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(FOR ADMINISTRATIVE USE ONLY)

Proceedings of the

CUMBERLAND-SHENANDOAH FRUIT WORKERS CONFERENCE

75TH ANNUAL MEETING

November 18 and 19, 1999
Winchester Holiday Inn
Winchester, Virginia

Conference Chair,
John M. Halbrendt
Pennsylvania State University
Fruit Research and Extension Center
Research Nematologist

75th Annual Cumberland-Shenandoah Fruit Workers Conference
November 18 and 19, 1999
Winchester, VA

Thursday Morning, November 18, 1999

8:30 - 9:00	Registration
9:00 - 9:30	Welcome and call of the States
	Apogee Workshop - Moderator: Dr. George M. Greene II
9:30 - 9:50	The Chemistry, Mode of Action and Registration Status of Apogee - Dr. John Harden, BASF Corp., Research Triangle Park, NC
9:50 - 10:10	BREAK
10:10-10:30	Horticultural Impact of Apogee on the NC Apple Production System - Dr. C. R. Unrath, North Carolina State University, Fletcher, NC
10:30 - 10:50	Horticultural Impact of Apogee on the Mid-Atlantic Apple Production System - Dr. Ross Byers, Virginia Tech and State University, Winchester, VA
10:50 - 11:10	Reducing the Secondary Spread of Fire Blight with Apogee - Dr. Alan Jones, Michigan State University, East Lansing, MI
11:10 - 11:30	Influence of Apogee on Selected Apple and Pear Pests - Dr. Gregory Paulson, Shippensburg University, Shippensburg, PA
11:30 - 11:50	Round Table Discussion on Apogee - All Speakers
11:50- 1:00	BUFFET LUNCH (included in registration)

Thursday Afternoon, November 18, 1999

1:00 - 5:00	Break out sessions for individual research paper presentations by discipline (Entomology, Horticulture and Plant Pathology). Paper titles and authors are listed in the following section.
5:00 - 7:30	DINNER (on your own)

Thursday Evening Discussion Session: Plum Pox Virus (PPV)

8:00 - 8:20	The PPV Situation in Pennsylvania - Dr. John M. Halbrendt, The Pennsylvania State University, Biglerville, PA Dr. Ruth Welliver, PDA, Bill Kleiner, Adams Co.
8:20 - 8:40	Dealing With PPV in the Long-Term - Dr. Ralph Scorza, USDA, ARS-AFRS, Kearneysville, WV
8:40 - 9:00	Discussion

Friday Morning, November 19, 1999

8:00 - 9:40	Continue Breakout Session for research papers
9:40-10:00	BREAK
10:00-11:00	Business Meeting
11:00	ADJOURN

Breakout Session - Entomology

November 18, 1999

Thursday - PM	**Moderator - Greg Krawczyk**
1:30 - 1:50	Mating Disruption of Codling Moth - 1999 - Doug Pfeiffer, V. Tech, Blacksburg, VA
1:50 - 2:10	Results of 1999 Mating Disruption Trials to Control OFM - Gerry Walker, Ontario Ministry of Agric., Food and Rural Affairs, Vineland Station, ON.
2:10 - 2:30	Evaluation of Codling Moth and Oriental Fruit Moth Mating Disruption Systems - Jim Walgenbach. NC State University, Mountain Horticultural Crops Research and Extension Center, Fletcher, NC
2:30 - 2:50	Novel Forms of Mating Disruption for Tufted Apple Bud Moth and Oriental Fruit Moth - Shawn Robertson and L. A. Hull, PSU FREC, Biglerville, PA
2:50 - 3:10	BREAK
3:10 - 3:30	Evaluation of Mating Disruption for Peachtree Borer and Lesser Peachtree Borer - Henry Hogmire, WVU, TFREC Kearneysville, WV
3:30 - 3:50	Experiences with Commercial Scale Mating Disruption Programs in New Jersey Peaches - Dean Polk, P. Winkler, D. Schmitt, M. Peters, E. Rizio, and A. Loyle., Rutgers Fruit Research and Extension Center, Cream Ridge, NJ
3:50 - 4:10	Reduced Risk Peach Pest Management Program - Atanas Atanasov, P. W. Shearer, D. Polk, and G. Hamilton. Rutgers Ag. Res. & Ext. Ctr. Bridgeton, NJ
4:10 - 4:30	Progress in Particle Film Technology for Insect Control in Pear and Apples - Gary Puterka and Michael D. Glenn, USDA-ARS AFRS, Kearneysville, WV
4:30 - 4:50	Tree Fruit Entomology Highlights: 1999 - Peter W. Shearer, Rutgers Ag. Res. & Ext. Ctr. Bridgeton, NJ

November 19, 1999

Friday - AM	
8:30 - 8:50	Influence of Habitat on Carabid Beetles and the Guild of Ground-dwelling Predatory Arthropods in Apples. - Clarissa R. Mathews, USDA, AFRS, Kearneysville, WV, D. G. Botrell, U. of Maryland, College Park, MD, and M. W. Brown, USDA
8:50-9:10	Monitoring for Resistance to Commonly Used Insecticides in Oriental Fruit Moth Populations from Pennsylvania Commercial Fruit Orchards - Greg Krawczyk and L. A. Hull, PSU FREC, Biglerville, PA.
9:10 - 9:30.	Monitoring Oriental Fruit Moth Susceptibility to Azinphos-methyl in New Jersey Orchards - Amin K. Usmani and P. Shearer, Rutgers Ag. Res. & Ext. Ctr., Bridgeton, NJ

Breakout Session - Plant Pathology

November 18, 1999

Thursday - PM **Moderator - Kenneth Hickey**

1:30 - 1:55	Laboratory and Orchard Fire Blight Management Experiments, 1999 - Keith Yoder, VA Tech Ag. Res. & Ext. Ctr., Winchester, VA
1:55 - 2:20	Effect of Apogee on Fire Blight of Apple - Noemi Halbrendt and K. D. Hickey, PSU Fruit Res. & Ext. Ctr., Biglerville, PA
2:20-2:45	Recovery of Endophytic *Erwinia amylovora* Bacteria From Symptomless Tissues in Mature Apple Trees - Tom van der Zwet, USDA-ARS, Appalachian Fruit Res. Stat., Kearneysville, WV, and K. D. Hickey, PSU Fruit Res. & Ext. Ctr., Biglerville, PA
2:45 - 2:50	DISCUSSION
2:50 - 3:10	BREAK
3:10-3:35	Evaluation of Actigard for Fire Blight Control - Alan L. Jones, Michigan State Univ., East Lansing, MI
3:35-4:00	Results of Fungicide Trials in the Hudson Valley - Dave Rosenberger, Fritz Meyer, and Cathy Ahlers, Cornell Univ., Hudson Valley Lab, Highland, NY
4:00-4:25	Highlights of 1999 Testing of Stobilurin and Other Experimental Fungicides on Apples - Keith Yoder, VA Tech Ag. Res. & Ext. Ctr., Winchester, VA
4:25-4:50	Results of Fungicide Evaluations on Apple - K. D. Hickey, J. May, N. O. Halbrendt, and E. McGlaughlin, PSU Fruit Res. & Ext. Ctr., Biglerville, PA

November 19, 1999

Friday - AM

8:00-8:25	Economics of Powdery Mildew Management on 'Ginger Gold' Apple - Keith Yoder, VA Tech Ag. Res. & Ext. Ctr., Winchester, VA
8:25-8:50	Peach Constriction Canker Yield and Economic Loss - Norman Lalancette and Dean Polk, Rutgers Univ., Ag. Res. & Ext. Ctr., Bridgeton, NJ
8:50-9:15	Efficacy of Fungicide Treatments on Stone Fruit Evaluation - K. D. Hickey, J. May, N. O. Halbrendt, and E. McGlaughlin, PSU Fruit Res. & Ext. Ctr., Biglerville, PA
9:15-9:40	DISCUSSION
9:40-10:00	BREAK
10:00-11:00	Business Meeting
11:00	ADJOURN

Breakout Session - Horticulture

November 18, 1999

Thursday - PM	**Moderator - George M. Greene**
1:30 - 1:50	Influence of Adjuvants, Ammonium Sulfate, Calcium Chloride, Hard Water and Apogee Formulations on Efficacy - Ross Byers, VP & SU, AHS-AREC, Winchester, VA
1:50 - 2:10	Apogee and Combinations with Ethephon for Apple Tree Growth Control and Return Bloom - Ross Byers, VP & SU, AHS-AREC, Winchester, VA
2:10 - 2:30	Horticultural Effects of Particle Film Application - Michael Glenn and Amnon Erez, USDA-ARS, Kearneysville, WV and Volcani Institute, Bet Dagan, Israel
2:30 - 2:50	Effects of Residues of Diuron, Simazine, and Terbacil on Newly Planted Apple and Peach Trees - Thomas Tworkoski and Stephen Miller, USDA-ARS, Kearneysville, WV
2:50 - 3:10	BREAK
3:10 - 3:30	The Effect of Preharvest AVG and Postharvest MCP Treatments on Peach Maturity and Storage Life - Michael L. Parker and Sylvia M. Blankenship, Norch Carolina State Univ., Raleigh, NC
3:30 - 3:50	Peach Maturity Delay with AVG - Robert Belding and Gail Lokaj, Rutgers Univ., Bridgeton, NJ
3:50 - 4:10	Influence of AVG, NAA, and MCP on Pre-harvest Fruit Drop and Apple Quality in Subsequent Cold Storage (1998-1999) - Ross Byers, VP & SU, AHS-AREC, Winchester, VA
4:10 - 4:30	Enterprise and Goldrush, Varieties for the Future? Rick Heflebower, Western Maryland Res. & Educ. Ctr., Keedysville, MD
4:30 - 4:50	Yield and Quality Attributes of Promising Apple Cultivars in West Virginia - Stephen Miller, USDA-ARS, Appalachian Fruit Res. Stat., Kearneysville, WV

November 19, 1999

Friday - AM	
8:00 - 8:20	Bloom and Post Bloom Apple and Peach Thinning Studies - Ross Byers, VP & SU, AHS-AREC, Winchester, VA
8:20 - 8:40	1999 Apple Thinning Trials in Pennsylvania - George M. Greene, PSU Fruit Res. & Ext. Ctr., Biglerville, PA 17307
8:40 - 9:00	Ethephon, Foliar Nutrient, and Gibberellin Sprays on Subsequent Season(s) Return Bloom and Fruit Set - Ross Byers, VP & SU, AHS-AREC, Winchester, VA
9:00-9:20	The Negative Interaction of Chemical Thinning with the Spray Oil Used with Agri-Mek - C. R. Unrath, NC State Univ., Mountain Hort. Crops Res. & Educ. Ctr., Fletcher, NC
9:20-9:40	Primocane Management Study for Eastern Thornless Blackberries on Rotatable Cross-Arm Trellis.II. Flowering and Fruiting - Ann K. Hummell and Fumiomi Takeda, USDA-ARS, Appalachian Fruit Res. Stat., Kearneysville, WV

IN THIS ISSUE

Conference Mailing List and 1999 Attendees (*)

Program Highlights and Business Meeting

Call of the States

Apogee™ Workshop

The Chemistry, Mode of Action, and Registration Status of Apogee™
J. S. Harden, G. G. Thomas, W. Rademacher

Horticultural Impact of 'Apogee™' on the North Carolina Apple Production System
C. R. Unrath

Horticultural Impact of Apogee™ on the Mid-Atlantic Apple Production System
Ross E. Byers

Reducing the Secondary Spread of Fire Blight with Apogee™
Alan L. Jones

Influence of Apogee™ on Selected Apple and Pear Pests
G. S. Paulson and L. A. Hull

Breakout Sessions

ENTOMOLOGY **TITLE/AUTHOR(S)**

Use of a Laminate Dispenser for Codling Moth Mating Disruption – 1999
D. G. Pfeiffer, J. A. Metzger, M. G. McClanan, M. H. Rhoades, J. C. Killian, and P. MacLean

Evaluation of Codling Moth and Oriental Fruit Moth Mating Disruption Systems
James F. Walgenbach

Novel Forms of Mating Disruption for Various Lepidopterous Pests of Apple
Shawn Robertson, Larry Hull, and Nic Ellis

Evaluation of Mating Disruption for Peachtree Borer and Lesser Peachtree Borer
Henry W. Hogmire

Reduced Risk Peach Pest Management Program
Atanas Atanassov, Peter W. Shearer, George Hamilton, and Dean Polk

Orchard Diversity, Reduced Insecticides and Fruit Quality: Preliminary Data
M. W. Brown and Clarissa R. Mathews

Monitoring for Resistance to Commonly Used Insecticides in Oriental Fruit Moth (*Grapholita molesta*) Populations from Pennsylvania Commercial Fruit Orchards
Greg Krawczyk and Larry A. Hull

Monitoring Oriental Fruit Moth Susceptibility to Azinphosmethyl in New Jersey Orchards
K. Amin Usmani and Peter W. Shearer

Differences in Four Baits Used in Trapping Plum Curculio (Coleoptera: Curculionidae) – 1999
M. E. McClanan, D. G. Pfeiffer, and J. C. Killian

Release of the Predatory Mite *Neoseiulus fallacis* (Garman) (Acari: Phytoseiidae) against *Panonychus ulmi* (Koch) (Acari: Tetranychidae) in a Virginia orchard – 1999
J. A. Metzger and D. G. Pfeiffer

PLANT PATHOLOGY **TITLE/AUTHOR(S)**

The Effect of Apogee™ on Fire Blight of Apple
Kenneth D. Hickey and Noemi O. Halbrendt

Results of Fungicide Trials in the Hudson Valley
David A. Rosenberger, Frederick W. Meyer, and Catherine A. Ahlers

Evaluation of Strobilurin and Other Experimental Fungicides on Stayman, and Idared Apples – 1999
K. S. Yoder, A. E. Chochran II, W. S. Royston, Jr., and S. W. Kilmer

Concentrate Application of Experimental Fungicides on Golden Delicious Apple – 1999
K. S. Yoder, A. E. Chochran II, W. S. Royston, Jr., and S. W. Kilmer

Sequential Schedules of Experimental and Registered Fungicides for Season-Long Disease Control on Idared Apple – 1999
K. S. Yoder, A. E. Chochran II, W. S. Royston, Jr., and S. W. Kilmer

Disease Control and Fruit Finish By Concentrate Applications of Vangard, Copper, and Dithiocarbamate Fungicides on Nittany Apple – 1999
K. S. Yoder, A. E. Chochran II, W. S. Royston, Jr., and S. W. Kilmer

Evaluation of Experimental Fungicides and Apogee™ for Fungal Disease Effects on Three Apple Cultivars – 1999
K. S. Yoder, A. E. Chochran II, W. S. Royston, Jr., and S. W. Kilmer

Suppression of Fire Blight Infection of Apple Shoots by Apogee™ – 1999
K. S. Yoder, A. E. Chochran II, W. S. Royston, Jr., and S. W. Kilmer

Laboratory Evaluation of Agri-Mycin for Systemic Protection of Unopened Golden Delicious and Rome Beauty Apple Blossoms from Fire Blight – 1999
K. S. Yoder, A. E. Chochran II, W. S. Royston, Jr., and S. W. Kilmer

Evaluation of Registered and Experimental Fungicides for Disease Control on Redhaven Peach and Redgold Nectarine – 1999
K. S. Yoder, A. E. Chochran II, W. S. Royston, Jr., and S. W. Kilmer

Efficacy of Fungicide Treatments Applied Concentrate for Disease Management on Apple – 1999
K. D. Hickey, J. May, N. O. Halbrendt, and E. McGlaughlin

Apple Disease Incidence with New Fungicides Applied at Tree-Row-Volume Rates – 1999
K. D. Hickey, J. May, N. O. Halbrendt, and E. McGlaughlin

DMI/Protectant Fungicide Combinations for Disease Management on Apple – 1999
K. D. Hickey, J. May, N. O. Halbrendt, and E. McGlaughlin

Apple Fungicide Programs Composed of Vangard, MBI/Protectant, Flint, and Benlate/Captan Applied Concentrate – 1999
K. D. Hickey, J. May, N. O. Halbrendt, and E. McGlaughlin

Fire Blight Incidence and Fruit Russet on Apple Trees Sprayed with Copper Compounds in 1999
K. D. Hickey, J. May, N. O. Halbrendt, and E. McGlaughlin

Peach Constriction Canker Yield and Economic Loss
Norman Lalanchette and Dean Polk

Incidence of Brown Rot and Peach Scab on Peach/Nectarine Sprayed Dilute with Fungicides – 1999
K. D. Hickey, J. May, N. O. Halbrendt, and E. McGlaughlin

Efficacy of Fungicide Treatments on Peach/Nectarine for Control of Brown Rot – 1999
K. D. Hickey, J. May, N. O. Halbrendt, and E. McGlaughlin

Control of Brown Rot and Cherry Leaf Spot with Fungicide Treatments – 1999
K. D. Hickey, J. May, N. O. Halbrendt, and E. McGlaughlin

HORTICULTURE **TITLE/AUTHOR(S)**

The Influence of Apogee and Combinations with Ethephon, Chemical Thinners, Cations, and Adjuvants for Apple Tree Growth Control and Return Bloom
Ross E. Byers

Effects of Residues of Diuron, Simazine, and Terbacil on Newly Planted Apple and Peach Trees
Thomas Tworkoski and Stephen Miller

The Effect of Pre-harvest AVG and Post-harvest MCP Applications on Peach Maturity and Storage Life
Michael L. Parker and Sylvia M. Blankenship

Pre-Harvest Fruit Drop Studies, Harvest Quality, and cold Storage of 'Golden Delicious' and 'Rome' Apples
Ross E. Byers

Yield and Quality Attributes of Promising Apple Cultivars in West Virginia
Stephen S. Miller

Bloom and Post-Bloom Apple and Peach Thinning Studies – 1998/1999
Ross E. Byers

1999 Apple Thinning Trials in Pennsylvania
George M. Greene II

Ethephon, Foliar Nutrient, and Gibberellin Sprays on Subsequent Season(s) Return Bloom and Fruit Set – 1997-1999
Ross E. Byers

The Negative Interaction of Chemical Thinners with Spray Oil Used in Conjunction with Agri-Mek in a Pesticide Cover Spray: an Observation
C. R. Unrath

Primocane Management Study for Eastern Thornless Blackberries on Rotatable Cross-Arm Trellis. II. Flowering and Fruiting
Fumiomi Takeda and Ann K. Hummell

Accel® (PGR) Concentration and Timing Adjustments to Evaluate Thinning and Size Responses in 'Liberty' Apple
Win Cowgill, Jeremy Compton, Gary Donato

Apogee™ (BAS-125W) for Vegtative Growth Suppression in Apple
Jeremy Compton, Win Cowgill, Gary Donato

1999 New Jersy Procure® 50WS Evalutions in Apple
W. P. Cowgill, Jr., J. M. Compton, R. Best, G. Donato, M. Maletta, M. Peters

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75th Cumberland-Shenandoah Fruit Workers Conference
Program Highlights and Business Meeting

The Penn State Fruit Research and Extension Center hosted the 75th meeting of the Cumberland-Shenandoah Fruit Workers Conference at the Holiday Inn in Winchester, VA. The meeting was held on Thursday and Friday, November 18-19, 1999 with 55 registered participants and 42 presented papers. Registration for the meeting was $50 to cover the cost of the proceedings, refreshment breaks, and lunch on Thursday. John Halbrendt was the general chair and secretary while Steve Miller served as the treasurer. George Greene was moderator of the "Apogee Workshop" and chair of the Horticulture session, Ken Hickey was chair of the Plant Pathology session and Greg Krawczyk was chair of the Entomology session.

The Thursday morning session began with a "Call of the States" which provided a brief report of crop, weather and pest conditions for the 1999 growing season from each of the states represented at the meeting. This was followed by an "Apogee Workshop" which included five presentations and a 'Round Table Discussion' on the potential benefits of Apogee to the tree fruit industry. Following the workshop, the meeting broke into three concurrent sessions (i.e. Horticulture, Entomology and Plant Pathology). The concurrent sessions met throughout Thursday afternoon and continued on Friday Morning. On Thursday evening a special Plum Pox Virus (PPV) session was convened. John Halbrendt talked about the discovery of PPV in Adams county, PA and gave an overview of the biology of this disease. Ralph Scorza presented an historical account of PPV in Europe and discussed PPV management strategies.

The business meeting was called to order by John Halbrendt. Paul Steiner initiated a discussion on the need for Plum Pox Virus educational materials that could be shared among the states. At the conclusion Paul volunteered to chair a committee to work on this issue.

Steve Miller gave the treasurer's report. A balance of $176.14 was forwarded from the 1998 meeting. Registration was increased from $40 to $50 dollars in 1999 to cover increasing costs associated with the meeting and printing. A total of $3650.00 was collected from 1999 registrations. The cost for meeting rooms, refreshments, and the noon meal was $1916.78. There were no miscellaneous costs associated with the 1999 meeting. Including interest, the CSFWC account had a balance of $1916.27 to cover the cost of publishing the Proceedings.

Future Meetings and Host States:

2000 – West Virginia
2001 – New Jersey / South Carolina
2002 – Virginia
2003 – Maryland / Delaware
2004 – North Carolina
2005 – USDA

Respectfully submitted,

John M. Halbrendt, General Chair, Secretary

Stephen S. Miller, Treasurer

STATE REPORTS
Presented During the Opening Session of the 75th Cumberland – Shenandoah Fruit Workers Conference

Massachusetts State Report (Kathleen Leahy)

- Fruit set was good to heavy this year. Despite the drought, fruit size at harvest was adequate, owing to the heavy rains in September. Little serious damage occurred from Hurricane Floyd. The peach crop in central Massachusetts was very low, owing to winter freezing injury.

- Insect and mite activity were surprisingly light, and harvest injury from insects was quite low. Tentiform/apple blotch leafminers were extremely high, though, with visual trunk trap captures over 1000 per trap in several locations. Pear thrips were very abundant pre-bloom in the Connecticut Valley and Berkshire area.

- Owing to the generally dry weather, little disease activity was noted. Sooty blotch and flyspeck did show up at harvest in some areas, again owing to September rain. No powdery mildew was seen.

New Jersey State Report - 1999 (Bob Belding)

- Season began with below average soil moisture
- Bloom was good, and fruit set was heavy
- Record peach crop was reduced 15% by hail
- Drought was severe for six weeks during growing season
- Late season hurricanes restored moisture but dropped both fruit and trees

Apples -
- Late season fruit sized well
- European apple sawfly and Two-spotted spider mite were above normal
- Movement of processing apples were off
- Worms in the fruit were above average

Peaches -
- Heavy thinning was required
- Irrigation was very beneficial
- Market was depressed due to increased California crop
- Sales of fruit 2 1/2" and below were off

New York State Report - 1999 (Dave Rosenberger)

- Drought conditions (worst in >100 years) prevailed form Aug 98 through late Aug 99. Drought was most severe in the Hudson Valley, less severe in western NY
- Despite high levels of apple scab inoculum in commercial orchards due to high levels of scab in 1998, scab did not develop as a serious problem. Instead mildew was the major apple disease in 1999.
- Brown rot developed on green sweet cherry fruit shortly after shuck-split. Disease pressure was apparently very high because cherry trees were not sprayed in 1998 due to a spring frost that destroyed most of the crop.
- Dry and hot weather favored development of two-spotted spider mites in apples

North Carolina State Report – 1999 (Mike Parker)

Apples -

- Crop turned out surprising well all things considered
- Rain was adequate until mid-July after which rain was below average
- Insect situation saw nothing exceptional
- Fire blight was the primary pest problem although only 2 bloom infection periods were detected

Peaches -

- Contrary to much of the SE, chilling was adequate
- Bloom was good and no frost/freeze injury occurred
- Very dry through June, however, the crop picked well and prices were good
- Excessive rain from 3 hurricanes in Sept. resulted in a "wash out" of late-season peaches

Province of Ontario Report – 1999 (Gerry Walker)

- Growing season was one of the driest on record; but this was exasperated by poor water reserves in the soil from the previous year (1998). Tree fruit blossom dates were 10-14 days ahead of normal and resulted in early harvest of the crops. Grapes were 2-3 weeks ahead of normal as a result of the warm spring and hot weather in end of May and June. Much of tender fruit acreage was irrigated, but irrigation of sod cultured orchards still resulted in depressed fruit size. Even significant grape acreage suffered from drought stress.

- Tarnished plant bug (TPB) pressure was up this season on peach/nectarine and this resulted in green fruit monitoring injury counts amounting to 7 to 25% while harvest assessments showed

0 to 2% old TPB catfacing type and 2 to 21% summer fruit injury at harvest. Inconsistent results, bring into question as to whether or not TPB can really be controlled and fruit injury prevented by the application of conventional insecticides. This increased pressure was a result of several factors: Higher than average population of overwintering adults; Warm spring ideal for egg laying and development of 1st summer generation; Orchards had more broadleaf weeds than normal as a result of dry weather resulting in poor performance of both contact, systemic, and pre-emergent herbicides. This increased the size of the resident population of TPB in orchards combined with droughty conditions drier up alternate food sources resulting in mass migration of TPB to the orchard to feed on terminals and fruit.

- Oriental fruit moth(OFM) pressure was light to moderate this season. Erratic spring temperatures resulted in a protracted OFM overwintering adult emergence from April 30 to May 24. This non-discrete emergence pattern made timing of insecticides difficult. Insecticide spray programs continue to provide good control of OFM as indicated by a survey of fruit injury at harvest ranged between 0% to 1.4% OFM of first pick. Resistance survey work was completed for a 4th year at 6 locations across the Niagara Peninsula. Resistance levels to the pyrethroid insecticides remain stable and low while resistance levels to the organophosphate insecticides also continue to drop. This means that our resistance management strategy is working. About a total of 125 acres at 10 locations were also treated experimentally with various forms of mating disruption technology to control OFM. All treatments provided as good or better results than conventional insecticide treated blocks. This new technology looks promising as a method of controlling OFM.

- European Red Mite populations were lower than expected this season (on all tree fruit) and it is speculated that it may be that temperatures and relative humidity levels were actually too high, depressing ERM.

- The number of blocks and the amount of two-spotted spider mite (TSSM) populations reported is higher again this year for a second year in a row. This may mark a shift in the mite pest complex. As expected the lowest rate on the Pyramite label (300 grams/ha) was insufficient to adequately control TSSM. Even at higher rates (450 to 600 grams/ha) Pyramite appears weak against TSSM. Similar observations have been noted on apple.

- There are more and more peach/nectarine blocks with silver mite showing up. The first symptoms are that leaves turn a silvery cast. High populations can greatly affect the photosynthetic rate of the leaves, yield and fruit size. This mite species is hard to see with a hand lens; is about the size of a pear rust mite and can only be seen with a microscope with a power of 30-40 times.

- Grape berry moth pressure was moderate to light across Niagara; while leafhoppers were also easily controlled. ERM was lower this year than 98; with less need for summer miticides.

- Disease pressure was both tree fruit and grape were low except for powdery mildew on grapes. All other diseases were easily controlled. Fire blight outbreaks did occur in Eastern Ontario as a result of warm temperatures during bloom and violent thunderstorm activity later in season.

Pennsylvania State Report – 1999 (Greg Krawczyk)

Horticulture

- The season started off with near normal rainfall up through mid-May. Time of Bloom was about normal, and the absence of any major frost events and good pollinating weather helped set a large crop. Some difficulties were observed in getting a good thinning of apple trees.

- After bloom up until August 8th no week had over an inch of rain. Additionally over 40 days had the temperature of at least 90F. The remainder of the season was wetter than normal and from Aug. 15th until Oct. 10th there was only 2 weeks when there was less than 1 inch of precipitation. Three weeks had over 2 1/2 inches of rain. With those late season rains most growers picked a substantially larger crop than estimated.

- PA growers are concerned with the possible effects of this large crop and low moisture on the next year's flower crop. (George Greene)

Pathology

- Disease incidence in PA was lower in 1999 than in previous years.

- At Biglerville there were 7 primary apple scab infection periods, but because of the drought condition apple scab levels on non-treated fruit ranged from 3.0 to 32 percent.

- Apple rust and fire blight were also low, but powdery mildew was moderate in severity.

- Apple rots were not evident until harvest time and generally were very low.

- Sooty blotch and flyspeck were first observed on 23 August, occurred at moderate level on non-treated fruit, and was very low in commercial orchards.

- Brown rot on cherries and peaches was lower than in most years and cherry leaf spot did not develop until September.

  With the extremely low inoculum levels of most of the fungal diseases, disease management in 2000 should be easier than normal. (Ken Hickey)

Nematology • The occurrence of Stem Pitting in peach and other stone fruit was similar to previous years; sporadic in some orchards but occasionally heavy in orchards that were not tested for nematodes or fumigated prior to establishment.

- A high incidence of what appears to be Apple Union Necrosis was observed in a block of Ginger Gold on M.26. The M 26 rootstock is known to be susceptible to Tomato Ringspot Virus but the susceptibility of Ginger Gold has not been reported.

- The Plum Pox Virus was positively identified from a peach orchard in Adams County Pennsylvania. A subsequent survey of the area Identified 17 additional stone fruit plantings infected with the virus including plum, nectarine and apricot. All infected orchards were within Huntington and Latimore townships. These townships are now under quarantine making it illegal to move trees or budwood out of the area. Details of the PPV situation will be presented in an evening session. (John Halbrendt)

Entomology• The biofix for OFM was established on April 23, for CM on May 04, for TABM on May 10, and for OBLR on May 30. The insect pest development models, based on accurate biofix worked quite precisely during the first generation flights of most species, but the unusual weather took it toll later during the season. The hot weather despite adding fast degree-days to the models, did not translate directly into faster insect development.

- European red mite populations after slow start accelerated later in the season, especially in late July and August.

- The trap data for tufted apple bud moth was at the very low level while compared to the previous years. The TABM egg masses search conducted every year in our research plots, during last season resulted in the lowest number of egg masses since the beginning of observations.

- The obliquebanded leafroller populations were again observed in numerous orchards during and after the apple bloom, but the summer generation was not a major threat to the fruit.

- The Oriental fruit moth was one of the most damaging pests in PA peach and apple orchards. Numerous fruit loads were rejected from processing plants because of the presence of internal worms. The actively feeding larvae were still present in some late harvested apples even during late October

- Our two relatively new pests European apple sawfly and apple maggot were encountered in various orchards, but no economic damage was observed. (Greg Krawczyk)

Virginia State Report – 1999 (Ross Byers)

Horticulture-

- dry soil conditions began as early as mid-May and lasted through early September.
- Heavy bloom and good fruit set combined with cool weather during the prime thinning period caused poor thinning responses, and a heavy crop load resulted.
- Hurricanes brought up to 10inches of rain or more by early September that apparently increased fruit size sufficiently that growers harvested most blocks..
- Fruit finish was excellent; harvest date was about a week behind normal by early September but late cultivars were about normal by the time harvested. (Ross Byers)

Pathology

- Apple scab pressure was light; the heaviest apple disease pressure this year was from powdery mildew
- Cumulative wetting hour (CWH) threshold of 250hr for sooty blotch and fly speck development (accumulation starting May10, ten days after petal fall) was not reached until July 22, later than any of the past 5 years. Through August, total CWH was 200 less than the driest of the past 5 years. Sooty blotch and fly speck were first observed on unprotected trees Sep 8, two months later than in 1998 but there was opportunity for summer disease development and testing of fungicide residual effectiveness with rains and heavy dews in September.
- We had the heaviest peach leaf curl seen on untreated trees in research plots at Winchester in23 years. (Keith Yoder)

Entomology

- Many pests were in lower numbers than usual.
- Important problems were seen with internal feeders in apple; these were a mix of codling moth and oriental fruit moth.
- European red mite, normally associated with hot, dry conditions, was generally at low levels, although spotty infestation were seen. (Doug Pfeiffer)

West Virginia State Report – 1999 (Henry Hogmire)

- Dry conditions from mid-summer of 1998 until July of 1999; above normal temperatures in January, February and April through September; cool temperatures in March and early April resulted in late, heavy bloom with potential for largest crops in 4-5 years; fall cultivars reached maturity 7 days ahead of expected; apple size was generally good to excellent, with the best finish on Goldens in this decade; shortage of labor and bins for the large apple crop were significant problems; overall quality of harvested peaches and apples was good to excellent.

- Dry conditions reduced shoot growth and shortened period of spirea aphid abundance; spotted tentiform leafminer was more abundant than in recent years; European red mites were troublesome where early-season control measures were not followed; apple maggot populations were significantly less than last year; codling moth and oriental fruit moth continued to cause fruit injury in some orchards resulting in processor load rejections, however, the problem was less severe than in 1998; fruit injury from tufted apple bud moth also was less than last year.

- Dry weather was generally unfavorable for the development of plant diseases, although levels of apple powdery mildew were high in some locations; apple scab ascospore release was delayed due to dry weather, with peak discharge occurring in early June; fire blight infection periods were recorded on May 7 and 8 toward the end of bloom, however, very little infection was observed in the field; summer disease incidence on apples was very low on early- and mid-season cultivars, but increasing frequency of wet periods in late August was favorable for the development of summer diseases on later-maturing cultivars; no serious disease problems were noted on stone fruits in 1999.

THE CHEMISTRY, MODE OF ACTION, AND REGISTRATION STATUS OF APOGEE

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Apogee is a new plant bioregulator for the control of excessive vegetative growth in apples. The product's active ingredient is prohexadione-calcium (common name proposed to ISO), which stands for calcium 3-oxido-4-propionyl-5-oxo-3-cyclohexene-carboxylate. Actual and future uses of the compound include anti-lodging in rice and small grains (Japan and Europe) and reduction of vegetative growth in apples, other fruit trees, and peanuts. The compound is covered by patent rights held by Kumiai Chemical Industries, Inc. of Japan. BASF Corporation has the development and sales rights for the United States.

The uptake of Apogee is primarily through green tissue from which it is translocated primarily acropetally. The mode of action for Apogee is blockage of gibberellin (GA) synthesis. Apogee inhibits dioxygenases involved in late steps of GA formation. Apogee functions as a structural mimic of 2-oxoglutaric acid (Figure 1), the co-substrate of the enzyme. Hence, the conversion of 2-oxoglutaric acid into succinic acid is inhibited. As a consequence, the metabolism of the other substrates of the enzyme, e.g. GA_{20} (inactive), into GA_1 (highly active) is also inhibited (Figure 2) resulting in reduced shoot growth. There may be further similar reactions inhibited involving different GAs. Apogee would likewise reduce metabolic inactivation of externally applied GAs, e.g. GA_3, because similar enzymes are involved. Paradoxically, this would lead to an intensification of GA action.

Aminocyclopropanecarboxylic (ACC) oxidase is another dioxygenase, which can be inhibited by Apogee. The resulting reduction in ethylene levels may account for a reduced senescence, which is often observed. Furthermore, this effect, in addition to the fact that more assimilates are available for being translocated into fruits instead of vegetative shoot growth, may be involved in reducing the intensity of the June fruit drop in apple and other fruits.

Applied at high rates, Apogee may inhibit 2-oxoglutaric acid-dependent dioxygenases involved in anthocyanin formation. However, there is no risk of inhibiting fruit coloration because the compound is applied early in the season and its metabolism is relatively rapid. Distinct effects on other parts of the flavonoid metabolism may be involved in the effect against fire blight and other pathogens.

Metabolism of Apogee in plant tissue (Figure 3) results in CO_2 and propane-1,2,3-tricarboxylic acid, which is naturally occurring in plants. In mammals, Apogee is rapidly absorbed and excreted with no metabolites or tissue bioaccumulation.

Apogee is very benign in terms of its toxicological properties. Acute toxicity studies resulted in minor effects at high dose levels (practically non-toxic) with no skin irritation and minimal eye irritation. Chronic studies resulted in minor effects at high doses with carcinogenicity, mutagenicity, and teratogenicity test results being negative.

Results from the US indicate residues of approximately 0.6 ppm of parent material if rates as high as 2,200 g/ha of active ingredient had been applied with a pre-harvest interval of only 45 days. Calculating with the most unfavorable results from chronic toxicological studies, this would indicate that a person weighing 70 kg may consume more than 23 kg of apple per day without passing the Acceptable Daily Intake (ADI) level. Residues in apple are expected to be much lower than 0.6 ppm under practical conditions.

EPA accepted Apogee as a "Reduced Risk Candidate" in November of 1998 due to the favorable toxicology package and the potential to reduce pesticide volumes. Review of the compound is under way and on the EPA fiscal year 2000 workplan. Registration is expected between March and June of 2000.

Background literature

Brown, R.G.S., Kawaide, H., Yang, Y.Y., Rademacher, W. and Kamiya, Y. (1997): Daminozide and prohexadione have similar modes of action as inhibitors of the late stages of gibberellin metabolism. Physiol. Plant. 101: 309 - 313.

Byers, R.E. and Yoder, K.S. (1997): The effect of BAS-125 W on apple tree growth, fruit quality, and fireblight suppression. HortScience 32 (3): 557 (abstract only).

Evans, R.R., Evans J.R. and Rademacher, W. (1997): Prohexadione calcium for suppression of vegetative growth in eastern apples. Acta Hort. 451: 663-666.

Owens, C.L. and Stover, E.W. (1997): Controlling flower initiation and vegetative growth of apple with prohexadione calcium (BAS-125 W), an experimental GA-biosynthesis inhibitor. HortScience 32 (3): 557 (abstract only).

Rademacher, W. (1993): On the mode of action of acylcyclohexanediones - a new type of plant growth retardant with possible relationship to daminozide. Acta Hort. 329: 31-34.

Rademacher, W., Temple-Smith, K.E., Griggs, D.L. and Hedden, P. (1992). The mode of action of acylcyclohexanediones - a new type of growth retardant. In: Progress in Plant Growth Regulation (C.M. Karssen, L.C. van Loon and D. Vreugdenhil, eds.), Kluwer Academic Publishers, Dordrecht, The Netherlands, ISBN 0-7923-1617-7, pp. 571-577.

Rademacher, W., Speakman, J.B., Evans, R.R., Evans, J.R., Roemmelt, S., Michalek, S., Lux-Endrich, A., Treutter, D., Iturriagagoitia-Bueno, T., John, P. (1998). Prohexadione-Ca - a new plant growth regulator for apple with interesting biochemical features. In: Proceedings of The 25th Annual Meeting of The Plant Growth Regulation Society of America (W.E. Shafer, ed.), Plant Growth Regulation Society of America, LaGrange, GA, pp. 113-118.

Winkler, V.W. (1997): Reduced risk concept for prohexadione calcium, a vegetative growth control plant growth regulator in apples. Acta Hort. 451: 667-671.

Figure 1.

Structural Similarity of Prohexadione-Ca with 2-Oxoglutaric Acid

(2-Oxoglutaric Acid is the Co-substrate for Dioxygenases Catalyzing GA Metabolism)

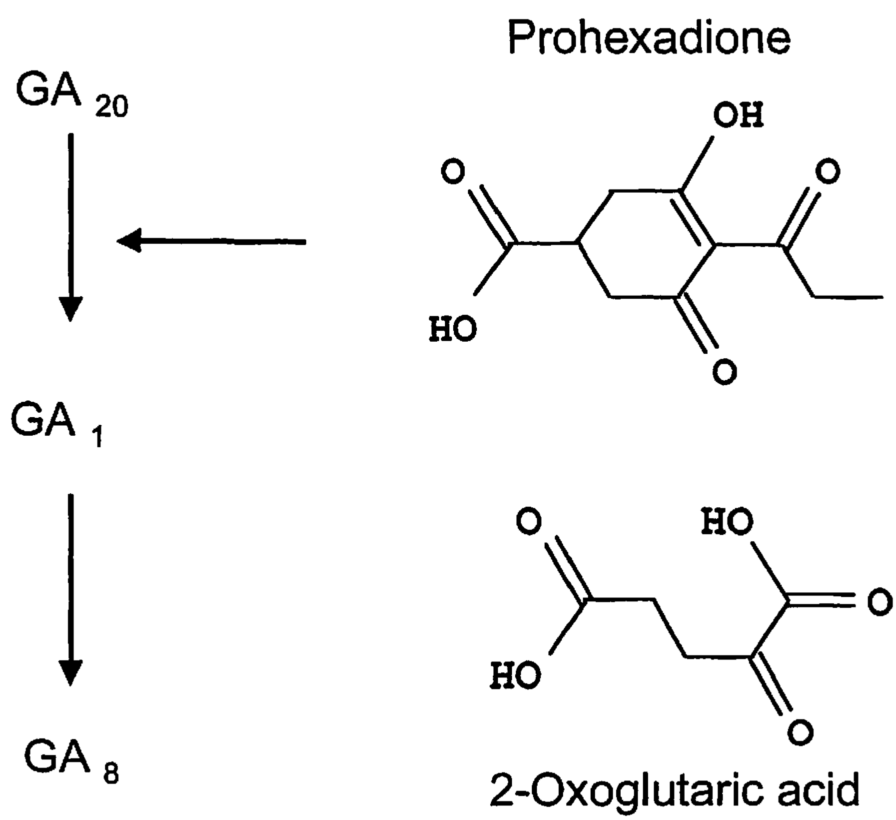


Figure 2.

Effect on Gibberellin (GA) Biosynthesis (Simplified)

(GAs = plant hormones for cell elongation)

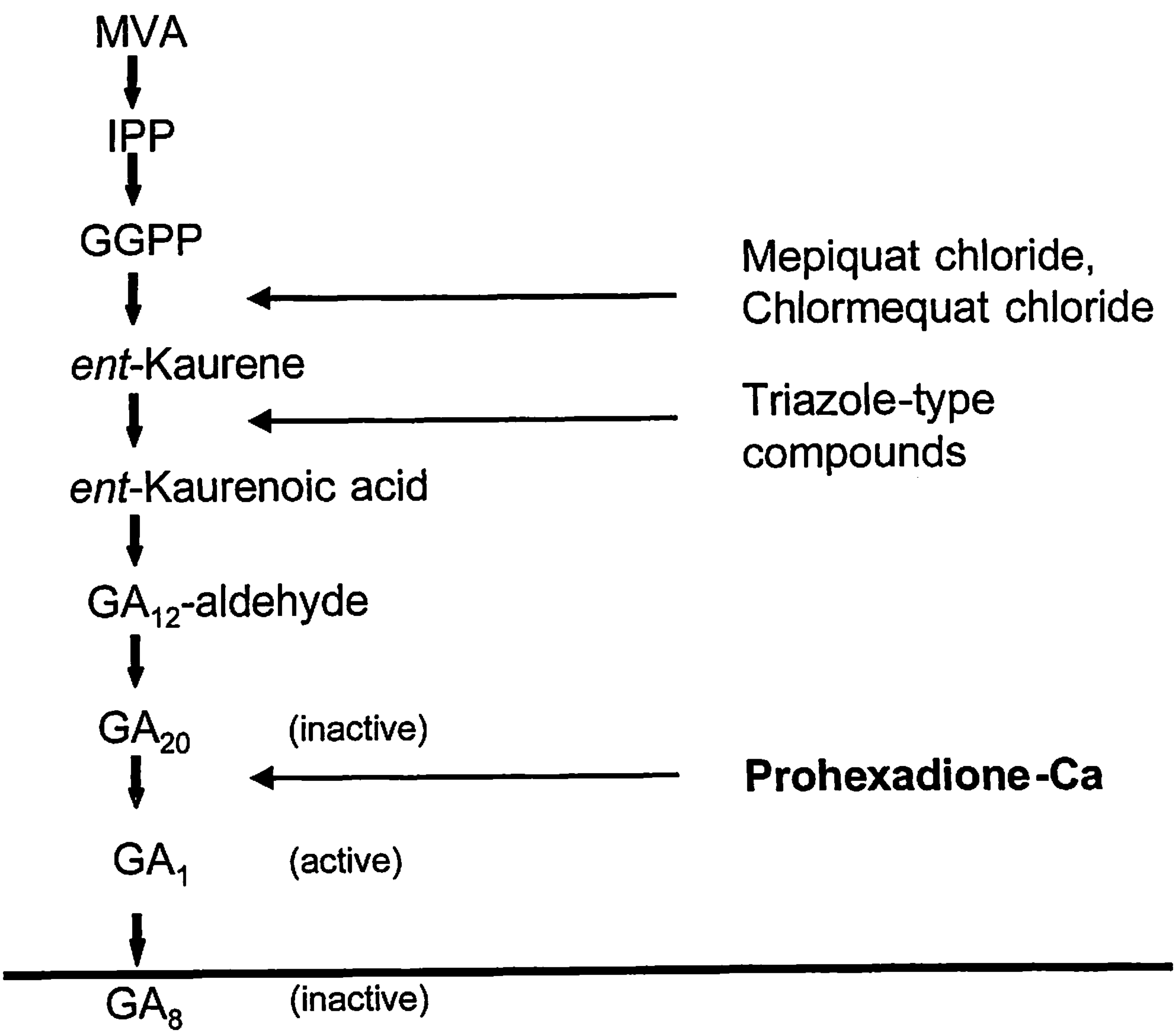
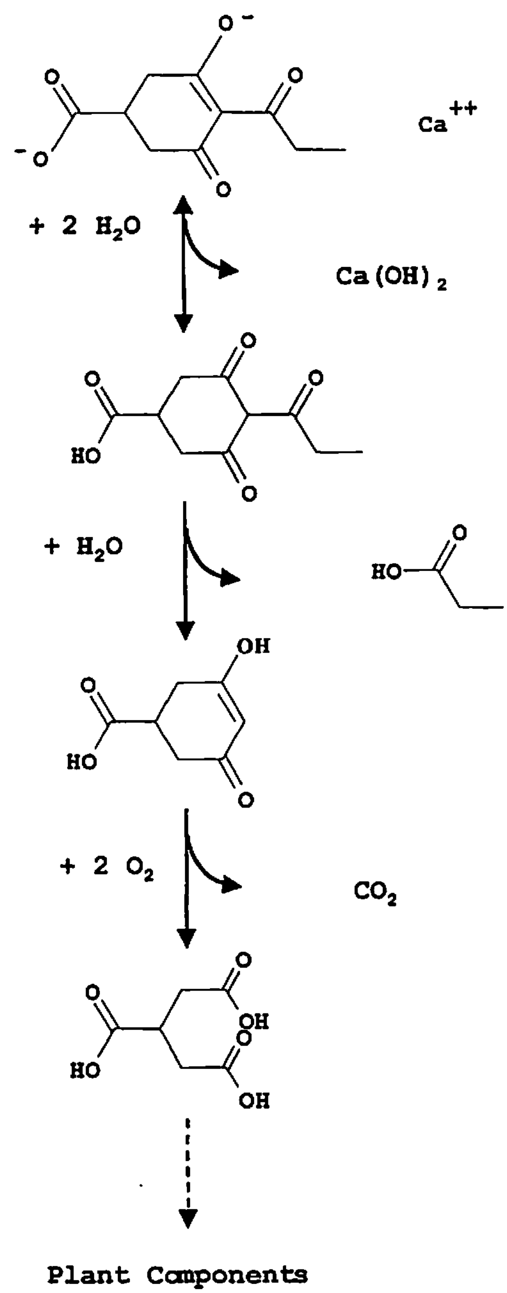


Figure 3.

