7 trees sprayed with GA_3 in 1997, 2) to investigate foliar nutrient sprays, multiple applications of ethephon, defruiting, and hand thinning on return bloom and fruiting of heavily set apple trees, and 3) to follow return bloom of 1999 and 2000 chemical thinning experiments.

Materials and Methods

Chemicals were applied to whole trees with a low-pressure hand-wand sprayer, a high pressure hand gun, or a Swanson 3-pt hitch airblast sprayer. The experimental designs for all experiments were randomized complete block designs (RCBD). Apple trees were selected for uniform flowering at bloom and were blocked according to row and terrain into replicate blocks for each of the treatments listed in the tables.

The number of flower clusters or the crop density (CD), was determined by counting the flower clusters or fruit on 2 or 3 pre-selected limbs per tree or on the entire tree. Two or three limbs per tree were tagged during the late pink stage, and at the point where limbs were tagged, limb circumferences were measured. The number of fruit on each limb were counted about 50 to 55 days after bloom, well after unfertilized fruit had dropped. Crop density (CD) on sample limbs was expressed as fruit•cm^2 limb cross-sectional area (LCSA). In the event that all the fruit on a tree was counted, crop density was expressed as fruit•cm^2 trunk cross-sectional area (TCSA). Past experience has indicated that when using these techniques the desirable crop load was approximately 4 to 6 fruit•cm^2 cross-sectional area limb (or trunk) after thinning (Byers and Carbaugh 1991; Byers, 1997); but this may vary by pruning style and type of limbs selected.

Data were analyzed with SAS (Sas Institute, Cary, N. C.), general linear model (GLM procedures) to evaluate the linear and quadratic effects, pre-planned single-degree of freedom contrasts of interest, or Duncan's New Multiple range tests.

<u>Gibberellin Trial (1997-2002)</u>

<u>Expt. 1.</u> In 1997, forty 8-year-old 'York'/MM. 7 trees were selected for 0 to 20 % of spurs flowering (visual estimate) except for one of the control treatments that had 90 to 100 % of the spurs flowering. Trees were blocked by row and terrain into 10 blocks of 4 treatments (Table 1). Trees were not hand or chemically thinned in 1997. Trees were either sprayed or not with GA_3 at a rates of 160 ppm or 320 ppm. In 1997, the number of fruit on limbs that were pre-tagged at bloom were counted and expressed as fruit•cm^2 limb cross-sectional area (LCSA). The percentage of spurs flowering in 1998 were visually estimated and fruit set on limbs tagged in 1997, were counted on 26 May 1998. In 1999, 2000, 2001, and 2002 visual estimates of the number of spurs flowering, flower clusters and fruit were counted on 2 representative limbs per tree. Trees were over sprayed with chemical thinners in 1998,1999, 2000, 2001, and 2002.

<u>Dormant pruning</u>

<u>Expt. 2</u>. In 2002, sixty 12-year-old 'York'/M.27 trees (10 blocks) were selected for 6 treatments (Table 2A&B). Half of trees selected were 0 to 10 % of spurs flowering (visual estimate) the other half 90 to 100 % of the spurs flowering. Trees in the "on year" were then hand pruned to thin crop to 50 % or 80 % of spur removal except for the control treatment which had no spur removal. In 2002, all fruit were harvested from each tree and fruit were individually sized by a computerized weight sizer/grader/computer (each fruit were weighed and sorted by any weight catagory). The intent is to continue pruning treatments annually for at least 2 years or several years while continuing to collect data on flowering, total yields/tree, yield for combined "on" and "off year" for each fruit diameter/price catogory, and cumulative value of crop for each treatment.

<u>Hand Thinning and Ethephon Return Bloom Trials (2001-2002)</u>

<u>Expt. 3.</u> In 2001, seventy-five 10-year-old 'Fuji'/M.27 trees were blocked according to row and terrain into 5 blocks for 15 treatments, and were defruited or sprayed with ethephon at various times from June to October 2001 (Table 3A). A 10-fruit sample from each tree (of trts# 1, 11, 13) was evaluated for maturity and fruit size on 4 Oct 01 (Table

3B). In 2002, the numbers of flower clusters was estimated as visual % of spurs flowering.

Expt. 4: In 2001, thirty 14-year-old 'Starkrimson'/Mark trees were blocked according to row and terrain into 6 blocks for 5 treatments, and were defruited or sprayed with ethephon at various times from August to September 2001 (Table 4). A 10-fruit sample from each tree was evaluated for maturity and fruit size on 24 Sept 01. In 2002, the numbers of flower clusters was estimated as visual % of spurs flowering.

Expt. 5. In 2001, thirty 10-year-old 'York'/M.27 trees were blocked according to row and terrain into 6 blocks for 5 treatments, and were defruited or sprayed with ethephon at various times from August to October 2001 (Table 5). A 10-fruit sample from each tree was evaluated for maturity and fruit size on 16 Oct 01. In 2002, the numbers of flower clusters was estimated as visual % of spurs flowering.

Chemical Thinning Trials (2001-2002)

Expt. 6. Thirty-six 14-year-old 'Starkrimson Delicious'/MM.106 & MM.111 trees (6 blocks) were selected for 6 treatments (Table 6A&B). Treatments were applied with Swanson 3-point-hitch airblast sprayer at 100 gal/acre on May 8 when fruit were 11 mm in diameter.

Expt. 7. Forty-five 13-year-old 'Ace Delicious'/MM.111 (9 blocks) were selected for 5 treatments (Table 7). Accel or 6-BA were applied in combination with either Oil or Li-700 and compared with an untreated control:). Treatments were applied with Swanson 3-point-hitch airblast sprayer at 100 gal/acre on May 8 when fruit were 11.3 mm in diameter.

Expt. 8. Forty-five 18-year-old 'Law Rome'/MM.106 trees (9 blocks) were used for 5 treatments (Table 8). Ethephon was applied at two chemical rates of 2.5 or 5.0 pt./acre at 100 or 400 gal/acre. Treatments were applied with a Swanson 3-point-hitch airblast sprayer on May 16 when fruit were 13 mm in diameter.

Expt. 9. One-hundred-twelve 10-year-old 'Starkrimson Delicious'/Mark trees (8 blocks) were selected for 14 treatments (Table 9). Sevin XLR Plus or Sevin 50WP and were compared alone or in combination with Accel, 6-BA, Oil, Silwet L-77 in selected combinations to ethephon and untreated controls. Sprays were applied dilute with a low pressure hand-wand sprayer on May 22 when fruit were 23.5 mm in diameter.

Expt. 10. Twenty four 26-year-old 'Empire'/MM.111. trees (6 blocks) were used for 4 treatments (Table 10). Accel was applied alone or with Oil, Li-700, or Silwet L-77 and were compared with an untreated control. Sprays were applied with a Swanson 3-point-hitch airblast sprayer at 100 gal/acre on 14 May when fruit were 15 mm in diameter.

Expt. 11. In 2001, the sterol inhibiting fungicides, Procure 50 W or Nova 40 W, were applied to 'Gala'/M.27 trees at the 0, 1X, 3X, and 9X the registered chemical rates (Table 11ABC). A 10 fruit maturity sample was obtained on 28 Aug from each tree. Fruit length, diameter, firmness, soluble solids, starch, red color and fruit weight were obtained. The remaining fruit on each tree were counted, fruit diameter and length obtained, and placed into 0.25-inch fruit diameter categories.

Apogee Trial (2001-2002)

Expt. 12. In 2001, seventy-eight 6-year-old 'Fuji'/M.9 trees (6 blocks) were selected for 13 treatments (Table 12). Prohexadione-calcium (Apogee) was applied at 125 ppm (to drip) in 3 applications to the same trees at FB+7, FB+28, and FB+59 days. In addition, Regulaid, NH_4SO_4, Choice, LI-700, Quest, $CaCl_2$, were applied in various combinations with Apogee (formulated as 27.5% ai) or technical pro-hexadione-calcium (93.2% ai; PHCA) in deionized water or "hard" well water as potential adjuvants, or water conditioners as indicated in Table 12. Ten of the longest scaffold shoots were tagged around the periphery of each tree and their lengths were measured on July 13. During dormancy, the10 scaffold shoots were pruned and the basal diameters and lengths of the terminal shoots recorded. In addition, the nodes/cm of the basal 40 cm and nodes/cm of the upper 30 cm of shoots were recorded. Trees were pruned and the total length of the shoots longer than 30 cm, the weight and time required to prune, the number of cuts, and the pruning weights/cm^2 trunk cross-sectional area (TCSA) per tree was recorded.

Results and Discussion

Gibberellin Trial (1997-2002)

Expt. 1. 'York'/M.7 trees selected for heavy bloom in 1997 had a heavy crop in 1997 and had only 3% of the spurs returning bloom in 1998 (trt #1) (Table 1, Figure 1) . 'York' trees selected for very little bloom in 1997 ("off year" of the biennial bearing cycle) and sprayed with 160 ppm GA_3 or 320 ppm GA_3 had significantly less return bloom in the 1998 ("on year") (61% and 46% spurs flowering, respectively, compared to control trees that had 99% of spurs flowering). This flower inhibition allowed more resting spurs and adequate bloom for a full crop in 1998, 2000, and 2002, but not in 1999 and 2001. Trees sprayed with GA_3 in the "off year" in 1997 returned bloom and cropped again in 1999, 2000, 2001, and 2002. Trees in the "off year" in 1997 that were not sprayed with GA_3, heavily cropped in 1998 and 2000, and 2002, but not in 1999 and 2001. These data show that 'York'/M.7 trees sprayed with GA_3 to in the "off year" of the biennial bearing cycle continued to bear on a more annual cycle for 4 years after a single spray.

Pruning Trial (2002)

Expt. 2. In 2002, pruning by removal of 50% or 80% of the spurs reduced the crop load from 4.04 to 2.75 fruit/cm2 truck cross sectional area. The average single fruit weight of all fruit on trees was increased at harvest by pruning. An analysis of % of fruit by size category indicated that pruning at either 50% or 80% level increased the % of fruit in size categories above >3.25 inches, >3.50 inches, and >3.75 inches. The number of fruit in each category was reduced in the 2.75-3.00 and >2.75 >3.00 inches, but were

equal in the >3.25; and greater in the >3.50 and > 3.75 inch categories as a result of detailed pruning of the spur system. If one assigns a value to each size category, ??????????????//////////////
pruning causes a decrease in value in the 1st year of pruning; but the expected return bloom in year 2 is expected to be of greater value.

Hand Thinning and Ethephon Return Bloom Trials (2001-2002)

Expt. 3. In 2001, 'Fuji'/M.27 trees defruited or sprayed with ethephon at various times were evaluated for return bloom in 2002 (Table 3). Ethephon did not cause intended fruit drop when applied Aug 8 or Aug 22. In 2001 a 10-fruit sample from each tree (of trts# 1, 11, 13) indicated that ethephon did not affect fruit diameter, L/D ratio, fruit firmness, starch, or soluble solids on 4 Oct 01 (Table 3). In 2002, defruiting trees by hand during the period of 13 Jun to 4 July provided an adequate return bloom (65 to 48% spurs flowering in 2002) for a crop in 2002; but neither defruiting by hand from 11 Jul to 4 Oct, or spraying with ethephon on Aug 8 or Aug 22 caused increased return bloom.

Expt. 4. In 2001, 'Starkrimson'/Mark trees defruited or sprayed with ethephon at various times were evaluated for return bloom in 2002 (Table 4). In 2001, a 10-fruit sample from each tree (of trts# 1, 4, 5) indicated that ethephon did not affect fruit L/D ratio, fruit firmness, starch, but the Aug 22 ethephon application increased soluble solids on 24 Sept 01 (Table 4). As expected the late ethephon application on 22 Aug more effectively removed fruit than the 8 August application. In 2002, neither defruiting trees by hand during or spraying with ethephon on Aug 8 or Aug 22 caused increased return bloom.

Expt. 5. In 2001, 'York'/M.27 trees defruited or sprayed with ethephon at various times were evaluated for return bloom in 2002 (Table 5). In 2001, a 10-fruit sample from each tree (of trts# 1, 4, 5) indicated that ethephon did not affect fruit diameter, L/D ratio, reduced fruit firmness and starch and slightly increased soluble solids on 16 Oct 01 (Table 5). Ethephon application on 8 Aug or 22 Aug was equally effective for fruit removal (approx. 50%). In 2002, neither defruiting trees by hand during or spraying with ethephon on Aug 8 or Aug 22 caused increased return bloom.

Chemical Thinning Trials (2001-2002)

Expt. 6. In 2001, sprays on 13-year-old 'Starkrimson Delicious'/MM.106 & MM.111 of NAA alone or in combination with 6-BA or Accel caused an increase in the numbers of small fruit < 25mm on 6 June and decreased the numbers of large fruit > 25 mm on 6 June when compared to the untreated control, 6-BA (90g/acre) + Li-700, or Accel (90g/acre) + Li-700 (Table 6A&B). At harvest on 11 Sept., NAA alone or in combinations with 6-BA (45g/acre) or Accel (45g/acre) increase the numbers of fruit below 2.25 inches and decreased the fruit numbers above 2.50 and 2.75 inches. NAA+Accel+Li-700 increase the total number of fruit/cm^2 limb cross sectional area and NAA+6-BA+Li-700 numerically was greater but was not significantly. In 2002, all of the treatments caused increased return bloom.

Expt. 7. In 2001, sprays on 14-year-old .'Ace Delicious'/MM.111 trees of 6-BA (90g/acre) + Li-700 or Oil (trts# 2, 4) provided more thinning than Accel (90g/acre) + Li-700 or Oil (trts# 3, 5) (Table 7). Oil was a superior adjuvant for thinning with 6-BA and Accel based on single degree of freedom contrasts. In 2002, none of the treatments caused increased return bloom. However when each treatment is compared to the control, none of the treatments individually caused thinning based on Duncan's multible range test ($P=\leq 0.05$). In 2002, none of the treatments caused increased return bloom.

Expt. 8. In 2001, ethephon applied at 5 pt/acre to 'Rome'/MM.106 when fruit were 13 mm in diameter caused more fruit thinning than at 2.5 pt/acre regardless of water volume (Table 8). While keeping the chemical rate/acre constant, the water rates of 100 gal/acre or 400gal/acre were equally effective. The greater fruit thinning with ethephon the greater was the fruit length and diameter at harvest; however, greater thinning did not affect the L/D ratio. In 2002, all of the treatments caused increased return bloom.

Expt. 9. In 2001, None of the treatments caused significant fruit thinning of 'Starkrimson Delicious'/Mark (young) when applied with a hand-wand sprayer to trees on 22 May at 23.5 mm fruit diameter (Table 9). Over all combinations, Sevin XLR caused more fruit injury than Sevin 50WP; but this difference was small. Sevin XLR caused slightly more fruit injury in lenticles than Sevin 50WP. The addition of Accel or Accel+Oil caused more injury than Sevin alone. Oil did not increase injury to fruit. Sevin + Accel + Oil or Sevin + 6-BA + Oil caused more injury than no treatment (trt#1). Pigmy fruit development <32 mm on 26 June was increased by Accel more than by 6-BA even when combined with Sevin+Oil. Sevin XLR, Sevin 50WP, or ethephon did not influence pigmy fruit development. Fruit larger than 32 mm was not affected by treatment. In 2002, none of the treatments caused increased return bloom.

Expt. 10. In 2001, none of the Accel treatments caused fruit thinning of 26-year-old 'Empire'/MM.111 trees (Table 10), but did increase the % of pigmy fruit when compared to the untreated control. In 2002, none of the treatments caused increased return bloom.

Expt. 11. In a 10 fruit sample from each tree the highest Nova 40 W rate (45 oz/acre) reduced the fruit length and weight (Table 11A, trt#7), but did not influence fruit diameter (Table 11A). At all chemical rates (1X, 3X, and 9X), Nova reduce the L/D ratio (Table 11A). No differences were found between the treatments regarding firmness, soluble solids, starch, or red color in the 10 fruit maturity sample.

When the whole tree's fruit sample (which included the 10 fruit sample) was sized and placed into 0.25-inch fruit diameter categories, the highest Nova 40 W rate (45 oz/acre)fruit were smaller than the control as indicated by the percentage of fruit <and> 2.5 inches, <and> 2.75 inches, % fruit 2.00 to 2.25 inches, and % fruit 2.75 to 3.00 inches (Table 11 B). No difference in fruit numbers/tree were noticed.

In the whole tree's fruit sample, fruit length, fruit weight and length diameter ratio was reduced by the highest Nova 40 W rate (45 oz/acre), but fruit diameter was not affected (Table 11 C). In 2002, none of the treatments affected return bloom.

Apogee Trial (2001-2002)

Expt. 12: In 2001, Prohexadione-calcium technical grade 93.2% (PHCA) applied at 125 ppm to 'Fuji'/M.9 trees (dilute to drip) in 3 applications at FB+7, FB+28, and FB+59 days in deionized water reduced tree growth somewhat (trt#2), and the addition of NH_4SO_4 to PHCA further suppressed tree growth (trt#3)(Table 2). However, if PHCA was mixed in well water (250ppm hardness), PHCA did not suppress tree growth (trt#4). Apogee (27.5% ai + some NH_4SO_4 sulfate in the formulation) + Regulaid (trt#6) in well water was not as effective as simply adding more NH_4SO_4 (trt#7); however, the Regulaid may have had some additional influence but not statistically (trt#8). If $CaCl_2$ was added to trt#6, the calcium completely inhibited the effect of the Apogee + Regulaid (trt#9); but if NH_4SO_4 was added at the same rate (w/w), the effectiveness was completely restored (trt#10). If Solubor is added to trt#6, the effectiveness of Apogee is compromised (trt#11), but $MgSO_4$ did not (trt#12). Apogee + Li-700 + Choice, a commercial water conditioner, was the most effective treatment (trt#13). Choice among other ingredients has NH_4SO_4 in the formulation (trt#13). Additional measurements taken 4 Dec 01after the summer growth period was complete indicated that re-growth after 13 July was substantially greater for treatments that suppressed growth the greatest before 13 July 01. Some of the Apogee treatments may have increased return bloom; but no trend was found related to shoot growth suppression.

Expected Significance to the Apple Industry

Chemical thinning promoted return bloom when substantial thinning occurred. The return bloom caused by a single ethephon thinning spray was probably caused by a reduction of crop load related to thinning and not as a direct effect of ethylene on flower bud differentiation. Defruiting trees by hand before 4 Jul was effective for a return bloom the following season; but after this date no effect on return bloom was found. Spraying of individual trees in the "off-year" with GA_3 (to reduce flowering in the "on-year") successfully altered flowering and fruit set the following year and the alternate bearing habit of 'York' trees became more annual for several seasons thereafter from a single application in the first year. Control of tree growth with Apogee did not affect flowering.

Acknowledgements

Appreciation to Seth Combs, Heath Combs, Jean Engelman, Tim Stern, Maurice Keeler, and Harriet Keeler for data collection, analysis, and technical assistance.

References

Abeles, F. B. 1992. Ethylene in plant biology. Academic Press, New York.

Byers, R. E. 2003. Flower and fruit thinning and vegetative fruiting balance. *In: Apples: Botany, Production and Uses. Ferree, D. C. and B. Barrett (ed.)* CAB International Wallingford, United Kingdom. (in press).

Byers, R.E. and D.H. Carbaugh. 2002. Effects of thinning time on yield, fruit size, and return bloom of 'York' and 'Golden Delicious' apple trees. J. Tree Fruit Production 3(1):55-62.

Byers, R. E. 1997. Effects of Bloom-Thinning Chemicals on apple fruit set. J. Tree Fruit Production. 2:13-31.
Byers, R.E. 1993. Controlling growth of bearing apple trees with ethephon. Hort. Sci. 28 (11):1103-1105.
Byers, R. E. and D. H. Carbaugh. 1991. Effect of chemical thinning sprays on apple fruit set. HortTechnology 1:41-48.
Jones, K. M. and T.B. Koen. 1985. Temperature effects on ethephon thinning of apples. J. Hort. Sci. 60 (1) : 21-24.
Jones, K. M., Koen, T. B. and Oakford, M. J. 1991. How volume of spray affects the thinning of 'Red Delicious' with ethephon. New Zealand J. of Crop and Hort. Sci. 19:31-36.
Olien, W. C. and M. J. Bukovac. 1978. The effect of temperature on rate of ethylene evolution from ethephon and from ethephon-treated leaves of sour cherry. J. Amer. Soc. Hort. Sci. 103 (2) : 199-202.
Walsh, C.S. and T. Solomos. 1987. Ethylene evolution by apple fruits during their early-season growth and development. Scientia Hortic. 32: 203-211.

Additional references available on request.