Prohexadione-Ca: Metabolism in Plants



I. (Parent)
Calcium 3-oxido-4-propionyl-5-oxo-3-cyclohexenecarboxylate

II.
3,5-Dioxo-4-propionyl-cyclo-hexane-1-carboxylic acid

Propionic acid

III.
3-Hydroxy-5-oxo-3-cyclo-hexene-1-carboxylic acid

IV.
Propane-1,2,3-tricarboxylic acid

HORTICULTURAL IMPACT OF 'APOGEE' ON THE NORTH CAROLINA APPLE PRODUCTION SYSTEM

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My early work with 'Apogee', 1994-1997 is scheduled to be published in the December 1999 issue of HortScience, Vol. 34 (7): p 6-9.

Initial studies showed that 'Apogee' was a very responsive vegetative growth retardant which reduced pruning time by reducing the number of cuts required. 'Apogee' dramatically shifts the proportion of current seasons shoots out of the 25 cm+ category to less than 25 cm, which allows many shoots that would normally be pruned to be left as potential productive "feather" length shoots.

It was soon discovered that the use of relatively high rates of 'Apogee' (250+ ppm) too early (PF to PF+ 2 weeks) resulted in increased fruit being retained on the tree. This is the only direct negative impact on fruit quality that has been observed.

The reduction in vegetative growth and tree density with 'Apogee' was sufficient to cause an "end of season" reduction in Tree Row Volume up to 25% over the control. This in turn has implications for reducing pesticide usage and cost.

A comparison of the seasonal shoot growth curve for 'Red Delicious' apple trees of a northern (N.Y.) latitude vs southern latitude (N.C.) indicates substantial differences in natural growth pattern. Northern trees grow off more quickly and stop growing much earlier, thus expect different strategies for 'Apogee' use as latitude changes. More locally, 'Granny Smith' in South Carolina showed a strikingly different seasonal growth pattern than North Carolina (ie, more growth throughout the season and extended growth increases during the later half of the growing season in S.C.).

Seven different strategies of 'Apogee' use, all of which controlled initial flush of growth, varied greatly in their ability to control later initiated water sprout growth. Under our conditions in N.C., the use of 4 or more sequential, lower rate applications was superior to the use of one or two higher rate applications. In S.C. the response was much different. The use of low rate application sequences that stopped in mid-summer were worse then not treating at all. It was necessary to continue the use of 'Apogee' all summer, as long as growth potential existed, to effect season long vegetative growth suppression, in S.C. and even then water sprout control was not very effective.

'Apogee' treatments responded well on other cultivars such as 'Jonagold' and 'Golden Delicious'.

The response to multiple years use of 'Apogee' on the same trees showed year to year consistency with no cumulative effect. The growth of formerly 'Apogee' treated trees (for 1-3 years) showed similar "year after" growth length by the end of the season, even though there were some initially accelerated trends in shoot extension.

Knowing the likelihood of 'Apogee' "use approval" in 2000, I viewed 1999 as a fine tuning year. A redo of application timing studies reaffirmed the importance of proper timing of 'Apogee' before excessive growth extension reduces season end results. The use of a responsive surfactant is required with 'Apogee' applications. 'Biosurf' has previously been shown to be totally ineffective with 'ReTain' use, and now has shown limited benefit with 'Apogee' treatments, as opposed to other surfactants tested. It is beginning to appear to me that 'Biosurf' is not a PGR friendly surfactant. Some concern has been raised about adding calcium nutrient materials in the tank with 'Apogee' since it is a calcium compound. However, for the liquid calcium, 'Nutri-Cal' formulation I tested there was no interaction in 'Apogee' response. With other calcium formulations problems may exist. Once 'Apogee' use rate per acre was properly established through TRV the use of concentrate application did not alter 'Apogee' response. An 'Apogee' formulation change recently raised concern about the amount of Ammonium Sulfate (AMS) in the formulation to stabilize 'Apogee' in the spray tank. 'Apogee' response comparisons suggest no loss of activity with the 27.5% a.i. formulation, nor any need to add extra AMS to the spray solution.

Several sequential treatment scenarios were compared on 'Granny Smith' in 1999. In N.C., all treatments that started the application sequence at the proper time (Petal Fall) were equally effective as compared to those which started later, after growth had commenced. In S.C., a more lengthy and elaborate application sequence of treatments was used to control the greater growth potential. A comparison of treatments showed that higher use rates at the start of the sequence could cause overcompensation and longer growth later in the season as compared to using low sequential treatments all season which used less chemical but were more effective. Repeat use of 7, 8, or 9 sequential applications in S.C. were similarly responsive to first year treatments.

'Apogee' treatments on vigorous 'Gala' trees in S.C. demonstrated the value of commencing the application sequence with a tight cluster application. The use of the tight cluster application on 'Gala' is equally responsive to starting application at Petal Fall and continuing them later into the growing season, which could violate PHI with 'Gala's' early maturity.

A survey of 'Apogee' response on several cultivars in different grower orchards showed an average of 51% growth reduction and a range of 32-72%. Fruit quality comparisons of control vs 'Apogee' treatments from 13 different cultivar locations showed an average trend toward improved size, color, and larger size packout. The only negative fruit quality factors are size from reduced fruit drop with high rate, early 'Apogee' applications discussed above and isolated incidences of added sunburn where canopy shade was reduced by 'Apogee'.

The following tables summarize; 1) the horticulturally important responses to effective 'Apogee' use and resultant impacts on orchard management strategies and fruit quality; 2) the critical factors necessary for achieving effective 'Apogee' response under our conditions in the Southeastern U.S. and, 3) my initial attempt to develop anticipated commercial use recommendation options for the Southeast.

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Horticultural impact of Apogee:

Responses:

- Reduced shoot growth.
- Reduced end of season T.R.V.
- In some cases, factors of fruit quality are enhanced.

These responses can translate into:

1 - Reduce or eliminate summer pruning time.

2 - Reduce dormant pruning (potentially skip a year).

3 - Reduced T.R.V.= Reduced pesticide usage ($).

4 - Improved (reduced) fruit packout from Quality changes.

Critical Foctors in Apogee Response:

- Apply on the basis of T.R.V. to properly determine rate per acre.
- Proper application timing.
- Proper Concentration.
- Use of an *acceptable* surfactant.
- Continue application as long as the potential for growth extension is present.

3.

Apogee - Commercial use application options for the Southeast

tmt	T.C.*	PF*	+ 2*	+4	+6	+ 8	+ 10	+12 wks	total oz /100 gal
low		3	3	3	3				12
vigor		6		6					12
mod.		3	3	3	3	3	3		18
vigor		6		6		6			18
high		3	3	3	3	3	3	3	21
vigor	3	3	3	3	3	3	3		21
crop		3	3	3	3	3	3	6	24
loss		6	6	6		6		6	30

*Most application sequences will start at 1"- 3" of new growth extension.

C.R. Unrath - NCSU

(Not for publication or distribution, 1999 CSFWC)

Horticultural Impact of Apogee on the Mid-Atlantic Apple Production System

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The primary objectives of pruning are to control tree size and shading within the tree canopy to increase spur vigor, spray penetration, fruit size, fruit quality, color and to maintain tree structure. In northern Virginia, over 80% of the apple crop is grown for processing and fruit color may not be important. Many of the cultivars grown are on vigorous rootstocks and require much pruning, especially in the tree tops. In order to cut costs and reduce labor requirements, many growers prune every second or third year; and yearly costs may be on the order of $150 to $200/acre. Dense canopies caused by current season shoot growth by not pruning in some years, may be detrimental to pest control, fruit quality, color, spray application costs, and yields in subsequent seasons. The advantage of Apogee sprays compared to pruning is that growth inhibition occurs early and continuously though out the season ***which can not be accomplished by pruning).***

The TRV calibration of airblast sprayers utilizes both tree size and canopy density for determining chemical rates per acre. It is presumed that pesticides might be reduced 10 to 20 % based on the foliar density factor alone and perhaps another 10 % due to a reduction in tree size especially for trees less than 75% TRV.

Although data is sparse, it is logical to assume that pests which do well on actively growing shoots, thick canopies, and dense foliage would do less well if trees were not so heavily foliated. Dr. Yoder at our lab has some data to show reduced fireblight, sooty bloch was reduced in Delicious but not in Golden Delicious or Rome and flyspeck was not reduced by Apogee sprays in any of the three cultivars compared to non-sprayed controls.

In our tests, Prohexadione calcium (BAS 125W 10DF or 9054.2 10DF) applied soon after bloom to apple trees reduced the current season's shoot length and weight, increased number of nodes on the lower 40 cm of shoots, reduced the number of pruning cuts, pruning time, and pruning weight per tree. Fruit diameter, soluble solids, starch, individual fruit weight, fruit drop, fruit cracking (Stayman), and fruit number per tree were increased slightly, but Apogee applications did not interfered with thinner activity. Fruit color and firmness were slightly increased in only one experiment. Growth suppression appeared to be greater on trees with heavier cropping, and more dwarfing rootstocks.

Expt. 1. In 1998, 3 applications of Apogee (63 ppm) or ethephon (135 ppm) did not suppress shoot growth of 'Fuji/M.9 trees at these low rates. Combinations of Apogee and ethephon gave good control of tree growth. Flowering and fruit set were not promoted by any of these applications.

Expt. 2. The 10% and the 27.5% Apogee formulations gave similar shoot growth suppression when applied with Regulaid or Oil plus L-77. The addition of CaCl to the 27.5% Apogee (125ppm) formulation caused poorer growth control, but the addition of NH4SO4 restored the effectiveness of the mixture. When using hard well water, Apogee plus NH4SO4 promoted better activity. The additives, NH4SO4, Ca Cl, Regulaid, and Oil plus L-77, alone had no effect on tree growth. Apogee plus L-77 plus Oil provided additional growth suppression when compared to Apogee plus Regulaid.

Expt. 3. Apogee caused a significant increase in fruit set compared to the control when applied at 250 ppm in 3 applications. Alone, NAA, Carbaryl+Oil, Carbary+Accel+Oil caused fruit thinning, but ethephon or shading 3 days did not cause significant thinning. Apogee did not have an effect on the final fruit set when the above chemical thinners were applied after the first Apogee application.

Expt. 4 Prohexadione calcium applied 8 days after full bloom (AFB) was more effective than when applied 19 days AFB. Multiple applications of 2, 3, and 4 sprays to the same trees at 3 week intervals gave additional shoot growth suppression with each application, but the last application seemed to slow summer re-growth substantially more than applications 2 and 3. Four applications of 250 ppm reduced shoot weight by 72%, shoot length by 60%, basal diameter of shoots by 25%, and reduced the number of pruning cuts, pruning time, and pruning weight per tree by 75%, 55% and 80%, respectively.

Several plant growth retardents (daminozide, ethephon, maleic hydrazide), auxins (napthalene acetic acid, TIBA), and sterol inhibitors (triazoles, placlobutrazol) have been studied for their potential to reduce vegetative growth of tree fruits in order to reduce pruning costs and to improve fruit quality. Interestingly, several reviews (Miller, 1988; Luckwill, 1970; Williams, 1984; Tukey and Williams, 1981; Looney, 1983; Faust (ed.). 1984) of plant growth regulators, indicate that most of these growth retardants have had many other beneficial responses that have had greater commercial importance than control of vegetative growth. Apogee inhibition of fireblight is a good example of a response that could have increasingly more importance when and if the bacterium becomes resistant to current pesticides.

The impact of Apogee will be dependent on its price. The value of apples for processing is rather depressed and some growers think in terms that *"if I do not put money into the crop, I do not have to get it out at harvest time"*. I do not necessarily agree with this philosophy but it will impact how much is used.

Literature Cited

Faust, M. (ed.). 1984 International workshop on controlling vigor in fruit trees. Acta Hort. 146. Intern. Soc. Hort. Sci., Netherlands.

Looney, N. E. 1983. Growth regulator usage in apple and pear production. In Plant Growth Regulation Chemicals, Vol. I. Pp. 27-40 (. G. Nickell, ed.). CRC Press, Boca Raton, FL.

Luckwill, L. C. 1970. The control of growth and fruitfulness of apple trees. In Physiology of Tree Crops, pp. 237-254. (L. C. Luckwill and C. V. Cutting, eds.). 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.

Tukey, R. B. And M. W. Williams. 1981. Tree fruit growth regulators and chemical thinning. Proc. 1981 Pacific Northwest Tree Fruit Shortcourse. Wash. Sta. Coop. Ext. Ser., Pullman.

Williams, M. W. 1984. Use of bioregulators to control vegetative growth of fruit trees and improve fruit efficiency. In Bioregulators Chemistry and Uses, pp.93-99 (R. L. Orydn F. R. Rittig, eds.). American Chemical Society, Washington.

REDUCING THE SECONDARY SPREAD OF FIRE BLIGHT WITH APOGEE

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Introduction

Apple trees are highly susceptible to fire blight when actively growing, but this period of susceptibility can be reduced to 1 to 2 wk with a single high-rate application of the growth retardant prohexadione calcium formulated as Apogee (27.5%) dry flowable (BAS 125 W). Prohexadione calcium inhibits the biosynthesis of gibberellin (2). Inhibition of gibberellin biosynthesis results in an early cessation of growth and reduced risk of infection by *Erwinia amylovora*.

Previous studies in Michigan and in other states indicate that Apogee offers a new and novel approach to fire blight control. Trees treated with 12 oz/100 gallons of Apogee 27.5 %W late in the bloom period have been found to exhibit a significantly lower incidence of secondary shoot blight than unsprayed trees. Also, the progression of blight in infected shoots is reduced. The level of fire blight control was reduced with the high-rate application was divided into two applications of 6 oz/100 gal Apogee 27.5%W.

On apple, measurable inhibition in growth was evident in about 2 wk after application and the inhibition lasts for 4 to 6 wk depending on tree vigor (the inhibition lasted longer in cooler regions). Resistance to fire blight developed during the 2-wk period after application and lasted until growth resumed. The objective of this study was to determine whether Apogee applied during bloom would reduce the severity of fire blight from infections to blossoms and shoots from infection that occurred 7 days after application.

Materials and Methods

Experiments were carried out on mature Jonathan and Golden Delicious apple trees on M106 rootstock. The treatments were replicated 6 times on 2-tree plots. All treatments were applied with a handgun sprayer to runoff. Apogee 27.5%W was applied once at 12 oz of product/100 gallons (high rate application, 250 ppm) or twice at 6 oz/100 gallons (split-rate application, 125 ppm). In 1999, treatments were initiated 10 May when trees were in full bloom; the second split-rate application was applied on 17 May at the end of petal fall.

Ten shoots around the outside of each tree were inoculated on 27 May by cutting two leaves per shoot near the tip with scissors dipped into a bacterial suspension of *Erwinia amylovora* containing 10^7 colony forming units (cfu) per ml. The length of infected tissue and total shoot length were recorded for each inoculated shoot on 9 June.

Results

The growth rate of shoots 17 and 31 days after treatment with the high-rate Apogee treated trees was less than that for shoots on check trees (Table 1). The two half-rate Apogee treatments reduced the rate of growth on Golden Delicious but not on Jonathan. A severe storm on 17 May, 7 days after the initiation of the Apogee treatments, created ideal conditions for blossom blight and trauma blight on Jonathan but not on Golden Delicious. On 14 June, significantly fewer strikes per tree were present on Jonathan trees treated with Apogee than on the check trees.

The extension of fire blight in inoculated shoots of Jonathan was greater than in shoots of Golden Delicious. On Jonathan and Golden Delicious the high rate of Apogee reduced the extension of blight in inoculated shoots by 29 to 50% compared to the control, respectively. The half-rate Apogee treatment did not reduce the extension of blight in inoculated shoots on either variety.

Table 1. The effect of Apogee treatments on growth of Jonathan and Golden Delicious apple shoots and on the incidence and severity of fire blight in 1999.

Product and rate per 100 gal (number of applications)	Timing	Inoculated shoots * Current growth infected (%)	Inoculated shoots * Control (%)	Blossom and terminal fire blight Strikes/tree On 14 June	Blossom and terminal fire blight Control (%)	Growth rate for shoots (mm/day) at various times after application 17 days	Growth rate for shoots (mm/day) at various times after application 31 days
Jonathan (susceptible variety)							
Apogee 27.5% 12 oz (x1)	10 May	69.6 b	29.3	22.8 b	53.5	7.2 b	6.3 b
Apogee 27.5% 6 oz (x2)	10, 17 May	92.3 a	9.2	24.8 b	49.9	8.6 a	10.4 a
None		98.4 a	--	59.3 a	--	9.0 a	9.4 a
Golden Delicious (less susceptible variety)							
Apogee 27.5% 12 oz (x1)	10 May	25.4 b	50.4	0.5	nd	6.8 c	6.1 c
Apogee 27.5% 6 oz (x2)	10, 17 May	54.3 a	0.0	0.2	nd	8.6 b	8.2 b
None	--	51.2 a	--	1.2	--	9.9 a	10.5 a

Means followed by the same letter are not significantly different according to LSD ($P \leq 0.05$).

Discussion

As the growth of apple trees slows over the season, susceptibility to fire blight also decreases due to ontogenetic resistance. Trees treated with Apogee exhibit a similar ontogenetic-type resistance response. As shoots cease growth following the inhibition of gibberellin biosynthesis, they exhibit less susceptibility to fire blight infection.

These studies confirms recent reports (1,3,4) that Apogee reduces the secondary spread of fire blight to vegetative shoot growth. Although the primary role of Apogee is the control of shoot blight, the data from 1999 indicated a reduction in the severity of blossom blight.

When Apogee is used for fire blight control, streptomycin or oxytetracycline should also be used for blossom blight control. Streptomycin is used to prevent blossom infection and to protect shoots until they become resistant within about 2 wk after a high-rate Apogee treatment. The effectiveness of Apogee last 4 – 6 weeks depending on tree vigor. In the northeastern United States, one application of Apogee should be sufficient for preventing fire blight spread in the summer, but in areas with longer growing season, a second application may be needed.

References

1. Breth, D.I., Momol, M.T., and Aldwinckle, H.S. 1998. Evaluation of BAS 125 for the control of fire blight on apple shoots. Fungicide and Nematicide Tests. 53:4.

2. Evans, J.R., Evans, R.R., Regusci, C.L., and Rademacher, W. 1999. Mode of action, metabolism, and uptake of BAS 125W, prohexadione-calcium. HortScience

3. Fernando, W.G.D., and Jones, A.L. 1998. Field evaluation of BAS 125W for fire blight management in 1997. Fungicide and Nematicide Tests. 53:5.

4. Yoder, K.S., Miller, S.S., and Byers, R.E. 1999. Suppression of fireblight in apple shoots by prohexadione-calcium following experimental and natural inoculation. HortScience

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INFLUENCE OF APOGEE ON SELECTED APPLE AND PEAR PESTS

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Some of the most difficult decisions that orchard managers are required to make are related to the problem of maximizing production by accurately controlling the balance between reproductive (fruitfulness) and vegetative growth. This is an extremely complicated task because there are so many factors that must be considered when making management decisions. These factors include pre-production factors, such as soil type and depth, drainage, and climate; planting time factors, such as variety and rootstock selection, and choice of training system; and finally post-planting production factors, such as fertilizer application rates, cropping level, and pruning. Many of the post-planting practices are labor intensive, time consuming, and expensive. In fact the cost of these activities is up to 20% of the preharvest cost of apple production. Excessive vegetative growth produces a tree canopy that is too dense for effective penetration of sprays resulting in increased fruit loss due to damage caused by insects and diseases. In addition it is difficult to maintain a pesticide residue on vigorously growing shoots without repeated pesticide applications. A dense canopy also results in less desirable fruit color and may contribute to the spread of diseases such as powdery mildew. A new plant growth regulator produced by BASF called Apogee (BAS 125 W) will provide orchard managers with a new tool to help them effectively manage vegetative growth.

Before Apogee is put into general use it is important to understand the effect of its use on populations of insects, both pestiferous and beneficial. The research reported here focused on the effect of Apogee on populations of two important pests of orchards; the obliquebanded leafroller (OBLR), *Choristoneura rosaceana* (Harris), in apples and pear psylla (PP), *Cacopsylla pyricola* (Foerster), in pears. Both of these pests have life histories that are strongly linked with the production of lush succulent leaves associated with new growth. Since applications of Apogee will reduce availability of new growth, our research evaluated the impact this would have on the behavior, growth and development of these pests. In addition, we evaluated the effect of Apogee on the efficacy of currently used PP and OBLR pesticide programs.

EXPERIMENTAL DESIGN

Pear Psylla I

Five treatments were applied to single tree plots in a randomized complete block design consisting of 4 replicates of 'Bartlett' for each treatment. The trees were planted on a 24 x 24 ft spacing and were 21 years old. The various treatments were applied to run off with a handgun from a truck-mounted hydraulic sprayer at 400 psi. An average spray volume of 3.0-4.0 gal was applied per tree. The various application timings for both Apogee and the insecticides can be found Table 1. All plots received a regular fungicide maintenance schedule of Benlate 50DF, Agrimycin, and Ziram 76WP. All treatments were evaluated by counting nymphs from leaf samples using a binocular microscope under 10X magnification at 6-9 day intervals. Counts were made on 15 spur leaf samples on 13 May, on 7 spur and 8 third most distal leaf samples on 24 May, and on 15 third most distal leaf samples from 1 Jun to 24 Jun. The cumulative number of PP nymph days per leaf was determined for each treatment from 13 May to 24 Jun. Adult PP were sampled by making a 2 min.

observation around the periphery of each tree. Ten actively growing pear shoots were tagged and measured periodically throughout the study.

Table 1. Treatments applied to pear trees for PP study.

Treatment	Rate/100 gals, lb AI)	Applied
1	170.0 g Apogee 27.5% (0.103) + 170.0 g Ammonium sulfate	11 & 25 May, 7 Jun
	158.0 ml Provado 1.6F (0.0668)	11 May, 3 & 14 Jun
2	284.0 g Apogee 27.5% (0.172) + 284.0 g Ammonium sulfate	11 May
	85.0 g Apogee 27.5% (0.052) + 85.0 g Ammonium sulfate	25 May, 7 Jun
	158.0 ml Provado 1.6F (0.0668)	11 May, 3 & 14 Jun
3	170.0 g Apogee 27.5% (0.103) + 170.0 g Ammonium sulfate	11 & 25 May, 7 Jun
	195.0 ml Agri-Mek 0.15EC (0.0234) + 473.0 ml LI-700	11 May
	125.0 g Pyramite 60WP (0.165)	14 Jun
4	158.0 ml Provado 1.6F (0.0668)	11 May, 3 & 14 Jun
5	Untreated Control	

Obliquebanded Leafroller

Six treatments were applied to single tree plots in a randomized complete block design consisting of 3 replicates of "Golden Delicious" and 3 replicates of "Fugi" for each treatment. The trees were planted on a 20 x 30 ft spacing and were 7 years old. The various Apogee treatments were applied to run off with a handgun from a truck-mounted hydraulic sprayer at 400 psi. An average spray volume of 3.0 gal was applied per tree. The insecticide treatments were applied with an Durand-Wayland airblast sprayer calibrated to deliver 100 GPA at 2.4 mph. The various application timings for both Apogee and the insecticides can be found Table 2. A routine schedule of fungicides (Benlate 50DF, Dithane 75DF, Nova 40WP, and Ziram 76WP) was maintained throughout the experiment. All treatments were evaluated by counting OBLR shelters/12 minutes/tree. Counts were made on 23 Jun, 30 Jun, 7 Jul, 14 Jul, 22 Jul, and 29 Jul. The location of each shelter in old vs. new vegetation was also noted and shelters were examined to determine if they contained a living OBLR larva. Fruit damage was assessed on 8 August. Ten actively growing shoots were tagged and measured periodically throughout the study.

Results

Pear Psylla

The number of PP nymphs was not significantly different across all sprayed treatments until 7 Jun when the number of nymphs on the Agri-Mek/Apogee and the control treatments rapidly increased (Table 3). Nymph populations on the two Apogee/Provado treatments continued to remain low throughout Jun while the number of nymphs increased on the Provado only treatment. The number of cumulative PP nymph days/leaf was the lowest on the high rate treatment of Apogee and Provado followed by low rate of Apogee and Provado (Table 3). A similar trend in treatment response for PP adults was also found on 7 Jun (Table 4); otherwise, no significant differences in adult populations were found during the study. Shoot length on all Apogee treated trees was shorter than on insecticide only trees on all sampling dates (Table 5).

Table 2. Treatments applied to apple trees for OBLR study.

Treatment	Rate/100 gals (lbs. AI)	Applied
1	176.0 g Apogee 27.5% (0.107) 88.0 g Apogee 27.5% (0.054) + 88.0 g Ammonium sulfate	14 May 26 May, 8 Jun
2	176.0 g Apogee 27.5% (0.107) + 176.0 g Ammonium sulfate	14 May 26 May, 8 Jun
3	176.0 g Apogee 27.5% (0.107) 88.0 g Apogee 27.5% (0.054) + 88.0 g Ammonium sulfate 530.0 ml Confirm 2F (0.3) 473.0 ml Latron B-1956	14 May 26 May, 8 Jun 1 Jul
4	176.0 g Apogee 27.5% (0.107) + 176.0 g Ammonium sulfate 530.0 ml Confirm 2F (0.3) 473.0 ml Latron B-1956	14 May 26 May, 8 Jun 1 Jul Jul
5	530.0 ml Confirm 2F (0.3) 473.0 ml Latron B-1956	1 Jul Jul
6	Untreated Control	

Table 3. Apogee and insecticides for PP control - pear psylla nymphs.

	Mean no. PP nymphs/leaf*						Cum. PP[1]
Treatment	13 May	24 May	1 Jun	7 Jun	16 Jun	24 Jun	5/6 - 6/24
1	1.4a	0.57a	0.83a	2.53a	1.53a	2.07a	121.9ab
2	0.7a	0.75a	0.67a	3.10a	1.42a	1.70a	69.9a
3	2.1ab	1.22a	0.32a	16.43b	2.58ab	2.37a	238.3c
4	1.1a	0.58a	1.23a	3.97a	6.73bc	9.02b	166.5b
5	3.1b	1.07a	1.45a	18.13b	9.87c	7.60b	356.6d

*Means followed by the same letter(s) are not significantly different (Fisher's Protected LSD, P ≤ 0.05).
[1]Mean cumulative number of PP nymph days/leaf from 6 May - 24 Jun.

Table 4. Apogee and insecticides for PP control - pear psylla adults.

	Mean no. PP adults/2 min*					
Treatment	28 May	1 Jun	7 Jun	16 Jun	24 Jun	30 Jun
1	105.8a	182.3a	82.4a	7.5a	11.5a	5.0a
2	122.8a	183.0a	63.3a	9.0a	5.3a	3.5a
3	131.5a	195.0a	152.8b	10.3a	4.3a	2.8a
4	121.3a	281.3a	213.0b	15.3a	17.8a	10.0a
5	189.3b	267.5a	226.0b	22.5a	9.3a	10.5a

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

Obliquebanded Leafroller

Variance in OBLR data due to varietal differences (Fugi vs. Golden Delicious) are not discussed because they did not significantly alter experimental results. There were significant treatment effects on the average number of OBLR shelters/tree (Table 6). Trees treated with both Apogee and Confirm had significantly lower numbers of OBLR shelters than other treatments. Treatments in which only Apogee or Confirm were applied also had significantly lower numbers of OBLR shelters/tree than the untreated control but were not significantly different than each other. These results were mirrored in the fruit damage assessments (Table 6) with the least fruit damage occurring in trees treated with Apogee and Confirm. Linear regression indicated a significant positive relationship between fruit damage and the number of OBLR shelters (R^2 = 0.42, P< 0.001). Treatments did not significantly effect the location of shelters in new vs. old vegetation nor the percentage of empty vs. occupied shelters(Table 6). Initially shoot growth data did not indicate a clear relationship between applications of Apogee and shoot growth but by mid-summer shoot growth on Apogee treated trees was significantly shorter than on non-Apogee treated trees (Table 8).

Table 5. Apogee and insecticides for PP control - shoot length.

Treatment	Mean shoot length (cm)*				
	20 May	28 May	10 Jun	23 Jun	9 Jul
1	17.0a	18.3a	20.1a	21.6a	21.5a
2	17.6a	20.1a	21.2a	22.3a	21.8a
3	17.6a	19.4a	21.4a	24.2a	22.9a
4	21.6b	26.6b	31.3b	34.5b	35.6b
5	21.0b	24.3b	29.4b	29.0ab	28.4ab

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

Table 6. Summary of statistical analyses for Apogee/Confirm apple study - OBLR shelters and fruit damage.

Treatment	*Mean % Empty Shelters	*Mean % shelters new vegetation	*Mean no. shelters	*Mean % damaged fruit
1	58.35 a	47.73 a	12.67 a	0.99 a
2	42.94 a	21.00 a	13.83 a	1.16 a
3	47.84 a	43.97 a	6.83 b	0.45 b
4	57.67 a	55.17 a	3.50 b	0.41 b
5	68.12 a	37.46 a	12.17 a	1.11 a
6	72.43 a	27.60 a	37.67 c	2.62 c
TOTAL	57.89	38.82	14.44	1.12

*Numbers in columns followed by the same letter are not significantly different (LSD P<0.05)

Table 7. Summary of statistical analyses for Apogee/Confirm apple study - shoot length.

Treatment	Mean shoot length (cm)*			
	18 May	28 May	10 Jun	21 July
1	20.7a	25.8a	26.2a	27.0a
2	19.4b	24.5a	25.7a	27.3a
3	20.5ab	26.2ac	27.1a	27.9a
4	21.0a	27.5bc	26.1a	27.8a
5	20.9a	29.3b	32.1b	34.8b
6	20.1ab	28.5b	31.4b	32.9b

*Numbers in columns followed by the same letter are not significantly different (LSD P<0.05)

Conclusions

Analyses of our data indicated that Apogee can perform an important role in future orchard pest management strategies. In our studies Apogee helped to suppress pest populations and control vegetative growth in both apple and pear orchards. In the future we hope to repeat the work reported here as well as carrying out additional evaluations of the effect of Apogee on other orchard pests and natural enemies.

Use of a Laminate Dispenser for Codling Moth Mating Disruption - 1999

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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. The pheromone blend was presented by Arn et al. (1992).

Table 1. Pheromone blend for codling moth.

Component	Proportion
E,E-8,10-12:OH	42.0
E,Z-8,10-12:OH	2.3
*E*9-12:OH	6.2
10:OH	1.2
12:OH	27.2
14:OH	3.9
16:OH	7.8
18:OH	9.3

II. Materials and Methods: A 4-ha (10-acre) block of 'Delicious' trees at Miller School and a similar block of 'Golden Delicious' and 'Winesap' trees at Spring Valley (Albemarle Co.) were treated with Hercon laminate pheromone dispensers (Hercon Environmental Company). Each dispenser contained 180 mg of the primary component of the CM pheromone, *E,E*-8,10-dodecadien-1-ol. Dispensers were placed at 525/ha at petal fall (21 April at Spring Valley, 26 April at Miller School). A conventional insecticide program was followed through first cover. A control block of the same varietal representation was located A control block of similar varietal representation was located about 50 m away at Spring Valley, and across a dirt farm road at Miller School. Four pheromone traps each for CM, OFM, VLR, TBM, and RBL were placed in each block and monitored weekly. Harvest injury was assessed on 27 August at Spring Valley and 10 September at Miller School. At that time, 200 'Golden Delicious' fruit were harvested both from the edge and center of each block at Spring Valley, and 300 'Delicious' from the edge and center of each block at Miller School.

III. Results and Discussion:

Flight data: Trapping data revealed high CM pressure at Spring Valley (Fig. 1). The flight in the first generation reached 4 moths per trap; at this time there was adequate trap shutdown. However, peak capture in the August-September flight reached about 11 moths per week, and the treatment was not able to adequately disorient moths. At Miller School (Fig. 3) very few moths were collected during most of the season, except for a short but intense bout of activity in the August-September flight. Large numbers of oriental fruit moth were collected in both sites (Figs. 2,4). The CM captures in late season in the pheromone-treated orchards were apparently not due to reduced release rates at the end of the season. GC analysis showed a fairly constant decline in residual pheromone content (Fig. 5) and average daily release rate (Fig. 6). We plan to use the same dispensers but with a higher application rate next season.

Damage data: Damage data are presented in Table 1. This was a severe year for injury by internal feeders. Such injury was found at both sites, though worse at Spring Valley, an orchard with a longer history of CM injury. Despite the high numbers of oriental fruit moths in traps at both sites, most larvae found in fruit were codling moths.

Table 1. Percent injured fruit in two mating disruption apple blocks in Albemarle Country, Virginia (1999).

		% Injured Fruit				
		Internal Leps	*Platynota*	RBL	PC	AM
Miller School Pheromone	Edge	6.0	5.0	0.0	0.3	0.0
	Middle	5.7	3.3	0.3	0.0	0.0
Miller School Control	Edge	4.7	0.7	0.7	0.3	0.0
	Middle	5.0	1.0	0.3	1.0	0.0
Spring Valley Pheromone	Edge	10.0	2.0	0.0	0.0	2.5
	Middle	16.0	5.5	0.0	0.5	0.0
Spring Valley Control	Edge	2.0	1.5	0.0	7.0	0.0
	Middle	0.5	0.0	0.0	0.0	0.0

IV. References Cited:

Arn, H., M. Toth and E. Priesner. 1992. List of sex pheromones of Lepidoptera and related attractants. IOBC, West Palearctic Regional Section. 2nd ed.

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.

Figure 1. Codling moths per trap in mating disruption and control blocks at Spring Valley – 1999.

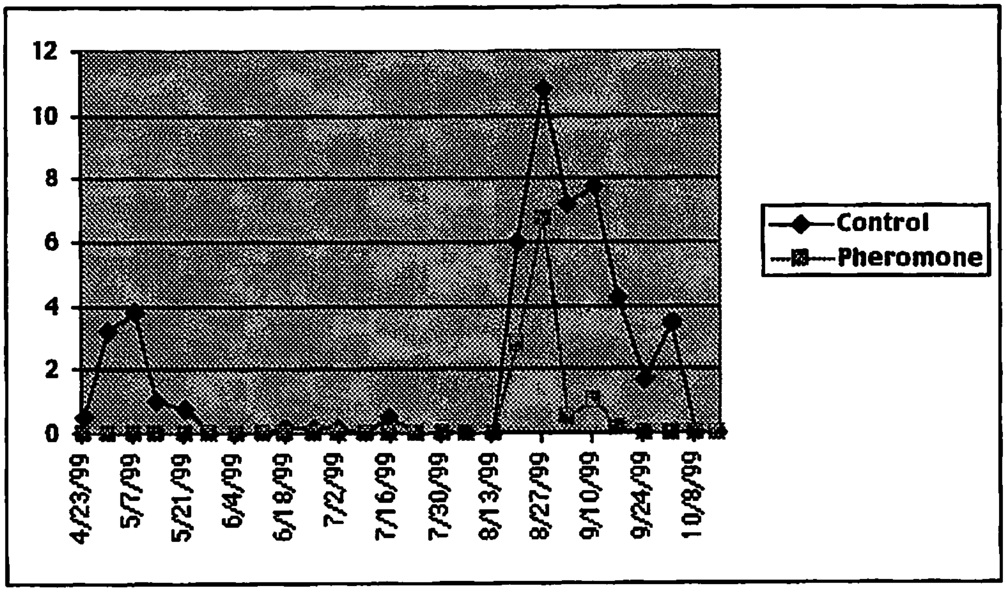


Figure 2. Oriental fruit moths per trap in mating disruption and control blocks at Spring Valley – 1999.

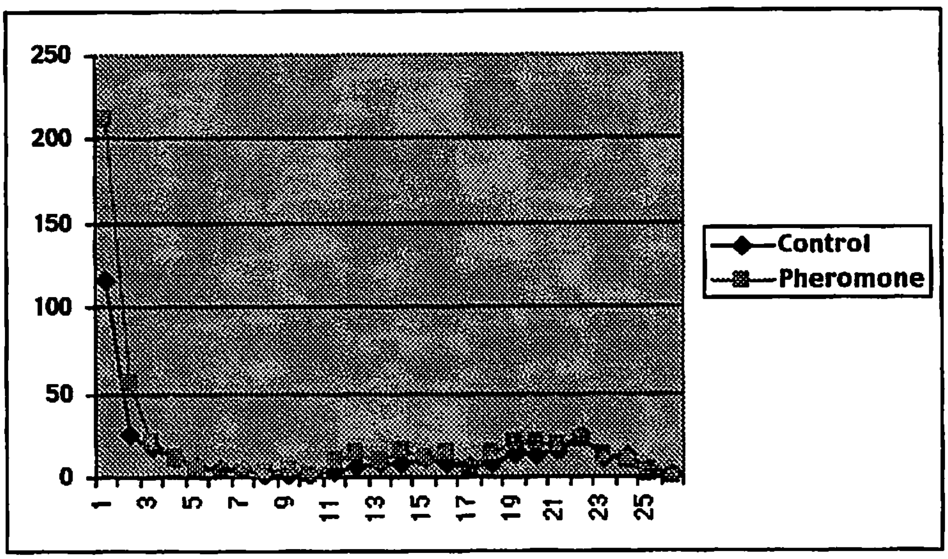


Figure 3. Codling moths per trap in mating disruption and control blocks at Miller School - 1999.

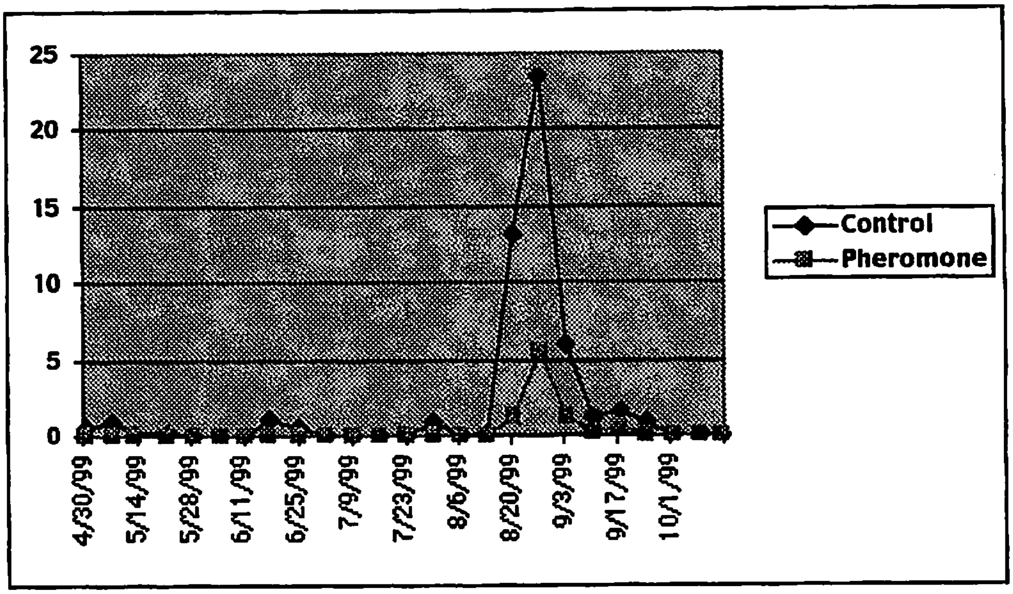


Figure 4. Oriental fruit moths per trap in mating disruption and control blocks at Miller School - 1999.

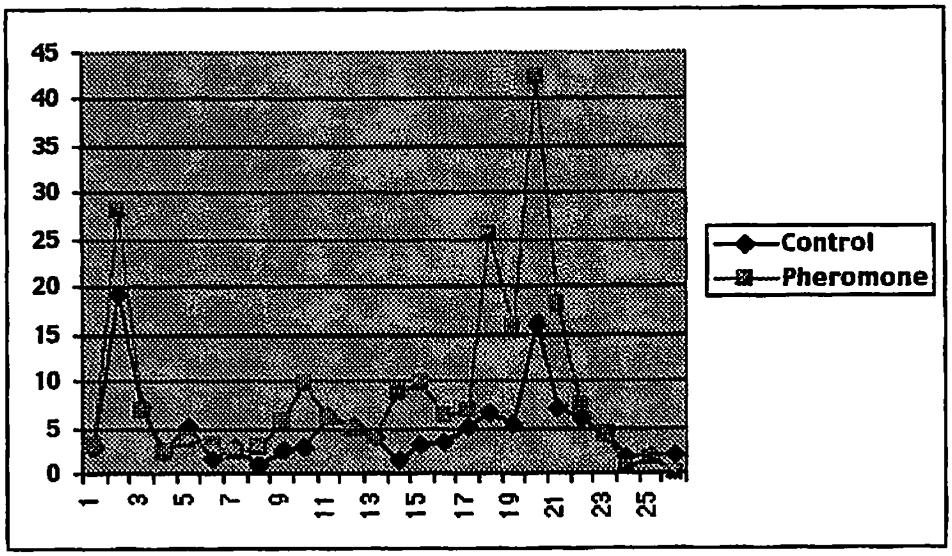


Figure 5. Residual *E,E*-8,10-dodecadien-1-ol in Hercon laminate dispensers at Miller School orchard, based on gas chromatographic analysis – 1999.