Not for Citation or Publication
Without Consent of the Author

MANAGING FRUIT QUALITY AND FLAVOR FOLLOWING 1-MCP TREATMENT

A. Nathan Reed
Fruit Research & Extension Center
Penn State University
Biglerville, PA 17307

SmartFresh (1-MCP) is a new, recently registered postharvest chemical that blocks the action of ethylene. The advantages of using 1-MCP include maintaining fruit firmness, juice acidity and the inhibition of scald. In blocking the effects of ethylene 1-MCP also has an impact on the production of fruit volatile and aroma compounds such as alcohols, esters and aldehydes.

This report describes two experiments associated with 1-MCP storage and treatment of Red Delicious and Gala apples. The first experiment was designed to characterize volatile production in Red Delicious and Gala following 1-MCP treatment and cold storage. The second experiment was designed to evaluate both analytically and through sensory evaluation the potential for enhancing fruit aroma following treatment with 1-MCP and storage.

For all experiments Red Delicious and Gala fruit were obtained from commercial orchard blocks and stored in either commercial CA facilities or research CA chambers. 1-MCP applications were made immediately following harvest at the label rate of 1 ppm for 24 hours at ambient temperature conditions.

<u>Characterization of volatiles</u>: Four orchard blocks of Red Delicious and Gala were sampled at commercial harvest timing. Baseline measurements of fruit volatiles were taken at harvest and at subsequent storage removals at 60, 120, 180 and 240 (Red Delicious only) days.

Experimental procedure for volatile analysis included selection of approximately 0.5 kg of fruit (either 3 or 4 fruit) per grower/block from each storage x treatment combination. The fruit were placed in a temperature-controlled environment (25 °C) in a 2.44 liter glass tube equipped with teflon seals and tubing. A stream (100 ml/min) of ultra clean air flushed the apples for 20 minutes. Air from the glass tube passed through a 250 ml dilution flask. Volatiles were collected on a solid phase micro-extraction (SPME) fiber placed directly in the air stream within the dilution flask. Four replicates of each grower/block were measured at harvest and at each removal from storage. At the prescribed storage removal times 0.5 kg of fruit were selected and allowed to warm to room temperature for 1 day prior to analysis. Additional SPME analyses were taken on each set 8 and 15 days following storage removal. All fruit were held at room temperature during the 15 day post-storage period. The volatiles collected with the SPME method were analyzed and identified by gas chromatography / mass spectrometry.

Enhancing aroma: 1-MCP and control fruit stored in CA for 180 days as outlined above were selected for exogenous volatile components. Baseline levels of volatile profiles were established for each grower/1-MCP treatment combination prior to volatile treatment. Volatiles were introduced at rates indicated in Table 1. Weighed samples of individual volatiles were placed in separate glass petri dishes. The volatiles along with the apples were placed in 0.20 m^3 chambers and sealed for 7 days at 0.5°C. Following volatile exposure the apples were kept at 0.5°C for the duration of the experiment. SPME analysis of aroma of the same groups of fruit were taken on days 1, 8, 15, 22, 29, 36 and 43 following volatile exposure.

Table 1. Addition of volatiles (g/m^3) to Gala and Red Delicious.

Volatile	Gala	Red Delicious
Butyl Acetate	6.78	9.14
Hexyl Acetate	1.71	3.75
2-Methyl butyl acetate	2.70	NA
4-Allylanisole	1.22	NA
Ethyl-2-methyl butyrate	NA	5.62

Sensory analysis: Second sets of 180-day CA stored Gala and Red Delicious were selected for volatile exposure and sensory analysis. Since 1-MCP was not registered for use at that time no fruit for sensory work were treated with 1-MCP. Volatiles were exposed at the rate described above (Table 1) for seven days. Following treatment treated fruit were kept separate from control fruit. Eight days after removal from treatment an experienced panel using a triangular difference and a preference test conducted sensory evaluations. Within a triangular difference test each panelist is given three fruit of which either one or two fruit are control fruit. The panelist's objective is to select which fruit is the odd fruit. In the preference test each panelist received a treated and a control fruit. The objective was to taste each fruit and then indicate a preference for a specific fruit based on the flavor or fruit aroma.

A third set of 180-day CA stored + 40 days in cold, RA conditions Gala and Red Delicious from single grower lots were treated as described above (Table 1). Following volatile exposure treated and control fruit were kept apart from each other but both were held at 0.5°C during the entire evaluation period. Triangular difference tests were conducted on a weekly basis beginning one week after treatment. Evaluations were conducted for six weeks on Gala and seven weeks on Red Delicious.

Results and Discussion:

More than 70 individual aroma compounds were found in Red Delicious and Gala apples. The majority of these were in common to both apple varieties. Figure 1 illustrates the analytical results for hexyl acetate present in Red Delicious and illustrates the general trend found in the other Red Delicious and Gala volatile compounds. Regular atmosphere (RA) stored fruit had the greatest production of volatiles following removal from cold storage at each analysis time. The volatile production of RA stored fruit decreased over time within each two-week, warm temperature holding period. In contrast the amount of volatile production increased in fruit removed from CA and in fruit treated with 1-MCP and held in either RA or CA. The order of volatile production associated with treatment and type of storage was found to be: RA > RA +1-MCP > CA > CA + 1-MCP.

Exposure to exogenous volatiles produced significant increases in those added elements following treatment. In Gala significantly greater levels of butyl acetate, hexyl acetate, 2-Methyl butyl acetate and 4-Allylanisole were analytically detected in treated fruit for 22, 29, 43 and 43 days following removal from treatment, respectively (Figure 2). In Red Delicious significantly higher levels of butyl acetate, hexyl acetate and ethyl-2-methyl butyrate were observed analytically for 22, 15 and 15 days, respectively, following removal from treatment (Figure 3). Grower lots also showed a response effect (data not shown). Postharvest treatment with 1-MCP did not appear to affect the absorption of exogenous volatiles.

Triangular difference tests in the first sensory analysis of enhanced flavor fruit conducted with experienced panels found significant differences ($p<0.05$) between treated and control fruit in both Gala and Red Delicious. However in the preference test no significant differences were found. For Red Delicious, 14 out of 32 panelists preferred the treated fruit. In Gala, 17 out of 30 panelists preferred the treated fruit

Results of the weekly triangular difference tests are illustrated in Figure 4 for the six and seven week trials of Gala and Red Delicious. The panelists were able to correctly identify the odd fruit in Gala apples in four out of the six weeks. The panelists were able to correctly identify the odd Red Delicious in six out of the seven weeks. In five out of the six weeks where differences were found in Red Delicious the level of significance was $p<0.01$.

These results indicate that both storage and 1-MCP treatments affect volatile profiles. Flavor addition or volatile enhancement can be accomplished and can be detected both analytically and by consumer panels. Sensory preference tests indicate that the detectable differences are subjective with respect to individual preference. Finding the right recipe that would result in a positive preference appears to be feasible but could also be elusive.

Partial funding for this project was received from the Washington State Tree Fruit Research Commission.

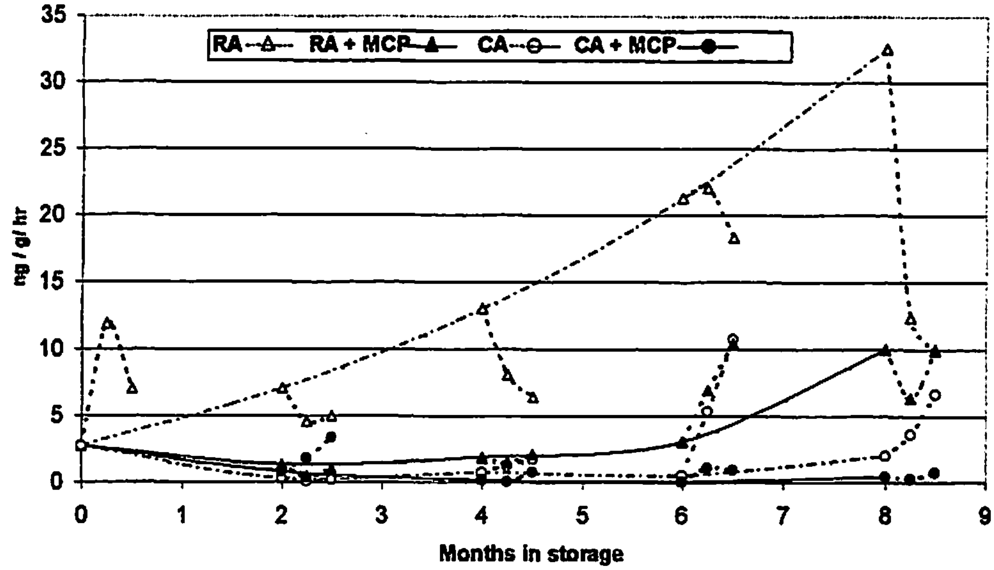


Figure 1. Levels of hexyl acetate in Red Delicious treated with 1-MCP and stored in regular or controlled atmosphere. Dashed lines (----) represent effect of two weeks at ambient temperature.

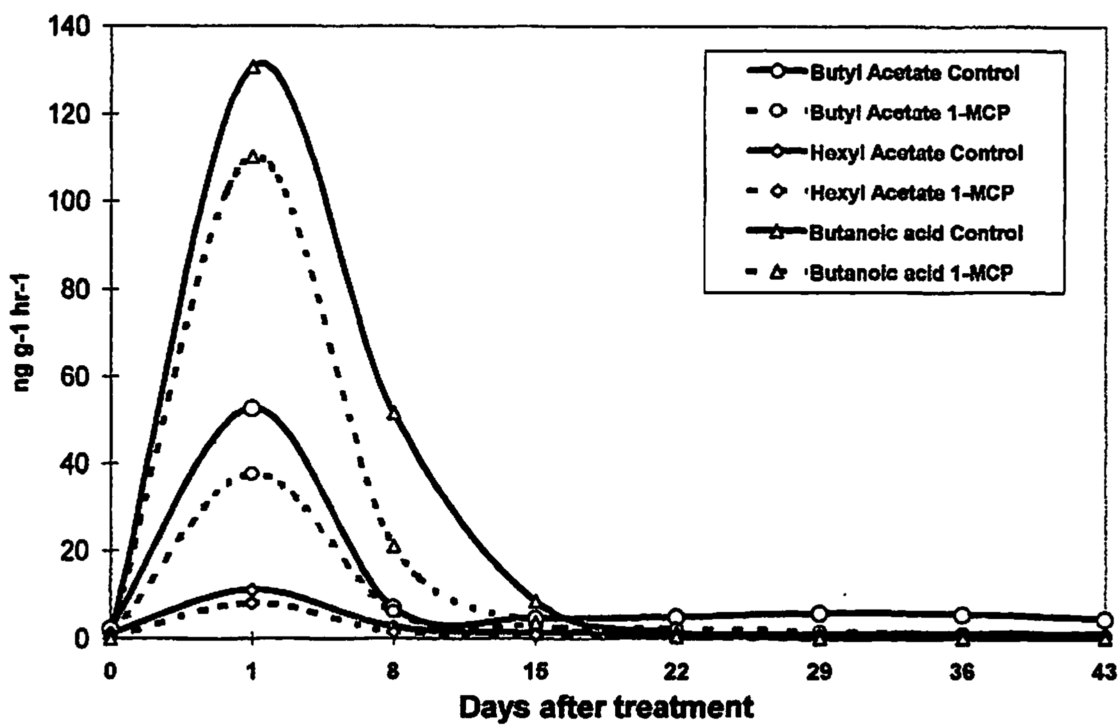


Figure 2. Volatile addition to control and 1-MCP treated Red Delicious.

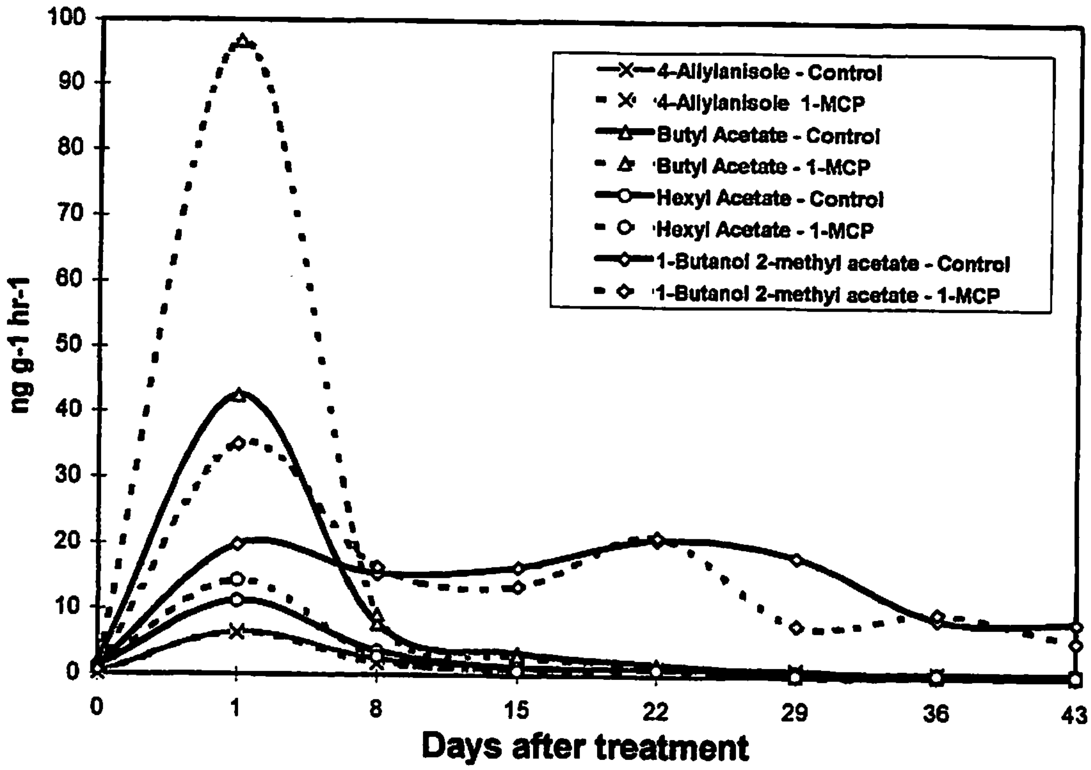


Figure 3. Volatile addition to control and 1-MCP treated Gala.

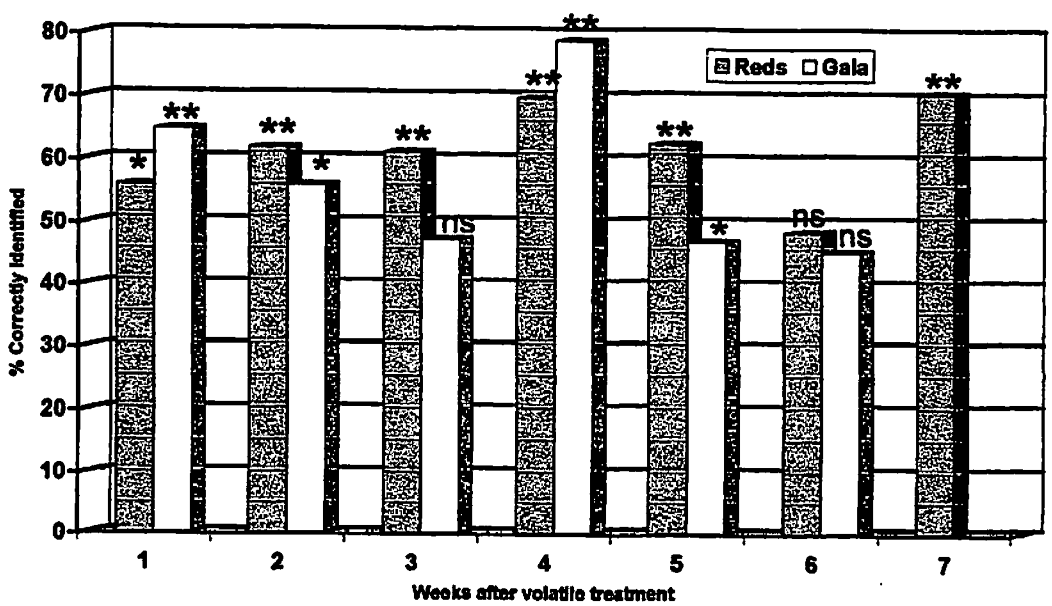


Figure 4. Sensory analysis by triangular differences in Red Delicious and Gala following exposure to exogenous aroma compounds.

Not for Citation or Publication
Without Consent of the Author

NONDESTRUCTIVE FRUIT TEXTURE ASSESSMENT

A. Nathan Reed
Fruit Research & Extension Center
Penn State University
Biglerville, PA 17307

Fruit firmness is a major quality issue within the fresh apple industry. Apart from fruit color, firmness is the most important factor that consumers respond to in judging the overall quality of individual fruit and deciding whether to make a repeat purchase.

Washington State has guidelines in place that require shippers to maintain a minimum 12 lb firmness threshold for Red Delicious and a 10 lb threshold for Golden Delicious. Firmness levels are measured by state department of agriculture inspectors using manually operated, portable Magness-Taylor like penetrometers mounted on drill presses. This procedure was established to insure firmness and quality through individual lot inspections on the packing line. Random inspections of fruit that find greater than 10% of the fruit not meeting the minimum firmness threshold are flagged and those lots cannot be sold and shipped to fresh market retailers. Fruit from rejected lots can be resorted, inspected a second time and sold if they meet the minimum criteria.

This system of inspection works to remove a percentage of fruit that might not be in the best long-term interest of growers and packers from a marketing aspect. The problem surrounding this sampling procedure is that it is destructive and it relies on a sub sample of the entire population. The best quality assurance procedure would be to inspect each individual fruit prior to packing.

A nondestructive technique of classifying fruit texture is based on an acoustical approach. Eshet Eilon, a company based in Israel, first offered a bench-top device (Frimtech) to measure acoustical properties of fruit in 1997. The instrument designed by Eshet Eilon measures the acoustical properties by placing a fruit or apple within an articulated cradle that was equipped with three foam pads with pizeoelectric strips that functioned as microphones to record the vibration of the fruit as it was tapped independently by three thin rods 180 degrees across from the microphone. In addition to picking up the acoustics of the fruit the Firmtech cradle also serves as a balance and electronically records the weight of each individual fruit. Based upon the three independent acoustical readings taken for each piece of fruit, the software determines the maximum frequency of fruit vibration. The unitless number that is displayed and recorded in a database by the instrument is the resultant of the following equation:

Acoustical Quality Index = [Frequency of vibration^2 * weight of the fruit ^ 2/3] / 1,000,000. Typically fruit have AQI values ranging from 8 - 50 depending on variety, time in storage and conditions of storage. Each measurement of AQI requires about 2 seconds to complete using the bench-top instrument.

This report describes a series of sensory tests that have been conducted between 1998 and 2002 using the described acoustical technique. The correlation between the destructive Magness-Taylor method and this acoustical method is very weak. The intent of these sensory trials is to determine if there is an alternative technique that can be associated with the perception of fruit texture and firmness.

In each of the tests described fruit were selected on the bases of the AQI value. Each test, with the exception of the last test of Gala (Trial 5), was based on groupings of AQI into four levels, A, B, C and D with A representing the lowest acoustical values and D the highest level. Table 1 details the grouping of each trial and the statistical significance of the results. Within each test of comparing the four levels of acoustics there are a total of six possible combinations: A-B, A-C, A-D, B-C, B-D and C-D.

Since 1997 Eshet Eilon has gone out of business. In 1999 Aweta, a large industrial manufacturer of fruit packing line equipment based in the Netherlands, produced a second bench-top acoustical device, Acoustical Firmness Sensor (AFS), for nondestructive measurement of internal fruit texture. The only major difference between the AFS and the Firmtech is that the AFS takes a single reading at a time. In tests comparing the Eshet Eilon equipment and the Aweta AFS (data not shown) no statistical differences were found in the acoustical values of apples tested on each device. Due to its portability, the Aweta AFS instrument was used in all subsequent trials (2-5). Within each of the trials each piece of fruit was measured three times and the average acoustical vibration frequency and weight response were used in segregating fruit.

The sensory trials were conducted with panels that represented either: 1. Consumers which had no requirement of prior training on the attribute of fruit texture analysis; 2. Experienced panelists that have participated in various other discriminatory trials involving food analysis; and 3. Trained panelists that are experienced and spend time in texture training on fruit samples prior to the formal sensory evaluation.

Sensory Trial 1. This sensory trial was conducted at the Food Science Lab at Oregon State University in the spring of 1998. Golden and Red Delicious apples were tested by a consumer panel, which represented "walk-ins" from the campus population. A total of 45 consumers were each given two pairs of apples in random order. With 45 panelists a total of 30 complete, six paired tests were completed. From each pair of fruit the panelist was asked to select which apple was firmer. The results of this trial are detailed in Table 1.