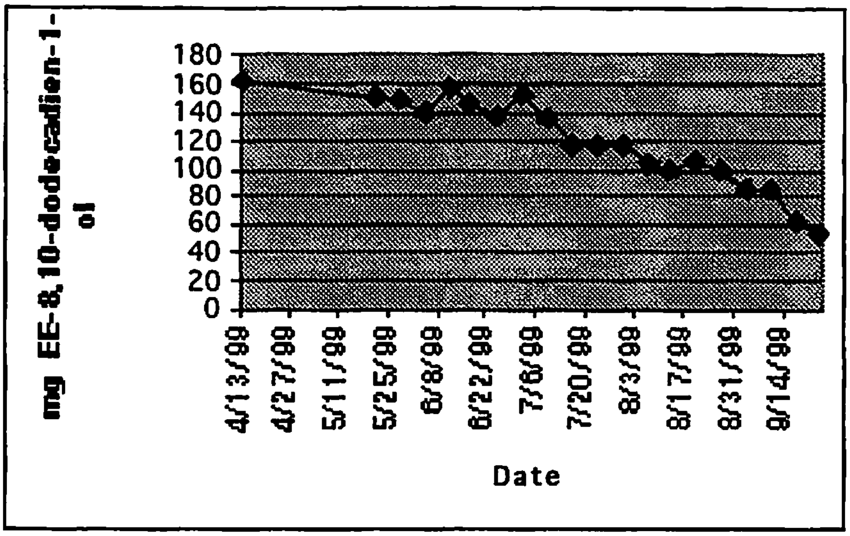
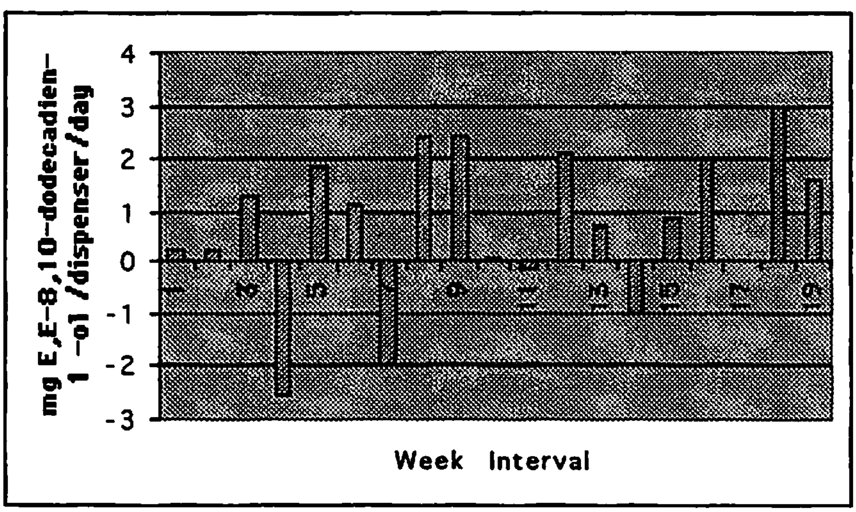


Figure 6. Average daily release rate of *E,E*-8,10-dodecadien-1-ol from Hercon laminate dispensers at Miller School orchard, based on gas chromatographic analysis – 1999.



Evaluation of Codling Moth and Oriental Fruit Moth Mating Disruption Systems

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During the past two years, the codling moth and Oriental fruit moth (OFM) have emerged as important pests of apple in North Carolina. Although the reason for this increased importance is unknown, two factors that are thought to be at least partially responsible. First, the OFM has not previously been considered a serious threat to apples in NC, and scouting programs and post petal fall insecticide applications have been targeted solely against the codling moth and tufted apple bud moth. Second, due to regulatory actions and OP resistant tufted apple bud moth populations, narrow-spectrum insecticides (i.e., Confirm, SpinTor, and Bt's) have replaced OPs in two to three cover spray applications. In general, these materials are not as effective as OPs in controlling codling moth and especially OFM.

Uncertainty over the efficacy and/or proper use patterns of many new insecticides for use against codling moth and OFM, coupled with future regulatory action which is expected to reduce the availability of OPs in apple production, pheromone-mediated mating disruption may soon play a more prominent role in the management of these insects. While mating disruption of codling moth has been examined in NC for the past 5 years, little information is available about the efficacy of OFM mating disruption in NC apple systems. OFM completes four generations per season in NC, with adult activity extending from late March/early April through September. The need to disrupt first generation adults (April and May) has been questioned in instances when insecticides that are effective against this insect are applied at petal fall, which is a common practice because of the need to control plum curculio. If disruption of the first generation can be avoided, it would likely result in a considerable cost savings, because most OFM pheromone dispensing systems are only expected to provide residual activity for three generations. Hence, one objective of this study was to compare the effect of using mating disruption for the first generation vs. the latter three generations only.

There are a number of different pheromone dispensing systems for mating disruption that are currently available or under development, but little information on the attributes and relative efficacy of these products in NC systems. Thus, a number of trials were also conducted to evaluate these products for mating disruption of both the OFM and codling moth.

Materials and Methods

Trials were conducted at multiple locations in commercial orchards to compare different application timings of OFM pheromones and to evaluate the efficacy of different pheromone dispensing systems. At all locations, treatments were evaluated based on pheromone trap catches in treated and untreated areas of orchards, and, where appropriate, by examining fruit for damage at harvest. Pheromone traps were placed in the orchard at the time treatments were applied and examined weekly and lures replaced monthly. Data are presented as mean season cumulative trap catches. Fruit damage assessments were conducted by examining 100 apples per tree from 5 to

12 trees per block (number of trees depended on size of blocks), and recording the number damaged by various insects. When live worms were found in fruit, worms were placed in 50% ethanol and returned to the laboratory and identified to species.

First Generation OFM Mating Disruption. Two different 10-acre orchards in Henderson County (Barnwell-TG and Staton-HG) were each used to compare the efficacy of applying Isomate-M100 dispensers prior to emergence of first generation OFM adults (1 April) to applications after the first generation flight period (late May). Each 10 acre orchard was divided into two 5-acre treatments; one of which was treated with Isomate M-100 dispensers on 1 April, which coincided with OFM biofix, and the remaining 5-acres was treated with Isomate-M100 on 27 and 31 May in the Barnwell-TG and Staton-HG orchards, respectively. All Isomate-M100 dispensers were hung at a density of 100 per acre (=23.2 gm pheromone/acre). Both treatments at both orchards were also treated with Isomate-C Plus dispensers (300 and 400 dispensers/acre at Staton and Barnwell, respectively) on 27 May for codling moth mating disruption. At the Staton-HG site, the only insecticides applied to this 10-acre block were Ambush at 2" green tip (2 April), and two applications of Confirm 2F (0.18 lb[AI]/A) on 18 June and 12 August for first and second generation tufted apple bud moth, respectively. At the Barnwell-TG site, the entire 10-acre orchard was sprayed with Asana XL at tight cluster (7 April), Imidan 70WP (1.7 lb[AI]/A) at petal fall on 8 May, and Confirm 2F (0.18 lb[AI]/A) on 13 June and 15 August. The Barnwell-TG orchard was a mixed block of 'Gala' and 'Jonagold', and the Staton-HG orchard was a solid block of 'Gold Delicious'. At harvest, 100 apples from each of 12 trees per treatment were examined for damage by insects. Harvest occurred on 12 August and 7 September in the Barnwell and Staton orchards, respectively.

Comparison of Confuse and Isomate Products: A small plot replicated trial (Nix orchard) and a large plot non-replicated trial (Barnwell-R orchard) each compared Confuse and Isomate products to disrupt both codling moth and OFM. At the Nix orchard, 0.2 acre blocks were treated with Confuse OFM and Confuse CM (each at 30 gm/A of pheromone), Confuse Mix (30 gm/A of each pheromone), Isomate-C+ (34.9 gm of E8,E10-12:OH/A) and Isomate-M 100 (23.2 gm pheromone/A), and an untreated control. Each plot was replicated 3 times with a 30 to 50 m buffer area separating plots. Pheromones were placed in the orchard on 10 May. The entire orchard (all plots) was sprayed with Confirm and OPs in cover sprays.

At the Barnwell-R orchard, the same treatments as at the Nix Orchard were evaluated, but plots were 5 acres in size and not replicated. The only insecticides applied after bloom to the pheromone blocks was Imidan at petal fall, and Confirm in June and August. Codling moth pheromone dispensers were applied on 27 April, OFM pheromone was applied on 20 May. The Confuse mix was applied on 20 May. On 1 Sept, 100 apples from each of 6 trees per treatment were examined for insect damage.

Microsprayer Trial: MSU microsprayers emitting OFM pheromone were evaluated in a 10 acre block of 'Rome Beauty' apples (Henderson-AR orchard). The entire orchard was also treated with Isomate C+ (300 dispensers/acre) for mating disruption of codling moth, and 2 applications each of Dipel DF, were applied against the first and second generations of tufted apple bud moth in June and August, respectively. One half of the orchard was equipped with one microsprayer per acre, and the remaining half with 3 microsprayers/acre. OFM pheromone was differentially diluted in Microsprayer canisters so that each treatment was emitting a total of 250 mg pheromone/day for 150 days (37.5 gm/acre per season). OFM pheromone traps were placed in two different locations of each treatment; in trees with microsprayers and in trees located between microsprayers. OFM populations were also monitored in two adjacent orchards; one treated with Isomate-M100 dispensers (100 per acre) and another non-pheromone treated orchard which was sprayed after bloom with organophosphates and Confirm. On 1 October, 100 apples from each of 8 trees per treatment were harvested and examined for insect damage.

Sprayable Pheromones: OFM sprayable pheromones were evaluated by making mid season (July and August) applications to 5- to 10-acre blocks and comparing pheromone trap catches in treated areas to non-pheromone treated areas. OFM sprayable pheromone was applied in 7 different orchards, but in 4 of the orchards OFM populations, as measured by pheromone trap catches in control areas, were too low to evaluate pheromone treatments. Orchards and treatments where sprayable pheromone was applied and where OFM populations were of sufficient density to evaluate treatments included: 1) Barnwell-L orchard (Henderson Co.) where 3M Sprayable and Thies Sprayable were each applied at 20 gm/acre of pheromone (125 gal water/acre) to 5-acre blocks on 12 July; 2) McCraw orchard (Henderson Co.) where Thies Sprayable was applied at 20 gm/acre of pheromone (100 gal water/acre) to a 10 acre block on 2 August; and 3) Davis orchard (Lincoln Co.) where Thies Sprayable was applied at 20 gm/acre of pheromone (250 gal water/acre) to a 5-acre block on 13 August.

Codling moth sprayable pheromone was applied in the W. Barnwell orchard on 16 August. Codling moth pheromone trap catches averaged >20 moths/trap throughout the summer months at this site, with an adjacent abandoned orchard the primary source of moths. Codling moth sprayable pheromone (Thies formulation) was applied at 25 and 50 gm/acre to a 5 and 2.5 acre block which was next to the abandoned orchard. The non-pheromone treated area was approximately 300 ft from the abandoned site. Two pheromone traps were hung in each of the three treatments; one with a 1X codling moth lure and the other with a 10X lure. In addition, all three treatments were sprayed with Imidan 70WP (1.75 lb[AI]/A) on the date of pheromone application and two weeks later.

Results

First Generation OFM Mating Disruption. At both locations, OFM trap catches in the control were highest during April and early May (35 to 42 DAT) and after in August and September (after 140 DAT). In the Staton-HG orchard, no moths were caught in the block where Isomate-M100 was applied in May, while a total of only 8 moths were caught in the block of the April treatment of Isomate, all of which were caught in September (Fig. 1). A similar trend was observed in the Barnwell-TG orchard, where a cumulative total of 10 and 5 moths/trap were caught in the April and May Isomate treatments, respectively (Fig. 2). In the Barnwell orchard, there was no damage caused by internal lepidopterous larvae, with plum curculio the primary cause of damage (Table 1). However, in the Staton-HG orchard, 1.7 and 3.2% of fruit exhibited internal lep damage in the April and May Isomate treatments, respectively. One-fourth of this damage contained live worms, all of which were OFM larvae. No damage was observed in either treatment during a preliminary damage assessment in July, indicating that the majority of this damage was caused in August. It is also important to note that a petal fall insecticide was not applied at the Staton-HG orchard. Under these circumstances, it appears that disruption of the first OFM generation (April application) may have aided in suppressing damage compared to the block where Isomate was delayed until after the first generation. However, further trials will be necessary to confirm this interpretation.

Comparison of Confuse and Isomate Products: In the small plot replicated trial at the Nix orchard, OFM populations were very low and did not enable treatment comparisons. However, there was a season cumulative total of 40 moths/trap in the control. The Isomate-C+ treatment provided season-long suppression of trap catches (Fig. 3), while trap catches in the Confuse O+C and Confuse Mix treatments began to increase between 60 and 90 DAT. The Confuse Mix treatment provided longer residual activity against codling moth compared with Confuse O+C. However, in the large plot trial at the Barnwell-R orchard, where Isomate again provided complete suppression of codling moth trap catches, there appeared to be little difference between the Confuse O+C and Confuse Mix treatments in terms of activity against codling moth (Fig. 4). In addition, Confuse O+C suppressed OFM trap catches more effectively than the Confuse Mix treatment (Fig. 5). Damage data from the Barnwell-R trial was relatively low in all treatments, but the Isomate treatment was the only one which had no internal lep damage. Greater success with the Confuse products probably would have been achieved with reapplication after 60 days. Plum curculio was again the primary cause of damage at this site.

Microsprayer Trial: At the Henderson orchard where MSU microsprayers were evaluated, the majority of OFM moths caught in pheromone traps of the control were first generation moths (Fig. 6). Both the 1 and 3 microsprayer treatments provided excellent suppression of OFM traps catches until about 140 DAT. The dramatic increase in OFM trap catches in the microsprayer treatments after 140 DAT is not surprising in that microsprayers were designed to emit pheromone for only 150 days. There was a considerable difference in traps placed in trees with microsprayers vs traps in trees without microsprayers. Catches were higher and increased earlier in traps placed between micropsrayers, and this trend was observed with in both the 1 and 3 microsprayer per acre density (Fig. 7). Internal lep damage in the microsprayer treatments did not differ between the 1 and 3 microsprayer/acre treatments, averaging 0.6 and 0.8 in the 1 and 3 density treatment, respectively. Approximately 60% of internal lep damaged fruit contained live worms, and all of these were OFM larvae; hence, the majority of internal damaged fruit appeared to be late season infestations, probably after microsprayers were no longer emitting pheromone. Microsprayers are estimated to have stopped emitting pheromone in mid to late August, or 4 to 6 wks before harvest. In an adjacent conventionally sprayed block there was no internal lep damage. TABM damage was relatively high at this site, and .60% of live worms collected from fruit were TABM larvae in the calyx end of fruit.

Sprayable Pheromones: At the three locations where OFM populations were of sufficient density to assess the efficacy of sprayable pheromones, both the 3M and Thies formulations resulted in excellent reductions in trap catches compared to non-pheromone treated areas. At the Barnwell-L orchard, both OFM sprayable formulations suppressed trap catches for the 10 to 11 wks after application (Fig. 8A). In addition, the Thies OFM formulation suppressed trap catches for at least 6 wks after application in both the McCraw and Davis orchards (Fig. 8B and 8C).

Finally, the Thies codling moth formulation of pheromone totally suppressed trap catches in both the 1X and 10X pheromone lures, respectively, for at least an 8 wk period. Although these pheromone trap data are very promising, fruit damage assessments were not a component of this trial and must obtained to determine if trap shutdown is correlated with prevention of damage.

Summary

Based on identification of larvae from fruit infested with internal feeding lepidoptera in these studies, most if not all damage was caused by OFM. This would suggest that codling moth mating disruption was successful in managing this pest. Success of mating disruption of the OFM appeared to vary with the timing of application and the type of pheromone dispenser used. When no insecticide was applied at petal fall, mating disruption of the first generation had less internal lep damage compared with delaying application of pheromone dispensers until after the first generation flight. When an insecticide effective against OFM was applied at petal fall, no internal lep damage was observed in either application timing of Isomate-M100 dispensers. Isomate-M100 dispensers provided longer residual activity than any of the Confuse paraffin emulsion formulations, and internal lep damage was also lower in Isomate treatments. Evaluation of MSU microsprayers showed that attraction of OFM males to pheromone traps was dependent on the location of traps within the orchard. Traps placed between sprayers attracted more moths than traps located in trees with microsprayers. Microsprayers ceased emitting pheromone in mid August, and the resurgence of OFM populations resulted in approximately 0.7% damage by OFM larvae. Sprayable pheromones exhibited excellent reduction in pheromone trap catches of both OFM and codling moth. Attraction of moths to pheromone traps was observed for a minimum of 6 wks after application, and in one orchard reductions in OFM catches were observed for >10 wks. However, future studies are necessary to determine if successful reductions in trap shutdown are correlated with disruption of mating and control of OFM populations.

Table 1. Mean (±SEM) percent insect-damaged apples in blocks treated with Isomate M-100 at first emergence of the first generation (1 April) and after emergence of the first generation was complete (27 May). Fruitland, NC. 1999

Treatment	% Damage			%	% of live worms		
	Internal leps	TABM	Plum curculio	Live worms	*Cydia*	*Grapholita*	*Platynota*
Barnwell-TG[1]							
Isomate on 1 April	0.0	0.0	3.8 (0.6)	0.0	--	--	--
Isomate 27 May	0.0	0.0	3.7 (3.7)	0.0	--	--	--
Standard[2]	0.0	0.5 (0.3)	4.2 (1.6)	0.0	--	--	--
Staton-HG[3]							
Isomate on 1 April	1.7 (0.6)	0.6 (0.2)	0.8 (0.4)	0.4 (0.2)	0.0	100.0	0.0
Isomate on 31 May	3.2 (1.1)	1.3 (0.3)	1.0 (0.8)	0.8 (0.5)	0.0	100.0	0.0

[1]At the Barnwell-TG orchard, Guthion 50WP (0.75 lb[ai]/A) was applied at petal fall to all treatments. The only insecticide applied to the Isomate treatments was Confirm (0.18 lb[AI]/A) against first generation TABM in June.

[2]The standard treatment was sprayed with Imidan, Guthion and Confirm during cover sprays.

[3]At the Staton-HG orchard, the only insecticide applied to either treatment after 1/2" green tip was an application of Confirm (0.18 lb[ai]/A) at against first and second generation TABM in June and August.

Table 2. Mean (±SEM) percent insect-damaged apples in blocks treated with different formulations of codling moth and Oriental fruit moth pheromone. Edneyville, NC. 1999

	% Damage		
Treatment[1]	Internal leps	TABM	Plum Curculio
Confuse CM + Confuse OFM	0.7 (0.5)	0.7 (0.5)	12.5 (1.6)
Confuse Mix	1.2 (0.7)	1.8 (1.0)	9.8 (1.6)
Isomate C+ Isomate M-100	0.0	0.7 (0.7)	10.8 (1.5)
Standard	0.2 (0.2)	0.7 (0.5)	7.9 (1.6)

[1]After bloom, the only insecticide applied to mating disruption treatments was Confirm (0.18 lb[ai]/A) in June and August for first generation tufted apple bud moth control. The standard treatment was sprayed with Guthion at petal fall, and cover sprays of Imidan and Confim.

Table 3. Mean (±SEM) percent insect-damaged apples in blocks treated with OFM pheromone with MSU Microsprayers and conventional pesticides. Henderson Orchard, Dana, NC. 1999

	% Damage			%	% of live worms		
Treatment	Internal leps	TABM	Plum curculio	Live worms	*Cydia*	*Grapholita*	*Platynota*
3 Microsprayer/A	0.6 (0.3)	8.4 (1.8)	0.4 (0.2)	1.1 (0.3)	0.0	50.0	50.0
1 Microsprayer/A	0.8 (0.3)	8.4 (1.6)	0.4 (0.2)	1.4 (0.6)	0.0	30.0	70.0
Conventional[1]	0.0	0.5 (0.3)	3.5 (3.2)	0.0	–	–	–

[1]The conventional treatment was sprayed with Ambush before bloom, and Imidan, Guthion and Confirm during cover sprays.

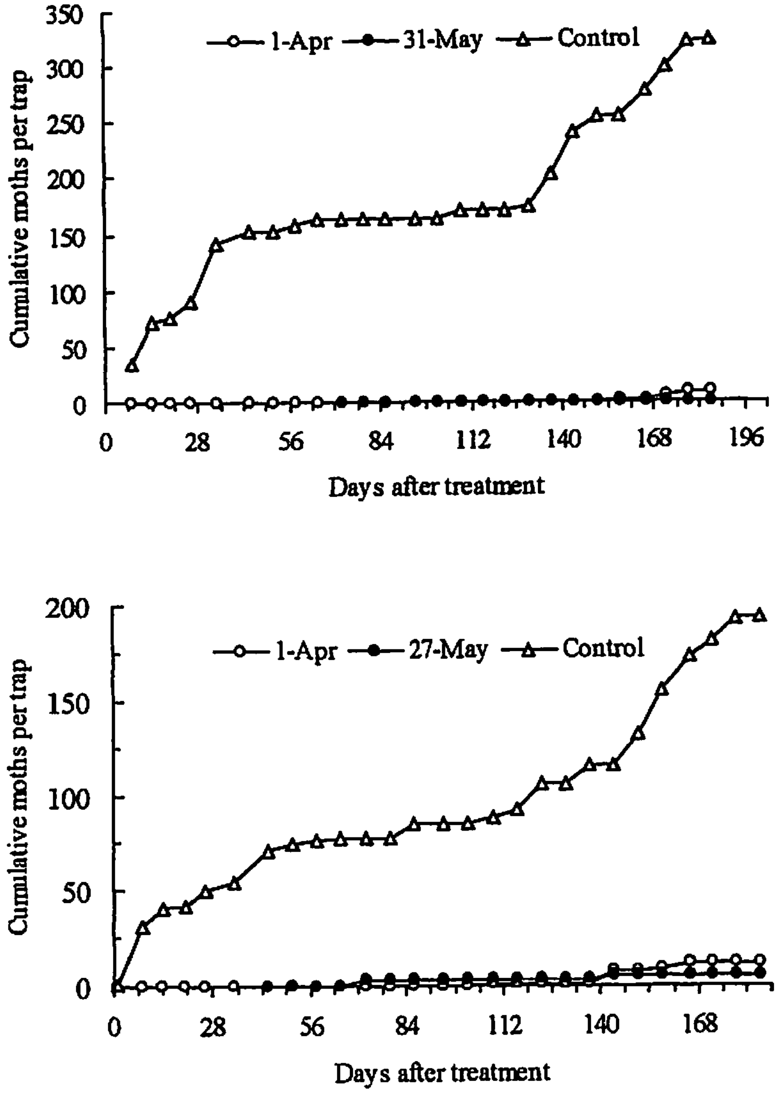


Fig. 1. Mean cumulative Oriental fruit moth trap catches in blocks treated with Isomate M-100 on 1April and late May, in Staton-HG (top graph) and Barnwell-TG (bottom graph) orchards. Henderson County, NC. 1999.

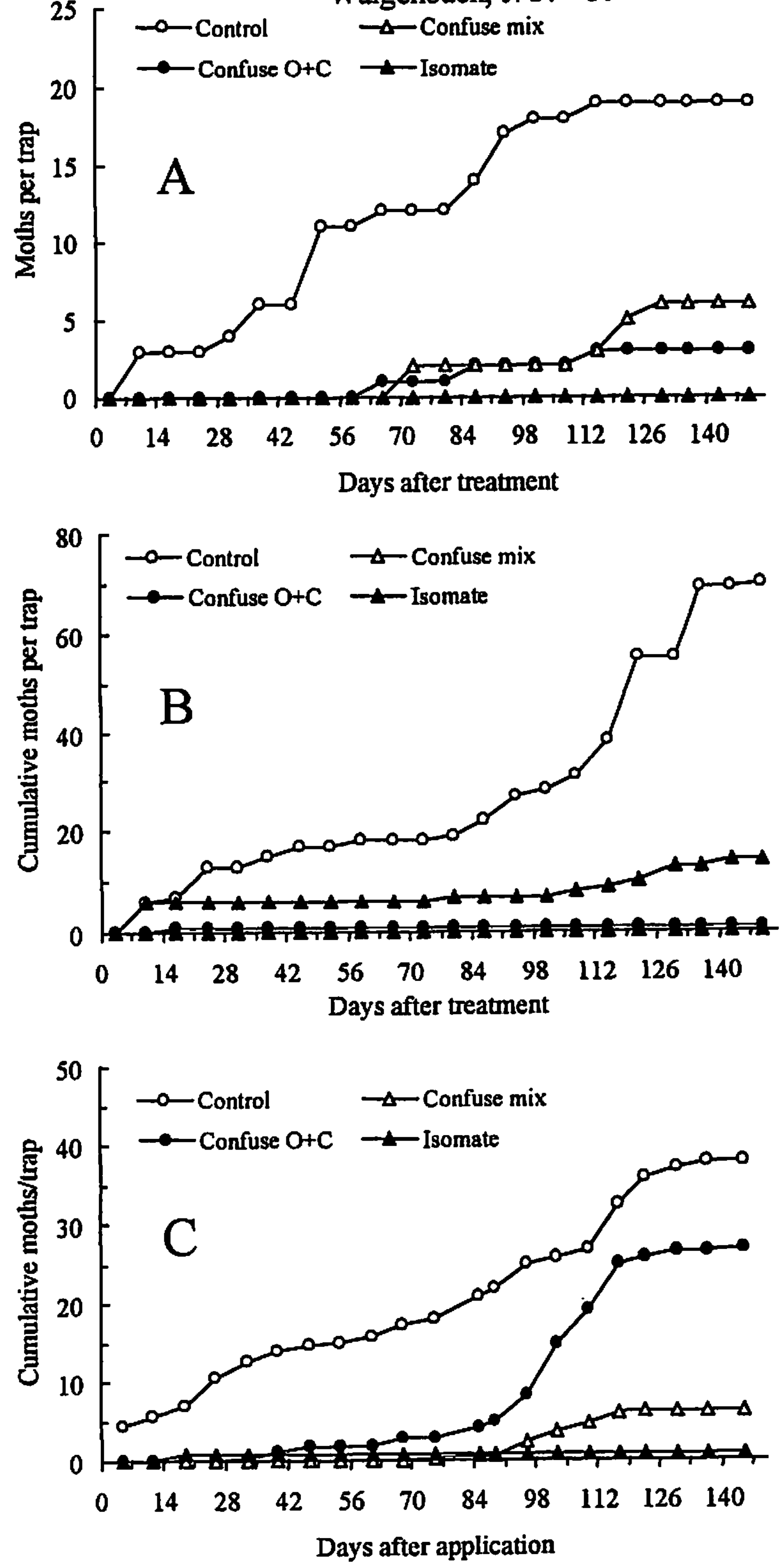
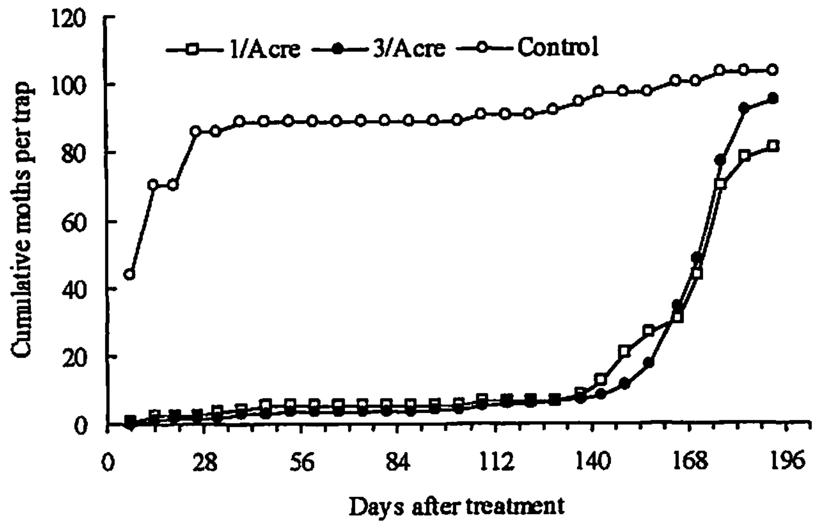


Fig. 2. Mean cumulative codling moth (A) and OFM (B, C) trap catches in plots treated with different formulations of codling moth and OFM pheromone. Small plot trial is shown in A (Nix Orchard) and large plot trial is shown in B and C (Barnwell-R orchard). Henderson County, NC. 1999.



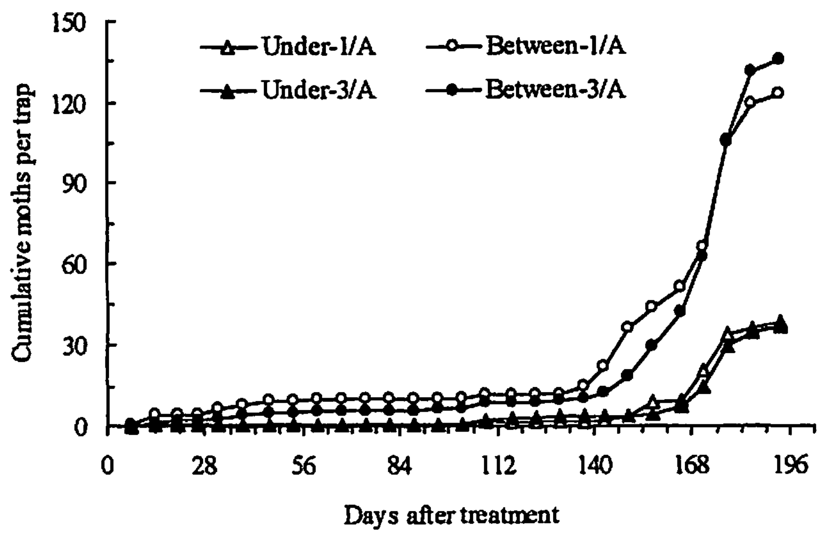


Fig. 3. Mean cumulative Oriental fruit moth trap catches in blocks treated with 1 and 3 MSU microsprayers per acre (top graph), and in traps placed underneath and between trees with microsprayers (bottom graph). Dana, NC. 1999.

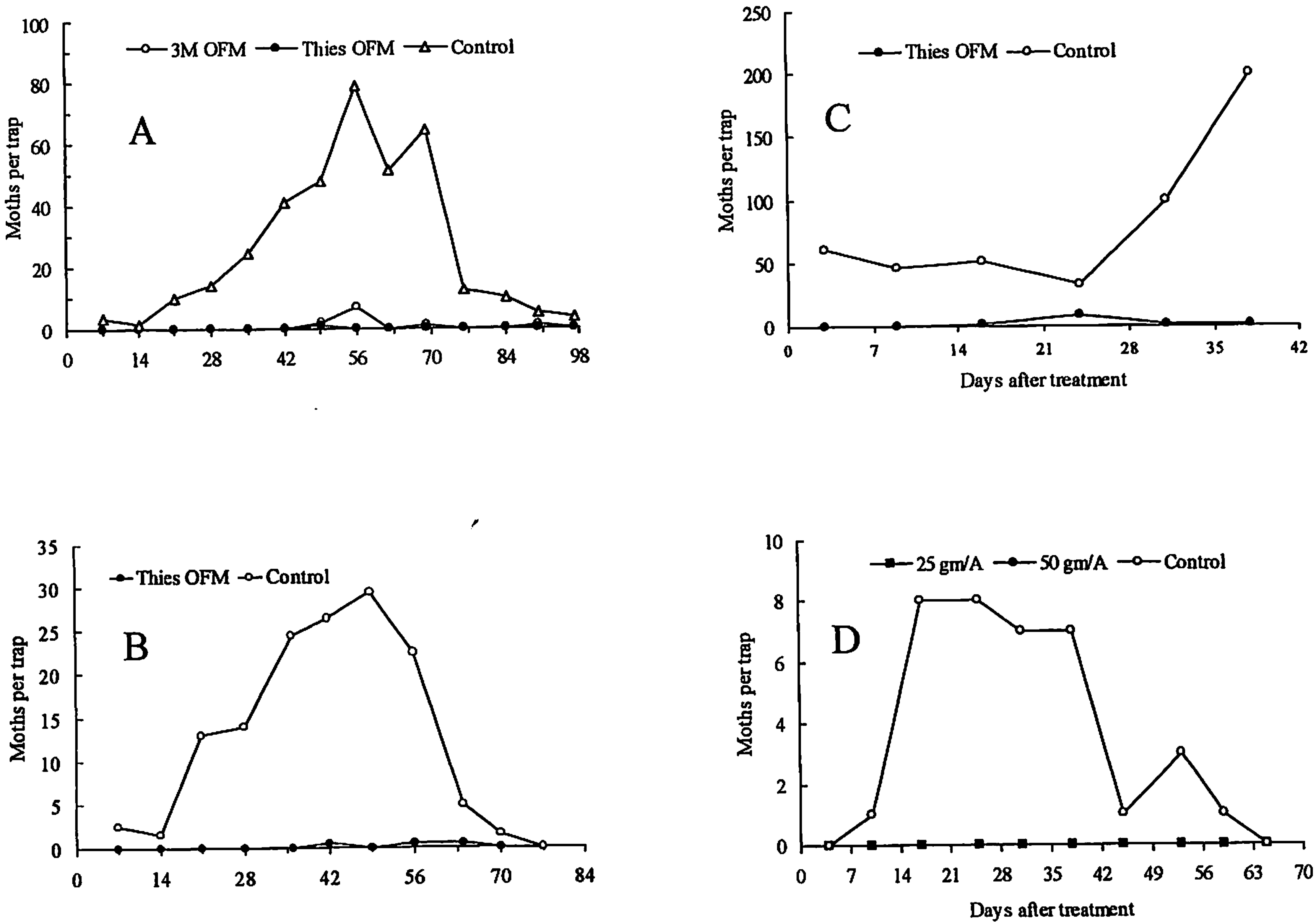


Fig. 4. Mean weekly pheromone trap catches in blocks of apples treated with sprayable formulations of OFM pheromone in Barnwell-L (A), McCraw (B) and Davis (C) orchards, and with sprayable codling moth pheromone at 25 and 50 gm/acre in the W. Barnwell orchard (D). 1999.

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Without Consent of the Author

NOVEL FORMS OF MATING DISRUPTION FOR VARIOUS LEPIDOPTEROUS PESTS OF APPLE

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Introduction

Codling moth (CM), *Cydia pomonella*, obliquebanded leafroller (OBLR), *Choristoneura rosaceana*, Oriental fruit moth (OFM), *Grapholita molesta,* and the tufted apple bud moth (TABM), *Platynota idaeusalis,* are four important pests of apple in Pennsylvania. In 1999 we tested some relatively new application methods for distributing sex pheromone throughout orchards for mating disruption: microencapsulated (MEC) pheromone (3M Canada), "puffers" (Paramount Farms), and microsprayers (Miller - Michigan State Univ. and Ford Motor Co.). These technologies may offer growers practical alternatives to traditional hand applied pheromone dispensers for mating disruption.

MEC (or sprayable) pheromone is mixed with water and applied with an airblast sprayer 1-2 times per brood of the target insect. "Puffers" are aerosol devices that can dispense pheromone at a designated interval (i.e., every 15-30 minutes) (Shorey and Gerber 1996, Shorey et al. 1996). Presently, at least two pheromone formulations can be housed in one aerosol device (i.e., CM and OFM pheromone within same canister) and the units are placed in trees at the rate of one unit per two acres treated. It is also suggested to treat the border rows of the orchard with hand applied pheromone dispensers as well. Microsprayers are metal canisters that dispense pheromone through fuel injectors. The units are placed in the orchard at the presently recommended rate of 2 units per acre and deliver a puff of pheromone every 4 minutes over the entire season (Miller, personal comm.).

Materials and Methods

<u>Sprayable pheromone (MEC) and microsprayers</u>

Mating disruption trials were carried out in two commercial apple orchards (Growers 1 and 2) in Adams County, Pa. At the Grower 1 site there were two treatments: mating disruption of TABM, CM and OFM using MEC pheromones, and a standard treatment that received the normal regimen of insecticides for tortricid control. The MEC block was 4.8 ha (12 acres) and the standard block was 6+ ha. (15+ acres). At the Grower 2 site there were three treatments: mating disruption of TABM with MEC pheromone, mating disruption of TABM with microsprayers, and a standard insecticide block. The standard and MEC blocks were 4.8 ha. (12 acres) each, and the microsprayer plot was 4 ha. (10 acres).

Plots at Grower 1 consisted of 'Yorking,' 'Jonathan' and 'Golden Delicious' trees ca. 3 m high and about 20 years old. Plots at Grower 2 consisted of 'Yorking' and 'Golden Delicious' trees ca. 2.5 m high and about 10 years old. Only 'Yorking' trees in each block were used for fruit injury estimates. Information on the MEC application dates and rates and the microsprayers are given in table 1. All plots received normal applications of fungicides and herbicides.

Sex pheromone traps for each of the four species were monitored once a week and all lures were changed every 4 weeks. We sampled 40 trees in each treatment for TABM leaf shelters on 29 July 1999, searching each tree for 5 minutes. All leaf shelters were examined to determine the presence of live TABM larvae and pupae. Forty trees per plot were again sampled for hatched TABM egg masses, searching each tree for 5 minutes on 2 August 1999.

Twenty 'Yorking' trees evenly distributed throughout each block were sampled on 4 August 1999 for fruit injury, looking at 100 apples per tree, 50 from the lower branches and 50 from the upper. Apples were examined *in situ* for injury. At harvest, 25 'Yorking' trees evenly distributed throughout each block were sampled by picking 100 fruit from each, 50 from the lower branches, 50 from the upper and 25 dropped fruit. TABM injury was divided into 1st and 2nd brood damage.

Table 1. List of dates and rates for applications of the various formulations of MEC and the microsprayers during 1999.

Grower	Date	TABM MEC	OFM MEC	CM MEC
Grower 1	24 May	24 g a.i./ha (60 g a.i./acre)		12 g a.i./ha (30 g a.i./acre)
	18 Jun		8 g a.i./ha (20 g a.i./acre)	
	31 Jul	24 g a.i./ha (60 g a.i./acre)	8 g a.i./ha (20 g a.i./acre)	12 g a.i./ha (30 g a.i./acre)
Grower 2	27 May	24 g a.i./ha (60 g a.i./acre)		
	31 Jul	24 g a.i./ha (60 g a.i./acre)		
Grower 2	17 May	Microsprayers 5 units/ha (2 units/acre)		

"Puffers"

We selected three apple orchards in Adams County, Pa. to evaluate the "puffer" system to disrupt mating of CM, OFM, OBLR and TABM. Each orchard containing the "puffers" was compared to a corresponding orchard that was treated with insecticides and owned by the same grower. At each grower site the "puffers" were placed in such a way to maintain, as closely as possible, a density of one unit per two acres. Each "puffer" unit housed either a canister containing CM plus OFM pheromone or OBLR plus TABM pheromone. Two units containing the pheromone formulations for the four species were hung in adjacent trees at each location within the orchard. Hand-applied pheromone dispensers were used to create an additional band of 10 meters around the "puffer" orchards to ensure pheromone dispersal into gaps not covered by the puffers. Only Growers 3 and 4 received the hand-applied dispensers. All hand-applied dispensers were hung at 1.5-2 m in height depending on the size of the trees. The growers treated the standard blocks at each site with a conventional schedule of insecticides throughout the season.

At the Grower 3 site the "puffer" block was approximately 6.6 ha. (16.6 acres) and planted to various varieties on dwarfing rootstocks at a density of 1196 trees/ha (484/acre). The standard block was an equal area in part of the grower's larger conventional orchards. All trees were approximately 2 m in height.

At the Grower 4 site the "puffer" block was approximately 4.6 ha. (11.4 acres) in size and planted to various varieties on semi-dwarfing rootstocks at a density of 193 trees/ha (78/acre). The standard block was an equal area in part of the grower's larger conventional orchards. All trees were approximately 4.2-4.5 m in height.

At the Grower 5 site the "puffer" block was approximately 2.6 ha. (6.4 acres) in size and planted to solid rows of 'Golden Delicious' and 'Yorking' on semi-dwarf rootstocks at a density of 193 tees/ha (77/acre). All trees were approximately 4.2-4.5 m in height. The apple block used for the standard site was a part of the grower's larger conventional orchards.

Sex pheromone traps for each of the four species were monitored weekly until early August at which time monitoring was changed to twice weekly for Growers 3 and 4. For Grower 5, all traps were monitored on a weekly basis. All pheromone lures were changed every 4 weeks. Trap bottoms were also changed every 4 weeks unless more than 50 moths were caught within one week. Leafroller shelters for both OBLR and TABM were counted in a 5-min examination of foliage on 25 trees or areas in each block in July. All larvae were collected and returned to the laboratory for identification. A mid-season evaluation of fruit injury was conducted in early August for Growers 3 and 4. A visual examination of 100 apples per tree on 50 trees per block was made *in situ* for Grower 3 and 100 per tree on 25 trees per block was made for Grower 4. At harvest time for Grower 3, 50 apples per tree on 50 trees per block were picked and examined for injury. For Grower 4, two fruit samples were made. The first fruit sample was collected in September by picking 100 fruit per tree on 20 trees per block plus up to 25 dropped fruit per tree and checked for injury. A second sample was made in October on another cultivar where 100 fruit per tree on 32 trees and up to 25 dropped fruit per tree were evaluated for injury. For Grower 5, 150 fruit per tree on 18 trees per block were picked and up to 25 dropped fruit per tree were examined for injury.

Results

MEC Sprayable Pheromone and Microsprayers

We expect lower (or no) trap catch in mating disruption blocks if the mating disruption system is working. Our assumption is that males cannot orient to the pheromone lure in the traps because they are "confused" by the high concentration of pheromone in the orchard. Trap shutdown refers to the degree that trap catch is reduced in the mating disruption block compared to the standard block. Although pheromone trap catch of TABM was lower in all of the mating disruption blocks than in the standard, trap shutdown for both the MEC sprayable and the microsprayer was far from 100% complete (Figs. 1 and 2). Trap catch seemed to be suppressed for a short period following each MEC spray, but it quickly rebounded. OFM trap catch was completely shut down in the mating disruption block at the Grower 1 site after the second MEC application and remained shut down until harvest (Fig. 3).

Egg mass counts and leaf shelter counts were extremely low at both sites and across all treatments so it was difficult to judge the efficacy of the treatments based on these counts (Table 2). Fruit injury was also low at both sites and across all treatments. First generation TABM fruit damage was significantly higher in the standard block than the MEC mating disruption block at Grower 1, but there was no significant difference between the standard and mating disruption blocks at Grower 2 (Table 3). For the second generation the situation was reversed and TABM fruit damage was significantly lower in the standard block than in the two mating disruption blocks at Grower 2, but there was no difference between the standard block and the MEC mating disruption block at Grower 1 (Table 3).

Although the TABM MEC pheromone and the microsprayers limited damage from TABM to well within acceptable levels for processing apples, population pressure was not extremely high in either test orchard. Low trap shutdown in both treatments may be indicative of problems either with the pheromone formulation, the longevity of the MEC beads or problems with the microsprayer canisters releasing pheromone on a consistent basis. It is possible that the MEC pheromone is not adhering well to trees, in which case we might experiment with adding a sticking adjuvant when applying pheromone. The OFM MEC pheromone gave very good trap shutdown and controlled OFM damage completely. The microsprayers performed fairly well in spite of many technical problems associated with keeping them functional in the field. Some of the microsprayers appeared to be leaking, while others fired at the desired rate, but failed to emit pheromone. Indeed, at the end of the season a few of the microsprayer canisters appeared as heavy as they did in the beginning of the season as if they retained the bulk of the pheromone.

"Puffers"

Populations of CM adults were quite low in all blocks and only at the Grower 3 site did the "puffer" system cause a distinct reduction in trap catch, and that only during the first brood. OFM populations were much higher than CM at all three grower sites and the "puffer" system reduced trap capture for the entire season at all sites in comparison to the standard blocks. No differences in the amount of fruit exhibiting signs of internal larvae "entries" (i.e., caused by

CM/OFM) were found between the "puffer" blocks and the standard insecticide blocks for any grower (Table 4).

The "puffer" system appeared to provide almost complete shutdown of OBLR adult trap catch for the first brood, but trap shutdown declined for the second brood. In 3 of the 6 fruit samples OBLR injury was higher in the "puffer" blocks than in standard blocks, and was less than in the standard block in only one sample (Table 4). The number of leafroller shelters containing live OBLR larvae was higher in the standard block than the "puffer" block for Grower 4 (Table 5).