Sensory Trial 2. This sensory trial was conducted at the National Food Lab in Dublin, CA, during the spring of 2000. In this trial a trained panel (n=10) was used to evaluate Golden and Red Delicious on a standard Hedonic scale of 1-15. Prior to the sensory analysis of apples the panel practiced with fruit and established comparative reference points of items such as bananas (3.0), Kraft cheese (4.5), wheat thin (7.0) and peanuts (9.5). Each of the ten panelists received a single fruit from each of the four acoustical classes in random order and associated a point value with each individual fruit based on the hardness of the first bite. Comments from the panelist concerning the toughness of the skin of Red Delicious were noted and evaluated at a future sensory test (Trial 4). The results of this trial are detailed in Table 1.

Sensory Trial 3. This trial was conducted at Penn State University's Food Sensory Lab in March of 2001. This trial was a replicate of the first trial conducted at Oregon State University in 1998. In this trial the acoustical groupings of Golden and Red Delicious varied from the initial trial (Table 1). In this trial 35 experienced participants each received six pairs of Red Delicious on the first day and six pairs of golden Delicious on the second day of the test. These panelists were "experienced" in that they have cooperated in other sensory trials held at the Food Sensory Lab on a range of products. The results of this trial are detailed in Table 1.

Sensory Trial 4. This trial was also conducted using Golden and Red Delicious at the Penn State University Sensory Lab in April of 2001. The trial was identical to Trial 3 with the exception that the fruit the panelists (n=33 for Golden Delicious and n = 31 for Red Delicious) tested were peeled and sliced into quarters prior to evaluation. This trial was conducted to eliminate the skin as a factor in the analysis of flesh texture. As a result of peeling acoustical values of fruit dropped approximately 1.5 to 2.0 units. The results of this test are detailed in Table 1.

Sensory Trial 5. This trial was conducted on three groups of Gala at the Penn State University Sensory Lab in spring of 2002. The panelists (n=92) were asked to make two comparisons: A vs B and A vs C. The results of this trial are detailed in Table 1.

Table 1. Results of sensory analysis of apple texture based on acoustical properties.

Sensory Trail	Location - Year	Panel Type	n	Variety	Acoustical Range A	B	C	D	Statistical Separation*
1	Oregon State University '98	Consumer	45	Golden Delicious	15-17	19-21	23-25	27-29	AB - CD
			45	Red Delicious	10-13	15-18	20-21	25-28	A - B - C - D
2	National Food Lab '00	Trained	10	Golden Delicious	15-18	20-21	24-25	27-30	AB - BC - D
			10	Red Delicious	11-15	16-18	21-22	25-31	ABC - D
3	Penn State University '01	Consumer	35	Golden Delicious	10-13	16-18	21-23	26-28	A - BCD
			35	Red Delicious	11-13	16-18	20-23	26-28	A - BCD
4	Penn State University '01	Experienced	33	Golden Delicious	8-10	12-15	17-19	22-27	ABC - CD
			31	Red Delicious	10-13	17-20	23-25	29-33	A - B - CD
5	Penn State University '02	Consumer	92	Gala**	9-14	18-21	26-31	---	AB and A - C

* significnace at $p < 0.05$
**only two comparisons made A vs B and A vs C

Discussion and conclusions:

The results of these trials indicate that panelists are able to differentiate fruit based on acoustical properties. In the 10 trials comparing four groups panelists established two groups five times, three groups four times and four groups once. In the single test of Gala with three acoustical groups they were able to distinguish between low and high acoustical values. The data collected also revealed that the relative order of texture assessment even if not statistically significant paralleled the acoustical readings.

When merging the data from these tests it appears that acoustical thresholds of 15 and 25 could be used as criteria for sorting fruit into premium, standard and utility grades. No fruit in any of the five trials that had acoustical values <15 were ever grouped with fruit that had acoustical values > 25. This segregation does not mean that all consumers would prefer to consume fruit with acoustically properties above 25. With proper education consumers will be able to make an educated decision about the expected mouth feel that an apple of a specific acoustical range would provide.

The technology and engineering required for acoustical sorting of individual fruit on a packing line is currently being developed. Eventually acoustics will become an important aspect of a total quality assurance program. This advancement in applied technology should assist in providing consistent quality and in turn boost fruit consumption.

Partial funding for this project was received from the Washington State Tree Fruit Research Commission.

Soil Management Affects Peach Tree Growth and Yields

Robert D. Belding and Gail R.W. Lokaj
Extension Specialist, Rutgers Cooperative Extension
Rutgers Agricultural Research and Extension Center
121 Northville Road, Bridgeton, NJ 08302

Orchard soil and orchard floor practices for managing competition for water and nutrients does not often get the attention it should. Additionally growers often do not consider the true value, or true 'cost' of weed competition in orchards. The growth of young orchard trees is linked to soil quality and orchard floor management practices including the size of areas maintained weed free (Parker and Meyer 1996; Welker and Glenn 1985, 1988).

Growers have attempted to solve the problem of adequate moisture and nutrient retention, as well as aeration of orchard soils, by adopting various land preparation options as may be dictated by the soil type and land terrain. Peach roots are strongly affected by sod competition and will not grow under a healthy grass sod. In fact, growth of trees on many soils is directly related to the area of weed free soil in the tree row. Adjusting the width of the weed free zone can be used to regulate vegetative growth of orchard trees. Derr (2001) noted that chemical weed control resulted in greater tree growth when compared to mechanical soil cultivation.

Organic mulches used to control weeds have been reported to be beneficial to tree fruit growth and yield (Childers 1949; Childers et al. 1995). Decomposition of organic plant material recycles vital nutrients required for plant growth (Heckman and Kluchinski 1996). Additionally, organic mulches increase soil organic matter, improve soil structure, reduce soil compaction, increase moisture infiltration capacity, suppress weed growth, reduce plant stress by lowering soil temperatures, increase tree growth, and increase yields (Merwin et al. 1996). Mulched plots produce higher fruit yields than plots maintained with herbicides or by cultivation (Merwin et al. 1995).

Planting apple trees into sod that has been killed has several reported benefits similar to other organic mulches (Welker and Glenn 1990). Killed sod mulch reduces soil temperature, reduces moisture loss from evaporation, increases water infiltration from rain or irrigation, and suppresses weed growth (Welker and Glenn 1988, 1990). Grass species may also have an effect on the growth response of peach trees planted using the killed sod method (Welker and Glenn 1990). Soil management affects moisture infiltration, retention of water in the soils, and availability of water to the plants. Tests comparing apple tree growth using organically mulched soils, herbicide-treated plots and managed sods have shown available soil water to be greatest under organic mulches (Neilsen and Hogue, 1992). Soil water availability to apple trees was intermediate for the herbicide treatments and least available under sod grass (Merwin and Stiles 1994).

On finer textured soils, several horticultural crops including orchards are commonly grown on raised beds to minimize root zone flooding and the subsequent anaerobiosis that inhibits root development and can lead to tree death from *Phytophthora spp.* infection (Funt et al., 1997) or weaken the tree so that death from winter injury occurs. On coarse textured soils, mulching has been shown to conserve soil water and minimize nutrient losses associated with leaching (Ji and Unger, 2001; Tanaka and Anderson, 1997; Yohannes, 1999). Funt et al. (1997) showed that raised beds increased peach trunk cross sectional area (TCSA) and yield efficiency over 5 years on a silt loam, noncalcareous soil in Ohio. Should mounding of the soil be considered a standard recommended practice for peach growers? Peaches require less moisture than apples or pears, but require better aeration. For this reason peaches generally perform better on sandy soils and sandy loam than on soils with poor internal drainage (Westwood, 1993). Also, the ground water table should be no closer than 1.0 m during the growing season because it limits root growth (Westwood, 1993). There is limited information on the field conditions under which a grower should consider adopting raised beds or mulching for peach production in the Mid-Atlantic region.

The objectives of this study were to determine the influence of weed interference, the influence of hard and tall fescue drive rows and fescue residue mulch, and raised beds, in a newly-established peach orchard on an Aura sandy loam and to compare on orchard floor weed dynamics and peach tree performance.

Materials and Methods

The study was carried out on an Aura gravelly sandy loam (Red Yellow Podzolic, 61% sand, 31% silt, 8% clay) at the Rutgers Agricultural Research and Extension Center, Bridgeton, New Jersey from 1996 to 1999. The soil has a family classification of fine loamy, mixed, mesic, of the subgroup Haupludults (U.S. Dept. of Agr., 1973). The site was flat and at the inception of the study, the soil pH was 6.5, with an organic matter content of 2.0%, and a cation exchange capacity of 5.7 meq/100cc. The land was under grass fallow for several years prior to the study.

The treatments were arranged in a two by six factorial comprising two PRE herbicide application treatments and six orchard floor management (OFMA) treatments. The PRE herbicide application treatments were no PRE herbicides and PRE herbicides applied as a tank mixture to the 3-m wide tree row strip every year, from 1996 to 1999, in early spring (March). The herbicides tank mixed were pendimethalin plus isoxaben at 3.6 + 0.84 kg ai/ha, or pendimethalin plus simazine at 3.6 + 1.12 kg ai/ha. These treatments were selected because they control the summer annual broadleaves and grasses present at the experimental site. The herbicides were applied with a CO_2 backpack sprayer calibrated to discharge 234 L/ha at 225 kPa using 8004 nozzle tips.

The orchard floor treatments were: i) no-till with initial vegetation burned down using glyphosate at 1.0 kg acid equivalent (ae)/ha prior to planting (the drive row was allowed to regenerate natural vegetation that was maintained by regular mowing), ii) conventional tillage of the tree row and the drive row using a disk plow to 15-cm depth at a 14-day interval, iii) hard fescue (*Festuca longifloia* var. "Reliant") planted drive row maintained by monthly mowing, allowing grass residue to drop in the drive row, iv) tall fescue (*Festuca arundinaceae* Schreb. var.'Kentucky-31') planted drive row maintained by monthly mowing allowing grass residue to drop in the drive row, v) hard fescue planted drive row with mowed fescue residue blown by the mower onto the tree row as mulch at each mowing, and vi) tall fescue planted drive row with mowed fescue residue blown by mower onto the tree row as mulch at each mowing. The grass mulch dry weight was estimated at 1.5 t/ha and about 1.5 cm thick at mowing. In the fescue plots, (OFMA treatments iii, iv, v, and vi) perennial ryegrass sod (PRS) was established in the 3-m tree row strip simultaneously with the planted fescue drive rows in the fall of 1995 and killed with glyphosate (1.0 kg ae/ha) once, in the early spring of 1996, prior to tree planting. Ryegrass was used because it establishes quickly and is easily killed.