For TABM populations, the "puffer" system effectively reduced adult trap capture for the first brood at all sites, but not as effectively as for OBLR. There was no difference in adult trap capture during the second brood between the "puffer" blocks and the standard blocks, indicating that the pheromone was either completely released from the canisters by the end of the first brood or the pheromone was no longer effective. For fruit injured by TABM larvae, 1 of 3 harvest samples for Grower 4 showed more fruit injured in the standard block than the "puffer" block; whereas, for Grower 5, more fruit were injured in the "puffer" block than the standard block (Table 4). A similar pattern was found for fruit injured by the second brood of TABM. When the fruit injured by TABM was combined for both broods (i.e., total TABM), the standard block had more injured fruit than the "puffer" block for Growers 3 and 4, but the standard block had less injured fruit than the "puffer" block for Grower 5. There was no difference between the two blocks for leaf shelters containing live TABM larvae (Table 5).

The percentage of clean fruit varied by grower and block. For Grower 3, there was no difference between the two treatment blocks (Table 4). For Grower 4, the mid-season sample and the 19 Oct. sample showed the standard block had a higher percentage of clean fruit, while the 9 Sep. sample showed a higher percentage of clean fruit in the "puffer" block. Grower 4 had a higher percentage of clean fruit in the standard block.

Phytotoxicity to both foliage and fruit was found around each "puffer" both laterally and vertically for a distance of up to 2 m depending on placement within the tree. We are not sure what may have caused this phytotoxicity (i.e., possibly the pheromone carrier within the canister), but the injury became progressively more severe as the season advanced.

Discussion

Pheromone trap shutdown was intermittent for TABM in the MEC blocks, which casts some doubt on the longevity of the sprayable pheromone in the field. Microsprayers performed about the same as sprayable pheromone for the control of TABM, but neither method controlled fruit injury as well as standard insecticides at Grower 2. It should be pointed out that due to an oversight at the point of shipment, the microsprayers did not contain the proper blend of TABM pheromone and may well have performed better had the precise pheromone been used. Grower 1 was able to control CM, OFM, and TABM with sprayable pheromones alone, but CM and OFM pressure was extremely low, and TABM pressure was not exceptionally high.

The "puffers" provided the same level of fruit protection as the standard insecticide programs except at Grower 5 where TABM pressure was the highest. CM trap catch was low in all blocks, but puffers still failed to shut down trap catch completely and a higher CM pressure situation may have resulted in fruit injury.

All three mating disruption strategies appeared to work well when pest populations were low. Mating disruption techniques such as these will give Pennsylvania growers more options when confronting pest situations with a shrinking organophosphate arsenal. Mating disruption may have to be limited to low insect pressure situations, however, or be combined with other integrated pest management techniques such as insect growth regulators or other "soft" pesticides when pest pressure is high. Future research should concentrate on the development of integrated pheromone and insecticide programs that reduce the use of synthetic insecticides and maximize the conservation of natural enemies.

References

Miller, J. 1999. Personal communication.

Shorey, H. H. and R. G. Gerber. 1996. Use of puffers for disruption of sex pheromone communication of codling moths (Lepidoptera: Tortricidae) in walnut orchards. Environmental Entomology 25:1398-1400.

Shorey, H. H., C. B. Sisk, and R. G. Gerber. 1996. Widely separated pheromone release sites for disruption of sex pheromone communication in two species of Lepidoptera. Environmental Entomology 25:446-451.

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The authors wish to sincerely thank 3M Canada, Michigan State University, Ford Motor Co., Dr. Alan Knight (USDA - Yakima) and Paramount Farms for allowing us the opportunity to work with them to evaluate their mating disruption products. We also want to acknowledge the following fruit growers for their willingness to allow us to test these new technologies in their orchards: Hollobaugh Bros., Mountain Ridge Farms, Barry Rice, Mark Rice and Sunny Hill Farms.

Table 2. Egg mass and leaf shelter counts in MEC, microsprayer and standard insecticide treatment programs-1999.

Grower	Treatment	Date of evaluation	No. of trees sampled	Egg masses per 5 min count	TABM leaf shelters per 5 min count
#1	MEC	21 July	40	----	0.07 a
	Standard	21 July	40	----	1.00 a
	MEC	2 Aug	46	0.000 a	----
	Standard	2 Aug	46	0.043 a	----
#2	MEC	29 July	40	----	0.18 a
	Standard	29 July	40	----	0.00 b
	Microsprayers	29 July	40	----	0.10 ab
	MEC	2 Aug	40	0.000 a	----
	Standard	2 Aug	40	0.025 a	----
	Microsprayers	2 Aug	40	0.025 a	----

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

Table 3. Efficacy of MEC formulations, microsprayers and standard insecticide program for preventing fruit injury-1999.

				Mean no. injured apples/100 apples				
Grower	Treatment	Date of evaluation	No. apples sampled	CM/OFM entries	OBLR	TABM 1	TABM 2	% Clean
#1	MEC	4 Aug	2000	0.00 a	0.95 a	0.55 a	----	98.5 a
	Standard	4 Aug	2000	0.00 a	0.00 b	0.15 a	----	99.9 a
	MEC	30 Sept	3125	0.06 a	0.48 a	1.54 a	1.82 a	96.1 a
	Standard	30 Sept	3125	0.00 a	0.22 a	0.58 b	1.28 a	97.9 b
#2	MEC	4 Aug	2000	0.00 a	0.10 a	0.35 a	----	99.6 a
	Standard	4 Aug	2000	0.00 a	0.00 a	0.00 a	----	100.0 a
	Microsprayers	4 Aug	2000	0.00 a	0.05 a	0.35 a	----	99.6 a
	MEC	6 Oct	3125	0.00 a	0.26 a	1.12 a	1.41 a	97.2 b
	Standard	6 Oct	3125	0.00 a	0.06 a	0.48 a	0.10 b	99.4 a
	Microsprayers	6 Oct	3125	0.00 a	0.35 a	0.90 a	1.54 a	97.2 b

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

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Table 4. **Efficacy of "puffer" system versus standard insecticide program for the prevention of fruit injury - 1999.**

Grower	Block	Date of evaluation	No. apples sampled	Mean no. injured apples/100 apples: CM/OFM entry	OBLR	TABM 1	TABM 2	PB	% clean
Grower 3	Puffer	5 Aug	5000	0.00 a	0.08 b	0.02 a	- -	0.04 a	99.82 a
	Standard	5 Aug	5000	0.00 a	0.00 a	0.02 a	- -	0.02 a	99.96 a
								Total TABM	
	Puffer	1 Oct	2500	0.00 a	0.12 a	0.12 a	0.00 a	0.12 a	99.76 a
	Standard	1 Oct	2500	0.00 a	0.04 a	0.32 a	0.12 a	0.44 b	99.52 a
								Total TABM	
Grower 4	Puffer	9 Sep	2134	0.05 a	1.26 a	0.63 a	0.63 a	1.26 a	97.43 a
	Standard	9 Sep	2273	0.18 a	2.34 b	1.82 b	0.69 a	2.52 b	94.96 b
								Total TABM	
	Puffer	19 Oct	4000	0.00 a	0.98 b	1.55 a	2.38 b	3.93 a	94.65 b
	Standard	19 Oct	3745	0.03 a	0.51 a	2.00 a	1.58 a	3.58 a	96.34 a
								Total TABM	
Grower 5	Puffer	21 Oct	3150	0.13 a	1.21 a	3.43 b	7.05 b	10.48 b	88.29 b
	Standard	21 Oct	3150	0.03 a	0.98 a	2.19 a	4.73 a	6.92 a	92.13 a

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

Table 5. **Efficacy of "puffer" system versus standard insecticide program on the establishment of various leafrollers - 1999.**

Grower	Block	Date	Total no. leafroller shelters/5 min.	No. with TABM	No. with OBLR
Grower 3	Puffer	27 Jul	0.42 b	0.13 a	0.00 a
	Standard	27 Jul	0.00 a	0.00 a	0.00 a
Grower 4	Puffer	8 Jul	1.13 a	- -	1.04 a
	Standard	8 Jul	2.50 b	- -	2.25 b
	Puffer	22 Jul	0.33 a	0.17 a	- -
	Standard	22 Jul	0.38 a	0.25 a	- -

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

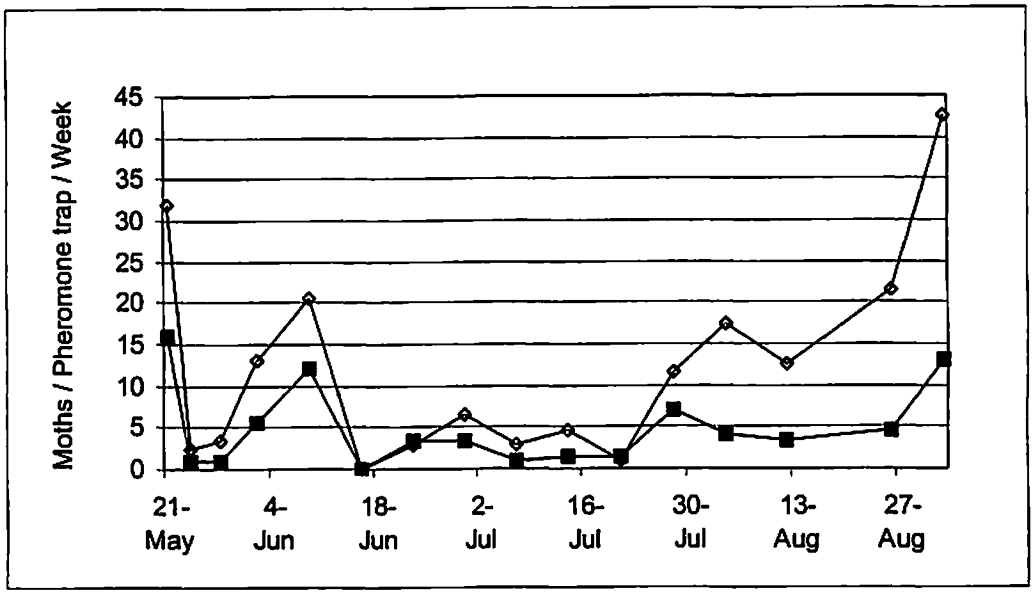

Fig. 1. Grower 1, 1999. Numbers of tufted apple bud moth caught in pheromone traps (4 traps per plot). Open diamonds, control plot; filled squares, 60 g a.i. TABM MEC applied 5/24/99 and 7/31/99.

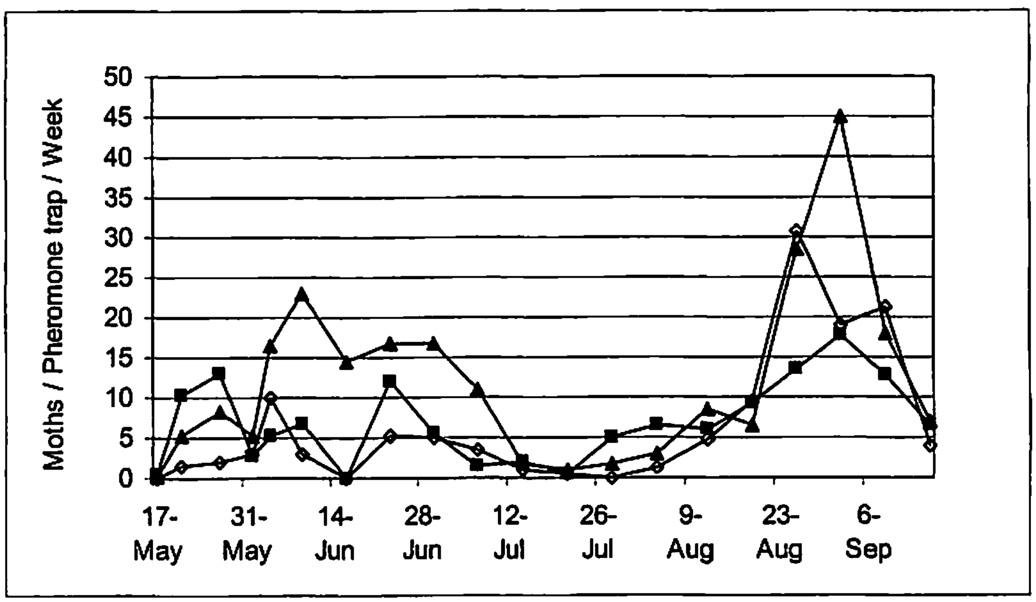

Fig. 2. Grower 2, 1999. Numbers of tufted apple bud moth caught in pheromone traps (4 traps per plot). Filled triangles, control plot; open diamonds, 2 microsprayers per acre; filled squares, 60 g a.i. TABM MEC applied 5/27/99 and 7/31/99.

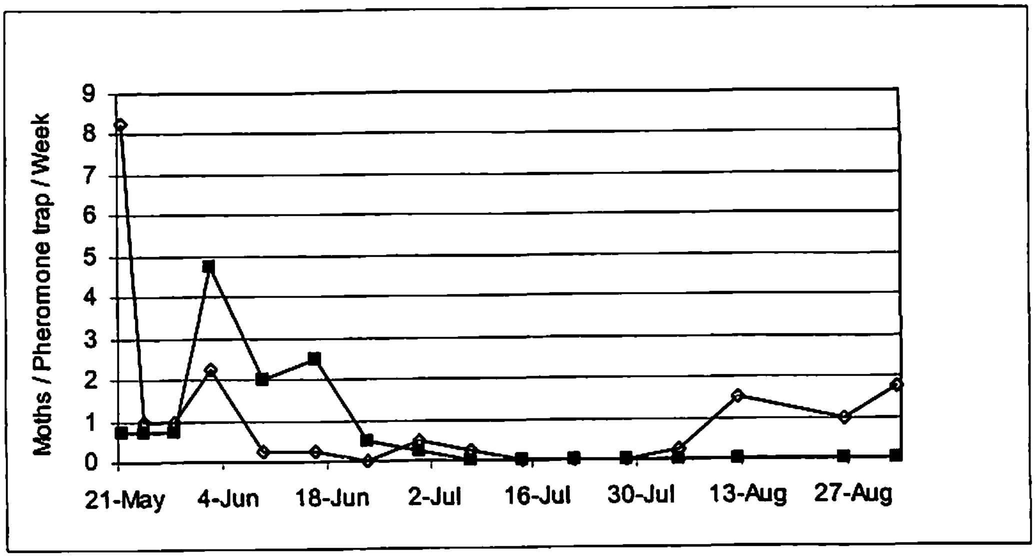

Fig. 3. Grower 1, 1999. Numbers of Oriental fruit moth caught in pheromone traps (4 traps per plot). Open squares, control plot; open diamonds, 20 g a.i./acre OFM MEC applied 5/24/99 and 7/31/99.

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EVALUATION OF MATING DISRUPTION FOR PEACHTREE BORER AND LESSER PEACHTREE BORER

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INTRODUCTION

Peachtree borer (PTB), *Synanthedon exitiosa* (Say), and lesser peachtree borer (LPTB), *Synanthedon pictipes* (Grote & Robinson), pose a significant threat to the productivity and survival of stone fruit trees in the mid-Atlantic region. Larval feeding of LPTB in wounds on the trunk, scaffold limbs and branches results in declining production with increasing orchard age as fruit bearing surface is lost from girdling and breakage. Larval feeding may also afford entry for disease organisms, such as Cytospora canker, and prevents wounds from healing which eventually results in limb and tree death. PTB larval feeding at the base of trees can result in complete girdling and death, especially of young trees, in a short time. Management of both borer species is typically accomplished by a specific handgun application(s) of insecticide. This practice is labor intensive, timing may conflict with other orchard activities, and control may be inadequate if coverage is not thorough. In addition, the fate of the most effective insecticide, chlorpyrifos, is in question because of FQPA. For these reasons, mating disruption (MD) , if effective, would appear to have a very good fit and be readily adopted by growers for the management of borer species. A study was initiated in 1999 to investigate MD as a management strategy for PTB and LPTB.

MATERIALS AND METHODS

This study was conducted in Jefferson County, W. Va. in a 9 acre Redhaven peach orchard planted in 1982 at a tree spacing of 16 x 24 ft. On May 11, 1999, Isomate-LPTB dispensers were installed at the rate of 200 per acre in the eastern 5 acre portion (13 rows x 44 trees/row) of this orchard. Dispensers were wrapped around branches at a height of 5-6 ft at a density of 2 per tree, with a single dispenser in every fifth tree. The western 4 acre portion of this orchard (11 rows x 44 trees/row) served as the control. The study site was bordered by a 14 acre nectarine orchard on the west and a 2.6 acre Summerglo peach orchard on the east.

Two Pherocon IC wing-type pheromone traps with Scentry lures were installed on May 11 (for LPTB) and May 25 (for PTB) in each section of the orchard. Traps were located at a height of 3-4 ft for PTB and 5-6 ft for LPTB in the center of rows 5 and 10 in the MD section, and rows 3 and 7 in the control section. Traps were checked weekly through Sep 30, with moths counted and removed. Lures were replaced on Jun 21 and

Jul 26 for LPTB, and Jun 28 and July 26 for PTB. Trap bottoms were replaced with lure changes and at other times as needed, based on trap capture.

On Jun 16, endosulfan 50W was applied at 1.5 lb/100 gal with handgun to 10 trees in rows 2-6 of the control section of the orchard. On Jul 13, at the beginning of second generation adult emergence of LPTB, all pupal exuvia were removed from ground to a height of 6 ft on 10 untreated and 10 endosulfan treated trees in rows 2-6 of the control section, and 10 trees in rows 6-10 of the MD section. Pupal exuvia were subsequently counted and removed biweekly from Jul 27 through Sep 23 (5 dates). Trees selected for pupal exuvia counts had a minimum of 3 active wounds.

RESULTS AND DISCUSSION

Isomate-LPTB resulted in excellent trap shutdown of LPTB (Figure 1). A mean total of only 5 moths was captured in the MD plot in August and early September. A difference was noted in the moth capture between the 2 traps in the control portion of the orchard. The trap (C-Close) that was only 5 rows (120 ft) west of the MD plot captured significantly fewer moths than the trap (C-Far) that was 9 rows (216 ft) west of the MD plot. Even though the prevailing winds are from the west, there was apparently some effect from the MD plot in suppressing trap capture in the closest control trap.

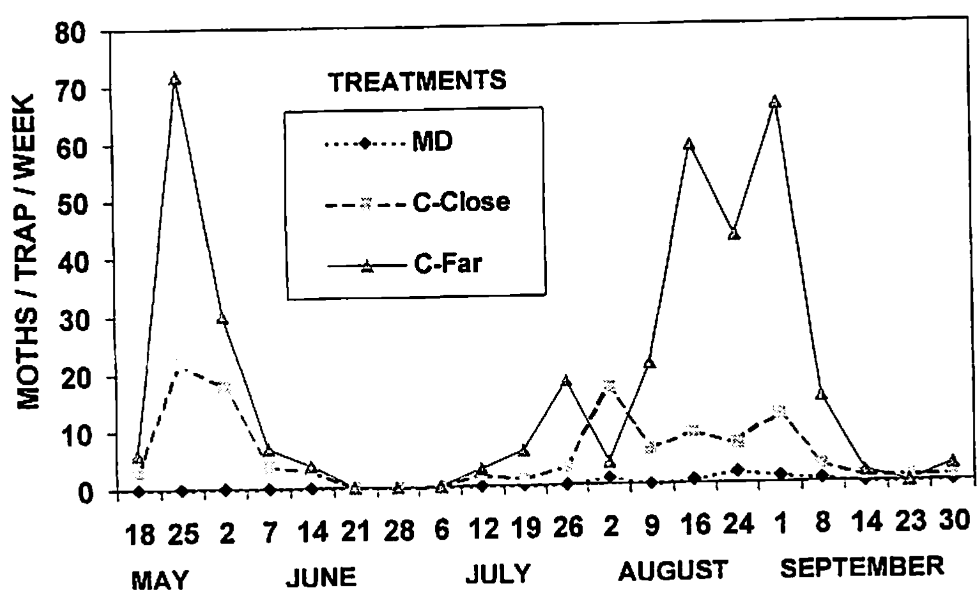

Figure 1. Pheromone trap capture of lesser peachtree borer moths in mating disruption (MD) and control (C-Close, C-Far) plots in a peach orchard in 1999.

Isomate-LPTB was also very effective in preventing trap capture of PTB, as there were no moths captured in the MD plot (Figure 2). Moth capture by both traps in the control plot was similar, except for 3 weeks in August when capture was lower in the closest trap (C-Close) than in the farthest trap (C-Far) from the MD plot. The population of PTB was lower than that of LPTB in this study site.

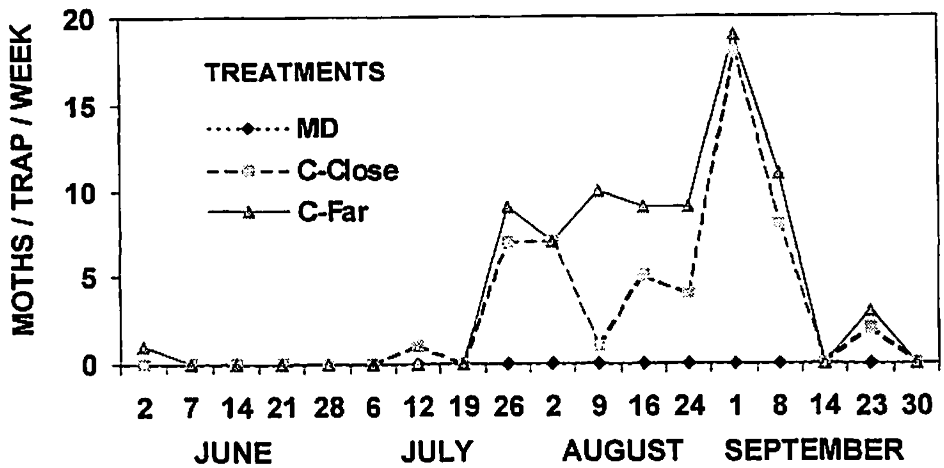

Figure 2. Pheromone trap capture of peachtree borer moths in mating disruption (MD) and control (C-Close, C-Far) plots in a peach orchard in 1999.

Pupal exuvia counts were higher in the MD plot than in the check plot and endosulfan treatment on 2 of 5 sampling dates (Figure 3). On Sep 9, four of the 10 single-tree replications in the MD plot had more than one pupal exuvia (range of 2-4).

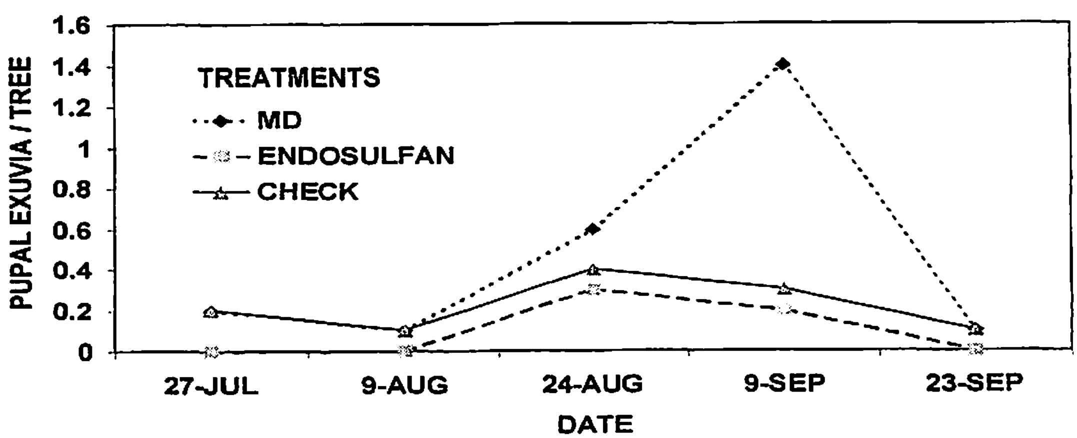

Figure 3. Lesser peachtree borer pupal exuvia counts on various sampling dates in mating disruption, endosulfan and control treatments in 1999.

Three of these 4 trees were approximately 100 ft from the edge of the MD plot. Although the dispersal distance of female LPTB is not known, the possibility exists that eggs were deposited on these trees by females that mated outside of the MD plot.

The seasonal total of LPTB pupal exuvia was also significantly higher in the MD plot than in the control plot and endosulfan treatment (Figure 4). Total incidence of pupal exuvia in the MD plot was greater than one per tree in 7 of 10 replications (range of 2-5). The endosulfan treatment reduced the incidence of LPTB in half as compared with incidence in the control plot.

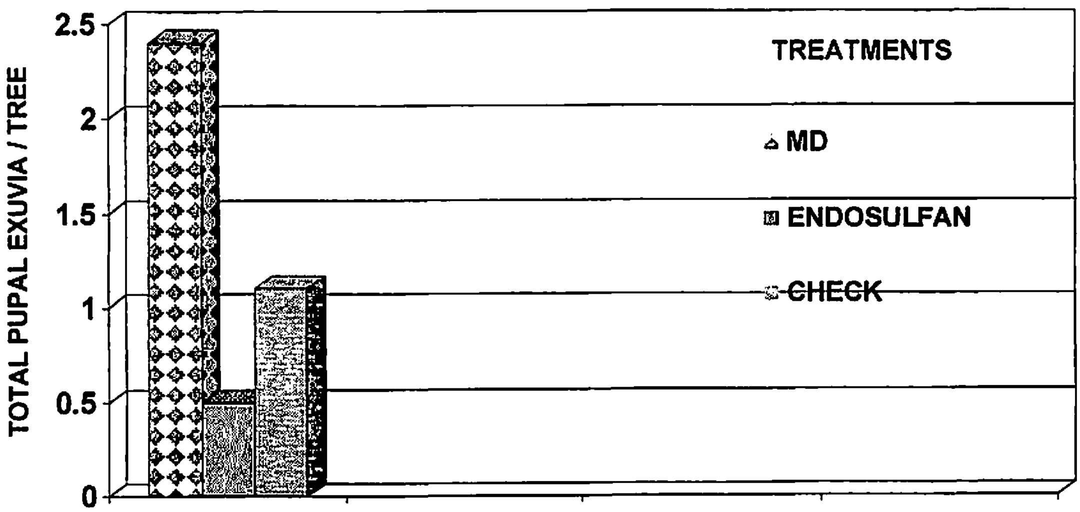

Figure 4. Seasonal total of lesser peachtree borer pupal exuvia in mating disruption, endosulfan and control treatments in 1999.

The 5 acre mating disruption plot was approximately 700 ft long and 300 ft wide. Within this site, Isomate-LPTB was very effective based on pheromone trap capture. The relatively narrow width of the study site may have been a factor in the failure of Isomate-LPTB to prevent injury, which most likely resulted from the movement of mated female moths from non-treated areas into the MD plot. Trees examined for pupal exuvia in the MD plot were selected in rows to the east of the plot center to avoid potential movement of mated females from the upwind control plot to the west This was done because it was felt there was less of a chance for movement of mated females from the untreated orchard (Summerglo) to the east into the MD plot to the west due to downwind influence from MD dispensers. Mated females probably did not move into the MD plot from the control Redhaven plot to the west, since the closest control trap had a lower capture than the more distant trap (Figure 1) , indicating partial disruption of mating. It is more likely that mated female moths entered the MD plot from the untreated Summergo orchard bordering on the east, where the downwind movement of pheromone was insufficient to prevent mating. Future research will need to identify more precisely the specific orchard parameters that must be met in order to ensure success of this management strategy.

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Reduced Risk Peach Pest Management Program

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ABSTRACT: We are implementing a multi-phase program to reduce organophosporus and carbamate insecticide use and mitigate the associated risks as they relate to peach production in New Jersey and elsewhere. The main thrust integrates good ground cover management practices with Oriental fruit moth (OFM) mating disruption to reduce insect pest abundance and damage. This Reduced Risk Peach Arthropod Management Program (RR) is being evaluated through comparisons with typical, conventionally managed peach orchard production practices. Concurrently, pesticide use data for NJ peaches has been collected to determine historic use patterns and will be collected again at the end of the 3rd year of this project to determine if NJ peach pesticide use patterns have changed as a result of this study. For the RR program, we established sod in the drive rows between the rows of peach trees and then compared pest densities with adjacent conventionally managed peach orchards. In the RR orchards, we found 42% fewer catfacing insects and 50% less catfacing damaged peaches when compared with levels found in conventionally managed orchards. OFM mating disruption gave approximately 4 months of non-insecticidal control of this major pest while providing control that was equivalent to 4+ additional organophosporus and carbamate insecticide sprays used in the conventional blocks. The decrease in the number of insecticide sprays in the RR orchards allowed beneficial insects to build up to levels almost twice that observed in conventionally managed orchards. Based upon this first year study, the RR program has provided a level of pest control that is equal to or better than conventional peach pest management programs.

Objective: Investigate and demonstrate the potential for good ground cover management and mating disruption to reduce insecticide use against key pests: The first year of this objective was implemented at four different sites; three sites were located on commercial farms and the fourth site at the Rutgers Agricultural Research & Extension Center, Bridgeton, NJ. At each site, a block of peaches ranging from 4-18 acres was divided in half and each half designated as either conventional (Conv.) or Reduced Risk Peach Arthropod Management Program (RR). Briefly, the Conv. blocks of peaches were farmed using conventional methods while the RR blocks contained managed sod drive rows and mating disruption. Sod was established in the RR blocks to reduce catfacing insect abundance and damage by eliminating flowering broadleaf weeds which are important alternate host plants of these pests. Mating disruption was implemented between the first and second flight of Oriental fruit moth (OFM) and was used as a non-insecticidal control measure against this pest in the RR blocks.

Sweep net samples were conducted to determine abundance of catfacing insects in the ground cover in both conventional and RR blocks. Sweep net samples revealed 3 adult tarnished plant bug generations in both the RR and Conv. peach blocks (Fig. 1). Most importantly,

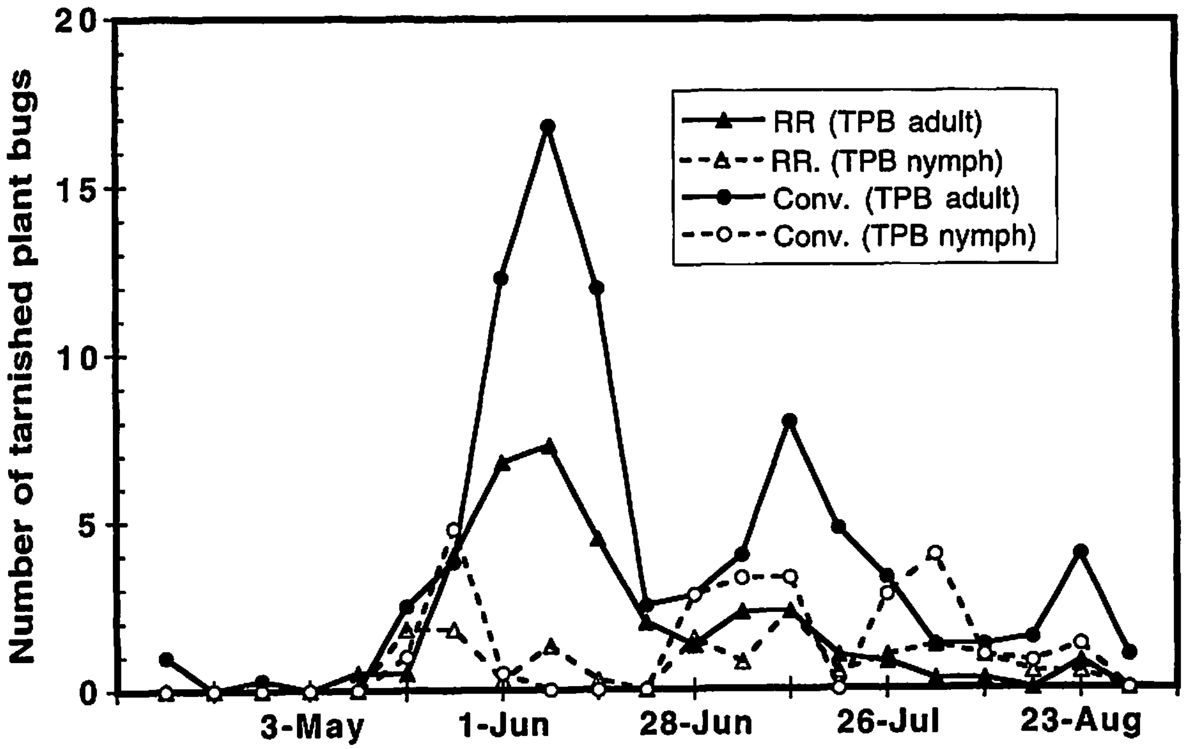

Fig. 1. Abundance of tarnished plant bug adults and nymphs collected from ground covers in Reduced Risk (RR) and conventional (Conv.) peach orchards.

managed sod in the RR orchards reduced both abundance of this pest and delayed its appearance into the RR blocks by 2-4 weeks when compared with conventional blocks (Fig. 1). Levels of all types of catfacing insects were lower in the RR blocks than the Conv. orchards (Table 1).

Table 1. Average seasonal total of catfacing insects collected from orchards with Reduced Risk and conventional ground cover management, 1999.

Program	Catfacing insects ±SEM				
	Tarnished plant bug	Brown stink bug	Green stink bug	Dusty stink bug	Total catfacing insects
Reduced Risk	63.7±23.3b	2.0±1.6b	2.7±2.2b	0.0±0.0ns	67.3±27.5b
Conventional	142.0±48.0a	10.3±5.5a	6.3±3.4a	3.0±2.1	161.0±56.7a

Means in the same column followed by different letters are significantly different ($P \leq 0.05$); ns=not significantly different.

Oriental fruit moth is another major peach pest. In 1999, NJ orchards had 4 generations (Fig. 2). We used the mating disruption technique to manage the 2nd-4th flights of this pest in the Reduced Risk blocks. In the RR orchards, growers placed between 350-400 dispensers per acre containing synthesized female sex pheromone in and around these RR blocks. They were reapplied at the end of July.

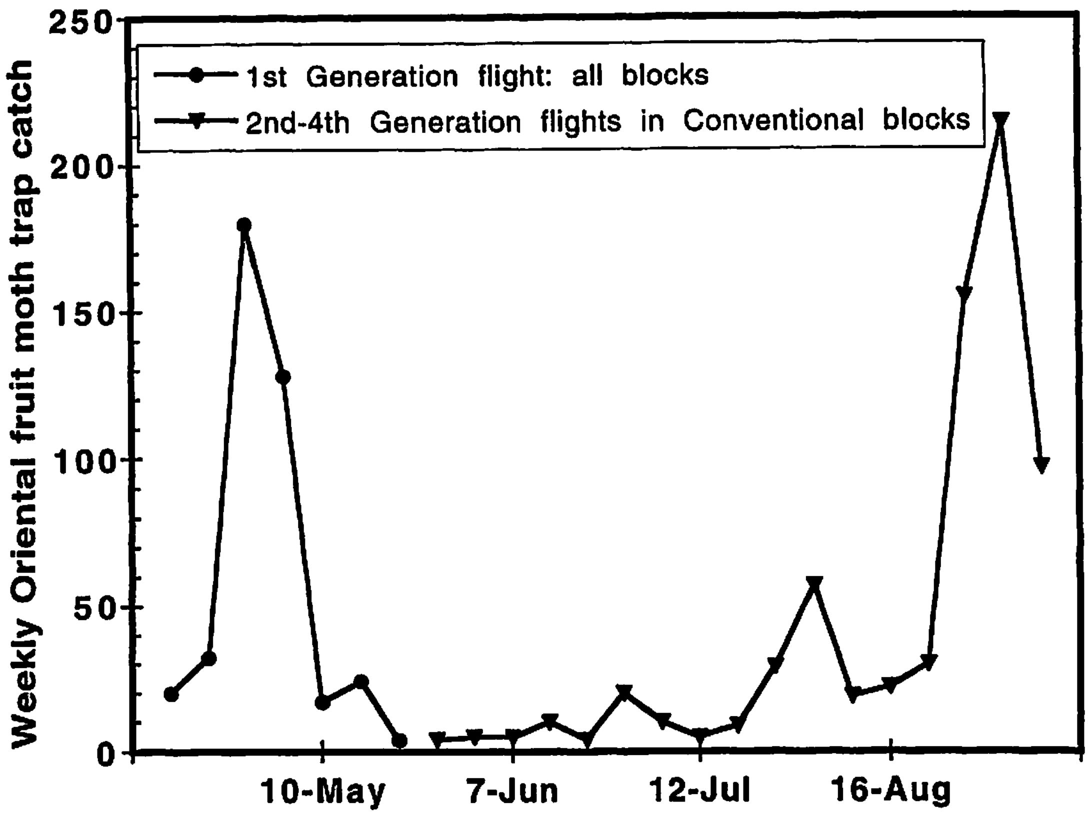

Figure 2. Seasonal flight of Oriental fruit moth in study peach orchards.

Figure 2 represents OFM trap catch in the various study blocks. Data for the first flight represents OFM trap capture in all blocks before the mating disruption dispensers were placed in the RR orchards. Trap catch data presented for the remaining season is from the conventional blocks. We only trapped eight male OFM moths during the 2^{nd}-4^{th} flights in all four RR orchards compared with the hundreds of OFM trapped in the conventional orchards (Fig. 2, Table 2). We tried higher concentrations of OFM pheromone in the traps to enhance capture of OFM male moths in the RR blocks. This did not increase OFM trap catch in the Reduced Risk blocks nor did the addition of codling moth pheromone which can act as a synergist to the OFM pheromone. Only in the conventional orchards did we observe an increase in OFM trap catch after adding the codling moth pheromone synergist (Table 2).

Failure to capture OFM moths in the RR blocks is an indication that male OFM cannot locate female moths or the synthesized pheromone used as bait in traps. However, trap shutdown cannot be used exclusively to evaluate success of mating disruption. Other parameters including shoot and fruit damage were used to evaluate the efficacy of mating disruption to control OFM.

Oriental fruit moth larvae will burrow into actively growing peach shoot tips and counting infested terminals is an indication of control success or failure. We looked for and counted OFM damaged shoot tips after each OFM generation from 22 trees per block in both the

RR and conventional orchards. We found no difference in the seasonal percent average infested shoots between the RR and conventional blocks. By the end of the season, we observed only 0.1 and 0.06% damaged shoots/tree in the RR and conventional blocks, respectively.

Table 2. Total number of Oriental fruit moth (OFM) and codling moth (CM) caught in pheromone traps with different pheromone loading rates

Load Rate		Number of OFM/trap		Total OFM/trap/CM load rate		Number of CM/trap		Total CM/trap/CM load rate	
OFM	CM	RR[1]	Conv.	RR	Conv.	RR	Conv.	RR	Conv.
1x	0	2	21	4	137	0	0	0	1
5x	0	1	9			0	0		
10x	0	0	33			0	1		
100x	0	1	74			0	0		
1x	1x	0	32	1	182	7	14	26	32
5x	1x	0	61			8	9		
10x	1x	0	35			6	4		
100x	1x	1	54			5	5		
1x	10x	1	30	3	282	8	4	18	18
5x	10x	0	63			7	7		
10x	10x	1	59			0	5		
100x	10x	1	130			3	2		

[1]RR = Reduced Risk program; Conv. = Conventional program

Presently, we have received the spray records from 3 of our 4 test sites to determine the exact number and amount of sprays applied to each of the two treatments. Organophosphorus sprays were applied to the Reduced Risk blocks from the start of the season through the end of the first OFM flight. More OP and carbamate sprays were applied to the conventional blocks than in the reduced risk blocks (Table 3). The reduction in OP and carbamate sprays used in the RR blocks can have significant impact on several factors including less insecticide exposure to the environment and workers, reduced spray bill, and less disruption of natural enemies which serve as biological control agents of secondary pests. This later factor was measured periodically through the growing season.

Table 3. Organophosphorus and carbamate use in Reduced Risk and Conventional programs.

	Reduced Risk program		Conventional program	
Orchard	#Applications[1]	lbs ai/A	#Applications[2]	lbs ai/A
1	3	2.15	6	3.65
2	3	1.0	8	2.6
3	--[3]	--	--	--
4	2	2.85	6	7.05
Average	2.7	2.0lb	6.7	4.4lb

[1]sprays applied before dispenser placement, [2]total seasonal sprays, [3]missing records

We made 3-minute timed observations on each of ten trees from all blocks (80 trees per sampling period) and recorded all natural enemies present. We observed significantly more ladybugs, lacewing adults and eggs, pirate bugs, parasitoid wasps, and spiders in the RR blocks compared with the levels of beneficial arthropods found in the conventional blocks (Table 4). We attribute these differences to fewer insecticide sprays applied to the RR blocks.

Fruit quality at harvest is one of the most meaningful indicators to growers regarding the success of their control program. We collected harvest samples to assess and compare levels of insect damage between the RR and conventional programs. At harvest, we evaluated 600 fruit per block from trees located in the orchard interior and along the orchard borders for a total of 4,800 fruit across all blocks and treatments. Percent damaged fruit was then calculated for various kinds of insect damage.

Table 4. Number of beneficial fauna monitored in orchards with Reduced Risk and conventional ground cover management, 1999

	Average ±SEM seasonal total of observed beneficial arthropods						
		Lacewings					
Program	Ladybug adults	Adults	Eggs	Larvae	Pirate bugs	Parasitoid wasps	Spiders
Reduced Risk	18.0±7a	4.0±1.1a	1377±352a	2.3±0.9ns	31.3±7.8a	29.0±5.1a	17.5±3.0a
Conventional	9.5±6b	1.8±0.6b	898±255b	1.0±0.4	14.8±5.0b	9.5±2.3b	7.5±1.4b

Means in the same column followed by different letters are significantly different ($P \leq 0.05$); ns=not significantly different.

Fruit damage caused by Oriental fruit moth was 0.2% in both the RR and conventional blocks indicating that mating dusruption provided control of OFM that was equivalent to conventional grower practices (Table 5). As anticipated, we had less catfacing damaged fruit in the RR blocks which is attributed to the clean sod drive rows that were not attractive to catfacing insects. While we did observe numerically higher levels of Japanese beetle and grasshopper chewing damage on fruit collected from the RR blocks, these differences are not considered significant.

Table 5. Percent damaged fruit collected from orchards managed with different pest management practices.

	Percent ±SEM damaged fruit					
Program	Catfacing damage	Oriental fruit moth	Tufted apple budmoth	Grasshopper	Japanese beetle	Lacewing pupae
Reduced Risk	0.8±0.3b	0.2 ±0.1ns	0.8±0.4ns	0.2±0.1ns	0.2±0.2ns	2.4±0.5b
Conventional	1.6±0.4a	0.2 ±0.1	1.3±0.5	0.1±0.1	0.0±0.0	4.2±0.7a

Means in the same column followed by different letters are significantly different ($P \leq 0.05$); ns=not significantly different.

One form of insect damage was new to us. A couple of growers elsewhere were complaining about lacewing pupae in the stem end of fruit. Evidently, larvae of these beneficial insects can pupate in the stem end of peaches and are considered as insect contamination because most of the pupae do not wash off during the packing process. We kept track of lacewing pupae during the harvest sample and were surprised to find more stem-end lacewing pupae in the conventionally managed fruit. This is contrary to what was observed during the visual surveys conducted for beneficial insects during the growing season (Table 4). It may be that the insecticides alter lacewing behavior or kill off lacewing natural enemies. This departure from what was expected warrants further study next year.

Orchard Diversity, Reduced Insecticides and Fruit Quality: Preliminary Data

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Objective: To study the effects of increasing orchard diversity, in conjunction with reduced levels of organophosphate insecticides, to increase levels of biological control of orchard insect pests. The ultimate goal is to develop an integrated fruit production system that maximizes biological control and minimizes the reliance on neurotoxic, broad-spectrum insecticides.

Experimental Design: Four. 0.5 ha (1.24 A) orchards were planted in April, 1997, with peach ('Loring/Lovell'), apple ('Granny Smith/EMLA 26' and 'Royal Empire/M9/EMLA 111'), pear ('Buerre Bosc/Bartlett' and 'Seckel/Bartlett') and sweet cherry ("Emperor Francis/Mazzard' and 'Ulster/Mazzard'). For the first two years, ground cover management was identical in all four blocks with a herbicide strip maintained in the tree rows, primarily with glyphosate and paraquat. All peach and cherry trees received a trunk spray of chlorpyrifos after peach harvest for borer control and all orchards had the same fungicide treatment schedule. All four orchards were also treated with mating disruption (Isomate-M) to control oriental fruit moth. Combinations of two planting designs and the presence or absence of flowering ground cover plants resulted in four treatments to compare the impact of different levels of plant diversity on pest management.