In early spring 1996, two-year old, bare rooted peach [*Prunus persica* (L.) Batsch var. Candor] trees were planted at 6- by 6-m spacing on 54-m rows using a 61-cm (24-inch) diameter auger. Each row was divided into two plots, each plot having three data trees with one guard tree on either end of the plot. Planting was done on bare ground in the no-till and conventionally tilled plots, and into killed PRS in the fescue plots. Trees were headed, at planting, to approximately 50 cm and were minimally pruned each spring to an open vase system for maximum tree size expression. To emphasize floor management treatment effects, neither fertilizers nor irrigation were applied for the duration of the study. Fruit were hand thinned 4-6 weeks post bloom to 15 cm between fruit.

Weed samples were collected (November) of 1996 and 1997 following a killing frost event that signaled the end of the growing season. Annual summer weed species were identified, cut at soil level, separated by species, and counted. Weeds were dried at 60° C for 96 h, and weighed. Weed densities were compared to tree growth and yield data to determine the effects of interference on tree growth.

Tree mortality and tree trunk cross sectional area (TCSA), as estimated from trunk diameters, were recorded annually as a measure of tree growth. Trunk cross sectional area was measured each year following leaf drop in the fall. The TCSA was calculated from trunk diameters measured 15 cm above the graft union, or midway between the root taper and the first lateral branch if the point 15 cm above the graft union included the swell from tree limbs.

In 1998 and 1999, mature fruit were harvested twice a week from one representative data trees within each plot. The tree selected was the first data tree from the nearest end of the row. In plots where the first data tree was dead or exhibited vole damage, the tree next to it was harvested. There were three to four harvests per plot annually. Fruit number and total fruit weight from each data tree was recorded at each harvest. Data were analyzed by SAS using ANOVA and the Waller-Duncan K-ratio t-test (SAS Institute, 2000) for mean separation.

RESULTS AND DISCUSSION

Weed control. Annual PRE application of a tank mixture of pendimethalin plus isoxaben or pendimethalin plus simazine to the 3-m tree row strip gave excellent weed control without injuring peaches (Table 1). PRE herbicide effectiveness in the tree row was not influenced by OFMA. However, weed populations in the no PRE herbicide treatments were influenced by OFMA. Killed PRS also had no effect on the efficacy of PRE herbicides.

Peach growth and development. Irrespective of OFMA, peach mortality was zero percent where weeds were effectively controlled with PRE herbicide applications. Without PRE weed control, peach mortality was highest (44.5%) in plots with killed PRS tree row plus hard fescue drive row plus hard fescue residue mulch, which was significantly greater than the lowest mortality (13.3%) observed in the conventionally tilled orchard floor plots. Mortality was attributed to weed interference and the creation of favorable vole (*Microtus sp.*) habitat. Competition for water and nutrients stressed some trees and they ultimately died from winter injury.

Vole damage in the no preemergence herbicide plots was also a major cause of tree mortality in this study, but the cause of individual tree mortality was not determined. Merwin et al. (1999) and Sullivan and Hogue (1987) reported that vole problems increased in orchards with mulch ground cover or dense vegetation compared to orchards with clean ground covers maintained with herbicides or by cultivation. Mulch or other vegetation provides cover for voles, particularly during the winter months, when they kill peach trees by eating the bark and girdling the tree. In this study, the small volume of clippings derived from the fescue drive row and used as tree row mulch in the herbicide treated plots decomposed before winter and failed to provide the voles with adequate cover. The lack of cover for voles helps explain why there was zero percent mortality in the herbicide treated plots.

In 1996, weed interference had no effect on peach TCSA. But, by 1999, continued weed interference reduced TCSA by an average of 62%. Among the PRE herbicide treated plots, OFMA had no effect on the measured TCSA in 1999. Finally, based on percent TCSA increase between 1996 and 1999, within the no PRE herbicide treated plots, hard fescue orchard floors averaged 27% more than the tall fescue and 38% more than the average of the conventionally tilled and no-till plots. This shows that sod managed in the drive row clearly did not hinder tree growth on this Aura gravelly, sandy loam.

Peach fruit weight was highly variable in 1998, the first year of fruiting. This high variability prevented the statistical detection of weed interference effect in 1998 except in the no preemergence herbicide no-till orchard floor where the yield was only 0.6 kg/tree compared to 7.4 kg/ tree, for the average of the other treatments. However, in 1999 weed interference reduced peach fruit yield by an average 73%. Within PRE herbicide treatments, OFMA had no effect on fruit yield. For all no PRE herbicide treatments, yield was 4.1 kg/tree or less while in all PRE treated plots, yield was 5.7 kg/tree or higher. Average fruit weight (= fruit size) was statistically the same in all the treatments, irrespective of weed control or OFMA. Fruit number was highly responsive to weed interference in 1999, but OFMA showed no significant influence. Weed interference reduced fruit number by 75% in 1999.

From 1996 to 1997, TCSA, a parameter closely associated with growth and yield in peach trees (Welker and Glenn, 1988), did not differ among methods of orchard floor preparation. Yield in 1998, the first fruiting year, ranged from an average of 10.5 to 18.0 kg (23 to 51 lbs.) per tree and from 36.0 to 45.2 kg (79 to 100 lbs.) per tree in 1999. Fruit number per tree averaged 64 in the first fruiting year and increased to an average of 214 fruit per tree in 1999. Average fruit size also did not vary significantly, averaging 207 g per fruit for 1998 and 1999 (Table 1). This suggests that under the conditions of this study, mounding and mulching did not enhance early peach tree performance as had been reported elsewhere (Funt et al., 1997; Glenn and Welker, 1989; Tanaka and Anderson, 1997).

Funt et al. (1997) noted that average fruit size was unaffected by external stresses while other tree growth measurements showed significant differences. Further, in associated work by the authors, trunk cross sectional area and fruit yield were significantly different due to external plant stresses, yet average fruit size was notably unaffected.

In an Ohio study, combined silt and clay made up over 80% of the Cardington/ Bennington silt loam soil, making it a fine soil with higher than average water holding capacity. Raised beds on these soils improved fruit mass by 56% over flat beds. TCSA and fruit numbers were strongly affected (Funt et al., 1997).

Surprisingly in the Ohio study, irrigation did not significantly increase yield, average fruit mass, or TCSA when used on this fine soil with good water holding capacity. A study of peach tree growth in Ontario on soils with very poor water holding capacity showed positive responses to irrigation in terms of tree growth, decreased winter injury, reduced perennial canker, and promoted tree survival (Layne and Tan, 1984). Annual and cumulative yield was also increased with irrigation, particularly in the later years of this 11-year study (Layne and Tan, 1984). It appears that soil moisture, particularly soil water-holding capacity, played the critical role in determining if mounding is a beneficial practice.

Soil type among these three studies reveal a basic finding, heavier soils benefit from mounding (aeration) and not from irrigation while the lighter soils benefit from irrigation and not mounding. Optimizing growth requires an understanding of what limits growth and production. Mounding increased tree growth and yield only where soils were heavy and trees on heavy soils did not respond to supplemental irrigation. Mounding soils on lighter soils without irrigation will not improve tree growth and yield. Only irrigation had that effect. Determining what soil type will benefit from mounding must then be based on soil gas exchange capacity caused by the lack of adequate drainage.

The major benefit of mounding fine textured soil has been to increase soil air space to prevent root stress from anaerobic conditions. Since increased soil moisture has been positively correlated with the distribution of *Phytphthora cactorum* spores (Horner and Wilcox, 1996), mounding poorly drained soils would be expected to decrease tree death from *Phytophthora* root rot. Since studies of soil mounding in peach orchards have contradictory results where soil type and orchard floor management vary, future studies should be extended over a range of soils to determine when mounding, mulching, and/or irrigation should be considered.

In summary, PRE herbicide treatments, much more than OFMA, expressed pronounced influence on young peach tree performance and vole influence. There was no interaction between weed control and OFMA except with respect to tree mortality. Tree mortality was not influenced by fescue type. The difference in tree size due to weed interference resulted in an average cumulative yield of 58 kg fruit per tree in the PRE herbicide treated plots compared to only 16 kg per tree in the no PRE herbicide plots, a 73% yield reduction due to weed interference. The dramatic effect of weed interference on tree growth and yield was not detected in average fruit size. This was unexpected. As all fruit were thinned to the recommended fruit density for the limb size, fruit grew to their potential for that season regardless of the external stress on the tree. Fruit to fruit competition rather than weed to tree competition influenced peach fruit size. Thinning fruit promptly reduced competition for carbohydrate supplies during the critical period for fruit potential determination, i.e. the four weeks after anthesis. This is contrary to observations in apples where fruit size and tree growth are affected by the same stresses (Miller 1983). Further studies are proposed to understand the basis for this lack of fruit size response to stress in peach trees.

This study also showed that mounding and/or the use of blown grass mulching under conditions of flat terrain and an Aura sandy loam soil was not effective for enhancing early peach performance. Mounding and/or blown grass mulching, without irrigation, did not result in significant improvements in tree growth or yield compared to the standard commercial practice in New Jersey of planting on flat terrain and using chemical weed control. The results of this study would likely be different on finer textured soils. Finally, managed fescue sod drive rows clearly did not reduce tree growth, yield, or fruit size in young peach trees grown in Aura gravelly, sandy loam soils.

LITERATURE CITED

Childers, N.F. 1949. Fruit Science, Orchard and Small Fruit Management. Edited by R.W. Gregory. p. 95-98. J.B. Lippincott, New York.

Childers, N.F., J.R. Morris, and G.S.Sibbett. 1995. Modern Fruit Science. p 248. Horticultural Publications, Gainesville, Florida.

Derr, J. F. 2001. Biological assessment of herbicide use in apple production I. Background and current use estimates. HortTechnology 11:11-19.

Funt, R.C., M.C. Schmittgen, and G.O. Schwab. 1997. Raised beds and micro irrigation influence peach production. HortScience 32:677-682.

Glenn, D.M. and W.V. Welker. 1989. Cultural practices for enhanced growth of young peach trees. Amer. J. Alternative Agr. 4:8-11.

Heckman, J.R. and D. Kluchinski. 1996. Chemical composition of municipal leaf waste and hand collected urban leaf litter. J. Env. Qual. 25:355-362.

Horner, I.J. and W.F. Wilcox. 1996. Spatial distribution of Phytophthora cactorum in New York apple orchard soils. Phytopath. 86:1122-1132.

Ji, S. and P.W.Unger. 2001. Soil water accumulation under different precipitation, potential evaporation, and straw mulch conditions. Soil Sci. Soc. Amer. J. 65:442-448.

Layne, R.E.C., and C.S. Tan. 1984. Long-term influence of irrigation and tree density on growth, survival,and production of peach. J. Amer. Soc. Hort. Sci. 109:795-799.

Merwin, I., J.A. Ray, and P.D. Curtis. 1999. Orchard groundcover management systems affect meadow vole populations and damage to apple trees. HortScience 34:271-274.

Merwin, I., J.A. Ray, T.S. Steenhuis, and J. Boll. 1996. Groundcover management systems influence fungicide and nitrate-N concentrations in leachate and runoff from a New York orchard. J. Amer. Soc. Hort. Sci. 121:249-257.

Merwin, I., D. Rosenberger, C. Engle, D. Rist, and M. Fargione. 1995. Comparing mulches, herbicides, and cultivation as orchard groundcover management systems. HortTechnology 5:151-158.

Merwin, I. and W.C. Stiles. 1994. Orchard groundcover management impacts on soil physical properties. J. Amer. Soc. Hort. Sci. 119:216-222.

Miller, S.S. 1983. Response of young "Topred Delicious" apple trees to orchard floor management and fertilization [Yield efficiency]. J. Amer. Soc. Hort. Sci. 108:638-642.

Neilsen, G.H. and E.J. Hogue. 1992. Long-term effects of orchard soil management on tree vigor and extractable soil nutrients. Can. J. Soil Sci. 72:617-621.

Parker, M.L. and J.R. Meyer. 1996. Peach tree vegetative and root growth respond to orchard floor management. HortScience 31:330-333.

SAS System for Windows. 1999-2000. Release 8.01. SAS Institute Inc., Cary, NC, USA.

Sullivan, T.P. and E.J. Hogue. 1987. Influence of orchard floor management on vole and pocket gopher populations and damage in apple orchards. J. Amer. Soc. Hort. Sci.112:972-977.

Tanaka, D.L. and R.L. Anderson. 1997. Soil water storage and precipitation storage efficiency of conservation tillage systems. J. Soil & Water Conservation. 52:363-367.

U.S. Department of Agriculture. 1973. Soil Survey of Cumberland County, New Jersey. U.S. Dept. of Agr., Washington, D.C. p. 65.

Welker, W.V. and D.M. Glenn. 1990. Peach tree growth as influenced by grass species used in a killed sod planting system. HortScience 25:514-515.

Welker, W.V. and D.M. Glenn. 1988. Growth response of young peach trees and changes in soil characteristics with sod and conventional planting systems. J. Amer. Soc. Hort. Sci. 113:652-656.

Welker, W.V. and D.M. Glenn. 1985. The relationship of sod proximity to the growth and nutrient composition of newly planted peach trees. HortScience 20:417-418.

Westwood, M.N. 1993. Temperate-Zone Pomology: Physiology and culture. 3rd Ed. Timber Press Inc, Portland, Oregon.

Yohannes, F. 1999. Improvement of water application efficiency by moisture conservation methods for establishment of planted tree seedlings. Commun. Soil Sci. & Plant Analysis. 30:1119-1125.

Table 1 Main effects of PRE Herbicide on tree survival, growth and fruiting.

	Probability Pr > f	Herbicide	No Herbicide
Weed Count	0.01**	3.1	54.8
Weed Wt. (g)	0.01**	152.2	1686.9
TCSA-1998	0.01**	47.9	15.8
TCSA-1999	0.01**	62.3	24.0
Cum. Yield	0.01**	58.7	15.8
Fruit Size	0.84ns	208.2	204.1
Mortality	0.01**	0	29.4

Means are based on 36 plots

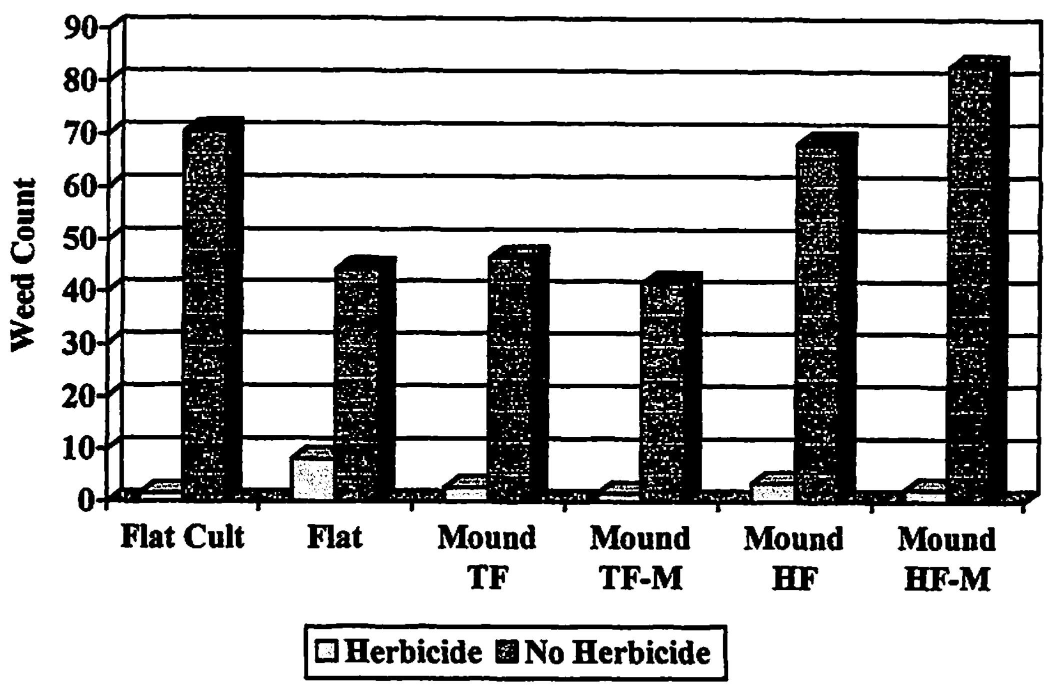


Figure 1. Weed Count from total of $1m^2$ using 6 replications per mean. Means within herbicide/no herbicide main effects were not statistically distinct.

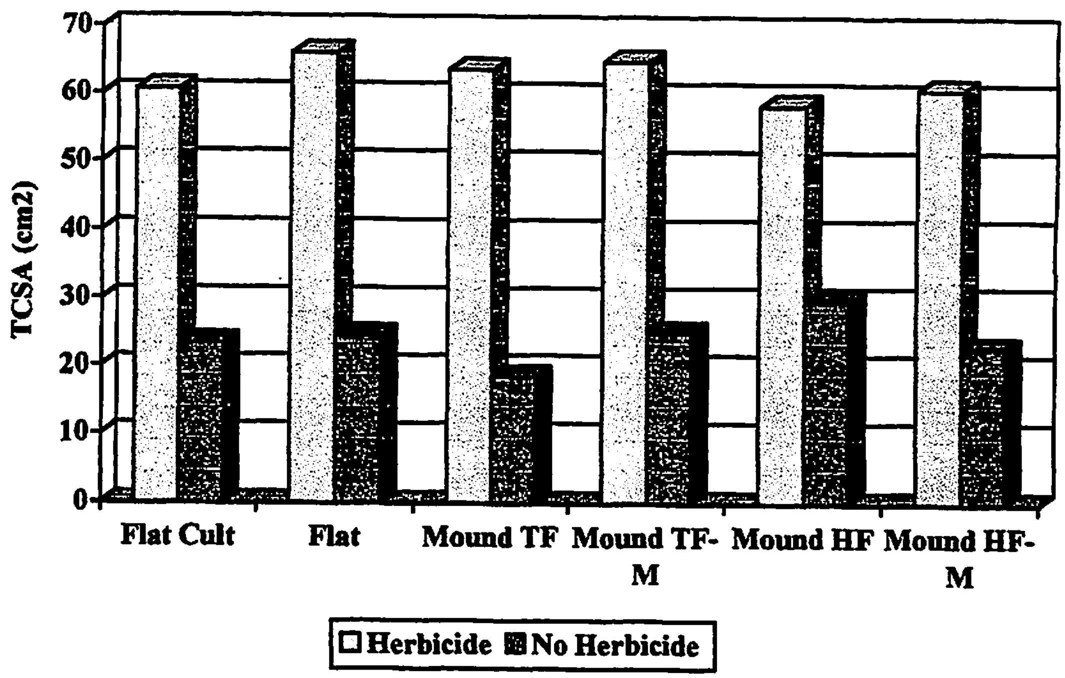


Figure 2. Trunk Cross Sectional Areausing 6 replications per mean. Means within herbicide/no herbicide main effects were not statistically distinct.

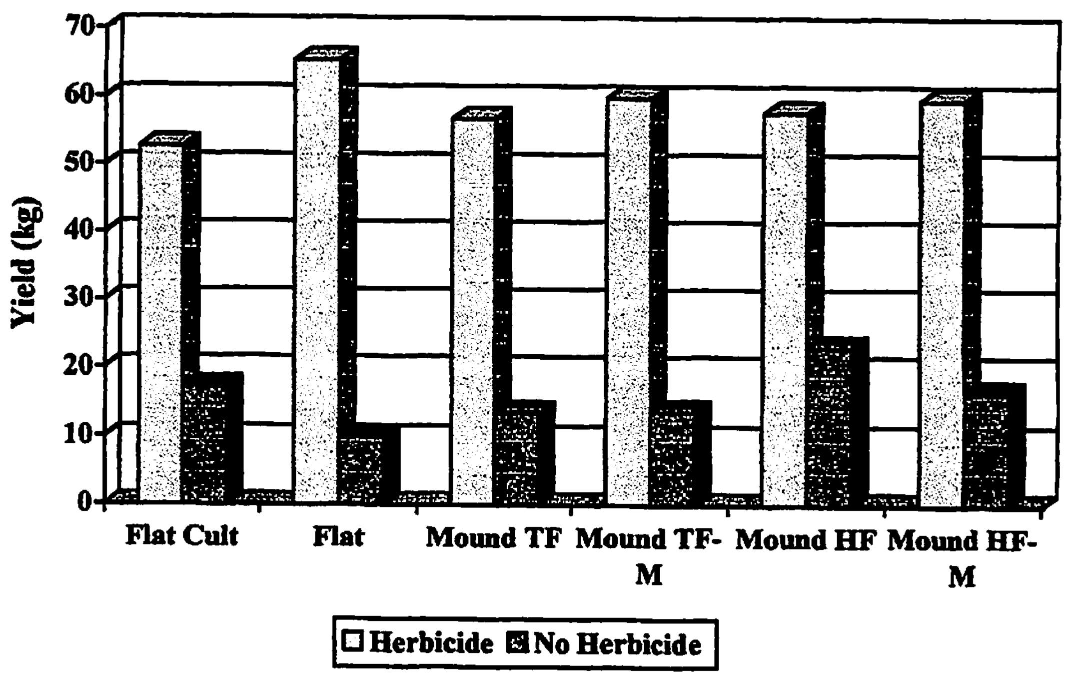


Figure 3 Cumulative Fruit Yieldusing 6 replications per mean and two harvest years. Means within herbicide/no herbicide main effects were not statistically distinct.