1. Conventional orchard. This orchard was planted half in a monoculture of peach and half in a monoculture of the two cultivars of apple. Pest management was with a conventional spray schedule as published in the Bulletin for Commercial Tree Fruit Growers (see Table 1).

2. Low spray/ground cover orchard. This orchard was planted with the same planting design as the conventional orchard with monocultures of peach and apple. In 1999, alternating strips of dill, buckwheat, *Phacelia*, and a wildflower mixture were planted in 0.75 m wide strips from the edge of the grass alley to the tree, leaving a 1.5 m bare strip in the tree row. A reduced spray schedule included only one complete spray of an organophosphate insecticide, two border sprays of organophosphates and 4 applications of Bt (Dipel) (Table 1).

3. Low spray/interplanted. This orchard was planted as a polyculture with alternating pairs of peach and apple within and between tree rows. To further increase plant diversity, ten pairs of peaches were replaced with sweet cherry and ten pairs of apple were replaced with pear. This orchard was sprayed with the low spray schedule (Table 1), and the orchard floor was managed as a conventional orchard.

4. Low spray/ground cover/interplanted. This orchard was planted as a polyculture as described for the low spray/interplanted orchard, had flowering ground cover plants as described for the low spray/ground cover orchard and was sprayed with the low spray schedule (Table 1).

Results--Apple: The apple fruit load was light (a total of from 79 to 301 fruit per orchard) and all fruit present at harvest were evaluated for insect and disease damage: 77 'Empire' and 601 'Granny Smith'. Overall apple fruit quality was higher in the conventional and the low spray/ground cover/interplanted orchards than in the low spray/ground cover and low spray/interplanted orchards (Table 2). This result indicates there may be an overall difference in location effects because the first two orchards were adjacent as were the latter two, but these two pairs of orchards were separated by about 100 m. The differences in fruit quality between these two pairs of orchards occur repeatedly with regard to both apple and peach.

The use of ground cover plants did not increase the damage caused by stink bug or plant bug, as might have been expected since the flowering ground cover plants are hosts for these pests. First and second generation plum curculio were higher in the low spray/ground cover and low spray/interplanted orchards than in the conventional and low spray/ground cover/interplanted orchard, following the overall location effect on quality. Internal lepidoptera damage was lowest in the conventional orchard; all larvae that were examined were codling moth. Among the diseases there were no clear patterns of fruit damage, a result of similar fungicide application schedules. The high levels of fly speck and sooty blotch indicate that more fungicide applications were needed.

Results--Peach: A total of 2000 peaches, 20 fruit randomly selected from 25 randomly selected trees per orchard, was examined for insect and disease damage. As with apple, the conventional and low spray/ground cover/interplanted orchards had the highest fruit quality, but the low spray/ground cover orchard also had significantly higher quality than the low spray/interplanted orchard (Table 3). The low spray/ground cover orchard did have the most insect damage of the four orchards, but the use of ground cover did not increase the amound of damage by stink bugs or catfacing damage. Damage from leafroller and second generation plum curculio was significantly lower (95% confidence interval test) in the conventional orchard. There was no fruit injury by oriental fruit moth. Disease injury, especially peach scab, showed the same location effect as did the apple damage data.

Results--Oriental Fruit Moth Mating Disruption: As stated above, there was no fruit injury in peach or apple from oriental fruit moth. Although there were no control blocks not treated with oriental fruit moth pheromone, our conclusion is that oriental fruit moth mating disruption was effective in controlling this pest on both peach and apple. Pheromone traps were monitored weekly from 31 March to 19 September, 1 trap per orchard and no oriental fruit moths were caught in the treated orchards. In a nearby untreated, unsprayed orchard, two traps did catch oriental fruit moths with peak trap captures of 29.3 moths/trap/week from 23 April to 13 May; 6.4 moths/trap/week from 23 June to 28 July; and 7.1 moths/trap/week from 12 August to 8 September. Based on the pesticide schedule in Table 1, the second and third generations of oriental fruit moth were not well targeted with insecticides. In 1998, flagging of peach shoots was counted with an average of 6.8 to 14.1 flagged shoots per peach tree on 28-29 May, showing that oriental fruit moth can be a problem in the area.

Conclusions:

- There was a consistent location effect that confounded differences between treatments. The low spray/ground cover and low spray/interplanted orchards at one location had more damage than the conventional and low spray/ground cover/interplanted orchards at the second location.
- Second generation plum curculio damage was a problem, with reduced sprays in peach and apple resulting in as high as 3.8% and 2.0% damage, respectively.
- More fungicide applications are needed in mid summer, particularly to control fly speck/sooty blotch and peach scab.
- Mating disruption of oriental fruit moth was effective in providing complete control of this pest in harvested peach and apple.

Table 1. Pesticide use for the orchard diversity study in 1999, Appalachian Fruit Research Station, Kearneysville, WV. *

Date	Conventional	Low Spray
8 April	chlorpyrifos, ziram	chlorpyrifos, ziram
20 April	myclobutanil, dodine	myclobutanil, dodine
5 May	myclobutanil, sulfur	myclobutanil, sulfur
11 May	azinphosmethyl	azinphosmethyl-border
20 May	esfenvalerate, myclobutanil, captan	phosmet-border, myclobutanil, captan
3 June	methomyl	Bt
23 June	endosulfan, phosmet, benomyl, sulfur	Bt, benomyl, sulfur
25 August	azinphosmethyl	Bt
1 September		Bt
15 September	chlorpyrifos- peach trunk spray	chlorpyrifos- peach trunk spray

* Isomate-M pheromone lures for oriental fruit moth mating disruption were put out on 1 April and 1 July in both apple and peach.

Table 2. Insect and disease damage to apples (data combined for 'Empire' and 'Granny Smith') in the orchard diversity study, Appalachian Fruit Research Station, Kearneysville, WV, 1999. Means within a row followed by the same letter are not significantly different, $P<0.05$, using confidence interval tests.

% of fruit evaluated	Conventional	Low Spray/ Ground Cover	Low Spray/ Inter-planted	Low Spray/ Ground Cover/ Inter-planted
Clean	22.9 a	15.2 b	7.3 c	21.4 a
Cull	12.1 b	55.7 a	50.2 a	19.0 b
Plant bug	1.4 b	3.8 a	1.3 b	0.0 b
Stink bug	26.6 a	12.7 b	11.3 b	22.6 a
Internal Lep.	1.9 c	6.4 b	13.3 a	3.6 bc
External Lep.	0.9 a	1.3 a	2.0 a	2.4 a
PC 1st gen.	0.9 b	8.9 a	3.7 b	2.4 b
PC 2nd gen.	0.5 bc	1.3 ab	2.0 a	0.0 c
Fly speck/ sooty blotch	52.3 c	77.2 b	85.0 a	47.6 c
Scab	0.0 b	0.0 b	0.0 b	1.2 a
Rot	0.5 b	5.1 a	3.3 a	6.0 a
Brooks spot	3.7 a	1.3 b	0.3 b	4.8 a
Red ring rot	3.3 c	11.4 a	7.3 b	0.0 d

Table 3. Insect and disease damage to peaches ('Loring') in the orchard diversity study, Appalachian Fruit Research Station, Kearneysville, WV, 1999. Means within a row followed by the same letter are not significantly different, $P<0.05$, using confidence interval tests.

% of fruit evaluated	Conventional	Low Spray/ Ground Cover	Low Spray/ Inter-planted	Low Spray/ Ground Cover/ Inter-planted
Clean	54.0 a	27.4 b	8.0 c	50.8 a
Cull	8.4 c	21.8 b	38.0 a	8.0 c
Catface	7.4 ab	8.6 a	6.2 b	5.6 b
Stink bug	6.0 a	4.4 a	4.6 a	5.6 a
OFM	0.0	0.0	0.0	0.0
External Lep.	0.4 c	2.0 a	1.6 ab	1.0 bc
PC 2nd gen.	0.2 c	3.8 a	1.6 b	1.4 b
Thrips	0.0 b	1.2 a	1.4 a	0.0 b
Gumosis	6.0 bc	7.0 b	12.8 a	4.0 c
Scab	17.0 c	50.8 b	85.2 a	16.6 c
Brown rot	0.4 b	1.8 a	0.2 b	0.8 a
Scar (hail)	17.0 d	28.6 b	31.4 a	20.6 c
Blemish	6.6 a	2.6 b	4.2 b	2.6 b
Other	0.0	0.2	0.0	0.0

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MONITORING FOR RESISTANCE TO COMMONLY USED INSECTICIDES IN ORIENTAL FRUIT MOTH (*GRAPHOLITA MOLESTA*) POPULATIONS FROM PENNSYLVANIA COMMERCIAL FRUIT ORCHARDS

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INTRODUCTION: The Oriental fruit moth, *Grapholita molesta* (Busck), is one of the most important pests of peach and nectarine in Pennsylvania and the mid-Atlantic region. First generation larvae attack growing shoots, while larvae from the next three generations and the occasional 5th generation feed primarily in the flesh of the fruit. Once inside of the shoot or fruit, the larva cannot be killed within insecticides.

Current integrated pest management (IPM) recommendations for the control of the Oriental fruit moth on peaches/nectarines allow for the use of compounds from four groups of insecticides: organophosphates (azinphos-methyl Guthion® and phosmet Imidan®); carbamates (carbaryl Sevin® and methomyl Lannate®); pyrethroids (esfenvalerate Asana® and permethrin); and chlorinated carbons (endosulfan). In all likelihood (i.e., FQPA) many of these products will be significantly curtailed in the near future. Additionally, a recent report from Ontario, Canada (Pree et al. 1998) has documented resistance by the Oriental fruit moth to azinphos-methyl and phosmet. Laboratory tests revealed that these populations had also developed cross-resistance to other insecticides. The increased level of injured fruit during the 1998 harvest and rapidly escalating numbers of moths collected in pheromone traps, encourage us to initiate a research on surveying the baseline pesticide susceptibility among various Oriental fruit moth populations throughout Pennsylvania.

The expected reduction in the availability and efficacy of various insecticide groups also forces us to search and develop new, more accurate and predictive methods for better timing what insecticides remain. The development of an egg hatch model for the Oriental fruit moth, similar to one we have already developed and currently being readily used by growers for the tufted apple bud moth on apples, should help not only for better timing of insecticide applications, but also improve their efficacy.

METHODS: Baseline Oriental fruit moth pesticide sensitivity: The Oriental fruit moth adult males were collected from apple and peach orchards throughout Pennsylvania and tested for their response to azinphos-methyl, phosmet and methomyl. Delta traps with removable floors and baited with the OFM sex pheromone were used for collecting male moths. The floors with captured male moths were removed from the traps every morning and brought to the laboratory. Male moths were topically treated on their dorsum with a droplet (1.0 µl) of insecticide dissolved in acetone or acetone alone (control). The bioassays were performed twice: during the flight of the first OFM generation (April/May) and during the flight of the third and fourth OFM generations (August/ September). The mortality readings were made at 24 hours after insecticide application. Mortality data were subjected to probit analysis (POLO).

Egg hatch model development: Starting three days after the establishment of the moth biofix (April 26) peach leaves were checked for the presence of Oriental fruit moth eggs. Using peach orchards located at the PSU Fruit Research and Extension Center in Biglerville, leaves and for the later generations also the fruit were thoroughly checked three times per week during the flight of each Oriental fruit moth generation. The collected eggs were placed in plastic cups with artificial diet and stored in the insectary under normal ambient conditions and checked daily for hatching. An egg hatch model was developed using a moth biofix, moth trap capture, and daily degree-day calculations for each generation of the Oriental fruit moth.

RESULTS

Baseline Oriental fruit moth pesticide sensitivity: Oriental fruit moth males from six apple and four peach orchards from Pennsylvania and one population from New Jersey were tested for their response to azinphos-methyl (Table 1). Only the bioassays with complete estimates of LC50 and LC90 values with established fiducial limits at 0.95 would be used for the result discussion. Based on LC50 value the most sensitive OFM population was collected from P2 orchard during the first generation flight. The least sensitive population to azinphos-methyl was collected from A4 orchard during the third/fourth generation flight (LC50 value). In orchards where two OFM generations were evaluated, the moth sensitivity to azinphos-methyl decreased toward the end of the season. The population from P5 (NJ) orchard had higher estimated LC50 and LC90 values than populations collected from Pennsylvania orchards.

The LC50 values for phosmet varied from 34.39 ppm for A3 3rd generation moths to 116.79 ppm for the A1 population collected during the 1st generation flight (Table 2). Similarly to azinphos-methyl, while two separate generations from one orchard were tested, the LC50 and LC90 values were higher for the moths collected later during the season. While compared the highest LC50 and LC90 values for the PA populations with the P5 population, the phosmet LC50 and LC90 values for the P5 population were higher 1.6 and 1.8 fold, respectively.

While tested with methomyl, the highest (3rd generation) and the lowest (1st generation) values for LC50 values were observed for the moths collected from the same A4 orchard (Table 3). The sensitivities of PA populations were at very similar at both LC50 and LC 90 level throughout all tested populations. The P5 population was more sensitive to methomyl than most tested PA populations.

Table 1. Oriental fruit moth adult male sensitivity to azinphos-methyl assessed using adult topical bioassay. Mortality data collected 24 hours after insecticide application.

Population	Generation	n	LC50 (ppm) (FL at 0.95)	LC90 (ppm) (FL at 0.95)
P1[1]	1st gen	262	**32.20** (9.2 – 52.4)	**99.58** (60.7 – 421.5)
P1	3rd gen	317	**54.52** (15.2 – 95.3)*	**401.70** (204.8 – 3233.7)*
P2	1st gen	143	**18.55** (10.1 – 27.6)	**82.91** (48.6 – 364.8)
P2	3rd gen	73	**31.01** (8.4 – 66.5)*	**410.46** (148.5 – 15081)*
P3	3rd gen	153	**150.71** (52.4 – 83.4)*	**942.90** (379.8 – 51775)*
P4	3rd gen	123	**47.09** (27.1 – 99.7)	**194.28** (94.1 – 2118.9)
P5	NJ strain	390	**88.61** (62.1 – 131.1)	**1038.82** (533.0 – 3225.7)
A1	1st gen	350	**62.43** (49.4 – 75.6)	**155.38** (124.3 – 215.8)
A2	1st gen	413	**36.25** (13.4 – 53. 8)	**95.78** (63.8 – 321.7)
A2	3rd gen	414	**46.11** (24.7 – 68.3)	**179.80** (117.1 – 403.3)
A3	1st gen	207	**137.44** (N/A)	**315.35** (N/A)
A3	3rd gen	207	**125.19** (81.5 – 186.7)*	**307.48** (199.6 – 2372.5)*
A4	1st gen	420	**29.04** (7.0 – 61.6)	**148.37** (69.3 – 958.4)
A4	3rd gen	372	**75.20** (32.5 – 114.0)	**286.39** (175.7 – 1216.1)
A5	3rd gen	559	**70.87** (38.6 – 99.8)	**330.58** (214.8 – 869.0)
A6	3rd gen	116	**30.62** (14.6 – 48.9)	**156.10** (85.2 – 919.1)

* - Fiducial limits (FL) at 0.90

(1) P - peach orchard; A - apple orchard

Table 2. Oriental fruit moth adult male sensitivity to phosmet assessed using adult topical bioassay. Mortality data collected 24 hours after insecticide application.

Population	Generation	n	LC50 (ppm) (FL at 0.95)	LC90 (ppm) (FL at 0.95)
P1 [(1)]	1st gen	95	**41.38** (14.7 – 66.7)	**155.80** (90.2 – 1205.1)
P1	3rd gen	148	**116.11** (53.2 – 392.5)	**1141.43** (356.1 – 248825.8)
P4	3rd gen	63	**39.67** (N/A)	**108.67** (N/A)
P5	NJ strain	180	**211.24** (125.8 – 729.8)	**2230.50** (670.5 – 73179)
A1	1st gen	390	**132.52** (102.4 – 159.7)	**239.10** (239.1 – 423.6)
A2	1st gen	56	**26.30** (N/A)	**96.31** (N/A)
A2	3rd gen	177	**116.79** (59.5 – 211.3)	**452.56** (237.7 – 7070.3)
A4	1st gen	225	**44.75** (27.8 – 62.6)	**178.28** (119.7 – 368.5)
A3	3rd gen	84	**34.39** (12.5 – 73.5)	**249.21** (102.8 – 7824)
A4	3rd gen	462	**97.72** (51.1 – 157.1)	**449.00** (243.7 – 3050.4)
A5	3rd gen	553	**106.84** (54.7 – 206.1)	**1234.30** (484.2 – 15106.0)

(1) - P - peach orchard; A - apple orchard

Table 3. Oriental fruit moth adult male sensitivity to <u>methomyl</u> assessed using adult topical bioassay. Mortality data collected 24 hours after insecticide application.

Population	Generation	n	LC50 (ppm) (FL at 0.95)	LC90 (ppm) (FL at 0.95)
P1 [1]	1st gen	220	**21.08** (3.3 – 38.1)	**91.53** (51.1 – 514.3)
P1	3rd gen	154	**52.64** (25.7 – 70. 9)*	**136.27** (94.9 – 550.5)*
P3	3rd gen	54	**26.16** (N/A)	**111.14** (N/A)
P4	3rd gen	113	**26.24** (15.8 – 39.6)	**90.75** (54.8 – 368.5)
P5	NJ strain	147	**24.59** (15.5 – 35.9)	**84.50** (52.5 – 278.4))
A1	1st gen	480	**29.20** (20.7 – 37.8)	**112.00** (86.1 – 165.1)
A2	1st gen	197	**31.12** (13.7 – 545.7)	**132.35** (78.5 – 871.0)
A2	3rd gen	261	**32.55** (14.7 – 58.4)	**149.15** (78.3 – 724.2)
A3	3rd gen	92	**38.47** (16.1 – 59.0)	**119.12** (75.2 – 444.0)
A4	1st gen	225	**16.02** (11.0 – 21.7)	**92.50** (64.5 – 154.1)
A4	3rd gen	625	**67.53** (44.3 – 87.9)	**182.20** (135.8 – 318.4)
A5	3rd gen	455	**88.69** (51.3 – 113.6)*	**194.05** (149.0 – 379.9)*

* - Fiducial limits (FL) at 0.90
(1) - P - peach orchard; A - apple orchard

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MONITORING ORIENTAL FRUIT MOTH SUSCEPTIBILITY TO AZINPHOSMETHYL IN NEW JERSEY ORCHARDS

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Introduction

The Oriental Fruit Moth, *Graphoilta molesta* (Busck), is a major pest of stone and pome fruit in northeastern United States and in eastern Canada (Pree 1985). While the *G. molesta* is usually a stone fruit pest of peach in Mid-Atlantic States, larvae have been found infesting apples during last few years. During 1998 season, numerous complaints were made throughout the east-coast region about the high incidence of "live worms" at Cumberland-Shenandoah Fruit Workers Conference (Tworkoski 1998). In New Jersey, several growers who applied azinphsomethyl during the 1998-growing season complained control failure, especially during the apple harvest season (P. W. Shearer, personal observation). Occasional concern of "wormy" apple fruit have for several years but most of the time outbreaks were blamed on codling moth (Lepidoptera: Tortricidae), a major pest of apple throughout the United States. After a close examination for the anal comb that is present on *G. molesta* larvae and by rearing the larvae to the adult stage in the laboratory, it was identified as *G. molesta*. (P. W. Shearer, personal observation). During 1998 Cumberland-Shenandoah Fruit Workers Conference (Puterka 1998), concerns were addressed of the "live worm" problem that occurred in harvested apple throughout the east-coast region. The "live worm" problem was mainly due to high late season populations of oriental fruit moth and to a lesser degree, codling moth.

Problems with *G. molesta* in apple are more severe in areas where peaches/nectarines and apple blocks are side by side or in close proximity. As peaches/nectarines are harvested, adult *G. molesta* will disperse to adjacent apple blocks. If *G. molesta* populations are already established in apple blocks, they can continue to develop and cause additional injury and problem (Rothschild and Vickers 1991). In New Jersey, more than ninety percent orchards have peaches and apples blocks side by side or in very close proximity.

For more than thirty years, azinphosmethyl has been used extensively in apples because of its effectiveness against many insect pests and because of its low toxicity to predators of European red mite. Control of *G. molesta* has been accomplished chiefly by azinphosmethyl and some populations have developed resistance to azinphosmethyl in eastern Canada (Kanga et al. 1997 and Pree et al. 1998). Last two years, reports of azinphosmethyl control failures have been reported in parts of New Jersey. In some locations, both the rates of application and the number of applications per season have increased as a result of reduced product efficacy (P. W. Shearer, personal communication). In response to this particular situation, a project was initiated to determine if *G. molesta* populations have developed tolerance to azinphosmethyl in New Jersey. This article reports the results of 1998 and 1999 bioassays that were conducted to estimate susceptibility of oriental fruit moth from selected New Jersey orchards to azinphosmethyl. The objectives of this study were to examine the levels of adult male *G. molesta* susceptibility to azinphsomethyl and to examine the effects of synergists to predict the resistance mechanism(s).

Materials and Methods

Chemicals. A technical grade sample of azinphosmethyl (92.9%; Bayer, Kansas City, MO) was tested. Piperonyl butoxide (91%; AgrEvo USA Company, Wilmington, DE) and DEF (*S,S,S*,-tri-*n*-butyl phosphorotrithioate) (98.7%; Bayer, Kansas City, MO) were evaluated as synergist of insecticide toxicity.

Insects. Male *G. molesta* moths were collected with pheromone traps in commercially managed apples blocks at the six different sites in southern New Jersey.

Topical Pheromone Trap Bioassays. The procedure used in topical pheromone trap assays was described by Riedl et al. (1985) to test codling moth susceptibility to azinphosmethyl. This assay has been slightly modified and used to test susceptibility of other orchard pests (Knight and Hull 1989, Varela et al. 1993, Shearer and Riedl 1994, Shearer et al. 1994, Varela et al. 1997). Briefly, Pherocon 1C traps were baited with *G. molesta* dispensers (Pherocon® Cap). The polybutene adhesive Tangletrap (Tanglefoot, Grand Rapid, MI) was evenly applied at 1 to 1.4 mg/cm^2 with a spatula as a thin coat to an area (12.5 by 23 cm) on a 1C trap bottom. Male moths were collected during peak flight of each generation by placing traps in orchards during evening hours and removing them early next morning and bringing the traps with moths back to the laboratory. Trapped moths were treated topically on thoracic dorsum with a microsyringe mounted on a repeating dispenser (Hamilton, Reno, NV) with 1.0 µl of acetone only (controls), 1.0 µl of an acetone solution of azinphosmethyl only, or 1.0 µl of an acetone solution of 1:10 ratio of azinphosmethyl plus synergist. Only moths attached to the adhesive on their ventral surface were used in the tests. Treated moths were placed in rearing chambers at 25°C, 70% RH, and a photoperiod of 16:8 (L:D) h. Mortality was assessed 24 h after treatment. No mortality of moths was observed with synergist alone. If control mortality exceeded 20%, data were not included in the analysis. Data were not obtained for all flights for all orchards because of the low numbers of moth trapped. Three to five replicates of 5 moths each were used per concentration with at least five different concentrations per test. To determine mortality, insects were prodded with a soft brush. Moths were scored as dead when there was no movement at all. A moth was scored as alive if it was able to move its antennae, legs, wings, or head every time it was prodded. Moths whose legs and wings were immobilized by the trap adhesive were also scored as alive if they exhibited some movement at the base of each wing. Moths were classified as moribund if they displayed one or more of the following movements: rapid and continuous fluttering of wings in response to prodding, rapid uncontrolled twitching of abdomen, wings, or antennae; extension of claspers with little movement; movement of body scales only. Categories of dead and moribund were combined for mortality analysis.

Statistical Analyses. Dosage-mortality regressions were analyzed by probit analysis as adapted for PC use (POLO PC, LeOra Software 1987, Berkeley, CA) which automatically corrected for control mortality using Abbott's formula. Data collected on different days for each flight were pooled. Resistance ratios were calculated by dividing the LC_{50}s values by the lowest LC_{50} value from the site 4 population during the fourth generation of 1999. Non-overlap of 95% CL was used as criteria for separating LC_{50}s using the response of moths collected from site 4 as the reference strain.

RESULTS

1998 Field Survey. The concentration-mortality responses to azinphosmethyl for adult *G. molesta* males captured during the fourth flight of 1998 indicated significant differences in the estimated LC_{50}s from all the sites (Table 1) when we compared with the site 4 population during fourth generation of 1999 (Table 3). The LC_{50} ranged from 148.0 to 224.2; the highest value was estimated for the population from the site 3. The resistance ratios ranged from 2.74 to 4.14 for the site 5 and site 3, respectively. Slopes of regression lines were ranged from 2.47 to 2.76, indicating genetically heterogeneous populations.

1999 Field Survey. The LC_{50}s of the toxicity responses to azinphosmethyl for adult *G. molesta* males captured during the first flight of 1999 from six sites are ranged from 63.2 to 110.8 (Table 2). Based on the non-overlapping 95% confidence limit, we found significant differences in the estimated LC_{50}s from sites 1 and 3. The resistance ratios ranged from 1.17 to 1.86, indicating a significant decline in the resistance of azinphosmethyl from 1998 field survey (Table 1). Slopes of dose mortality curves were ranged from 3.12 to 4.76, indicating more homogeneous populations.

The LC_{50}s of the toxicity responses from the fourth flight during 1999 ranged from 54.1 to 148.1 (Table 3). We found significant differences in the estimated LC_{50}s from sites 1, 2, 3, and 6 when compared with the site 4. The resistance ratios ranged from 1.00 to 2.74, indicating a moderate increased in the resistance ratios from the first flight of 1999. Slopes of regression lines were ranged from 2.91 to 4.36, indicating the presence of homogeneous populations.

A significant synergistic interaction between DEF and azinphosmethyl was observed with all sites when compared with the response to azinphosmethyl alone of respective populations within the same generation during first and fourth flights (Table 4 and 6), with the exception of site 5 population of fourth flight. The synergistic ratios ranged from 4.79 to 9.34, indicating the presence of high esterases activity (Table 4). However, no significant synergism of azinphosmethyl toxicity was apparent with Piperonyl butoxide during first and fourth flights (Table 5 and 7). Based on the non-overlapping 95% confidence limit, the comparison of LC_{50}s from first and fourth generations (Table 4 and 6) of 1999 indicated no significant increase in the activity of esterases. Fifteen of 17 LC_{50}s had slopes < 2.0 with DEF and Piperonyl butoxide, showing that the populations are significantly heterogeneous in the presence of synergists (Table 4 - 7).

References

Kanga, L. H. B., D. J. Pree, L. van Lier, and K. J. Whitty. 1997. Mechanisms of resistance to organophosphorus and carbamate insecticides in oriental fruit moth populations (*Grapholita Molesta Busck*). Pestic. Biochem. Physiol. 59: 11-23.

Knight, A. L. and L. A. Hull. 1989. Use of pheromone traps to monitor azinphosmethyl resistance in tufted apple bud moth (Lepidoptera: Tortricidae). J. Econ. Entomol. 82: 1019-1026.

Pree, D. J. 1985. *Grapholita molesta. In* "Handbook of Insect Rearing" (P. Singh and R. F. Moore, Eds.), Vol. 2, pp. 307-311 Elsevier, Amsterdam.

Pree, D. J., K. J. Whitty, and L. van Driel. 1998. Resistance to insecticides in oriental fruit moth populations (*Grapholita molesta*) from the niagara peninsula of Ontario. Can. Entomol. 130: 245-256.

Puterka 1998. Entomology Research Priorities Group Discussion. *In* 74th proceedings Cumberland-Shenandoah Fruit Workers Conference, Winchester, Virginia.

Riedl, H., A. Seaman, and F. Henrie. 1985 Monitoring susceptibility to azinphosmethyl in filed populations of the codling moth (Lepidoptera: Tortricidae) with pheromone traps. J. Econ. Entomol. 78: 692-699.

Rothschild, G. H. L., and R. A. Vickers. 1991. Biology, ecology and control of the oriental fruit moth. In "Tortricide Pests Their Biology, Natural Enemies and Control" (L. P. S. van der Geest and H. H. Evenhuis), Vol. 5, pp. 389-412 Elsevier, Amsterdam.

Shearer, P. W. and H. Riedl. 1994. Comparison of pheromone trap bioassays for monitoring insecticide resistance of *Phyllonorycter elmaella* (Lepidoptera: Gracillariidae). J. Econ. Entomol. 87: 1450-1454.

Shearer, P. W., L. G. Varela, H. Riedl, S. C. Welter, and V. P. Jones. 1994. Topical pheromone trap assay for monitoring insecticide resistance of *Phyllonorycter elmaella* (Lepidoptera: Gracillariidae). J. Econ. Entomol. 87: 1441-1449.

Tworkoski 1998. Summary of "Call of the States." *In* 74th proceedings Cumberland-Shenandoah Fruit Workers Conference, Winchester, Virginia.

Varela, L. G., V. P. Jones, J. F. Brunner, H. Riedl, and S. C. Welter. 1993. Monitoring and characterization of insecticide resistance in codling moth (Lepidoptera: Tortricidae) in four western states. J. Econ. Entomol. 86: 1-10.

Table 1. Toxicity of azinphosmethyl to male *G. molesta* moths during fourth generation of 1998[a]

Site	Slope ± SE	LC_{50} (95% CL)	χ2	RR_{50}[b]
1	2.66 ± 0.55	220.7* (141.0 – 292.1)	2.67	4.08
3	2.76 ± 0.50	224.2* (166.0 – 281.7)	0.29	4.14
5	2.62 ± 0.25	148.0* (107.2 – 190.4)	3.05	2.74
6	2.47 ± 0.15	178.6* (159.5 – 197.9)	0.84	3.30

[a] LCs expressed as ppm

[b] Resistance ratios (RR) indicating the fold-difference for each population in comparison with the lowest LC_{50} from the site 4 population during the fourth generation of 1999.

* Indicating LC_{50}s significantly different based on non-overlapping 95% CL when compared with the Site 4 population during the fourth generation of 1999.

Table 2. Toxicity of azinphosmethyl to male *G. molesta* moths during first generation of 1999[a]

Site	Slope ± SE	LC_{50} (95% CL)	χ2 (df)	RR_{50}[b]
1	4.76 ± 0.45	96.0* (87.5 – 103.7)	0.50	1.77
2	3.12 ± 0.85	68.2 (27.2 – 94.6)	1.84	1.26
3	3.65 ± 0.53	100.8* (82.4 – 117.4)	0.91	1.86
4	3.18 ± 1.09	63.2 (22.1 – 83.2)	1.53	1.17
5	4.23 ± 1.07	74.5 948.7 – 92.7)	0.32	1.38
6	3.16 ± 0.39	70.7 (58.1 – 81.3)	2.48	1.31

[a] LCs expressed as ppm

[b] Resistance ratios (RR) indicating the fold-difference for each population in comparison with the lowest LC_{50} from the site 4 population during the fourth generation of 1999.

* Indicating LC_{50}s significantly different based on non-overlapping 95% CL when compared with the Site 4 population during the fourth generation of 1999.

Table 3. Toxicity of azinphosmethyl to male *G. molesta* moths during fourth generation of 1999[a]

Site	Slope ± SE	LC_{50} (95% CL)	χ2	RR_{50}[b]
1	3.18 ± 0.72	133.9* (92.9 – 167.4)	1.21	2.48
2	4.03 ± 0.79	132.6* (101.3 – 158.8)	0.65	2.45
3	4.36 ± 0.63	148.1* (127.7 – 167.3)	4.23	2.74
4	3.65 ± 1.06	54.1 (27.8 – 68.2)	0.72	1.00
5	2.91 ± 0.29	67.0 (49.7 – 83.9)	8.34	1.24
6	3.25 ± 0.68	142.6* (69.2 – 182.4)	1.21	2.64

[a] LCs expressed as ppm

[b] Resistance ratios (RR) indicating the fold-difference for each population in comparison with the lowest LC_{50} from the site 4 population during the fourth generation of 1999.

* Indicating LC_{50}s significantly different based on non-overlapping 95% CL when compared with the Site 4 population during the fourth generation of 1999.

Table 4. Effect of DEF on the toxicity of azinphosmethyl to male *G. molesta* moths during first generation of 1999[a]

Site	Slope ± SE	LC_{50} (95% CL)	χ2	SR_{50}[b]
1	1.77 ± 0.23	15.6* (11.8 – 22.0)	2.13	6.14
2	1.13 ± 0.23	7.30* (4.20 – 12.3)	1.44	9.34
3	1.46 ± 0.16	13.4* (10.6 – 17.1)	4.10	7.53
4	1.79 ± 0.47	11.7* (5.70 – 21.2)	0.39	4.79
5	1.65 ± 0.31	13.5* (9.23 – 21.9)	0.60	5.52
6	1.54 ± 0.24	16.1* (11.5 – 21.9)	1.54	4.39

[a] LCs expressed as ppm

[b] Synergistic ratio (SR), dividing LC_{50} azinphosmethyl alone of respective population within same generation by LC_{50} azinphosmethyl plus syngergist.

* Indicating LC_{50}s significantly different based on non-overlapping 95% CL when compared with the respective populations within same generation.

Table 5. Effect of PB on the toxicity of azinphosmethyl to male *G. molesta* moths during first generation of 1999[a]

Site	Slope ± SE	LC_{50} (95% CL)	$\chi 2$	SR_{50}[b]
1	1.82 ± 0.29	105.0 (75.1 – 145.1)	1.35	0.91
2	1.85 ± 0.28	51.5 (38.1 – 71.5)	1.09	0.76
3	1.41 ± 0.24	95.3 (69.9 – 133.9)	2.84	1.34
5	1.82 ± 0.32	61.6 (42.5 – 90.2)	0.27	1.02
6	1.59 ± 0.34	60.7 (38.1 – 89.8)	1.13	1.16

[a] LCs expressed as ppm
[b] Synergistic ratio (SR), dividing LC_{50} azinphosmethyl alone of respective population within same generation by LC_{50} azinphosmethyl plus syngergist.

Table 6. Effect of DEF on the toxicity of azinphosmethyl to male *G. molesta* moths during fourth generation of 1999[a]

Site	Slope ± SE	LC_{50} (95% CL)	$\chi 2$	SR_{50}[b]
2	1.48 ± 0.28	9.54* (4.87 – 14.9)	1.21	13.9
3	1.11 ± 0.13	13.2* (9.79 – 17.9)	2.56	11.2
5	1.13 ± 0.16	28.0 (19.4 – 50.0)	4.13	2.39
6	1.29 ± 0.18	13.7* (9.20 – 19.4)	2.74	10.4

[a] LCs expressed as ppm
[b] Synergistic ratio (SR), dividing LC_{50} azinphosmethyl alone of respective population within same generation by LC_{50} azinphosmethyl plus syngergist.
* Indicating LC_{50}s significantly different based on non-overlapping 95% CL when compared with the respective populations within same generation.

Table 7. Effect of PB on the toxicity of azinphosmethyl to male *G. molesta* moths collected during fourth generation[a]

Site	Slope ± SE	LC_{50} (95% CL)	$\chi 2$ (df)	SR_{50}[b]
3	2.57 ± 0.78	124.4 (58.8 – 187.8)	0.13 (3)	1.19

6	3.03 ± 1.09	133.6 (59.0 – 192.3)	1.50 (3)	1.07

[a] LCs expressed as ppm
[b] Synergistic ratio (SR), dividing LC_{50} azinphosmethyl alone of respective population within same generation by LC_{50} azinphosmethyl plus synergist.

Differences in Four Baits used in Trapping Plum Curculio (Coleoptera: Curculionidae) - 1999

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Introduction: Endemic to eastern North America, plum curculio, *Conotrachelus nenuphar* (Herbst), is a pest of stone and pome crops. This pest overwinters in nearby woodlots, unmanaged trees, or hedgerows (Butkewich & Prokopy 1993, Prokopy et al. 1999). Its migration into the orchards begins about bloom (Bobb 1952). Once in the orchards it feeds on leaf shoots, buds and twigs until immature fruit appears on the tree (Chapman 1938, Bobb 1952, Armstrong 1958). The plum curculio feeds on and oviposits in the immature fruit when it appears on the tree (Chapman 1938, Bobb 1952, Armstrong 1958). This damage makes the fruit unsaleable and can cause great economic losses.

Because of plum curculio's nocturnal habits early in the spring (Butkewich & Prokopy 1993), essential monitoring is difficult. Often the presence of plum curculio in an orchard goes unnoticed until damage scars on the fruit become visible (Butkewich & Prokopy 1993). Trapping is under development for monitoring plum curculio populations in an orchard. However, the unbaited black pyramid traps tested by Prokopy et al. (1999) are largely ineffective. These traps were originally designed for pecan weevil (Tedders and Wood 1994).

The discovery of an aggregation pheromone, grandisoic acid (a proposed trivial name for (+)-(1R,2S)-1-methyl-2-(1-methylethenyl)cyclobutaneacetic acid), by Eller & Bartelt (1996) may increase the effectiveness of the pyramid traps. Butkewich and Prokopy (1997) experimented in the field to test the olfactory and visual cues used by the plum curculio to locate host trees. They concluded that plum curculio use both olfactory and visual cues to find a host tree.

In this study we test several olfactory lures in pyramid traps for plum curculio preference.

Materials and Methods: Plum curculio were collected in pyramid traps, a dark (black) pyramid that stands on the ground with an inverted wire cone trap on top. Traps were placed under trees in apple and peach orchards in Augusta and Orange Counties during the summer of 1999. These traps were set out in May and removed in October. Each trap was placed in an edge row at the base of a tree. In Augusta County two replications of each treatment were conducted in 2 blocks of apples. In Orange County, one replication of each treatment was conducted in the apple block and two replications were placed in the peach block. The following baits were compared with unbaited control traps: grandisoic acid, ethyl isovalerate, limonene, and plum essence. A racemic blend of grandisoic acid was obtained from IPM Technologies (Portland OR) and Scenturion (Clinton WA). Ethyl isovalerate and limonene were found to be attractive to plum curculio by Leskey et al. (1998), and were obtained from IPM Technologies. Butkewich and Prokopy (1993), using a bioassay, found that plum leaves are more attractive than either fruit or non-host plants. A proprietary plum essence blend is used here. The traps were checked weekly and the number of plum curculio in each trap was counted and recorded. In Augusta County, grandisoic acid from IPM Technologies was compared with ethyl isovalerate, limonene and plum essence. In Orange County, grandisoic acid from both sources was compared with plum essence, and ethyl isovalerate. Data were analyzed using a random block design to take into account the effect of the variation in blocks as well as treatments. For the orchards in which the treatments were statistically significant Tukey's HSD was used to separate the means. Due to low capture rates in the later part of the growing season, only the first 8 weeks of captures have been analyzed.

Results and Discussion: In the Augusta County orchard, significantly more plum curculios were caught in the control or in traps baited with grandisoic acid than with plum essence or limonene; ethyl isovalerate was intermediate, being significantly different from neither group. The fact that significantly more plum curculios were caught in the control than in the limonene or plum essence could be explained if these two substances function as a deterrent. This possibility has not been tested though. In Orange County, there were no significant difference among the treatments. Only three replications were used at this site, in the future more replications should be used.

In the future, the single isomer of grandisoic acid that was described by Eller & Bartelt (1996) should be used, instead of the racemic blend currently available. Many male-produced aggregation pheromones are more attractive when in combination with host plant volatiles (Landolt 1997). Combinations of the blends used here in isolation will be evaluated next year.

Table 1. Cumulative plum curculio adults captured in Tedders traps in Augusta and Orange Counties, Virginia (four and three traps per treatment, respectively).

Treatment	Augusta	Orange
grandisoic acid (S)	5.0b	4.0a
grandisoic acid (I)	--	1.0a
limonene	0.5a	--
ethyl isovalerate	2.2ab	2.7a
plum essence	0.8a	2.7a
unbaited control	3.5b	1.0a

Means were separated using Tukey's HSD (α=0.05)

References Cited:

Armstrong, T. 1958. Life-history and ecology of the plum curculio, *Conotrachelus nenuphar* (Hbst.) (Coleoptera: Curculionidae), in the Niagara Peninsula, Ontario. Can. Entomol. 90: 8-17.

Bobb, M. L. 1952. The life history and control of the plum curculio in Virginia. Va. Agric. Exp. Stn. Bull. 453: 5-30.

Butkewich, S. L. and R. J. Prokopy. 1993. The effect of short-range host odor stimuli on host fruit finding and feeding behavior of plum curculio adults (Coleoptera: Curculionidae). J. Chem. Ecol. 19: 825-835.

Butkewich, S. L. and R. J. Prokopy. 1997. Attraction of adult plum curculios (Coleoptera: Curculionidae) to host-tree odor and visual stimuli in the field. J. Entomol. Sci. 32: 1-6.

Chapman, P. J. 1938. The plum curculio as an apple pest. N. Y. State Agric. Exp. Stn. Bull. 684: 75pp.

Eller, F. J. and R. J. Bartelt. 1996. Grandisoic acid, a male-produced aggregation pheromone for the plum curculio, *Conotrachelus nenuphar*. J. Nat. Prod. 59: 451-453.

Landolt, P. J. 1997. Sex attractant and aggregation pheromones of male phytophagous insects. Am. Entomol. 43: 12-22.

Leskey, T., M. Prokopy, A. Yanopolous, M. Young, B. Hogg, F. Boyd, and R. Prokopy. 1998a. Two odor compounds hold promise for increasing trap effectiveness for plum curculio. Univ. Mass. Fruit Notes 63 (3) (http://www-unix.oit.umass.edu/~autio/Fruit_Notes/a4-633.html)

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

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

Release of the predatory mite *Neoseiulus fallacis* (Garman) (Acari: Phytoseiidae) against *Panonychus ulmi* (Koch) (Acari: Tetranychidae) in a Virginia vineyard - 1999

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Introduction

The European red mite, *Panonychus ulmi* (Koch) is an economically important pest on a wide variety of agricultural crops. In the eastern United States and Canada it is the most important spider mite pest on grapes (Schruft 1985). As the grape industry has grown the last ten years in Virginia, mite problems have also increased. Resistance to acaricides has already become evident in some vineyards. Currently there are only two effective acaricides registered on grapes and as resistance begins to occur control options are limited.

As an alternative to acaricides, biological control has been tried on many different crops that are prone to spider mite outbreaks. Some of these crops include apple (Croft and MacRae 1992, Steinburg and Cohen 1992, Croft and Slone 1997), grape (Kinn and Doutt 1972, Duso 1992, Duso and Pasqualetto 1993), strawberry (Croft and Coop 1998) and hops (Strong and Croft 1995). These experiments used a variety of phytoseiid mites with varying degrees of success.

The predatory mite *Neoseiulus fallacis* (Garman) occurs in temperate humid areas of North America including Virginia. This species has been shown to be a major mortality factor of both *Tetranychus* spp. and *P. ulmi* on fruit trees in these areas (McMurtry and Croft 1997). *N. fallacis* is available in large quantities from several commercial suppliers in the United States

Neoseiulus fallacis is common in many Virginia orchards but is rarely found in vineyards, probably due to the widespread use of broad spectrum pesticides. A survey in 1987 of Virginia grape growers found that 95% of these growers were using carbaryl, a nonselective pesticide, mainly for Japanese beetle control (Pfeiffer et al. 1990). Carbaryl has been shown to cause 90-100% mortality to *N. fallacis* in laboratory studies (Hislop and Prokopy 1981). This is a possible detriment to vineyard releases. Laboratory bioassays are planned to determine if other vineyard pesticides are toxic to *N. fallacis.*

During the 1999 field season, one release of *N. fallacis* was made in a commercial vineyard in the Shenandoah Valley of Virginia. More releases were planned but the 1999 season was not conducive to mite outbreaks and no suitable site could be found. This may have been due to the low Japanese beetle population. Growers generally use carbaryl for Japanese beetle control. The use of carbaryl has a tendency to induce spider mite outbreaks (Cone et al. 1990). Additional field releases are planned for the summer of 2000.

The main objective of the release was to look at dispersal of *N. fallacis* in order to determine how long it takes for *N. fallacis* to spread through the vineyard. This should indicate how many release points are ideal and the number of *N. fallacis* that should be released for satisfactory control.

Materials and Methods

The vineyard used for the release was Landwirt Vineyard, located in Rockingham County, Virginia. The variety in the block was Riesling, planted at 1500 vines per hectare in a north/south row orientation. *N. fallacis* were obtained from The Green Spot, Ltd., a commercial supplier of biological control materials. They were shipped on bean leaves along with a small number of twospotted spider mites to provide food during shipping.

The experimental plot was 0.2 hectares, 12 rows by 25 vines. One hundred and fifty *N. fallacis* were released on one vine in each of the middle six rows. The vines chosen for release were staggered so that they were not directly across from one another. This was in order to allow observations on dispersal of mites across rows as well as along the rows. A total of 900 mites were released in the plot. This rate was chosen by modifying a release program that Coop and Croft (1999) developed for strawberries in California. They received satisfactory dispersal and control by releasing 1500 *N. fallacis* into a 2.5 hectare field. This rate was multiplied by six to approximate the difference in crop size between grapes and strawberries. In the laboratory the mites were counted into 6 separate containers each containing bean leaves with 150 mites. At the field site, the leaves were paper clipped into the middle of several shoots closest to the trunk. They were released within 24 hours of arrival. The mites were transported to the field in a cooler to maintain a constant environment.

The release was done in the late afternoon on 5/13/99. An initial population count of *P. ulmi* was taken prior to the release. The vineyard was than sampled weekly for four weeks and then every other week until early August. Sampling was performed in a grid pattern throughout the release plot. Every third vine in each row was sampled for a total of 96 vines. Five leaves on each vine were examined for number of *N. fallacis* and number of *P. ulmi*.

Results and Discussion

The initial population of *P. ulmi* was not above threshold (ten mites per leaf), but did have an average of 2.3 mites per leaf with as high as 11 per leaf on one vine. Therefore a population of *P. ulmi* was present as prey for *N. fallacis*. On the evening of the release the area experienced a heavy thunderstorm which may have had an effect upon the release as mite numbers often tend to go down immediately following heavy rain.

Figure 1 shows the population levels of *P. ulmi* over time. There was a large drop after the initial count and the population never reached its initial level during the remainder of the season.

The first week after the release, 3 *N. fallacis* were observed in the vineyard and they were all located on vines where the releases were made. The following week, 2 *N. fallacis* were observed again only on release vines. The third week after the release, 2 *N.*

fallacis were observed on release vines. The rest of the season no *N. fallacis* were observed.

From this data it is impossible to draw any conclusions about the dispersal capabilities of *N. fallacis*. There are several factors that may have played a role in the failure of *N. fallacis* to establish. The main reason may simply be lack of prey, the *P. ulmi* population dropped to nearly zero on 5/27/99 and never was higher than one per leaf the rest of the season. In addition the rain event the evening of the release may have washed the newly released mites off of the vines. The results may also have been a result of sampling error. The mites are small and difficult to see in the field. However since some were observed on the early dates, it is more likely that the predators were no longer present. Finally, this was a commercial vineyard undergoing a regular spray program. The effect of many pesticides being used in vineyards on *N. fallacis* has not yet been determined but some of the materials may well have a detrimental effect on the predator.

Currently laboratory work is underway using a slide dip bioassay to examine the effects of insecticides, fungicides and herbicides used in Virginia vineyards. In addition further releases are planned next summer if suitable sites can be found. The release method will be modified slightly. The same number will be released in a 0.1 hectare plot and ten leaves per vine will be examined to get a better representation of each vine.

From this preliminary data, it is apparent that further investigation is warranted before any recommendations on biological control of *P.ulmi* by *N. fallacis* in Virginia vineyards can be made.

References

Cone, W.W., L.C. Wright, and M.M. Conant. 1990. Management of insect pest populations in a developing, cool-climate grape industry. p. 27-43. *In* N. J. Bostanian, L.T. Wilson and T.J. Dennehy [eds.]. Monitoring and Integrated Management of Arthropod Pests of Small Fruit Crops. Intercept, Andover, U.K.

Croft, B.A. and L.B. Coop. 1998. Heat units, release rate, prey density, and plant age effects on dispersal by *Neoseiulus fallacis* (Acari: Phytoseiidae) after inoculation into strawberry. J. Econ. Entomol. 91: 94-100.

Croft, B.A. and I.V. MacRae. 1992. Persistence of *Typhlodromus pyri* and *Metaseiulus occidentalis* (Acari: Phytoseiidae) on apple after inoculative release and competition with *Zetzellia mali* (Acari: Stigmaeidae). Environ. Entomol. 21: 1168-1177.

Croft, B.A. and D.H. Slone. 1997. Equilibrium densities of European red mite (Acari: Tetranychidae) after exposure to three levels of predaceous mite diversity on apple. Environ. Entomol. 26: 391-399.

Duso, C. 1992. Role of *Amblyseius aberrans* (Oud.), *Typhlodromus pyri* Scheuten and *Amblyseius andersoni* (Chant)(Acari, Phytoseiidae) in vineyards. J. Appl. Entomol. 114: 455-462.

Duso, C. and C. Pasqualetto. 1993. Factors affecting the potential of phytoseiid mites (Acari: Phytoseiidae) as biocontrol agents in north-Italian vineyards. Exp. Appl. Acarol. 17: 241-258.

Hislop, R.G. and R.J. Prokopy. 1981. Integrated management of phytophagous mites in Massachusetts (U.S.A.) apple orchards 2. Influence of pesticides on the predator *Amblyseius fallacis* (Acarina: Phytoseiidae) under laboratory and field conditions. Protect. Ecol. 3: 157-172.

Kinn, D.N. and R.L. Doutt. 1972. Natural control of spider mites on wine grape varieties in northern California. Environ. Entomol. 1: 513-518.

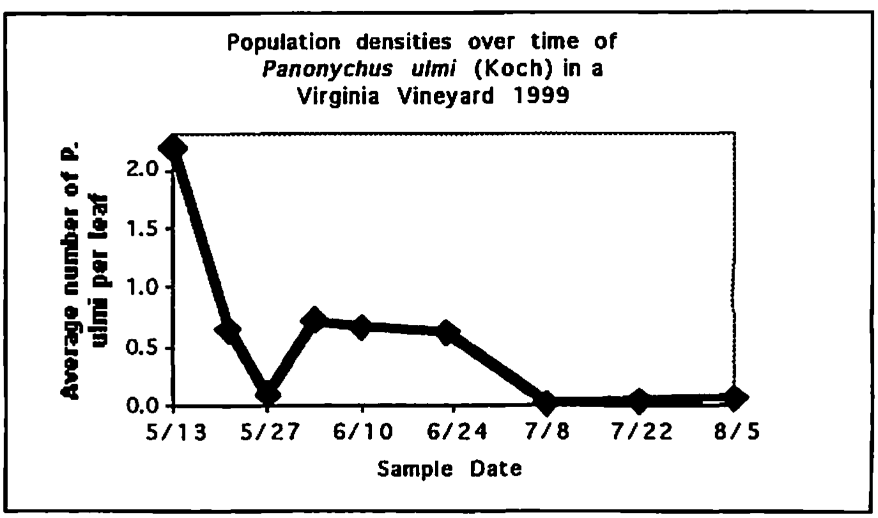
McMurtry, J.A. and B.A. Croft. 1997. Life-styles of phytoseiid mites and their roles in biological control. Annu. Rev. Entomol. 42: 291-321.

Pfeiffer, D.G., T.J. Boucher, M.W. Lachance, and J.C. Killian. 1990. Entomological research in Virginia (U.S.A.) vineyards. p. 45-61. *In* N. J. Bostanian, L.T. Wilson and T.J. Dennehy [eds.]. Monitoring and Integrated Management of Arthropod Pests of Small Fruit Crops. Intercept, Andover, U.K.

Schruft, G.A. 1985. Grape. p. 359-366. *In* W. Helle, M. W. Sabelis [eds.], Spider mites: Their biology, natural enemies and control, Vol. 1B. Amsterdam: Elsevier.

Strong, W.B. and B.A. Croft. 1995. Inoculative release of phytoseiid mites (Acarina: Phytoseiidae) into the rapidly expanding canopy of hops for control of *Tetranychus urticae* (Acarina: Tetranychidae). Environ. Entomol. 24: 446-453.

Figure 1



Effect of Apogee™ on Fire Blight of Apple

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INTRODUCTION: Management of the shoot blight phase of fire blight on apple continues to be a major challenge to growers and researchers alike. The challenge has intensified with more extensive plantings of highly susceptible apple cultivars such as 'Braeburn', 'Fuji', 'Gala', 'Ginger Gold', 'Jonagold', 'Jonathan', and other 'Jonathan' crosses. Trees that are grown with high vigor from excessive fertilization or very fertile soils are more susceptible to the shoot blight phase and have presented the greatest management problems. In the last year or two new hope for improved fire blight management has surfaced with the introduction of Apogee™ (prohexadione calcium evaluated as BAS 125 27.5W). This plant growth regulator is a gibberellin biosynthesis inhibitor which reduces vegetative growth of apple trees and reduces the susceptibility of shoots to fire blight. It is not a biocide and does not inhibit the growth of the fire blight pathogen *Erwinia amylovora* in vitro. Research results obtained in Virginia, Michigan, and Pennsylvania have shown that this compound is effective when applied to actively growing shoots. Several experiments were conducted in this investigation in 1999 to show the response to Apogee™ rates applied to several apple cultivars.

METHODS: Apogee™ 27.5W applied at different rates at the late bloom, petal-fall, and first cover growth stages was evaluated in two experimental orchards with moderate vigor and located at the Penn State Fruit Research and Extension Center experimental farm at Biglerville, PA (Test 1). The first orchard consisted of mature semi-dwarf trees ('Golden Delicious', 'Rome Beauty', and 'Delicious' planted on M.7 rootstocks) planted 30 X 35 ft and pruned to a height of 12-15 ft. Treatments plots contained three trees, one of each cultivar planted in a group at each site, but data was obtained only on 'Rome Beauty' and 'Golden Delicious'. The second orchard located nearby was a planting of 'York Imperial'/M.106 of similar size and planting distance. Treatments in both orchards were arranged in a randomized complete block design with 3-4 replicates and applied as dilute sprays with a high pressure orchard sprayer operated at 400 psi and equipped with a 9-nozzle boom which delivered 2.8 gal/tree (208 gal/A). Application dates and respective growth stages on 'Rome Beauty' and 'Golden Delicious' were: 12 May (late bloom, shoots 3-6 in.), 19 May (petal-fall, shoots 6-10 in.), and 26 May (first cover, shoots 10-15 in.). Application dates on 'York Imperial' were 17, 24 May and 1 Jun. Apogee™ was applied in one, two, or three applications at rates of 12.0, 6.0, or 4.0 oz/100 gal. Ammonium sulfate 1.0 lb/100 gal and Latron B-1956 16.0 fl oz/100 gal were added to all Apogee treatments. After a delay of a minimum of 14 days after the first application, 10 vegetative nonbearing shoots, selected at the time of the first application, were inoculated with *Erwinia amylovora* (1 X 10^8 cfu/ml) by exising half of the youngest two apical leaves with scissors dipped into the inoculum. All selected shoots were measured at the time of the first application on 12 May and again on 27 Jul when observed for presence of fire blight. A second experiment (Test 2) was conducted in each orchard to determine the length of the effective activity of the Apogee™ treatments. Applications were timed the same as in Test 1, but inoculations were made on 26, 29 May, 2 and 11 Jun (14, 17, 21, and 23 days after the first application on 12 May) (late bloom, shoots 3-6 in. long). To establish the inoculation intervals, separate sets of shoots (10/replicate) on each test tree were inoculated at various dates.

Incidence of blight was recorded as necrosis on the inoculated leaves or as shoot blight. The severity of blight on inoculated shoots was expressed as a percent of the shoot that was blighted (a proportion of the shoot showing blighted tissue). All data obtained were analyzed for significant differences among means by using appropriate transformations, analysis of variance, and the Tukey-Kramer HSD test ($P = \leq 0.05$) or mean separation. Since there were four inoculation dates in Test 2, mean comparisons were made only among treatments which were inoculated on the same date.

RESULTS: Incidence of fire blight was observed on 27 Jul and evident as necrosis only on the inoculated leaves or as blighted shoots. Differences among the treatment means varied with rate and cultivar and statistical separation often was not possible because of variation in shoot colonization among replicate trees. In Test 1 all inoculated nontreated shoots of 'Rome Beauty', 'Golden Delicious', and 'York Imperial' showed shoot blight on 27-30 Jul. Trees treated with Apogee™ 12.0 oz/100 gal at late bloom had significantly less blight with 72, 63, and 28% on the three cultivars, respectively. Shoot infections on 'Golden Delicious' trees sprayed with the 12.0 oz rate at petal-fall were significantly lower than the nontreated, but not different on 'Rome Beauty' or 'York Imperial' (Tables 1, 2, 3). 'Golden Delicious' and "York Imperial' trees treated with the 6.0 oz rate applied in two or three sprays (12, 19, 26 May) had significantly less shoot blight than the nontreated trees. These treatment differences were not significant on 'Rome Beauty'. Apogee™ applied at 4.0 oz/100 gal in three applications completely prevented shoot infection on 'York Imperial' (Table 3), but treatment means were not significantly different from the nontreated on 'Rome Beauty' (Table 1) and 'Golden Delicious' (Table 2).

Shoot blight severity, as measured by the percentage of the shoot length on all inoculated shoots (total percent severity, Tables 1, 2, 3), was significantly lower on all treatment rates on 'York Imperial' except the 12.0 oz rate applied in late bloom (17 May). On 'Rome Beauty' only the 12.0 oz rate applied at petal-fall significantly reduced the blight severity in the shoot. This treatment and the 6.0 oz rate applied in two applications significantly reduced blight severity when inoculated on 2 and 7 Jun on 'Golden Delicious' and "York Imperial', respectively.

The mean number of natural infections on nontreated trees in Test 1 was 0.0, 4.5, and 10.0/tree on 'Golden Delicious', 'Rome Beauty', and 'York Imperial', respectively. 'Rome Beauty' trees sprayed with the 12.0 oz rate at petal-fall and the 6.0 and 4.0 oz rates applied in three applications had 0.5 or less infected shoots/tree which were significantly different from the nontreated. Infections on 'York Imperial' were appreciably less than the nontreated, but differences were generally not significant. The length of the seasonal vegetative growth on nonfruiting shoots on nontreated trees was 13.0-14.0 inches. Most of the treatments significantly reduced shoot length which ranged between 46 and 69% of those on nontreated trees.

In Test 2, inoculations were made on 14, 17, 21, and 23 days after the first Apogee™ application on trees treated with only one spray. The interval between inoculations and the second application on trees sprayed with two or three applications was 7, 10, and 14 days and 0, 3, and 7 days after the third application. In this test, incidence of shoot blight on nontreated trees of the three cultivars was 97-100% on the first three inoculation dates, but was only 6.7, 24.1, and 43.3% on 'Golden Delicious', 'Rome Beauty', and 'York Imperial', respectively when inoculated on 11 Jun (Tables 4, 5, 6). Fire blight incidence on treated trees of the three cultivars generally was significantly lower than the nontreated on each of the inoculation dates. The level of blight on the treated trees below that on the nontreated was 32 to 74% on 'Rome Beauty', 42 to 77% on 'Golden Delicious', and 17 to 82% on 'York Imperial'. Treatments remained effective for at least 21 days after application and natural infections were limited to 0.3 to 3.0 infected shoots/tree compared to 11.7 on the nontreated 'Rome Beauty'.

Table 1 . (TEST 1) Fire Blight on Vegetative Shoots of 'Rome Beauty' Apple Treated with Apogee 27.5W and Inoculated with *Erwinia amylovora* in1999. Penn State Fruit Research & Extension Center, Old 3-C Block, Biglerville, PA. K.D. Hickey and N. O. Halbrendt.

Apogee 27.5W Rate/100 gal	No. Appl.[1]	Percent Infections[2]		Severity Percent			Number Natural Infections[6]	Shoot Growth Length[7]
		Apical	Shoot	Shoot[3]	Shoot + Apical[4]	Total[5]		
Inoculated on 26 May, 14 days after Apogee application on 12 May								
Nontreated	0	0.0 a[8]	100.0 b	92.7 a	92.7 a	92.7 a	4.5 a	13.2 a
12.0 oz (12 May)	1	28.3 b	71.7 a	58.3 a	48.5 a	48.5 a	0.8 a	8.6 a
Inoculated on 2 Jun, 14 days after P. fall (19 May) and 14 days after second Apogee application								
Nontreated	0	2.8 a	72.5 a	79.8 a	78.0 b	81.3 b	4.5 b	13.2 b
12.0 oz (19 May)	1	73.1 c	21.9 a	69.2 a	23.7 a	23.0 a	0.3 a	7.0 a
6.0 oz (12, 19 May)	2	26.1 b	68.3 a	85.8 a	56.3 ab	51.5 ab	1.0 ab	9.1 ab
Inoculated on 9 Jun, 14 days after third Apogee application (26 May)								
Nontreated	0	25.0 a	70.0 a	86.8 a	67.5 a	64.0 a	4.5 b	13.2 b
6.0 oz (12, 19, 26 May)	3	72.5 b	17.5 a	61.0 a	12.5 a	15.3 a	0.5 a	7.0 a
4.0 oz (12, 19, 26 May)	3	40.8 ab	44.2 a	62.0 a	40.0 a	35.9 a	0.3 a	7.1 a

1 Spray applications made on: 12 May (L. bloom), shoots 3-6 in. long; second application - 19 May (PF), shoots 6-10 in. long; and third application 26 May (first cover), shoots 10-15 in. long.
2 Obtained by observing on 27 Jul 10 vegetative terminals per replicate (4 reps) which were inoculated with *Erwinia amylovora* (1 X 10^8 cfu/ml).
3 Mean percentage of shoot length blighted on blighted shoots only.
4 Mean percentage of shoot length blighted on blighted shoots and those with only apical necrosis (0.09 in.).
5 Mean percentage of shoot length blighted on all inoculated shoots.
6 Number of fire blighted shoots per tree from natural infections.
7 Mean length (inches) of shoot growth of inoculated shoots between 12 May and 27 Jul. The mean length of nontreated, uninoculated shoots was 14.0 inches.
8 Means followed by the same letter(s) are not significantly different, Tukey-Kramer HSD Test (P = ≤ 0.05).

** Not for Publication **

Table 2 . (TEST 1) Fire Blight on Vegetative Shoots of 'Golden Delicious' Apple Treated with Apogee 27.5W and Inoculated with *Erwinia amylovora* in1999. Penn State Fruit Research & Extension Center, Old 3-C Block, Biglerville, PA. K.D. Hickey and N. O. Halbrendt.

Apogee 27.5W Rate/100 gal	No. Appl.[1]	Percent Infections[2] Apical	Percent Infections[2] Shoot	Severity Percent Shoot[3]	Severity Percent Shoot + Apical[4]	Severity Percent Total[5]	Number Natural Infections[6]	Shoot Growth Length[7]
Inoculated 26 May, 14 days after first application on 12 May								
Nontreated	0	0.0 a[8]	100.0 a	66.7 a	66.7 a	50.0 a	0.0 a	11.5 a
12.0 oz (12 May)	1	37.5 b	62.5 b	70.0 a	41.5 a	26.0 a	0.0 a	7.2 b
Inoculated 2 Jun, 14 days after Petal-fall (19 May) and 14 days after second Apogee application								
Nontreated	0	32.2 a	62.8 b	53.5 b	44.8 b	43.0 b	0.0	11.5 b
12.0 oz (19 May)	1	50.8 a	10.8 a	55.5 ab	13.0 a	9.1 a	0.0	5.3 a
6.0 oz (12, 19 May)	2	54.9 a	18.6 a	12.3 a	4.0 a	3.3 a	0.0	7.2 a
Inoculated 9 Jun, 14 days after third application Apogee application (26 May)								
Nontreated	0	64.4 a	16.8 b	32.0 a	9.5 a	8.1 a	0.0	11.5 b
6.0 oz (12, 19, 26 May)	3	53.3 a	2.5 a	25.0 a	15.3 a	3.0 a	0.0	6.5 a
4.0 oz (12, 19, 26 May)	3	77.5 a	5.0 ab	26.8 a	4.8 a	3.9 a	0.0	5.7 a

1 Spray applications made on: first application, 12 May (L. bloom), shoots 3-6 in. long; second application, 19 May (P. fall), shoots 6-10 in. long; third application, 26 May (first cover), shoots 10-15 in. long.

2 Obtained by observing on 27 Jul 10 vegetative terminals per replicate (4 reps) which were inoculated with *Erwinia amylovora* (1 X 10^8 cfu/ml).

3 Mean percentage of shoot length blighted on blighted shoots only.

4 Mean percentage of shoot length blighted on blighted shoots and those with only apical necrosis (0.09 in.).

5 Mean percentage of shoot length blighted on all inoculated shoots.

6 Number of fire blighted shoots per tree from natural infections.

7 Mean length of shoot growth of inoculated shoots between 12 May and 27 Jul. The mean length of nontreated, uninoculated shoots was 13.0 inches.

8 Means followed by the same letter(s) are not significantly different, Tukey-Kramer HSD Test (P = ≤ 0.05).

** Not for Publication **

Table. 3 (Test 1) Fireblight on Vegetative Shoots of 'York Imperial' Apple Treated with Apogee 27.5W and Inoculated with *Erwinia amylovora* in 1999. Penn State Fruit Research & Extension Center, Collar Rot Block, Biglerville, PA. K. D. Hickey and N. O. Halbrendt.

Apogee 27.5W Rate/100 gal	No. Appl. [1]	Percent Infections [2]		Severity Percent			Number Natural Infections [6]	Shoot Growth Length [7]
		Apical	Shoot	Shoot [3]	Shoot + Apical [4]	Total [5]		
Inoculated on 1 Jun, 14 days after first Apogee™ application on 17 May:								
Nontreated	0	0.0 ^{a}	100.0 ^{b}	59.1 ^{a}	59.1 ^{a}	59.1 ^{a}	10.0 ^{a}	11.7 ^{b}
12.0 oz (17 May)	1	60.0 ^{b}	27.5 ^{a}	69.8 ^{a}	18.3 ^{a}	20.9 ^{a}	1.0 ^{a}	7.1 ^{a}
Inoculated on 7 Jun, 14 days after the first and 14 days after the second Apogee™ application:								
Nontreated	0	0.0 ^{b}	100.0 ^{b}	71.6 ^{a}	71.6 ^{c}	71.6 ^{c}	10.0 ^{a}	11.8 ^{b}
12.0 oz (24 May)	1	5.2 ^{a}	94.7 ^{b}	40.2 ^{a}	37.8 ^{b}	37.8 ^{b}	3.2 ^{a}	7.1 ^{a}
6.0 oz (17, 24 May)	2	50.2 ^{a}	7.7 ^{a}	32.8 ^{a}	6.7 ^{a}	4.0 ^{a}	6.5 ^{a}	6.2 ^{a}
Inoculated on 14 Jun, 14 days after the 3rd Apogee™ application:								
Nontreated	0	2.2 ^{a}	86.9 ^{b}	24.0 ^{b}	21.7 ^{b}	21.0 ^{b}	10.0 ^{b}	11.7 ^{b}
6.0 oz (17, 24 May, 1 Jun)	3	7.4 ^{a}	0.0 ^{a}	0.0 ^{a}	1.3 ^{a}	0.77 ^{a}	1.2 ^{a}	5.5 ^{a}
4.0 oz (17, 24 May, 1 Jun)	3	3.6 ^{a}	0.0 ^{a}	0.0 ^{a}	0.92 ^{a}	0.26 ^{a}	4.5 a^{b}	6.1 ^{a}

[1] Spray applications made on: 17 May (L. bloom) shoots 3-6 inches; second application 24 May (P.fall), shoots 6-10 in. long and 3rd application 1 Jun (1st cover), 10-15 in. long.

[2] Obtained by observing on 30 Jul 10 vegetative terminals per replicate (4 reps) which were inoculated with *E. amylovora* (1×10^8 cfu/ml)

[3] Mean percentage of shoot length blighted on blighted shoots only.

[4] Mean percentage of shoot length blighted on blighted shoots and those with apical necrosis (0.09 in).

[5] Mean percentage of shoot length blighted on all inoculated shoots.

[6] Number of fire blighted shoot per tree from natural infections.

[7] Mean length (inches) of shoot growth of inoculated and uninoculated shoots between 16 May and 30 Jul. The mean length of nontreated, uninoculated shoots was 13 inches.

[8] Mean followed by the same letter (s) are not significantly different, Tukey-Kramer HSD Test ($P = \leq 0.05$).

Not for publication

Table 4 . (TEST 2) Fire Blight on Vegetative Shoots of 'Rome Beauty' Apple Treated with Apogee 27.5W and Inoculated with *Erwinia amylovora* in 1999. Penn State Fruit Research & Extension Center, Old 3-C Block, Biglerville, PA. K.D. Hickey and N. O. Halbrendt.

Apogee 27.5W Rate/100 gal	No. Appl.[1]	Percent Infections[2] Apical	Percent Infections[2] Shoot	Severity Percent Shoot[3]	Severity Percent Shoot + Apical[4]	Severity Percent Total[5]	Number Natural Infections[6]	Shoot Growth Length[7]
Inoculated on 26 May, 14 days after first, 7 days after second, and 0 day after third Apogee™ applications								
Nontreated	0	0.0 a[8]	100.0 a	89.0 b	89.0 b	89.0 b	11.7 b	16.6 b
12.0 oz (12 May)	1	50.0 a	50.0 a	38.7 ab	25.0 a	25.0 a	0.3 a	7.9 a
6.0 oz (12, 19 May)	2	42.5 a	57.5 a	46.3 ab	27.0 a	27.0 a	1.7 a	6.9 a
6.0 oz (12, 19, 26 May)	3	31.5 a	68.5 a	43.3 ab	28.7 a	28.7 a	3.0 ab	6.1 a
4.0 oz (12, 19, 26 May)	3	55.0 a	45.0 a	20.0 a	18.5 a	18.5 a	2.3 ab	7.3 a
Inoculated on 29 May, 17 days after first, 10 days after second, and 3 days after third Apogee™ applications								
Nontreated	0	0.0 a	96.7 b	100.0 a	100.0 a	96.7 b	11.7 b	16.6 b
6.0 oz (12, 19 May)	2	26.7 a	53.3 ab	100.0 a	61.5 a	53.7 ab	1.7 a	6.9 a
6.0 oz (12, 19, 26 May)	3	33.3 a	23.3 a	99.0 a	69.3 a	23.3 a	3.0 ab	6.1 a
4.0 oz (12, 19, 26 May)	3	16.7 a	60.0 ab	100.0 a	79.7 a	60.0 ab	2.3 a	6.8 a
Inoculated on 2 Jun, 21 days after first, 14 days after second, and 7 days after third Apogee™ applications:								
Nontreated	0	3.7 a	96.3 b	77.7 a	77.7 a	77.7 b	11.7 b	16.6 b
12.0 oz (12 May)	1	16.7 ab	49.5 ab	85.7 a	59.7 a	41.7 ab	0.3 a	7.9 a
12.0 oz (19 May)	1	48.5 b	44.4 a	100.0 a	48.7 a	45.0 ab	0.7 a	4.0 a
6.0 oz (12, 19, 26 May)	3	48.9 b	34.4 a	88.7 a	44.0 a	29.7 a	3.0 ab	6.1 a
4.0 oz (12, 19, 26 May)	3	22.5 ab	21.7 a	59.0 a	32.7 a	16.3 a	2.3 ab	6.8 a

Table 4 . (TEST 2) (continued) Fire Blight on Vegetative Shoots of 'Rome Beauty' Apple Treated with Apogee 27.5W and Inoculated with *Erwinia amylovora* in 1999. Penn State Fruit Research & Extension Center, Old 3-C Block, Biglerville, PA. K.D. Hickey and N. O. Halbrendt.

Apogee 27.5W Rate/100 gal	No. Appl.[1]	Percent Infections[2] Apical	Percent Infections[2] Shoot	Severity Percent Shoot[3]	Severity Percent Shoot + Apical[4]	Severity Percent Total[5]	Number Natural Infections[6]	Shoot Growth Length[7]
Inoculated on 11 Jun, 23 days after 19 May (P. fall) Apogee™ application:								
Nontreated	0	59.3 a[8]	24.1 b	39.7 a	12.3 a	11.7 a	11.7 b	16.6 b
12.0 oz (19 May)	1	80.9 a	3.3 a	6.7 a	1.7 a	1.7 a	0.7 a	4.0 a

1 Spray applications made as follows: first application - 12 May (L. bloom), shoots 3-6 in. long; second application - 19 May (PF), shoots 6-10 in. long; and third application 26 May (first cover), shoots 10-15 in. long.

2 Obtained by observing on 27 Jul 10 vegetative terminals per replicate (3 reps) which were inoculated with *Erwinia amylovora* (1 X 10^8 cfu/ml).

3 Mean percentage of shoot length blighted on blighted shoots only.

4 Mean percentage of shoot length blighted on blighted shoots and those with only apical necrosis (0.09 in.).

5 Mean percentage of shoot length blighted on all inoculated shoots.

6 Number of fire blighted shoots per tree from natural infections.

7 Mean length of shoot growth of inoculated shoots between 12 May and 27 Jul. The mean length of nontreated, uninoculated shoots was 13.0 inches.

8 Means followed by the same letter(s) are not significantly different, Tukey-Kramer HSD Test (P = ≤ 0.05).

** Not for Publication **

Table 5 . (TEST 2) Fire Blight on Vegetative Shoots of 'Golden Delicious' Apple Treated with Apogee 27.5W and Inoculated with *Erwinia amylovora* in 1999. Penn State Fruit Research & Extension Center, Old 3-C Block, Biglerville, PA. K.D. Hickey and N. O. Halbrendt.

Apogee 27.5W Rate/100 gal	No. Appl.[1]	Percent Infections[2] Apical	Percent Infections[2] Shoot	Severity Percent Shoot[3]	Severity Percent Shoot + Apical[4]	Severity Percent Total[5]	Number Natural Infections[6]	Shoot Growth Length[7]
Inoculated on 26 May, 14 days after first, 7 days after the second, and 0 days after the third Apogee™ application								
Nontreated	0	0.0 a[8]	100.0 b	85.7 a	85.7 b	85.7 b	0.3 a	13.6 b
12.0 oz (12 May)	1	48.5 ab	44.1 ab	40.9 a	23.1 a	24.3 a	0.0 a	4.7 a
6.0 oz (12, 19 May)	2	41.9 ab	58.1 ab	40.4 a	28.5 a	28.5 ab	0.0 a	6.0 a
6.0 oz (12, 19, 26 May)	3	41.5 ab	58.5 ab	48.9 a	30.4 ab	30.4 ab	0.3 a	5.2 a
4.0 oz	3	53.7 b	43.0 a	63.0 a	17.6 a	18.0 a	0.0 a	6.5 a
Inoculated on 29 May, 10 days after second and 3 days after third Apogee application:								
Nontreated	0	0.0 a	96.7 c	100.0 a	100.0 b	96.7 c	0.3 a	13.6 b
6.0 oz (12, 19 May)	2	16.7 a	56.7 ab	100.0 a	76.8 ab	56.9 ab	0.0 a	6.0 a
6.0 oz (12, 19, 26 May)	3	33.3 a	23.3 a	99.7 a	46.6 a	23.5 a	0.3 a	5.2 a
4.0 oz (12, 19, 26 May)	3	16.7 a	60.0 b	100.0 a	79.7 ab	60.2 b	0.0 a	6.5 a
Inoculated on 2 Jun, 21 days after 12 May, 14 days after 19 May, and 7 days after 26 May Apogee applications:								
Nontreated	0	13.3 a	80.0 b	53.8 a	45.9 a	43.1 b	0.3 a	13.7 b
12.0 oz (12 May)	1	23.3 a	13.3 a	43.0 a	36.6 a	5.3 a	0.0 a	4.7 a
12.0 oz (19 May)	1	44.8 a	6.7 a	18.9 a	7.0 a	4.1 a	0.3 a	4.4 a
6.0 oz (12, 19, 26 May)	3	46.7 a	13.3 a	15.3 a	4.7 a	2.1 a	0.3 a	5.2 a
4.0 oz (12, 19, 26 May)	3	23.3 a	3.3 a	14.8 a	15.5 a	1.7 a	0.0 a	6.5 a

Table 5 . (TEST 2) (continued) Fire Blight on Vegetative Shoots of 'Golden Delicious' Apple Treated with Apogee 27.5W and Inoculated with *Erwinia amylovora* in 1999. Penn State Fruit Research & Extension Center, Old 3-C Block, Biglerville, PA. K.D. Hickey and N. O. Halbrendt.

Apogee 27.5W Rate/100 gal	No. Appl.[1]	Percent Infections[2]		Severity Percent			Number Natural Infections[6]	Shoot Growth Length[7]
		Apical	Shoot	Shoot[3]	Shoot + Apical[4]	Total[5]		
Inoculated on 11 Jun, 23 days after 19 May (P. fall) Apogee application:								
Nontreated	0	47.8 a[8]	6.7 a	2.6	1.7 a	0.8 a	0.3 a	13.7 b
12.0 oz (19 May)	1	47.8 a	0.0 a	0.0 a	0.9 a	0.4 a	0.3 a	4.4 a

1 Spray applications made as follows: first application - 12 May (L. bloom), shoots 3-6 in. long; second application - 19 May (PF), shoots 6-10 in. long; and third application 26 May (first cover), shoots 10-15 in. long.
2 Obtained by observing on 27 Jul 10 vegetative terminals per replicate (3 reps) which were inoculated with *Erwinia amylovora* (1×10^8 cfu/ml).
3 Mean percentage of shoot length blighted on blighted shoots only.
4 Mean percentage of shoot length blighted on blighted shoots and those with only apical necrosis (0.09 in.).
5 Mean percentage of shoot length blighted on all inoculated shoots.
6 Number of fire blighted shoots per tree from natural infections.
7 Mean length of shoot growth of inoculated shoots between 12 May and 27 Jul. The mean length of nontreated, uninoculated shoots was 13.0 inches.
8 Means followed by the same letter(s) are not significantly different, Tukey-Kramer HSD Test ($P = \leq 0.05$).

** Not for Publication **

Table. 6 (Test 2) Fireblight on Vegetative Shoots of 'York Imperial' Apple Treated with Apogee 27.5W and Inoculated with *Erwinia amylovora* in 1999. Penn State Fruit Research & Extension Center, Collar Rot Block, Biglerville, PA. K. D. Hickey and N. O. Halbrendt.

Apogee 27.5W Rate/100 gal	No. Appl. [1]	Percent Infections [2] Apical	Percent Infections [2] Shoot	Severity Percent Shoot [3]	Severity Percent Shoot + Apical [4]	Severity Percent Total [5]	Number Natural Infections [6]	Shoot Growth Length [7]
Inoculated on 1 Jun, 14 days after first, 7 days after second, and 0 day after 3rd Apogee™ applications:								
Nontreated	0	0.0 a	100.0 c	66.0 a	66.0 b	66.0 b	6.0 a	12.9 b
12.0 oz (17 May)	1	48.3 ab	48.3 ab	34.6 a	11.3 a	10.6 a	5.0 a	5.7 a
12.0 oz (24 May)	1	70.3 bc	70.3 bc	36.3 a	23.0 ab	23.0 a	3.0 a	6.2 a
6.0 oz (17, 24 May)	2	69.2 b	20.3 a	51.6 a	15.6 a	14.0 a	0.33 a	5.9 a
6.0 oz (17, 24 May, 1 Jun)	3	70.0 b	30.0 ab	77.3 a	23.3 ab	23.3 a	0.33 a	8.1 a
4.0 oz (17, 24 May, 1 Jun)	3	40.3 ab	31.1 ab	59.3 a	30.0 a	21.3 a	5.0 a	6.9 a
Inoculated on 4 Jun, 17 days after the first, 10 days after the second, and 3 days after the 3rd Apogee™ applications:								
Nontreated	0	0.0 a	96.6 a	81.0 a	80.3 a	80.3 a	6.0 a	12.9 b
12.0 oz (24 May)	1	20.37 a	79.6 a	75.6 a	64.0 a	64.0 a	3.0 a	6.2 a
6.0 oz (17, 24 May)	2	36.6 a	53.3 a	75.0 a	49.3 a	45.6 a	0.33 a	5.9 a
6.0 oz (17, 24 May, 1 Jun)	3	32.3 a	67.6 a	82.0 a	55.0 a	55.0 a	0.33 a	8.1 a
4.0 oz (17, 24 May, 1 Jun)	3	21.1 a	75.1 a	72.6 a	56.0 a	54.0 a	5.0 a	6.9 a
Inoculated on 7 Jun, 21 days after first, 14 days after second, 7 days after the 3rd Apogee™ applications:								
Nontreated	0	0.0 a	96.6 b	68.3 a	68.3 b	65.0 b	6.0 a	12.9 b
12.0 oz (17 May)	1	55.5 b	20.7 a	57.0 a	15.6 a	13.3 a	5.0 a	5.7 a
6.0 oz (17, 24 May)	2	30.83 ab	29.3 a	47.7 a	15.9 a	5.6 a	0.33 a	7.8 a
6.0 oz (17, 24 May, 1 Jun)	3	81.91 b	14.7 a	54.0 a	12.0 a	12.0 a	0.33 a	8.1 a
4.0 oz (17, 24 May, 1 Jun)	3	53.3 ab	23.3 a	30.0 a	12.3 a	9.3 a	5.0 a	6.9 a

Table. 6 (Test 2) (continued). Fireblight on Vegetative Shoots of 'York Imperial' Apple Treated with Apogee 27.5W and Inoculated with *Erwinia amylovora* in 1999.
Penn State Fruit Research & Extension Center, Collar Rot Block, Biglerville, PA. K. D. Hickey and N. O. Halbrendt

Apogee 27.5W Rate/100 gal	No. Appl. [1]	Percent Infections [2]		Severity Percent			Number Natural Infections [6]	Shoot Growth Length [7]
		Apical	Shoot	Shoot [3]	Shoot + Apical [4]	Total [5]		
Inoculated on 11 Jun, 23 days after the 24 May (P. fall) Apogee application:								
Nontreated	0	23.3 a	43.3 a	21.6 b	14.0 b	8.6 b	6.0 a	12.9 b
12 oz (24 May)	1	100.0 b	0.0 b	0.0 a	0.96 a	0.96 a	3.0 a	6.2 a

1 Spray applications made as follows: 1st applic. - 17 May (late-bloom), shoots 3-6 in. long; 2nd applic. - 24 May (petal-fall), shoots 6-10 in. and 3rd applic. 1 Jun (1st cover), 10-15 in. long.

2 Obtained by observing on 30 Jul 10 vegetative terminals per replicate (3 reps) which were inoculated with *E. amylovora* (1 x 10^8 cfu/ml).

3 Mean percentage of shoot length blighted on blighted shoots only.

4 Mean percentage of shoot length blighted on blighted shoots and those with apical necrosis (0.09 in).

5 Mean percentage of shoot length blighted on all inoculated shoots.

6 number of fire blighted shoot per tree from natural infections.

7 Mean length of shoot growth of inoculated and uninoculated shoots between 16 May and 30 Jul. The mean length of nontreated, uninoculated shoots was 13 inches.

8 Mean followed by the same letter (s) are not significantly different, Tukey-Kramer HSD Test (P = ≤ 0.05).

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RESULTS OF FUNGICIDE TRIALS IN THE HUDSON VALLEY

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Three field experiments are summarized in this report and the most significant findings from each experiment are presented. Primary infection periods for apple scab and the proportions of total ascospores captured on a Burkard volumetric spore trap during the 1999 season were 22 Apr (35 hr wetting, 47 F, 37% of spores), 3-4 May (12 hr, 53 F, 15%), 8 May (32 hr, 59 F, 17%), 18 May (37 hr, 62 F, 24%), and 23 May (26 hr, 62 F, 3%). The first primary scab lesions were noted in control trees on 7 May. Ten secondary scab infection periods occurred between 7 May and 10 Jul. The infection period at king bloom on 3-4 May provided ideal conditions for infection and development of quince rust. The incidence of quince rust was higher on thinned fruit in June than on mature fruit at harvest because the side fruitlets that had most of the quince rust were more likely than king fruit to be lost during June drop. King fruit may have had less quince rust because the open petals on king flowers at the time of the infection period may have reduced the exposure of these fruit to inoculum. Spring and summer were exceptionally hot and dry with total rainfall of only 2.67, 0.79, 1.14, and 2.58 inches for May, June, July, and August, respectively. Maximum daily temperature was ≥ 90 F for 26 days during summer, and mean daily temperature for May through August was 3.2 F above the mean for the previous three years.

TRIAL 1 — Evaluation of Strobilurins and Other New Fungicides for Controlling Apple Diseases. Treatments were compared using three-tree plots of trickle-irrigated trees on M.9 rootstock. Each plot contained one tree each of Jerseymac, Redcort, and Golden Delicious. Treatments were replicated four times, with two replicates on 13-year-old trees and two replicates on adjacent five-year-old trees. Unsprayed buffer rows were maintained between sprayed rows. Plots within rows were separated by large cedar trees that provided inoculum for cedar apple rust. Overwintering leaves from the buffer rows provided high levels of scab inoculum. Fungicide treatments were sprayed to runoff using a handgun at 220 psi. Applications were made on 10 Apr (half-inch green), 20 Apr (tight cluster), 30 Apr (pink), 11 May (petal fall), 22 May, 5, 25 Jun, 16 Jul, and 4, 18 Aug, except that Jerseymac trees were not sprayed on the last two dates. Incidence of foliar diseases was evaluated by observing all leaves on 20 clusters or terminals per tree except that only the five youngest leaves on 20 terminals were used to assess powdery mildew. Disease incidence on fruit was assessed by observing 50 fruitlets in June and 100 fruit at harvest. Quince rust on Jerseymac was evaluated by observing 50 thinned fruit collected from the ground beneath trees on 3-5 Jun just after the peak of June drop.

All of the treatments provided acceptable control of apple scab and powdery mildew. The two lower rates of TM41501 controlled fruit scab on Jerseymac as well as Nova used alone. The higher rates of TM41501 were more effective. Indar and Flint (where the latter was applied on both 30 Apr and 11 May) did not adequately control quince rust. Incidence of quince rust in treatments involving Sovran reflected the activity of the Nova sprays applied in the rotation before and after the quince rust infection period. Early terminal leaves on control trees were severely affected by cedar apple rust. Flyspeck failed to develop in these test plots even though unsprayed Liberty trees in an adjacent planting had 46% of fruit with flyspeck by 5 Oct. In this trial, only 1.4% of Redcort and 2.1% of Golden Delicious fruit from control plots had flyspeck on their respective harvest dates of 9 Sep and 5 Oct, and all treatments had less than 1% flyspeck at harvest. Even after postharvest incubation, only 8.3% of Golden Delicious fruit showed flyspeck. The highest rate of TM41501 caused severe reductions in leaf size and shoot development on all three cultivars. Treatments with the highest rate of TM41501 were discontinued after 22 May, but the treated trees still appeared stunted at the end of the season.

TRIAL 2 — Controlling Diseases on Jerseymac and Ginger Gold Apple Trees with Biocontrol and Contact Fungicides. Fungicides were evaluated on trickle-irrigated 12-yr-old trees on M.9 rootstock that had been top-worked to Ginger Gold or Jerseymac in 1996 and 1997. Treatments were replicated four times on two-tree plots that contained one tree of each cultivar. Trees were spaced 10 feet apart within rows and 20 feet between rows. Plots within rows were separated by single unsprayed buffer trees. Treatments were sprayed to runoff using a handgun at 220 psi. Applications were made on 6 Apr (quarter-inch green), 15 Apr (early tight cluster), 25 Apr (early pink), 5 May (full bloom), 13 May (petal fall), 23, 28 May, 16 Jun and 8 Jul. However, the four treatments involving Serenade were applied 24 May instead of 23 May because rain disrupted the applications on 23 May. On 25 May, Nova 40W was applied at 1.5 oz/100 gal to the Serenade plots to eradicate the scab infections that might have been initiated in those plots when they were left unprotected for the infection period of May 23-24. Incidence of foliar diseases was evaluated by observing all leaves on 20 clusters or terminals per tree except that only the five youngest leaves on 20 terminals were used to assess powdery mildew. Disease incidence on fruit was assessed by observing 50 fruitlets per tree in May or June and 100 fruit per tree at harvest. For the evaluation of quince rust on 3 Jun, 50 randomly-selected thinned fruit were collected from the ground beneath Jerseymac trees following the peak of June drop. Ginger Gold fruit were evaluated for diseases at harvest, then incubated for 14 days at 100% relative humidity to encourage development of latent infections not visible at harvest.