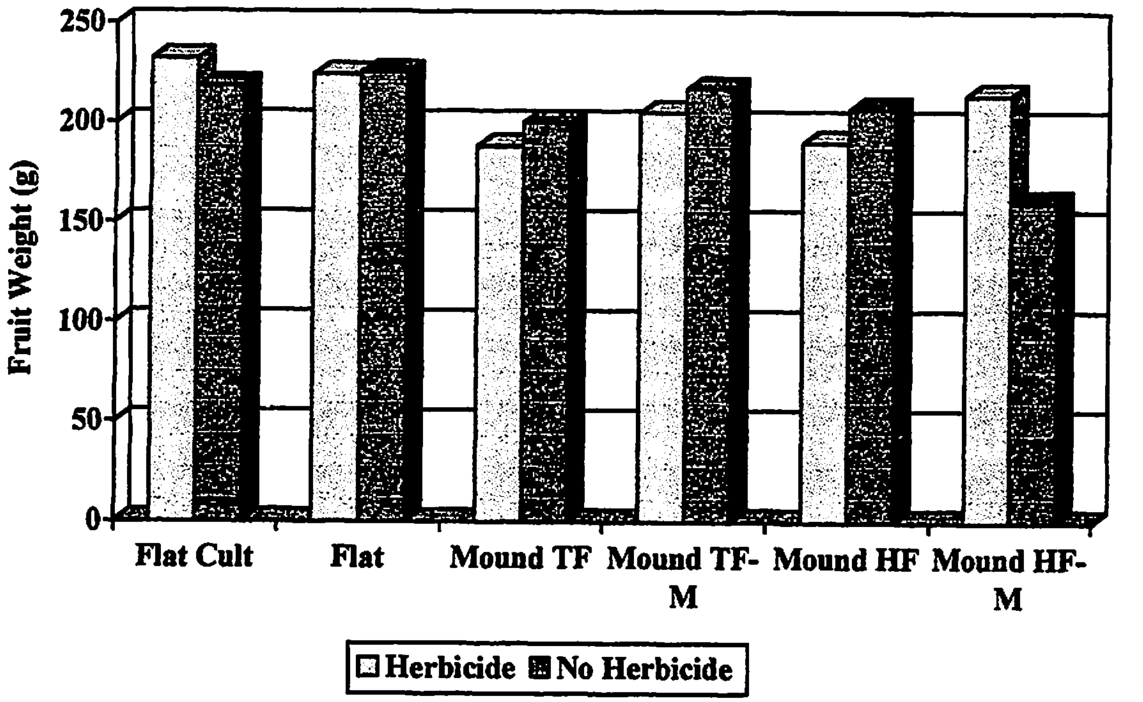


Figure 4 Average Fruit Size using 6 replications per mean and two years harvest. Means were not statistically distinct.

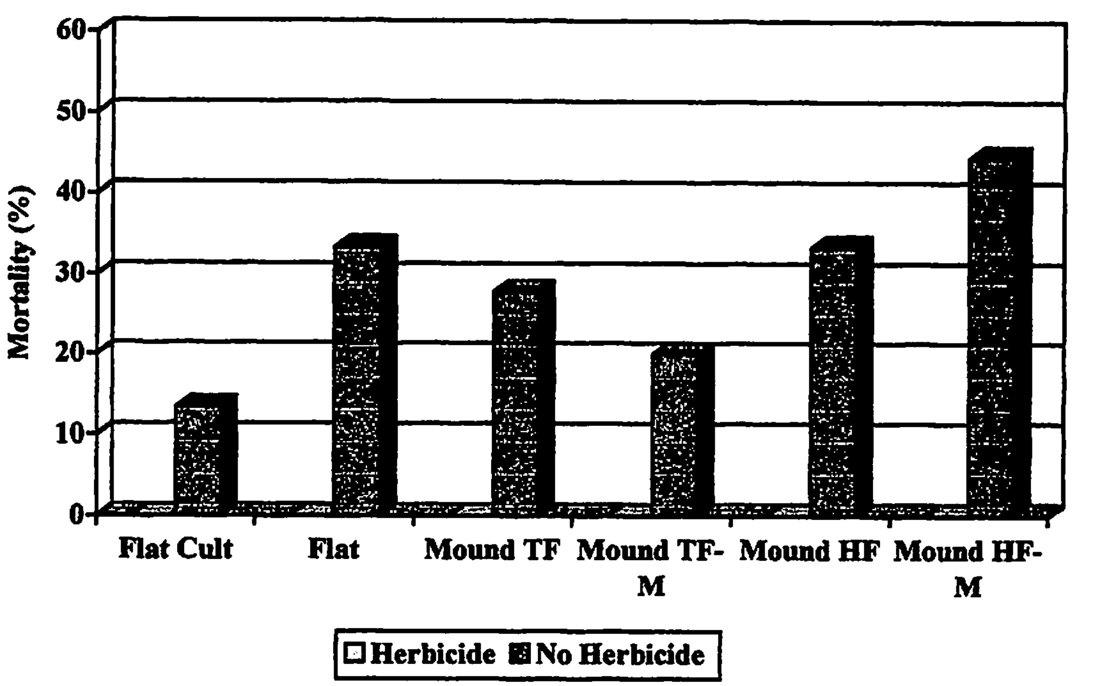


Figure 5 Percent Mortality using 6 replications per mean. Means were not statistically distinct.

WEED SUPPRESSION WITH ORGANIC MULCH IN ORCHARDS

Thomas Tworkoski
USDA-ARS
Appalachian Fruit Research Station
Kearneysville, WV 25430

Weeds cause yield loss in tree fruit crops by competing for nutrients and pollinators and by being habitats for insect and disease pests. Herbicides often are used by growers to control weeds but alternatives may become necessary with regulatory agency and public restrictions on use of synthetic herbicides. This research evaluated composted poultry litter (CPL) and composted sawdust (CSD) weed suppresser when used as mulch beneath mature peach (*Prunus persica* (L.) Batsch.) and apple (*Malus xdomestica*) trees. The objectives were to determine effect of (1) rate of mulch application and (2) mulch plus synthetic or natural herbicide or trimming on weed control in an orchard.

Experiment 1. Single tree plots beneath 10-yr.-old 'Sunhigh' peach trees on 'Lovell' rootstock were treated with diuron and terbacil (1 kg ha^{-1}) in May 1998 and then received CPL (0, 3, and 10 cm depth). The CPL was obtained from the Potomac Valley Conservation Facility in Moorefield, W. Va. Weeds were eradicated in 1998 by residual herbicides but in 1999 weed cover of the ground increased, as measured by the average visual estimate of two people. The 0, 3, and 10 cm mulch treatment had 21, 34, and 2% weed cover early and 76, 61, and 27% weed cover late in the in the second season after treatment. Most weeds in this orchard were annual plants. Mulch did not affect weed control provided by residual herbicides in the first season and the higher rate of mulch improved weed control in the second season after application. However, additional management likely would be necessary to suppress weeds beyond the second season.

Experiment 2. Multiple tree plots beneath 15-yr.-old 'Delicious', 'York Imperial', 'Stayman', and 'Empire' apple trees on M.7A rootstock were spot treated with glyphosate and then half the plots received diuron and terbacil (1 kg ha^{-1}) in June 1999. Subplots of the main plots were then treated with 0, 6, and 12 cm depths of CPL. Emergent weeds were mowed with a string trimmer in June 2000. Unlike experiment 1, residual herbicides did not improve weed control the first season after application, probably because weeds were mostly perennial rather than annual and because glyphosate effectively suppressed perennial weeds. Like experiment 1, CPL mulch provided weed suppression, giving 65, 42, and 24 % weed cover in the 0, 6, and 12 cm mulch treatments, respectively, at the beginning of the second season after application. Although a string trimmer was used for additional weed management, weed abundance had significantly increased to an average 91% weed cover by the end of the second growing season.

Experiment 3. Multiple tree plots beneath 5-yr.-old 'Ace Spur Delicious' apple on M.7 rootstock and 'Redhaven' peach on 'Lovell' rootstock received four treatments: 5% aqueous eugenol applied in May and June; CSD mulch (8 cm depth) in June plus 5% aqueous eugenol applied in May and June; paraquat (0.56 kg ha^{-1}) applied in May, June, July, and August, and untreated control. Hardwood and pine sawdust was partially composted in uncovered windrows for 24 months with occasional turning. Eugenol (2-Methoxy -4-(2-propenyl)phenol) was included as a 'natural product herbicide' (isolated from cinnamon, *Cinnamomum zeylanicum*), which is contact-active and may be an alternative to paraquat. Eugenol gave 54% weed cover and CSD mulch plus eugenol gave 8% weed cover by the end of the first season after application. Paraquat did not differ from CSD mulch plus eugenol, with 2% weed cover. Perennial weeds were present in the CSD mulch plus eugenol treatment, indicating that additional weed control will be needed for future weed management. Additional weed management may include contact-active herbicides, such as eugenol, but spot treatments of systemic herbicides, such as glyphosate, may be needed.

These experiments demonstrated that organic mulches, such as CPL and CSD, can be used as a weed management tool in orchards. Weed suppression increased with mulch depth above 3 cm and annual weeds were more readily managed than perennial weeds by the organic mulches. Eugenol, the 'natural-product' herbicide, may be used with mulch for a weed management system that has reduced use of synthetic herbicides. Perennial weeds may require use of systemic herbicides, such as glyphosate.