Dry spring weather and the exceptionally high susceptibility of Ginger Gold to powdery mildew combined to provide a severe test for mildew control. Captan plus Bayleton provided excellent control of mildew. Trees treated with Thiram plus Microthiol Special (sulfur) had less mildew on 1 Jun than on 23 May because the shorter spray interval and warmer weather in late May enhanced activity of sulfur. Treatments involving Milsana and Serenade did not provide adequate control of mildew, although mildew levels in the Serenade plots dropped after the single Nova application was made on 25 May. Captan plus Bayleton was significantly more effective than Captan plus Milsana for controlling scab on early terminal leaves. We could not determine if Bayleton improved activity of Captan or if Milsana reduced activity of Captan against scab. Treatments involving Thiram or Bayleton provided the best control of quince rust. Milsana and Serenade were relatively ineffective against quince rust, but Serenade provided excellent control of cedar apple rust on leaves (data not shown). A few of the Jerseymac fruit from trees treated with Serenade developed black lenticel spotting, a form of phytotoxicity that could have been caused either by Serenade or by Bond that was applied with Serenade. Milsana caused a severe petal burn when applied at 5 May during full bloom, but the petal burn did not appear to affect fruit set. None of the treatments had an adverse effect on fruit finish.

TRIAL 3: Controlling Flyspeck without Captan, Mancozeb, and Benzimidazole Fungicides: Registrations for captan, mancozeb, and benzimidazole fungicides could be revised as a result of EPA actions under the 1996 Food Quality Protection Act. Alternatives to these fungicides were evaluated to determine their effectiveness for controlling flyspeck and sooty blotch. Trees used for this experiment received no fungicides until the first treatments were applied on 21 May, about 6 days after petal fall. All treatments were replicated four times in 6-tree plots of 13-yr-old Liberty trees on M.9 rootstock. Trees were planted in double rows with 6 ft between trees and 10 ft between rows, and with 20 ft drive rows between double rows. Inoculum was introduced on 25 May by tying 12 inch sections of heavily-colonized blackberry canes into the center two trees in each plot. Additional inoculum was present in the woodlots located on both ends of the 350-ft long rows. All fungicide treatments were applied to runoff using a handgun at 220 psi. The fungicide programs were evaluated by harvesting 50 apples per plot at irregular intervals from 12 Jul to 5 Oct except that 100 fruit were harvested at normal maturity on 14 Sep. For all harvests, fruit were evaluated immediately after harvest and again after two weeks of incubation in plastic bags at 70 F and 100% relative humidity. The incubation period allowed development of infections that were not visible at harvest. Accumulated hours of wetting shown in the table below were determined using a DeWit Leaf Wetness Meter. The accumulations include all hours of wetting (including dew periods) that registered on the wetness recorder.

Severity of flyspeck was more severe than anticipated for such a dry season. As of 12 Jul, approximately 30% of fruit across all treatments showed flyspeck after incubation and none of the treatments were different from the control (P=0.73). The first two fungicide applications apparently failed to control flyspeck during the long spray interval between 11 Jun and 13 Jul. Data collected later in the season therefore represent a combination of residual plus post-infection activity of the fungicides. The amount of flyspeck on incubated fruit from the 6 Aug harvest was a good predictor of flyspeck incidence on fruit on 5 Oct (about 2 weeks after optimum harvest). Incidence of flyspeck on incubated fruit increased between the 6 Aug and 14 Sep harvest dates, presumably as a result of secondary infections caused by conidia blown into the orchard from the bordering woodlots. The incidence of visible symptoms on fruit from unsprayed trees increased dramatically between 1 and 14 Sep. Research by Brown & Sutton (*Plant Disease* 79:1165-1168 [1995]) showed that at least 270 hours of leaf wetting are required for development of flyspeck symptoms on apple fruit. Thus, infections that developed in early September probably occurred shortly after petal fall.

Sovran was more effective than the other fungicides and apparently has good post-infection activity against flyspeck. Thirty percent of incubated fruit from Sovran plots had flyspeck at the 12 Jul harvest, but that dropped to 6% on 6 Aug as a result of the spray that was applied on 13 Jul. Data from incubated fruit from 6 Aug and 14 Sep and the field rating of 6 Oct were combined in a repeated measures analysis to allow a more precise comparison of treatment means. Based on the repeated measures analysis, Thiram at 2 lb was as effective as the Benlate/Captan standard. Adding Microthiol Special to either Ziram or Thiram did not significantly improve their activity against flyspeck. Both Thiram and Sovran might be useful as substitutes for mancozeb, captan, and benzimidazoles in summer spray programs, but Sovran has the advantage of post-infection activity against flyspeck.

Table 1: Effectiveness of treatments in Trial 1 for controlling powdery mildew

Material and rate of formulated product per 100 gal	Application dates	% Redcort terminal leaves with mildew 28 May
Control		17.0 e *
Nova 40W 1.5 oz + Dithane 75DF NT 1 lb	10, 20, 30 Apr; 11, 22 May; 5 Jun	
Benlate 50WP 3 oz + Captan 50W 1 lb	25 Jun; 16 Jul; 4, 18 Aug	0.7 abcd
Indar 75W 0.5 oz + Latron B 1956 4 floz	10, 20, 30 Apr; 11, 22 May; 5, 25 Jun; 16 Jul; 4, 18 Aug	2.2 cd
TM41501 125SC 3 floz	10, 20, 30 Apr; 11, 22 May; 5, 25 Jun; 16 Jul; 4, 18 Aug	0.1 ab
TM41501 125SC 4.3 floz	10, 20, 30 Apr; 11, 22 May; 5, 25 Jun; 16 Jul; 4, 18 Aug	0.1 ab
TM41501 125SC 8.7 floz	10, 20, 30 Apr; 11, 22 May; 5, 25 Jun; 16 Jul; 4, 18 Aug	0.7 abcd
TM41501 125SC 17.3 floz	10, 20, 30 Apr; 11, 22 May	
Benlate 50WP 3 oz + Captan 50W 1 lb	25 Jun; 16 Jul; 4, 18 Aug	0.1 abc
Nova 40W 1.6 oz	10, 20, 30 Apr; 11, 22 May; 5, 25 Jun; 16 Jul; 4, 18 Aug	0.6 abcd
Flint 50WG 0.67 oz	10, 20, 30 Apr; 11, 22 May; 5 Jun	
Flint 50WG 0.5 oz + Captan 50W 1 lb	25 Jun; 16 Jul; 4, 18 Aug	0.7 abcd
Flint 50WG 0.67 oz	10, 20, 30 Apr	
Rubigan 1EC 3 floz +Dithane 75DF NT 1 lb	11, 22 May; 5 Jun	
Benlate 50WP 3 oz + Captan 50W 1 lb	25 Jun; 16 Jul; 4, 18 Aug	2.8 d
Flint 50WG 0.67 oz	10 Apr 30 Apr 22 May	
Nova 40W 1.5 oz + Dithane 75DF NT 1 lb	20 Apr 11 May 5 Jun	
Benlate 50WP 3 oz + Captan 50W 1 lb	25 Jun; 16 Jul	
Flint 50WG 1 oz	4, 18 Aug	1.6 bcd
Sovran 50W 1.3 oz	10, 20 Apr .. 22 May; 5 Jun	
Nova 40W 1.5 oz + Dithane 75DF NT 1 lb	30 Apr; 11 May	
Benlate 50WP 3 oz + Captan 50W 1 lb	25 Jun; 16 Jul; 4, 18 Aug	0.0 a
Sovran 50W 1 oz	10, 20 Apr 22 May; 5 Jun 4, 18 Aug	
Nova 40W 1.5 oz + Dithane 75DF NT 1 lb	30 Apr; 11 May	
Benlate 50WP 3 oz + Captan 50W 1 lb	25 Jun; 16 Jul ..	0.2 abc
Nova 40W 1.5 oz + Thiram Granuflo 75 WDG 1 lb	10, 20, 30 Apr; 11, 22 May; 5 Jun	
Benlate 50WP 3 oz + Captan 50W 1 lb	25 Jun; 16 Jul; 4 Aug	
Thiram Granuflo 75 WDG 2 lb + Benlate 50W 3 oz..	18 Aug	0.4 abcd

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

Table 2: Effectiveness of treatments in Trial 1 for controlling scab, quince rust, and cedar apple rust.

Material and rate of formulated product per 100 gal	% Jerseymac term. leaves with scab		% Jerseymac fruit with scab		% Jerseymac fruit with quince rust		% Golden Del. leaves with cedar apple rust
	9 Jun	17 Aug	8 Jun	27 Jul	3 Jun	27 Jul	14 Jul
Control	65.2 b [1]	78.1 c	63.1 b	86.2 e	41.0 f	38.0 c	49.6 e
Nova + Dithane [2] // Benlate + Captan [3]	0.2 a	0.6 b	0.0 a	0.4 ab	0.0 a	0.0 a	0.0 a
Indar 75W 0.5 oz + Latron B 1956 4 floz	0.2 a	0.4 ab	0.1 a	0.6 abcd	8.0 de	0.1 a	4.4 cd
TM41501 125SC 3 floz	0.0 a	0.1 ab	0.0 a	3.7 d	1.0 abc	0.0 a	0.1 a
TM41501 125SC 4.3 floz	<0.1 a	0.0 a	0.0 a	3.2 cd	1.1 abc	0.0 a	0.0 a
TM41501 125SC 8.7 floz	0.1 a	0.0 a	0.0 a	0.5 abc	0.9 abc	0.0 a	0.0 a
TM41501 125SC 17.3 floz // Benlate + Captan [3]	0.0 a	<0.1 ab	0.0 a	0.0 a	0.0 a	0.2 ab	2.1 bc
Nova 40W 1.6 oz	0.0 a	0.2 ab	0.7 a	3.1 bcd	0.1 ab	0.0 a	0.0 a
Flint 50WG 0.67 oz Flint 50WG 0.5 oz + Captan 50W 1 lb	<0.1 a	<0.1 ab	0.1 a	0.0 a	9.5 e	1.6 b	6.8 d
Flint 50WG 0.67 oz Rubigan 1EC 3 floz + Dithane DF NT 1 lb Benlate + Captan [3]	0.1 a	0.1 ab	0.1 a	0.4 abc	3.0 cd	0.0 a	0.2 ab
Flint 50WG 0.67 oz // Nova + Dithane [2] Benlate + Captan [3] // Flint 50WG 1 oz	<0.1 a	0.1 ab	0.0 a	0.5 abc	2.0 bc	0.0 a	0.5 ab
Sovran 50W 1.3 oz // Nova + Dithane [2] Benlate + Captan [3]	0.3 a	0.2 ab	0.1 a	0.6 abc	0.0 a	0.0 a	0.5 ab
Sovran 50W 1 oz // Nova + Dithane [2] Benlate + Captan [3] // Sovran 1 oz	0.1 a	<0.1 ab	0.1 a	0.2 a	1.0 abc	0.0 a	<0.1 a
Nova 40W 1.5 oz + Thiram Granuflo 75 WDG 1 lb Benlate + Captan [3] Thiram 2 lb + Benlate 50W 3 oz	<0.1 a	0.0 a	0.0 a	0.9 abcd	0.0 a	0.0 a	<0.1 a

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

[2] Nova 40W 1.5 oz + Dithane 75DF NT 1 lb

[3] Benlate 50WP 3 oz + Captan 50W 1 lb

Table 3: Effectiveness of treatments in Trial 2 for controlling mildew

Materials and rate of formulated product per 100 gal	Spray dates			% Ginger Gold leaves with mildew 20 May	1 Jun
Control				54.8 f[1]	87.3 h
Captan 50W 1 lb	6, 15 Apr				
Captan 50W 1 lb + Bayleton 50DF 1 oz		25 Apr; 5, 13, 23, 28 May			
Captan 50W 1 lb + Benlate 50W 2 oz			16 Jun; 8 Jul	0.0 a	0.1 a
Dithane 75DF NT 1 lb	6, 15, 25 Apr; 5, 13, 23, 28 May				
Captan 50W 1 lb + Benlate 50W 2 oz			16 Jun; 8 Jul	5.9 b	26.4 def
Penncozeb 75DF 1 lb	6, 15, 25 Apr; 5, 13, 23, 28 May				
Captan 50W 1 lb + Benlate 50W 2 oz			16 Jun; 8 Jul	15.5 d	51.2 g
Penncozeb 75DF 8 oz + Captan 50W 0.5 lb	6, 15, 25 Apr; 5, 13, 23, 28 May				
Captan 50W 1 lb + Benlate 50W 2 oz			16 Jun; 8 Jul	17.5 de	59.6 g
Thiram Granuflo 75WDG 1 lb + Captan 50W 0.5 lb	6, 15, 25 Apr; 5, 13, 23, 28 May				
Ziram Granuflo 76WDG 1 lb + Benlate 50W 2 oz			16 Jun; 8 Jul	14.7 cd	31.8 f
Thiram Granuflo 75WDG 1 lb (=TG 1 lb)	6, 15 Apr				
TG 1 lb + Microthiol Special 1 lb		25 Apr; 5, 13, 23, 28 May			
TG 1 lb + Benlate 50W 2 oz			16 Jun; 8 Jul	7.0 b	1.6 ab
Vangard 75WG 1.667 oz	6, 15 Apr				
Vangard 75WG 1 oz +Dithane 75DF NT 1 lb		25 Apr; 5, 13, 23 May			
Dithane 75DF NT 1 lb		28 May			
Captan 50W 1 lb + Benlate 50W 2 oz			16 Jun; 8 Jul	8.0 bc	28.8 ef
Captan 50W 1 lb	6, 15 Apr				
Milsana 0.38% (48 fl oz)+ Captan 50W 1 lb		25 Apr; 5, 13, 23, 28 May			
Captan 50W 1 lb			16 Jun;		
Captan 50W 1 lb + Benlate 50W 2 oz			8 Jul	25.1 e	51.4 g
Serenade WP (10^6 cfu/g) 2.7 lb + Bond 1 pt[2]	6, 15, 25 Apr; 5, 13, 24, 28 May, 16 Jun; 8 Jul			18.8 de	8.0 bc
Serenade WP (10^6 cfu/g) 3.3 lb + Bond 1 pt[2]	6, 15, 25 Apr; 5, 13, 24, 28 May, 16 Jun; 8 Jul			18.3 de	14.9 cd
Serenade AS[3] 6.7 pt + Bond 1 pt[2]	6, 15, 25 Apr; 5, 13, 24, 28 May, 16 Jun; 8 Jul			20.1 de	10.0 c
Serenade AS[3] 8.3 pt + Bond 1 pt[2]	6, 15, 25 Apr; 5, 13, 24, 28 May, 16 Jun; 8 Jul			24.2 e	17.5 cde

[1] Numbers within columns followed by the same small letter do not differ significantly, Fisher's Protected LSD ($P \leq 0.05$). The angular transformation was used for the analysis of percentage data. [2] Bond was sprayed at 1 qt/100 on 6 and 15 Apr, then at 1 pt/100 for the remainder of the season; Nova 40W 1.5 oz/100 was applied to these treatments on 25 May. [3] Serenade AS (3.8×10^5 cfu/ml)

Table 4: Effectiveness of treatments in Trial 2 for controlling scab and quince rust

Materials and rate of formulated product per 100 gal	% Jerseymac terminal leaves with apple scab 7 Jun	% Jerseymac terminal leaves with apple scab 25 Aug	% Jerseymac fruit with scab 8 Jun	% Jerseymac fruit with scab 21 Jul	% Jerseymac fruit with quince rust 3 Jun	% Jerseymac fruit with quince rust 21 Jul
Control	36.7 e[1]	88.4 g	55.8 f	85.3 d	50.6 g	44.1 e
Captan 50W 1 lb Captan 50W 1 lb + Bayleton 50DF 1 oz Captan 50W 1 lb + Benlate 50W 2 oz	0.6 a	2.9 ab	0.0 a	0.9 a	0.1 ab	0.0 a
Dithane 75DF NT 1 lb Captan 50W 1 lb + Benlate 50W 2 oz	2.7 bcd	6.3 bcde	0.2 ab	1.9 a	2.4 bcd	2.0 ab
Penncozeb 75DF 1 lb Captan 50W 1 lb + Benlate 50W 2 oz	2.6 bcd	7.1 cde	0.6 abc	3.9 a	3.9 cd	2.8 bc
Penncozeb 75DF 8 oz + Captan 50W 0.5 lb Captan 50W 1 lb + Benlate 50W 2 oz	1.6 abc	2.2 a	0.0 a	0.9 a	8.0 de	2.3 ab
Thiram Granuflo 75WDG 1 lb + Capt. 50W 0.5 lb Ziram Granuflo 76WDG 1 lb + Benlate 50W 2 oz	1.2 abc	5.1 abcd	0.2 ab	0.3 a	0.0 a	0.0 a
Thiram Granuflo 75WDG 1 lb (=TG 1 lb) TG 1 lb + Microthiol Special 1 lb TG 1 lb + Benlate 50W 2 oz	2.5 bcd	2.2 a	0.9 abcd	0.6 a	0.8 abc	0.0 a
Vangard 75WG 1.667 oz Vangard 75WG 1 oz + Dithane 75DF NT 1 lb Dithane 75DF NT 1 lb Captan 50W 1 lb +Benlate 50W 2 oz	1.1 ab	3.3 abc	0.9 abcd	0.2 a	3.5 cd	1.7 ab
Captan 50W 1 lb Milsana 0.38% (48 fl oz)+ Captan 50W 1 lb Captan 50W 1 lb + Benlate 50W 2 oz	2.4 bcd	5.2 abcd	4.1 abcde	0.4 a	15.7 e	14.4 d
Serenade WP (10^6 cfu/g) 2.7 lb + Bond 1 pt[2]	4.1 d	10.3 e	7.0 cde	29.5 b	31.7 f	10.3 cd
Serenade WP (10^6 cfu/g) 3.3 lb + Bond 1 pt[2]	4.3 d	24.8 f	9.8 e	47.0 bc	39.5 fg	6.4 bcd
Serenade AS[3] 6.7 pt + Bond 1 pt[2]	3.2 cd	8.0 de	5.3 bcde	31.5 b	31.4 f	10.6 d
Serenade AS[3] 8.3 pt + Bond 1 pt[2]	5.0 d	8.6 de	9.0 de	50.0 c	39.5 fg	12.6 d

[1] Numbers within columns followed by the same small letter do not differ significantly, Fisher's Protected LSD (P≤0.05). The angular transformation was used for the analysis of percentage data. [2] Bond was sprayed at the rate of 1 qt/100 on 6 and 15 Apr, then 1 pt/100 for the remainder of the season; Nova 40W 1.5 oz/100 was applied to these treatments on 25 May. [3] Serenade AS (3.8 x 10^5 cfu/ml)

Table 5: Development of flyspeck and accumulation of wetting as measured in Trial 3

	Dates for field ratings or harvest of fruit from unsprayed trees								
	12 Jul	30 Jul	6 Aug	23 Aug	27 Aug	1 Sep	8 Sep	14 Sep	5 Oct
% fruit with flyspeck in field ratings	0	0	0	1	0	2	13	31	46
% fruit with flyspeck after incubation	31	—	58	—	—	—	—	84	—
Accumulated hr wetting from 10-d after petal fall	95	110	112	162	178	181	228	259	355
Accumulated hr wetting from petal fall, May 15	166	181	182	233	248	251	299	330	426

Table 6: Incidence of flyspeck on Liberty fruit at harvest and following incubation in Trial 3

Materials and rate of formulated product per 100 gal[1]	% fruit with flyspeck from harvests on:[2] 12 Jul after incubation	6 Aug after incubation	14 Sep field rating	14 Sep after incubation	5 Oct field rating	Means from repeated measures analysis[3]
Control	30.9 a [4]	58.4 e	31.0 d	83.8 d	45.9 d	63.7 e
Dithane 75DF NT 1 lb (2 sprays) Captan 50W 1 lb + Benlate 50W 3 oz (2 sprays)	19.2 a	13.1 ab	8.3 bc	30.5 b	15.9 b	19.3 b
Microthiol Special 80W 1 lb	35.9 a	29.1 cd	15.7 c	50.5 c	30.9 cd	36.6 d
Ziram 76W 1 lb	29.2 a	24.9 bcd	11.3 bc	49.6 c	24.3 bc	32.4 cd
Thiram Granuflo 75WDG 1 lb	35.8 a	32.4 d	14.0 c	50.6 c	19.7 bc	33.7 d
Thiram Granuflo 75WDG 2 lb	28.5 a	15.4 abc	6.9 ab	28.3 ab	17.4 bc	20.1 bc
Ziram 76W 1 lb + Microthiol Special 80W 1 lb	27.0 a	23.3 bcd	8.7 bc	40.1 bc	18.0 bc	26.7 bcd
Thiram Granuflo 75WDG 1 lb + Microthiol Special 80W 1 lb	37.1 a	20.0 bcd	8.6 bc	46.9 c	25.8 bc	30.4 bcd
Sovran 50W 1.25 oz	29.9 a	6.3 a	3.0 a	16.3 a	5.4 a	8.8 a

[1] Treatments were applied 21 May; 11 Jun; 13 Jul; 10 Aug.

[2] Evaluations were based on 50 fruit per plot harvested on 12 Jul, 6 Aug, and 5 Oct and 100 fruit/plot harvested 14 Sep. Following initial ratings on the first three dates, fruit were incubated for 2 weeks at room temperature and 100% RH then re-evaluated.

[3] Grand means from repeated-measures analysis of the incubated fruit from 6 Aug and 14 Sep and the field rating from 5 Oct.

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

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

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EVALUATION OF STROBILURIN AND OTHER EXPERIMENTAL FUNGICIDES ON STAYMAN, AND IDARED APPLES, 1999: Twelve treatments involving experimental and recently registered fungicides and combinations designed for season-long disease and fungicide resistance management were compared on 13-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 1998 to stabilize mildew inoculum pressure for 1999. 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: 2 Apr (GT, green tip, Vangard only); 13 Apr (All treatments, Idared open cluster, Stayman, TC tight cluster); 22 Apr (P, pink); 5 May (PF, petal fall); 1st–5th covers (1C-5C) 19 May, 3 June, 22 June, 14 July, 11 Aug. Insecticides, applied separately to the entire test block with the same equipment, included Asana XL + oil, Guthion 3F, Lannate LV, Penncap-M, Sevin XLR, and Imidan 70WSB. Cedar rust galls were placed over each Idared test tree 15 Apr and 1 Jun; bitter rot mummies and wild blackberry canes with the sooty blotch and flyspeck fungi were placed over each Idared test tree 1 Jun. 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 1 Jul (Idared) or 7 Jul (Stayman). Fruit samples were taken from each replicate tree 27 Sep (Idared), 13 Oct (Stayman), and rated after 2-4 wks' storage at 1C. Percentage data were converted by the square root arcsin transformation for statistical analysis.

The dry early and mid season weather favored much stronger test conditions for powdery mildew than for scab. All treatments gave mildew control comparable to, or better than, the commercial standard, Nova (Table 1). TM-41501 effectiveness was somewhat variable at the lower rates but the lowest rate was significantly better than Nova ($p=0.05$). Two treatments with the early season component involving Flint 2 oz/A, gave more mildew suppression than Nova and Sovran 4 oz/A was equal to Nova. All treatments gave excellent control of relatively light scab infection and mildew infection on fruit. Cedar-apple rust, most of which occurred four days after the first cover spray, was well controlled by the fungicides in all the treatments at that time. Following the lowest mid-season summer disease pressure in this test block in more than 5 years, sooty blotch and flyspeck began appearing on non-treated trees about 3 wk after the last application, resulting in a good test of residual effectiveness in September (Table 2). All rates of TM-41501 were weak for control of sooty blotch, and the lowest rates were also weak on flyspeck. Sovran and Flint, applied alone in the late covers, were generally as effective as Benlate + Captan. Although there were significant fruit finish differences between some treatments, no treatment significantly increased or decreased russetting or opalescence compared to non-treated trees. Fruit finish ratings may have been partially affected by mildew infection.

Table 1. 1999 Evaluation of experimental fungicides for early season apple disease management on Stayman and Idared apples

		Idared						Stayman			
		mildew %			% scab		rust,	mildew		% scab	
Treatment and rate/acre	Timing	leaves	lf area	fruit	leaves	fruit	% lvs	leaves	lf area	leaves	fruit
No fungicide	---	53 d	31 b	16 b	14 c	9 b	15 b	43 b	7 b	14.4 b	1 b
Nova 40W 4 oz + Polyram 80WDG 3 lb Benlate 50W 8 oz + Captan 50W 3 lb	OC-3C 4C-5C	9 c	2 a	0 a	0 a	0 a	0 a	15 a	2 a	0.6 a	0 a
Sovran 50WG 4.0 oz Nova 40W 4 oz + Polyram 80WDG 3 lb Benlate 50W 8 oz + Captan 50W 3 lb	OC-P, 2-3C PF-1C 4C-5C	6 ab	1 a	3 a	0 a	0 a	0 a	7 a	1 a	0.2 a	0 a
Sovran 50WG 4.0 oz Nova 40W 4 oz + Polyram 80WDG 3 lb Sovran 50WG 4.0 oz	OC-P, 2-3C PF-1C 4C-5C	7 abc	1 a	1 a	0 a	0 a	0 a	9 a	2 a	0.4 a	0 a
Sovran 50WG 4.0 oz	OC-5C	9 bc	2 a	0 a	0 a	0 a	0 a	7 a	1 a	0.4 a	0 a
TM-41501 125SC 9 fl oz	OC-5C	4 a	1 a	0 a	0 a	0 a	0 a	9 a	1 a	0.0 a	0 a
TM-41501 125SC 13 fl oz	OC-5C	10 bc	2 a	2 a	1 b	0 a	0 a	8 a	1 a	0.2 a	0 a
TM-41501 125SC 26 fl oz	OC-5C	7 abc	1 a	1 a	0 a	0 a	0 a	9 a	1 a	0.0 a	0 a
TM-41501 125SC 52 fl oz	OC-5C	7 abc	2 a	3 a	0 a	0 a	0 a	5 a	1 a	0.0 a	0 a
Flint 50WG 2 oz Flint 50WG 1.5 oz + Ziram 76DF 2.2 lb	OC-PF 1C-5C	4 a	1 a	0 a	0 a	0 a	0 a	9 a	1 a	0.0 a	0 a
Vangard 75WG 5.0 oz Vangard 75WG 3 oz + Dithane RSNT 75DF 3 lb Benlate 50W 8 oz + Captan 50W 3.0 lb	GT, TC Pink-PF 1C-5C	6 ab	1 a	1 a	0 a	0 a	0 a	8 a	1 a	0.2 a	0 a
Flint 50WG 2 oz Flint 50WG 1.5 oz + Captan 50W 2.2 lb	OC-PF 1C-5C	5 a	1 a	0 a	0 a	0 a	0 a	10 a	1 a	0.2 a	0 a
Flint 50WG 2 oz	OC-5C	7 abc	1 a	2 a	0 a	0 a	0 a	8 a	1 a	0.0 a	0 a

Counts of ten shoots from each of four single-tree reps 1 Jul (Idared) or 7 Jul (Stayman) or 25 fruit per tree after harvest.
Mean separation by Waller-Duncan K-ratio t-test (p=0.05).

Fungicide treatments applied with a Swanson Model DA-400 airblast sprayer at 100 gal/A to both sides of the tree on each application date as follows: 2 Apr (GT, green tip, #11 only); 13 Apr (All trts Idared open cluster, Stayman, TC tight cluster); 22 Apr (P, pink); 5 May (PF, petal fall); 1st–5th covers (1C-5C) 19 May, 3 June, 22 June, 14 July, 11 Aug.

Table 2. Effects of experimental fungicides on summer diseases and fruit finish of Stayman and Idared apples, 1999

		Sooty blotch				Flyspeck, % fruit infected		Fruit finish*		
		Idared		Stayman				opalescence		Stayman
Treatment and rate/acre	Timing	% fruit	% area	% fruit	% area	Idared	Stayman	Idared	Stayman	russet
No fungicide	---	91 e	6.5 f	85 f	8.5 e	55 d	62 e	1.3 abc	2.4 abc	2.3 ab
Nova 40W 4 oz + Polyram 80WDG 3 lb Benlate 50W 8 oz + Captan 50W 3 lb	OC-3C 4C-5C	13 abc	0.7 a-d	24 bcd	1.9 a-d	2 ab	14 cd	1.3 abc	2.5 bc	2.4 ab
Sovran 50WG 4.0 oz Nova 40W 4 oz + Polyram 80WDG 3 lb Benlate 50W 8 oz + Captan 50W 3 lb	OC-P, 2-3C PF-1C 4C-5C	5 a	0.3 ab	13 ab	0.8 ab	3 abc	8 bc	1.4 abc	2.2 abc	2.0 ab
Sovran 50WG 4.0 oz Nova 40W 4 oz + Polyram 80WDG 3 lb Sovran 50WG 4.0 oz	OC-P, 2-3C PF-1C 4C-5C	12 ab	0.6 abc	11 ab	0.6 a	0 a	0 a	1.1 ab	2.1 ab	2.1 ab
Sovran 50WG 4.0 oz	OC-5C	9 ab	0.5 abc	17 ab	1.4 abc	0 a	5 ab	0.9 a	1.7 a	1.8 ab
TM-41501 125SC 9 fl oz	OC-5C	37 cd	2.5 de	46 e	4.0 d	10 c	27 d	1.8 c	1.9 ab	2.0 ab
TM-41501 125SC 13 fl oz	OC-5C	28 bcd	1.7 cde	45 de	4.0 d	0 a	16 bcd	1.2 ab	2.2 abc	2.1 ab
TM-41501 125SC 26 fl oz	OC-5C	34 bcd	2.2 cde	39 de	3.1 cd	7 bc	7 bc	1.4 bc	2.9 c	2.8 b
TM-41501 125SC 52 fl oz	OC-5C	41 d	3.0 e	33 cde	2.5 bcd	3 abc	4 abc	1.4 abc	2.3 abc	2.0 ab
Flint 50WG 2 oz Flint 50WG 1.5 oz + Ziram 76DF 2.2 lb	OC-PF 1C-5C	3 a	0.1 a	7 a	0.7 a	3 abc	6 bc	1.3 abc	2.1 ab	2.0 ab
Vangard 75WG 5.0 oz Vangard 75WG 3 oz + Dithane RSNT 75DF 3 lb Benlate 50W 8 oz + Captan 50W 3.0 lb	GT, TC Pink-PF 1C-5C	14 abc	0.8 a-d	21 abc	1.8 abc	3 abc	12 bcd	1.1 ab	1.9 ab	2.0 ab
Flint 50WG 2 oz Flint 50WG 1.5 oz + Captan 50W 2.2 lb	OC-PF 1C-5C	10 ab	0.6 abc	11 ab	0.5 a	4 abc	4 abc	1.5 bc	1.8 ab	1.7 a
Flint 50WG 2 oz	OC-5C	21 a-d	1.5 b-e	15 ab	0.9 ab	1 ab	4 abc	1.2 ab	1.7 a	2.3 ab

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Counts of 25 fruit from each of four single-tree replicates. Idared harvested 27 Sep, rated 25 Oct; Stayman harvested 13 Oct, rated 2 Nov; All samples stored at 1 C between harvest and rating.

Fungicide treatments applied with a Swanson Model DA-400 airblast sprayer at 100 gal/A to both sides of the tree on each application date as follows: 2 Apr (GT, green tip, #11 only); 13 Apr (All trts Idared open cluster, Stayman, TC tight cluster); 22 Apr (P, pink); 5 May (PF, petal fall); 1st–5th covers (1C-5C) 19 May, 3 June, 22 June, 14 July, 11 Aug.

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

APPLE (*Malus domestica* 'Golden Delicious')
Scab; *Venturia inaequalis*
Powdery mildew; *Podosphaera leucotricha*
Cedar-apple rust, *Gymnosporangium juniperi-virginianae*
Sooty blotch; disease complex
Fly speck; *Zygophiala jamaicensis*
Rots
Fruit russet

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CONCENTRATE APPLICATIONS OF EXPERIMENTAL FUNGICIDES ON GOLDEN DELICIOUS APPLE, 1999: Nine treatments involving experimental and recently registered compounds and a standard were compared on 27-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: 10 Apr (tight cluster, TC all treatments); 22 Apr (open cluster OC-pink); 5 May (petal fall, PF); first – fifth covers, 1C-5C: 18 May, 2 June, 15 June, 8 July, 5 Aug. Other applications applied to the entire test block with the same equipment included Asana+oil, Guthion 3F, Lannate LV, Imidan 70WSB and Penncap-M. Cedar rust galls were placed over each test tree 15 Apr and 1 Jun; bitter rot mummies and wild blackberry canes with the sooty blotch and flyspeck fungi were placed over each Idared test tree 1 Jun.. Foliar data represent averages of counts of all leaves on 10 terminal shoots from each of four replicate trees 2 Aug. A 25-fruit sample from each replicate tree was harvested 23 Sep and again on 5 Oct and rated after 3-5 weeks' storage at 1C.

Because of an extended drought, scab development was very light (Table 3). Cedar-apple rust, most of which occurred four days after the first cover spray, was well controlled by all the treatments at that time. Powdery mildew was also controlled by all treatments under relatively light disease pressure. Although sooty blotch and flyspeck development were delayed two months compared to 1998, treatment intervals were extended to 3-4 weeks in mid-season and symptoms began to appear on non-treated trees about 3 wk after the last application, resulting in a good test of residual effectiveness in September (Table 4). Treatments that gave residual control for six weeks began to break down by 8 weeks, including the Benlate+Captan summer standard. An apparent weakness by the lower rate of the 50EG formulation of Sovran in the first sampling could not be shown at the higher rate or by the heavier disease incidence in later samples. Flyspeck was also generally well-controlled in early samples but some Sovran rate differences were noted in the later sampling. Higher rates of Sovran also improved control of rot spots at the later sampling. In a year in which Golden Delicious fruit finish was generally good, no treatment significantly increased or decreased russetting compared to non-treated trees.

Table 3. Effects of experimental fungicides on early season diseases and fruit finish of Golden Delicious apples

Treatment and rate/acre	Timing	Scab, % leaves	Scab, % fruit	C-A rust, % leaves	Mildew, % leaves	Fruit finish grade or rating*: % of fruit X-fancy & Fancy*	Fruit finish grade or rating*: % of fruit X-fancy	Fruit finish grade or rating*: Russet rating (0-5)**
No fungicide	---	4.9 b	4 b	11.4 b	11.0 b	98 a	89 a	1.57 bc
Sovran 50WG 4.0 oz Nova 40W 4 oz + Manzate 200 75DF 3lb	TC-OC, 2C-5C PF & 1C	0.0 a	0 a	0.0 a	0.0 a	100 a	89 a	1.20 abc
Nova 40W 4 oz + Manzate 200 75DF 3lb Sovran 50WG 4.0 oz Benlate 50W 8 oz + Captan 50W 5 lb	TC-OC, 2C-3C PF & 1C 4C-5C	0.8 a	0 a	0.0 a	0.5 a	100 a	97 a	1.35 bc
Sovran 50WG 2.0 oz	TC-5C	0.0 a	0 a	0.9 a	1.0 a	100 a	96 a	0.74 a
Sovran 50EG 2.0 oz	TC-5C	0.0 a	0 a	1.5 a	2.5 a	99 a	87 a	1.76 c
Sovran 50WG 4.0 oz	TC-5C	0.0 a	0 a	4.2 a	3.1 a	100 a	91 a	1.26 abc
Sovran 50EG 4.0 oz	TC-5C	0.2 a	0 a	0.0 a	1.4 a	100 a	95 a	1.01 ab
Nova 40W 5 oz Dithane RSNT 75WDG 3 lb Benlate 50W 8 oz + Captan 50W 5 lb	TC-3C 4C-5C	0.0 a	0 a	0.0 a	0.4 a	100 a	99 a	0.74 a
RH 7592 75W 2 oz/A + Latron B-1956 4 fl oz / 100 gal	TC-5C	0.2 a	0 a	0.0 a	1.0 a	99 a	96 a	1.63 c
RH 7592 75W 1 oz + Sovran 50WG 2.0 oz	TC-5C	0.4 a	0 a	0.2 a	2.9 a	99 a	97 a	1.33 bc

Mean separation by Waller-Duncan K-ratio t-test (p=0.05).
Counts of ten shoots 2 Aug or 25 fruit 23 Sep from each of four single-tree reps.
*USDA grades after down-grading by russet. **Russet rated on a scale of 0-5 (0=perfect finish; 5=severe russet).

Fungicide treatments were applied to both sides of the tree with a Swanson Model DA-400 airblast sprayer at 100 gal/A on each date as follows: 10 Apr (tight cluster, TC all treatments); 22 Apr (open cluster OC-pink); 5 May (petal fall, PF); first – fifth covers, 1C-5C: 18 May, 2 June, 15 June, 8 July, 5 Aug.

Insecticides: 6 Apr (Oil 6 gal/A + Asana XL 10 fl oz /A); 13 May (Thinner– Sevin XLR + NAA 10 ppm + Regulaid 11 fl oz/A); 11 May, 3 Jun, (Guthion 3F 2 pt + Lannate LV 1.5 pt /A); 18 Jun (Penncap-M 3 pt + Lannate LV 1.5 pt /A); 7 Jul (Imidan 70WSB 1.5 lb + Lannate LV 1.5 pt /A); 5 Aug (Imidan 70WSB 2 lb).

Table 4. Effectiveness of experimental fungicides for summer disease management on Golden Delicious apples

Treatment and rate/acre	Timing	Sooty blotch infection 23 Sept % fruit	Sooty blotch infection 23 Sept % area	Sooty blotch infection 5 Oct % fruit	Sooty blotch infection 5 Oct % area	Flyspeck infection 23 Sept % fruit	Flyspeck infection 5 Oct % fruit	Flyspeck infection 5 Oct % area	% fruit with rot spots 23 Sept	% fruit with rot spots 5 Oct
0 No fungicide	---	53 c	3.6 c	99 d	22 e	18 c	77 e	5.1 e	5 a	23 c
6 Sovran 50WG 4.0 oz Nova 40W 4 oz + Manzate 200 75DF 3lb	TC-OC, 2C-5C PF & 1C	7 ab	0.3 ab	53 ab	3 ab	1 ab	8 ab	0.2 abc	0 a	0 a
7 Nova 40W 4 oz + Manzate 200 75DF 3lb Sovran 50WG 4.0 oz Benlate 50W 8 oz + Captan 50W 5 lb	TC-OC, 2C-3C PF & 1C 4C-5C	3 ab	0.2 ab	43 a	3 ab	0 a	8 ab	0.3 abc	0 a	0 a
8 Sovran 50WG 2.0 oz	TC-5C	12 ab	0.6 ab	86 cd	10 cd	1 ab	43 d	2.1 d	0 a	10 bc
9 Sovran 50EG 2.0 oz	TC-5C	39 c	2.4 c	87 cd	11 d	7 b	37 cd	1.7 d	0 a	16 bc
10 Sovran 50WG 4.0 oz	TC-5C	12 b	0.7 b	79 c	7 bcd	0 a	17 bc	0.6 c	0 a	3 ab
11 Sovran 50EG 4.0 oz	TC-5C	3 ab	0.1 ab	51 ab	5 ab	0 a	6 ab	0.3 abc	0 a	2 ab
12 Nova 40W 5 oz Dithane RSNT 75WDG 3 lb Benlate 50W 8 oz + Captan 50W 5 lb	TC-3C 4C-5C	0 a	0.0 a	30 a	1 a	0 a	1 a	0.02 a	0 a	0 a
13 RH 7592 75W 2 oz/A + Latron B-1956 4 fl oz / 100 gal	TC-5C	4 ab	0.2 ab	72 bc	5 bc	0 a	2 a	0.04 ab	0 a	7 ab
14 RH 7592 75W 1 oz + Sovran 50WG 2.0 oz	TC-5C	12 ab	0.6 ab	47 ab	4 ab	0 a	10 ab	0.4 bc	0 a	5 ab

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

Counts of 25 fruit from each of four single-tree reps 28 Oct. Fruit samples were harvested 23 Sep or 5 Oct and stored at stored at 1 C between harvest and rating.

Fungicide treatments were applied to both sides of the tree with a Swanson Model DA-400 airblast sprayer at 100 gal/A on each application date as follows: 10 Apr (tight cluster, TC all treatments); 22 Apr (open cluster OC-pink); 5 May (petal fall, PF); first – fifth covers, 1C-5C: 18 May, 2 June, 15 June, 8 July, 5 Aug.

Insecticides: 6 Apr (Oil 6 gal/A + Asana XL 10 fl oz /A); 13 May (Thinner-- Sevin XLR + NAA 10 ppm + Regulaid 11 fl oz/A); 11 May, 3 Jun, (Guthion 3F 2 pt + Lannate LV 1.5 pt /A); 18 Jun (Penncap-M 3 pt + Lannate LV 1.5 pt /A); 7 Jul (Imidan 70WSB 1.5 lb + Lannate LV 1.5 pt /A); 5 Aug (Imidan 70WSB 2 lb).

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

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SEQUENTIAL SCHEDULES OF EXPERIMENTAL AND REGISTERED FUNGICIDES FOR SEASON-LONG DISEASE CONTROL ON IDARED APPLE, 1999: Eight treatments involving recently registered and experimental fungicides and a standard were evaluated for control of powdery mildew and other diseases on 17-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: 10 Apr (TC, all treatments); 22 Apr (pink- 15% bloom); 4 May (PF, petal fall); 1st-6th covers (1C-6C) 14 May, 29 May, 11 Jun, 24 Jun, 4 Jul, 11 Aug. Other applications applied to the entire test block with the same equipment included Asana XL+oil, Guthion 3F, Lannate LV, Sevin XLR, Imidan and Penncap-M. Bitter rot mummies and wild blackberry canes with the sooty blotch and fly speck fungi were placed over each Idared test tree 2 Jun. 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 23 Jun. A 25-fruit sample from each replicate tree was harvested 5 Oct and rated after three weeks' storage at 1C. Percentage data were converted by the square root arcsin transformation for statistical analysis.

Mildew inoculum was relatively high on this susceptible cultivar and 34 days were favorable for infection from 24 Apr–15 Jun. Under heavy mildew pressure treatments involving Nova gave significantly better mildew control than the other six treatments which were similarly effective. All treatments gave good control of mildew fruit infection. Scab pressure was light with little foliar infection, and all treatments except GWN-4200 gave adequate control of fruit infection. Following the lowest mid-season summer disease pressure in this test block in more than 5 years, sooty blotch and flyspeck began appearing on non-treated trees about 3 wk after the last application, resulting in a good test of residual effectiveness in September for treatments last applied 11 Aug. GWN-4200, applied alone season-long, gave significant control of sooty blotch and fly speck but was weaker than other treatments. Sovran in tank-mix combination with Topsin-M during the 4th–6th cover sprays gave significantly better control of fly speck than Ziram+Topsin-M, and the three treatments which ended with Sovran all gave excellent fly speck control. No treatments significantly affected fruit finish compared to non-treated trees.

Table 5. Sequential schedules of experimental and registered fungicides for season-long disease control on Idared apple, 1999

			Mildew infection (%)			Fruit disease incidence (%)					Fruit finish (0-5)*	
							Sooty blotch		flyspeck		Opal-	
	Treatment and rate/A	Timing	leaves	% area	fruit	scab	fruit	area	fruit	area	esence	russet
0	No fungicide	---	61.9 c	76.9 c	15 b	8 c	87 c	8.2 c	68 e	3.2 e	1.3 ab	1.4 a
1	Nova 40W 4 oz + Dithane RSNT 75DF 3 lb	TC-3C	4.3 a	1.0 a	1 a	0 a					1.2 ab	1.6 a
	Topsin-M 70W 8 oz + Ziram 76DF 3 lb	4C-6C					17 a	1.0 a	26 cd	0.9 cd		
2	Nova 40W 4 oz + Penncozeb 75DF 3 lb	TC-3C	7.4 a	1.6 a	0 a	0 a					1.2 ab	1.6 a
	Topsin-M 70W 8 oz + Sovran 50WG 3.0 oz	4C-6C					12 a	0.9 a	3 a	0.1 a		
3	GWN-4200 20W 75g	TC-3C	21.3 b	4.1 b	1 a	0 a					1.0 a	1.3 a
	Topsin-M 70W 8 oz + Ziram 76DF 3 lb	4C-6C					13 a	1.0 a	9 ab	0.2 ab		
4	GWN-4200 20W 100g	TC-3C	23.5 b	5.1 b	0 a	2 ab					1.1 ab	1.5 a
	Topsin-M 70W 8 oz + Ziram 76DF 3 lb	4C-6C					9 a	0.4 a	15 bc	0.5 bc		
5	GWN-4200 20W 150g	TC-6C	26.7 b	8.2 b	1 a	4 b	44 b	3.2 b	38 d	1.3 d	1.6 b	1.8 a
6	Sovran 50WG 4.0 oz	TC, 4C-6C					16 a	1.0 a	5 ab	0.1 a		
	Rubigan 1E 9 fl oz + Dithane RSNT 75DF 3 lb	Pink-3C	23.2 b	4.4 b	0 a	0 a					1.0 a	1.2 a
7	Sovran 50WG 4.0 oz	TC, 4C-6C					19 a	1.3 ab	4 a	0.1 a		
	Procure 50WS 8 oz + Dithane RSNT 75DF 3 lb	Pink-3C	23.3 b	4.8 b	0 a	0 a					1.2 ab	1.7 a
8	Rubigan 1E 9 fl oz + Dithane RSNT 75DF 3 lb	Pink-3C	26.1 b	4.8 b	4 a	0 a					1.1 ab	1.6 a
	Sovran 50WG 4.0 oz	4C-6C					17 a	0.9 a	4 a	0.1 a		

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Counts of ten terminal shoots from each of four replicate trees 23 Jun. A 25-fruit sample from each replicate tree was harvested 5 Oct and rated after three weeks' storage at 1C.

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

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:: 10 Apr (TC, all treatments); 22 Apr (pink- 15% bloom); 4 May (PF, petal fall); 1st-6th covers (1C-6C) 14 May, 29 May, 11 Jun, 24Jun, 4 Jul, 11 Aug.

Insecticides: 6 Apr (Oil 6 gal/A + Asana XL 10 fl oz /A); 13 May (Thinner-- Sevin XLR + NAA 10 ppm+Regulaid 11 fl oz/A); 3 Jun (Guthion 3F 2 pt + Lannate LV 1.5 pt /A); 18 Jun (Penncap-M 3 pt+Lannate LV 1.5 pt /A); 7 Jul and 28 July (Imidan 70WSB 1.5 lb + Lannate LV 1.5 pt /A).

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

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DISEASE CONTROL AND FRUIT FINISH BY CONCENTRATE APPLICATIONS OF VANGARD, COPPER, AND DITHIOCARBAMATE FUNGICIDES ON NITTANY APPLE, 1999: Ten treatments involving registered Vangard, dithiocarbamate and copper fungicides were evaluated for broad spectrum disease management and fruit russetting potential on 17-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. Similar treatments had been applied to all trees except #2 and #10 in 1998. Treatments were applied to both sides of the tree on each application date with a Swanson Model DA-400 airblast sprayer at 100 gal/A as follows: 2 Apr (ST-GT, Treatments #5, 6, 7, & 9 only); 10 Apr (½" G, all trts.); 22 Apr (OC); 30 Apr (pink- 50% bloom); 1st- 5th covers: 11 May, 29 May, 15 June, 8 July, 5 August. Insecticides, applied separately to the entire test block with the same equipment, included Asana XL + oil, Guthion 3F, Lannate LV, Penncap-M, Sevin XLR, and Imidan 70WSB. Bitter rot mummies and wild blackberry canes with the sooty blotch and flyspeck fungi were placed over each Idared test tree 2 Jun. 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 23 Aug. A 25-fruit sample from each replicate tree was harvested 12 Oct and rated after 3 weeks' storage at 1C.

Scab inoculum was relatively light in this test block and much of the early season was dry. Under light scab pressure all treatments gave adequate commercial control, however a few significant differences were noted (Table 6). Vangard allowed slightly more scab on foliage but less on fruit when compared to Syllit in the early sprays through bloom. Under moderate mildew pressure all treatments involving Nova gave good to excellent control and treatments relying on copper were generally weaker. Cedar-apple rust infection, most of which occurred midway between the first and second cover sprays, was not well controlled by the copper treatments and half rates of ziram + captan. Fire blight strikes, which were highly variable across the test block were generally less severe on the copper treatments as a group than on the non-copper treatments. Following low mid-season summer disease pressure, sooty blotch and flyspeck began appearing on non-treated trees in September, resulting in a good test of residual effectiveness. Sooty blotch was adequately controlled by all treatments under moderate disease pressure. Treatments with captan alone in in the third-fifth cover sprays had more fly speck than a treatment ending with ziram. All treatments involving copper during the bloom- petal fall period had a significant increase in russet compared to non-treated fruit.

Table 6. Comparison of registered fungicides and copper schedules on Nittany apple

	Treatment and rate/acre	Timing	Scab % lvs	Scab fruit	Mildew % leaves	Mildew % lf area	C-A rust, % lvs	Blight strikes / tree	% of fruit inf. sooty blotch	% of fruit inf. fly speck	Russet rating (0-5)*
0	No fungicide	---	16.1 d	9 c	28.6 e	4.2 d	8 b	13.0 a	41 b	69 e	1.2 a
1	Nova 40W 4 oz + Dithane RSNT 75DF 3 lb	1/2" G-2C	0.5 ab	0 a	4.9 ab	0.9 ab	0 a	18.5 a	11 a	22 cd	1.6 abc
	Captan 50W 6 lb	3C-5C									
2	Vangard 75WG 5.0 oz	1/2" G-BI	1.8 bc	0 a	8.1 bcd	1.4 bc	1 a	11.5 a	6 a	29 d	1.1 a
	Vangard 3 oz + Dithane RSNT 75DF 3 lb	1C-2C									
	Captan 50W 6 lb	3C-5C									
3	Nova 40W 4 oz+Thiram Granuflo 75WDG 3.0 lb	1/2" G-2C	0.7 ab	0 a	7.3 bcd	1.3 bc	0 a	20.3 a	0 a	5 ab	1.4 abc
	Thiram Granuflo 75WDG 6.0 lb	3C-5C									
4	Nova 40W 4 oz+Ziram Granuflo 76WDG 3.0 lb	1/2" G -2C	0.3 ab	0 a	5.6 abc	0.8 ab	0 a	12.8 a	0 a	6 abc	1.4 abc
	Ziram Granuflo 76WDG 6.0 lb	3C-5C									
5	Basic Copper "53" 5 lb + Hydrated Lime 8 lb	GT									
	Basic Copper "53" 1.5 lb + Hydrated Lime 8 lb	1/2" G-1C	0.7 abc	1 ab	15.4 de	2.2 cd	5 b	5.8 a	1 a	3 a	2.2 d
	Basic Copper "53" 4 lb + Hydrated Lime 12 lb	2C-3C									
	Basic Copper "53" 4 lb + Hydrated Lime 8 lb	4C-5C									
6	Basic Copper "53" 5 lb + Hydrated Lime 8 lb	GT									
	Basic Copper "53" 1.5 lb + Hydrated Lime 8 lb	1/2" G-1C	1.1 bc	0 a	12.5 cd	1.6 bc	4 b	1.8 a	1 a	4 ab	1.7 bcd
	Basic Copper "53" 1.5 lb + Hydrated Lime 12 lb	2C-3C									
	Basic Copper "53" 4 lb + Hydrated Lime 8 lb	4C-5C									
7	Basic Copper "53" 5 lb + Hydrated Lime 8 lb	GT									
	Nova 40W 4 oz + Dithane RSNT 75DF 3 lb	1/2" G-2C	0.0 a	0 a	1.1 a	0.2 a	0 a	6.3 a	6 a	18 bcd	1.3 ab
	Captan 50W 3 lb + Ziram 76WDG 3 lb	3C-5C									
8	Basic Copper "53" 1.5 lb + Hydrated Lime 8 lb	GT									
	Basic Copper "53" 1.5 lb + Hydrated Lime 8 lb	1/2" G-1C	3.1 c	0 a	10.6 bcd	1.6 bc	9 b	0.8 a	4 a	3 ab	1.9 cd
	Captan 50W 3 lb + Ziram 76WDG 3 lb	2C-3C									
	Basic Copper "53" 4 lb + Hydrated Lime 8 lb	4C-5C									
9	Basic Copper "53" 1.5 lb + Hydrated Lime 8 lb	GT									
	Captan 50W 3 lb + Ziram 76WDG 3 lb	1/2" G-5C	1.1 ab	0 a	12.7 cd	1.8 bc	5 b	2.5 a	0 a	4 ab	1.9 cd
10	Syllit 65W 1.5 lb	1/2" G-BI	0.0 a	2 b	4.8 abc	1.0 bc	0 a	9.0 a	1 a	5 ab	1.6 abc
	Vangard 3 oz + Dithane RSNT 75DF 3 lb	PF-2C									
	Ziram 76DF 6 lb	3C-5C									

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Similar treatments were applied to all trees except #2 and #10 in 1998. Counts of ten terminal shoots from each of four single-tree replicates 23 Aug. A 25-fruit sample from each replicate tree was harvested 12 Oct and rated after 3 weeks' storage at 1C.

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

APPLE (*Malus domestica* 'Golden Delicious', 'Red Delicious', and Rome Beauty')
Scab; *Venturia inaequalis*
Powdery mildew; *Podosphaera leucotricha*
Sooty blotch; Disease complex
Fly speck; *Zygophiala jamaicensis*
Fruit rots
Fruit finish

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EVALUATION OF EXPERIMENTAL FUNGICIDES AND APOGEE FOR FUNGAL DISEASE EFFECTS ON THREE APPLE CULTIVARS, 1999: TM-41501, GWN-4200 and supplemental fungal disease effects of the plant growth regulator, Apogee, were evaluated on 10-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 1998 to allow buildup of powdery mildew inoculum. Regular fungicide treatments were applied dilute to the point of runoff with a single nozzle handgun at 200 psi to all cultivars as follows: 14 Apr (Red Del. OC, open cluster, G. Delicious ½"G-TC, half-inch green to tight cluster, Rome ½"G-TC); 22 Apr (Red Delicious pink, G. Del. OC, Rome, TC, tight cluster); 5 May(R. Del. beyond petal fall, PF, G. Del. PF, Rome, bloom); 1st-5th covers (1C-5C) 20 May, 3 June, 18 June, 8 July and 5 Aug. Apogee was applied separately, also as dilute sprays, to treatments #6, 8, and 9 at the following dates and growth stages: 14 Apr (R. Del. only, OC); 23 Apr (Golden Delicious only, pink); 27 Apr, (Rome only, pink). Insecticides applied separately with a commercial airblast sprayer included Asana XL oil, Guthion 3F, Lannate LV, Sevin XLR, Spintor, and Provado 1.6F. Bitter rot mummies and wild blackberry canes with the sooty blotch and flyspeck fungi were placed over each Golden Delicious test tree 2 Jun. 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 12 July (Rome), 14 July (Golden Delicious) or 26 July (Red Delicious). Fruit samples were taken from each replicate tree 30 Sep (Red and Golden Delicious) or 14 Oct (Rome), and rated after 3-4 wks' storage at 1C. Percentage data were converted by the square root arcsin transformation for statistical analysis.

The first treatments were applied 3 days after the first scab infection period. At that time Red Delicious and Golden Delicious had green tissue exposed for infection but Rome did not, resulting in less infection and better control by protectant treatments on Rome. Under moderate disease pressure TM-41501 gave good scab control on all cultivars. GWN-4200 gave good control on Rome foliage and on fruit of all cultivars but was weaker on foliage of Red and Golden Delicious, possibly as a result of failure to control infection that had occurred before the first application. TM-41501 also controlled mildew under heavy pressure and was significantly better than GWN-4200 and ziram-sulfur on Rome; GWN-4200 was comparable to Nova, and sulfur was significantly less effective. Sooty blotch and fly speck began to appear in September following a dry season. TM-41501gave a rate gradient for sooty blotch on Red Delicious but not on Golden Delicious or Rome. Apogee treatment without additional fungicide protection gave weak, but statistically significant, effects on scab on leaves and fruit of Red Delicious and Rome, on Golden Delicious fruit, and on mildew on Rome leaves. In applying the treatments early in the season it was hoped that growth would be stopped early, thus reducing susceptibility of the shoots; however, measurement of the sample shoots indicated that this was not the case, and that disease suppression effects were not related to growth reduction, at least on those shoots. No significant differences could be detected on trees treated, versus not treated, with Apogee under the ziram-sulfur or Nova-ziram schedules in any disease category although there appeared to be ample disease present to test for such effects with mildew on Rome and sooty blotch and fly speck on Golden Delicious.

Table 7. Test of experimental fungicides and Apogee for early season apple disease control effects

		Scab, % leaves or fruit infected						Mildew incidence or % area					Mean sample shoot length, cm		
		R. Delicious		G. Delicious		Rome		Rome			G. Delicious				
Rate per 100 gal dilute*	Timing	leaves	fruit	leaves	fruit	leaves	fruit	leaves	area	fruit	leaves	area	R. Del	Rome	G. Del
0 No fungicides	---	23 e	18 c	29 d	18 c	20 d	10 c	58 f	20 d	0 a	39 d	8 c	14.2 a	31.7 ab	30.6 a
1 TM-41501 125SC 2.25 fl oz	OC-5C	2 ab	0 a	2 abc	0 a	2 ab	1 a	9 ab	2 a	0 a	9 ab	1 a	--	--	--
2 TM-41501 125SC 3.25 fl oz	OC-5C	1 a	0 a	1 a	1 a	2 ab	0 a	6 a	2 a	0 a	6 a	1 a	--	--	--
3 TM-41501 125SC 6.5 fl oz	OC-5C	1 a	0 a	0.4 a	0 a	1 ab	0 a	8 ab	2 a	0 a	11 ab	2 ab	--	--	--
4 GWN-4200 20W 37.5g Ziram 76DF 1 lb	Thru 2ndC 3C-5C	8 c	1 a	7 c	2 a	1 ab	1 a	15 bc	3 ab	0 a	14 bc	2 ab	--	--	--
5 Nova 40W 1 oz Ziram 76DF 1 lb	Thru 2ndC 3C-5C	1 a	0 a	0.4 a	0 a	0.2 a	1 a	12 abc	3 ab	0 a	7 ab	2 ab	13.7 a	40.3 c	37.1 bc
6 Nova 40W 1 oz Apogee 27.5WDG 12.1 oz (250 ppm) Ziram 76DF 1 lb	Thru 2ndC 1 app. (OC) 3C-5C	2 ab	2 a	1 ab	0 a	1 ab	1 a	15 bc	3 ab	0 a	6 a	1 a	10.3 a	29.6 a	28.8 a
7 Ziram 76DF 12 oz + Sulfur 1.5 lb Ziram 76DF 1 lb	Thru 2ndC 3C-5C	4 bc	0 a	4 c	0 a	3 b	0 a	20 cd	3 ab	1 b	22 c	3 b	13.6 a	37.6 bc	39.0 c
8 Ziram 76DF 12 oz + Sulfur 1.5 lb Apogee 27.5WDG 12.1 oz (250 ppm) Ziram 76DF 1 lb	Thru 2ndC 1 app. (OC) 3C-5C	4 bc	1 a	4 bc	0 a	2 b	0 a	28 de	5 bc	0 a	21 c	3 b	14.2 a	32.5 abc	27.5 a
9 Apogee 27.5WDG 12.1 oz (250 ppm)	1 app. (OC)	15 d	10 b	22 d	8 b	9 c	4 b	33 e	7 c	4 c	36 d	7 c	13.5 a	32.3 ab	31.3 ab

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Four single-tree replicates of each cultivar.

Counts of ten terminal shoots per tree 12 July (Rome), 14 July (Golden Delicious) or 26 July (Red Delicious) or 25 fruit per tree after harvest.

*Treatments: Dilute treatments applied to the point of runoff with a single nozzle handgun at 200 psi. Treatments were applied to Rome trees that were not treated in 1998.

Application dates:

14 Apr-- Red Del. OC, open cluster, G. Delicious ½"G-TC, Rome ½"G. All treatments. Apogee on #6, 8, and 9 on R. Del. only).
22 Apr – Regular reatments 1-8. Red Delicious pink, G. Del. OC, Rome, TC, tight cluster.
Apogee only at pink on treatments #6, 8, and 9 on Golden Delicious 23 Apr and Rome 27 Apr.
5 May-- Regular treatments 1-8. R. Del. beyond petal fall, PF, G. Del. PF, Rome, bloom.
1st-5th covers (1C-5C) 9, all cultivars: 20 May, 3 June, 18 June, 8 July and 5 Aug.

Table 8. Test of fungicides and Apogee for summer disease control on Red Delicious, Golden Delicious, Rome Beauty

		Sooty blotch, % fruit or % area infected						Flyspeck, % fruit			% rots
		Red Delicious		G. Delicious		Rome					
Rate per 100 gal dilute*	Timing	fruit	% area	fruit	% area	fruit	% area	R. Del	G. Del	Rome	G. Del
0 No fungicides	—	38 e	2.1 d	81 c	8.1 c	66 e	8.3 c	26 c	25 a	35 d	6 b
1 TM-41501 125SC 2.25 fl oz	OC-5C	12 cd	0.4 b	36 a	2.7 a	13 abc	0.7 abc	4 ab	4 a	3 ab	0 a
2 TM-41501 125SC 3.25 fl oz	OC-5C	5 bc	0.2 b	33 a	3.0 a	22 bc	1.3 bc	11 ab	15 a	8 bc	1 ab
3 TM-41501 125SC 6.5 fl oz	OC-5C	0 a	0.0 a	33 a	2.2 a	18 abc	1.1 abc	4 ab	6 a	1 a	0 a
4 GWN-4200 20W 37.5g	Thru 2ndC										
Ziram 76DF 1 lb	3C-5C	4 b	0.3 b	48 a	4.8 abc	29 cd	2.2 cd	10 abc	13 a	12 c	0 a
5 Nova 40W 1 oz	Thru 2ndC										
Ziram 76DF 1 lb	3C-5C	4 ab	0.2 ab	54 ab	4.0 ab	8 a	0.5 a	4 a	13 a	0 a	2 ab
6 Nova 40W 1 oz	Thru 2ndC										
Apogee 27.5WDG 12.1 oz (250 ppm)	1 app. at OC										
Ziram 76DF 1 lb	3C-5C	9 bc	0.4 b	50 ab	3.3 a	9 ab	0.7 ab	5 ab	13 a	4 ab	0 a
7 Ziram 76DF 12 oz + Sulfur 1.5 lb	Thru 2ndC										
Ziram 76DF 1 lb	3C-5C	4 b	0.1 ab	51 ab	4.0 ab	16 abc	1.0 abc	7 ab	10 a	7 bc	0 a
8 Ziram 76DF 12 oz + Sulfur 1.5 lb	Thru 2ndC										
Apogee 27.5WDG 12.1 oz (250 ppm)	1 app. at OC										
Ziram 76DF 1 lb	3C-5C	5 b	0.2 ab	46 a	3.3 a	9 ab	0.5 ab	5 a	7 a	8 bc	0 a
9 Apogee 27.5WDG 12.1 oz (250 ppm)	1 app. at OC	21 d	1.0 c	71 bc	7.6 bc	46 de	3.7 d	14 bc	21 a	34 d	1 ab

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Fruit samples were taken from each replicate tree 30 Sep (Red and Golden Delicious) or 14 Oct (Rome), and rated after 3-4 wks' storage at 1C.

*Treatments: Dilute treatments applied to the point of runoff with a single nozzle handgun at 200 psi. Treatments were applied to Rome trees that were not treated in 1998.

Application dates:

14 Apr-- Red Del. OC, open cluster, G. Delicious ½"G-TC, Rome ½"G. All treatments. Apogee on #6, 8, and 9 on R. Del. only).
22 Apr – Regular reatments 1-8. Red Delicious pink, G. Del. OC, Rome, TC, tight cluster.
Apogee only at pink on treatments #6, 8, and 9 on Golden Delicious 23 Apr and Rome 27 Apr.
5 May-- Regular treatments 1-8. R. Del. beyond petal fall, PF, G. Del. PF, Rome, bloom.
1st-5th covers (1C-5C) 9, all cultivars: 20 May, 3 June, 18 June, 8 July and 5 Aug.

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

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SUPPRESSION OF FIRE BLIGHT INFECTION OF APPLE SHOOTS BY APOGEE, 1999: Fireblight is an increasingly important disease in apple production throughout the mid-Atlantic region. Factors related to its increase in prominence include more plantings of highly susceptible scion/rootstock combinations, and the use of crabapple pollinizers within high density orchards. Streptomycin resistance by the fireblight bacterium, *Erwinia amylovora*, has not yet not been proven in the mid-Atlantic region. However, this concern, and the increasing planting of highly susceptible scions and rootstocks, heightens the need to avoid cultural practices which increase tree susceptibility. The research reported here is part of a continuing study of the effects of the plant growth regulator, prohexadione-Ca (Apogee) on suppression of shoot blight in apple trees. Previous studies 1994-98 showed the onset of shoot growth suppression and the start of reduction of susceptibility at 7-14 days after application. The effect was generally rate-related (at 125 and 250 ppm) and varied with cultivar (Golden Delicious and Rome). A synergistic effect has been observed, increasing the apparent effectiveness of streptomycin applied a week after Apogee. Shoot susceptibility (likelihood of infection) was related to perceived shoot vigor, but not entirely so. 1999 treatments were designed to test for improved activity by including ammonium sulfate as suggested on the label for situations where the spray water is high in calcium, and to test for interactions between Apogee and ethephon (Ethrel) as applied to promote return bloom of biennial bearing cultivars.

Apogee 27.5DF treatments of 125 or 250 ppm were applied to pairs of Rome Beauty and Golden Delicious trees in a five-replicate randomized block design 4 May 1999. Agri-Mycin was applied to trees previously treated with Apogee 250 ppm and to previously untreated trees 13 May, the day before the first inoculation 14 May. Treatments were applied dilute to runoff with a single nozzle handgun at 400 psi. Regulaid was included with all Apogee, Ethrel, and Ammonium sulfate treatments at 4 fl oz /100 gal. A second Apogee application was to treatment #2 only, 25 May. Test shoots flagged 6 May, ten shoots per cultivar per inoculation date. Six non-inoculated shoots were also flagged 6 May for growth measurements at 20, 30, 60 and 90 days after Apogee treatment (DAT). Test shoots were inoculated 14 May, and 24 May (10 or 20 DAT). Shoot tips were inoculated in the last leaf node with a No. 25 hypodermic syringe holding one droplet of a bacterial suspension solution containing approximately $1X10^8$ cells/ml. Inoculum was obtained by growing an *E. amylovora* culture on nutrient yeast dextrose agar for one or two days at 25°C, and harvesting and suspending the bacteria in a phosphate buffer. At the time of inoculation, shoots were rated for perceived vigor based on the following scale: 1- very succulent, active growth; 2- less susceptible than 1 but still growing actively; 3- indications that growth is stopping, but with a small growing leaf at the shoot tip; 4- growth recently stopped; youngest leaf less than half size; 5- growth stopped; youngest leaf more than half size. Fireblight incidence and visible extent of canker progression were assessed on excised shoots 24 Jun.

1999 inoculations resulted in very heavy shoot infection of test trees, averaging nearly 100% both days on Rome and 72- 92% on Golden Delicious, resulting in less suppression of percent shoots infected than seen in previous years. On Rome the only significant suppression was 14% by Apogee 250 ppm 20 DAT. However, there was a greater suppression of canker length of infected shoots than seen previously. Inclusion of ammonium sulfate with Apogee improved effectiveness of Apogee, giving activity by 6 oz / 100gal (125 ppm) effectiveness comparable to 250 ppm as indicated by non-inoculated shoot length, shoot vigor rating, and mean canker lengths. Similar effects were observed on Golden Delicious but there was a stronger effect on percent shoots infected than on Rome, similar to what had been observed previously at 10 and 20 DAT. Ammonium sulfate applied alone had no significant effect compared to non-treated trees of either cultivar. Ethrel had no positive or negative effect applied alone or in combination with Apogee.

A paper reporting the work from 1994-1997 is due to be published in December 1999 HortScience:

Yoder, K. S., S. S. Miller and R. E. Byers. 1999. Suppression of fireblight in apple shoots by prohexadione-calcium (BAS 125 W) following experimental and natural inoculation *conditions*. HortScience 34:11-13.

Table 9. 1999 evaluation of Apogee, Agri-Mycin and Ethrel for suppression of fireblight on Rome Beauty apple shoots inoculated 10 or 20 days after treatment (DAT), Winchester, VA

Treatment and rate/100 gal dilute*	Timing	% shoots inf. inoculated DAT		Mean shoot vigor rating DAT		Effect of DAT on canker length (cm): All inoc. shoots		Effect of DAT on canker length (cm): Inf. shoots only		Non-inoculated shoot length (cm)**		
		10 DAT	20 DAT	10 DAT	20 DAT	10 DAT	20 DAT	10 DAT	20 DAT	24 May	4 Jun	15 Jun
0 No treatment	---	98 ab	100 b	1.9 a	2.5 b	11.1 bc	18.8 bc	11.2 ab	18.8 cd	18.5 d	21.5 d	21.8 cd
1 Apogee 27.5DF 12 oz + Regulaid 4 fl oz	Bloom only (5/4)	89 ab	86 a	1.7 a	3.4 a	6.7 a	8.5 a	7.5 a	9.7 a	10.3 a	11.1 a	11.4 a
2 Apogee 27.5DF 6 oz + Regulaid 4 fl oz	Bloom + 3 wk (5/4 & 5/25)	94 ab	98 ab	1.5 a	2.9 ab	9.4 abc	13.6 ab	10.0 ab	14.0 abc	12.9 abc	14.0 abc	14.6 abc
3 Apogee 27.5DF 6 oz + Regulaid 4 fl oz	Bloom only (5/4)	90 ab	96 ab	1.6 a	3.3 ab	9.4 abc	13.3 ab	9.9 ab	13.9 abc	13.3 a-d	14.0 abc	14.2 abc
4 Apogee 27.5DF 12 oz + Regulaid 4 fl oz............ Agri-Mycin 17 8 oz	Bloom (5/4) 1 day pre-inoc. (5/13)	83 a	87 ab	1.6 a	3.2 ab	7.2 ab	10.6 a	8.5 ab	12.0 ab	9.8 a	10.3 a	10.5 a
5 Agri-Mycin 17 8 oz	1 day pre-inoc. (5/13)	95 ab	98 ab	1.7 a	2.4 b	11.7 c	17.4 bc	12.2 b	17.8 bcd	18.3 cd	22.0 d	22.8 d
6 Apogee 27.5DF 6 oz + Ethrel 5 fl oz Regulaid 4 fl oz	Bloom only (5/4)	100 b	98 ab	1.2 a	3.0 ab	11.3 c	14.1 abc	11.3 ab	14.4 abc	12.0 ab	12.6 ab	13.1 ab
7 Ethrel 5 fl oz Regulaid 4 fl oz	Bloom only (5/4)	96 ab	88 ab	2.0 a	2.5 b	11.7 c	19.9 c	12.3 b	22.6 d	18.2 cd	21.2 cd	21.8 cd
8 Apogee 27.5DF 6 oz + Ammonium sulfate 6 oz+ Regulaid 4 fl oz	Bloom only (5/4)	93 ab	90 ab	2.1 a	3.4 a	7.1 a	10.1 a	7.5 a	11.5 a	8.8 a	10.9 a	11.3 a
9 Ammonium sulfate 6 oz+ Regulaid 4 fl oz	Bloom only (5/4)	98 ab	92 ab	1.5 a	2.6 b	12.0 c	17.0 bc	12.2 b	18.0 cd	16.5 bcd	19.0 bcd	20.5 bcd

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

* Dilute treatments applied to the point runoff with a single nozzle handgun at 400 psi. Apogee treatments applied 4 May; Agri-Mycin (1-day pre-inoc. treatment for first inoculation) applied to treatments 4 & 5 13 May (Rome petal fall); second Apogee application, treatment, #2 only, 25 May.

** Six non-inoculated shoots/tree were measured at 20, 30, 60, and 90 days.

Test shoots flagged 6 May (10 / cultivar / inoculation date). Two inoculation dates at 10 and 20 days: 14 May, and 24 May. Shoots inoculated in the last leaf node at the shoot tip with a No. 25 hypodermic syringe holding one droplet of a suspension of $1X10^8$ *E. amylovora* cells/ml.

Flag colors: 1st inoculations, 14 May- pink/black; 2nd inoculations, 24 May-orange.

Table 10. 1999 evaluation of Apogee, Agri-Mycin and Ethrel for suppression of fireblight on Golden Delicious apple shoots, inoculated 10 or 20 days after treatment (DAT), Winchester, VA

Treatment and rate/100 gal dilute*	Timing	% shoots inf. inoculated DAT		Mean shoot vigor rating DAT		Effect of DAT on canker length (cm): All inoc. shoots		Effect of DAT on canker length (cm): Inf. shoots only		Non-inoculated shoot length (cm)**		
		10 DAT	20 DAT	10 DAT	20 DAT	10 DAT	20 DAT	10 DAT	20 DAT	24 May	4 Jun	15 Jun
0 No treatment	---	92 d	72 c	1.6 a	2.9 a	7.7 abc	12.2 cd	8.2 ab	15.1 a	20.9 d	23.1 d	23.6 c
1 Apogee 27.5DF 12 oz + Regulaid 4 fl oz	Bloom only (5/4)	70 abc	32 a	1.8 a	3.0 a	4.3 ab	4.3 a	6.1 ab	13.4 a	14.1 ab	14.7 a	14.9 a
2 Apogee 27.5DF 6 oz + Regulaid 4 fl oz	Bloom + 3 wk (5/4 & 5/25)	70 abc	49 ab	1.9 a	3.2 a	6.1 ab	8.0 abc	8.1 ab	13.8 a	13.9 ab	14.3 a	14.6 a
3 Apogee 27.5DF 6 oz + Regulaid 4 fl oz	Bloom only (5/4)	62 ab	48 ab	1.7 a	3.0 a	4.4 ab	5.4 ab	6.8 ab	11.0 a	15.4 abc	15.9 abc	16.0 ab
4 Apogee 27.5DF 12 oz +		67 abc	52 ab	1.8 a	3.0 a	4.1 ab	6.5 abc	5.3 a	13.4 a	14.1 ab	14.8 ab	15.0 a

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

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Laboratory evaluation of Agri-Mycin for systemic protection of unopened Golden Delicious and Rome Beauty apple blossoms from fire blight, 1999. With continuing improvement in the ability to predict fire blight epidemics and concern about the potential development of resistance to streptomycin, fine-tuning of the streptomycin application schedule is desirable. A lingering question about whether streptomycin applied to unopened blossoms will protect them after they open was addressed in this laboratory experiment.

Methods. Fruiting spurs with unopened blossoms were collected from non-treated trees 29 Apr. The basal ends of the spurs were cut at an angle to allow water uptake to maintain blossom cluster turgor throughout the course of the experiment. The openings of flasks were covered with Parafilm M and the cut tip of the spur was placed through a hole in a Parafilm M cover into a flask containing tap water. Any open blossoms were removed with a scissors prior to treatment. The test involved four replications with 30-65 blossoms per replication in a randomized block design. Treatments were applied 29 April. The streptomycin spray was applied to the entire flower cluster and cluster leaves to the point of runoff with a small hand sprayer. As a second treatment a cotton swab was used to apply streptomycin to the pedicel only. Test blossoms were inoculated 24 hours after treatment. Prior to inoculation, the number of open susceptible blossoms was noted. Blossoms were inoculated by misting two ml of a suspension containing or $1X10^6$ or $1X10^7$ *E. amylovora* cells/ml into each test cluster. Following inoculation, clusters were allowed to dry overnight, enclosed in plastic storage containers, and incubated at 22-24C on the lab bench. Blossom nectary and pedicel infection symptoms were rated six and eight days after inoculation respectively. Symptoms were rated as positive if nectaries were discolored or if discoloration appeared to be advancing from the distal end of the pedicel and if more than half of the pedicel was discolored.

Results and discussion. The higher inoculum rate significantly increased symptom incidence on Rome blossoms and pedicels and on Golden Delicious pedicels. A spray of streptomycin 100 ppm applied to clusters of closed blossoms significantly reduced the development of fire blight symptoms on blossoms inoculated 24 hrs after treatment. On Rome, symptoms on both blossoms and pedicels were significantly suppressed; on Golden Delicious nectary symptom incidence was not suppressed but advanced infection into pedicels was inhibited. The cotton swab application of streptomycin failed to suppress symptoms on blossoms or pedicels of either cultivar, possibly because of difficulty in applying the material uniformly or injuring the trichomes on the pedicels. Regardless, the spray application method is more commercially relevant, and spray treatment data indicate that the suggested four-day application interval will help to protect unopened blossoms, some of which could receive two applications before opening. In commercial practice, inoculum levels likely would be lower than those used in this test and the inhibitory protective effect of streptomycin might be more pronounced.

Fireblight symptoms on nectaries and pedicels following treatment of unopened blossoms

		Rome Beauty blossoms				Golden Delicious blossoms			
	E. amy.	nectaries		pedicels		nectaries		pedicels	
Treatment	inoculum rate cfu/ml	% symp-toms	% con-trol	% symp-toms	% con-trol	% symp-toms	% con-trol	% symp-toms	% con-trol
No treatment	$1X10^6$	36.9 b	---	48.3 cd	---	73.1 ab	---	63.8 b	---
Streptomycin 100 ppm spray	$1X10^6$	18.2 a	50.7	10.3 a	78.7	71.5 a	2.1	24.1 a	62.2
Strep 100 ppm pedicel swab	$1X10^6$	33.7 b	8.7	36.4 bc	24.1	87.4 b	0	62.4 b	2.2
No treatment	$1X10^7$	61.5 c	---	66.6 e	---	87.4 ab	---	80.1 b	---
Streptomycin 100ppm spray	$1X10^7$	40.8 b	33.7	22.6 b	66.1	86.4 a	1.1	30.5 a	61.9
Strep 100 ppm pedicel swab	$1X10^7$	65.4 c	0	61.2 de	8.1	94.8 b	0	69.5 b	13.2

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

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

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EVALUATION OF REGISTERED AND EXPERIMENTAL FUNGICIDES FOR DISEASE CONTROL ON REDHAVEN PEACH AND REDGOLD NECTARINE, 1999: Several experimental and registered fungicides were compared for broad spectrum disease control on 7-yr-old trees. The planting is composed of 3-tree sets, each including Redhaven peach (which was not treated with fungicides in 1998 to allow the buildup of scab inoculum), Redgold nectarine in test in 1998, and Loring peach which was not treated with fungicides in 1999. Brown rot inoculum was introduced into the orchard by placing three mummified fruit in each test tree before bloom. Dilute treatments were applied to the point of run-off (approximately 200 gal/A) with a single nozzle handgun at 300 psi in a randomized block design with four single-tree replicates. Treatments to Redhaven were as follows: Leaf curl applications treatments (Thiram and Ziram Granuflo and Tenn-Cop only): 23 Mar (BS, bud swell); all treatments: 2 Apr (pink) 13 Apr (Bl, bloom); 22 Apr (late bloom PF, petal fall); 1st-5th covers 5 May, 21 May, 3 June, 22 June, 7 July. 21 July (2-wk pre-harvest Redhaven, 6th cover Redgold); 28 July (1-wk pre-harvest Redhaven only), 3 Aug (1 day pre-harvest Redhaven, 2 wk pre-harvest Redgold), 11 Aug (1 wk pre-harvest Redgold). Commercial insecticides were applied to the entire test block at 2-3 wk intervals with a commercial airblast sprayer. Samples of 40 apparently rot-free Redhaven fruit per replicate tree were harvested 4 Aug, 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 10,000 benzimidazole-sensitive *M. fructicola* conidia/ml. All were incubated in polyethylene bags at ambient temperature 22-30C (mean 26.5C) for the indicated interval before assessing rot development. Redgold fruit were harvested 18 Aug and handled as indicated for Redhaven. Ambient temperatures during Redgold incubation were 20-30C (mean 24.2C)

Leaf curl infection on untreated Redhaven trees was the heaviest in research plots on 23 years. Leaf curl incidence was higher on Redhaven than on Redgold, a result of not receiving fungicides in 1998. Ziram and Thiram Granuflo and Tenn-Cop, applied at bud swell 23 Mar, gave excellent control as expected. Elite, Indar, and one rate of GWN-4200, first applied at pink also gave significant leaf curl suppression. Weather conditions throughout the early cover spray period were not unusually favorable for scab infection and all treatments gave excellent control with 38% of untreated fruit infected. Brown rot incidence was light on non-inoculated peach and nectarine fruit, in spite of hail injury which occurred on about half of the nectarine fruit several days before harvest. Inoculation increased disease pressure on most treatments, providing a good test of residual effectiveness. Indar and Elite gave good brown rot control for standard comparison on peach, as did schedules ending with Thiram 7 days PHI with a 1-day PHI of Indar. This treatment was less effective on nectarine where it ended with Thiram and did not receive the pre-harvest Indar application. TM-41501 gave excellent brown rot control on peach throughout the incubation period. A rate response by TM-41501 was apparent on nectarine and the highest rate and Indar gave superior control throughout the incubation period. GWN-4200 gave significant brown suppression at the highest rate on peach but was only residual to five or six days at the highest rate on nectarine. Benlate + captan was moderately effective as a standard and culturing of isolates from several sample fruit indicated that the results were not affected by benzimidazole resistance.

Table 11. Control of leaf curl, scab and brown rot by standard and experimental treatments on Redhaven peach

Treatment and rate/100 gal dilute	Timing*	Leaf curl ratings: Buds/inf. /shoot	Leaf curl ratings: % shoot area inf	% fruit with scab	Brown rot after days' incubation, % inoc. fruit inf.: 3 day	5 day	7 day	9 day	% fruit not rotted after 9 days incub.: inoc.	non-inoc.
No fungicide	---	41 e	30 d	34 b	14 c	26 c	45 d	96 e	24 g	43 d
Thiram Granuflo 75WDG 1.7 lb	BS-PF, 14 & 7 PHI	0 a	0 a	0 a						
Microfine Sulfur 90W 3 lb	Covers									
Indar 75W 1 oz+B-1956 4 fl oz	1 day PHI				1 a	3 a	9 ab	13 bc	76 ab	81 a
Ziram Granuflo 76 WDG 1.7 lb	BS-PF, 14 PHI	0 a	0 a	0 a						
Microfine Sulfur 90W 3 lb	Covers									
Thiram Granuflo 75WDG 1.7 lb	7 PHI									
Indar 75W 1 oz+B-1956 4 fl oz	1 day PHI				0 a	0 a	8 ab	9 abc	74 abc	80 a
Tenn-Cop 5E 2 qt	BS	0 a	0 a							
Benlate 50W 4 oz+ Captan 50W 1 lb	P- pre-harvest			0 a	1 a	4 ab	10 ab	15 abc	81 ab	73 abc
Indar 75W 1 oz+B-1956 4 fl oz	P- pre-harvest	22 bcd	5 bc	0 a	1 a	3 a	3 a	4 ab	90 a	88 a
Elite 45DF 2.5 oz	P-PF, pre-har	13 b	2 ab	0 a	0 a	0 a	5 ab	11 bc	70 a-d	78 a
Microfine Sulfur 90W 3lb	Covers									
TM-41501 125SC 4.5 fl oz	P- pre-harvest	33 de	17 cd	1 a	3 ab	4 ab	5 ab	9 abc	56 b-e	59 bcd
TM-41501 125SC 6.5 fl oz	P- pre-harvest	28 cde	7 bc	0 a	0 a	0 a	5 ab	11 abc	50 c-f	70 abc
TM-41501 125SC 13 fl oz	P- pre-harvest	27 cde	10 bc	0 a	0 a	0 a	0 a	0 a	85 a	79 ab
GWN-4200 20W 37.5g + +B-1956 4 fl oz	P-PF, pre-harvest	29 cde	7 bc	0 a	6 bc	11 bc	36 cd	46 de	26 fg	46 d
Microfine Sulfur 90W 3lb	Covers									
GWN-4200 20W 50.0g + +B-1956 4 fl oz	P-PF, pre-harvest	18 bc	5 bc	0 a	8 bc	14 bc	35 cd	43 de	39 efg	43 d
Microfine Sulfur 90W 3lb	Covers									
GWN-4200 20W 75.0g + +B-1956 4 fl oz	P-PF, pre-harvest	34 de	13 bc	0 a	0 a	0 a	16 bc	24 cd	48 d-g	58 cd
Microfine Sulfur 90W 3lb	Covers									

Averages of four single tree replications, 20 fruit per replicate. Mean separation by Waller-Duncan K-ratio t-test (p=0.05).

Fungicide application dates: 23 March (BS, bud swell, Thiram and Ziram Granuflo and Tenn-Cop only); 2 Apr (P, pink, all treatments); 13 Apr (bloom); 22 Apr (late bloom-petal fall); 1st-5th cover schedule: 5 May, 21 May, 3 June, 22 June, 7 July, 21 July (2-wk pre-harvest, Redhaven), 28 July (1-wk preharvest Redhaven only), 3 Aug (1 day pre-harvest, Redhaven). Sampled 4 Aug.

Table 12. Control of brown rot by standard and experimental treatments on Redgold nectarine

		% inoculated fruit with brown rot after indicated days' incubation							% non-inoculated fruit with brown rot			
Treatment and rate/100 gal dilute	Timing*	5 day	6 day	7 day	9 day	12 day	14 day	16 day	9 day	12 day	14 day	20 day
No fungicide	---	11 c	18 c	28 d	51 fg	79 ef	85 fg	95 f	9 b	15 b	19 c	34 c
Thiram Granuflo 75WDG 1.7 lb	BS-PF, 14 & 7 PHI	6 bc	11 c	16 cd	26 cde	43 cd	51 cd	56 cd	0 a	0 a	0 a	1 a
Microfine Sulfur 90W 3 lb	Covers											
Ziram Granuflo 76 WDG 1.7 lb	BS-PF, 14 PHI											
Microfine Sulfur 90W 3 lb	Covers											
Thiram Granuflo 75WDG 1.7 lb	7 PHI	9 bc	13 bc	15 bcd	29 def	49 d	43 de	70 de	0 a	1 a	1 ab	3 a
Tenn-Cop 5E 2 qt	BS											
Benlate 50W 4 oz+ Captan 50W 1 lb	P- pre-harvest	1 a	3 a	5 abc	11 bcd	21 bc	26 bc	34 bc	0 a	0 a	0 a	1 a
Indar 75W 1 oz+B-1956 4 fl oz	P- pre-harvest	0 a	0 a	0 a	0 a	6 a	10 ab	13 a	0 a	0 a	0 a	0 a
Elite 45DF 2.5 oz	P-PF, pre-har	0 a	0 a	0 a	3 ab	8 a	13 ab	21 ab	0 a	0 a	0 a	0 a
Microfine Sulfur 90W 3lb	Covers											
TM-41501 125SC 4.5 fl oz	P- pre-harvest	0 a	4 a	8 abc	11 bc	23 bc	26 bc	35 bc	0 a	0 a	1 ab	3 a
TM-41501 125SC 6.5 fl oz	P- pre-harvest	0 a	0 a	4 ab	9 bcd	16 ab	24 b	34 bc	0 a	0 a	0 a	1 a
TM-41501 125SC 13 fl oz	P- pre-harvest	0 a	0 a	1 a	3 ab	6 a	8 a	14 a	0 a	0 a	0 a	0 a
GWN-4200 20W 37.5g + +B-1956 4 fl oz	P-PF, pre-harvest	8 bc	15 c	21 d	35 ef	64 de	69 def	80 de	1 ab	3 a	5 abc	10 ab
Microfine Sulfur 90W 3lb	Covers											
GWN-4200 20W 50.0g + +B-1956 4 fl oz	P-PF, pre-harvest	5 b	16 c	31 d	60 g	81 f	89 g	95 f	1 ab	1 a	1 ab	6 ab
Microfine Sulfur 90W 3lb	Covers											
GWN-4200 20W 75.0g + +B-1956 4 fl oz	P-PF, pre-harvest	1 a	5 ab	18 cd	45 efg	65 de	78 efg	88 ef	1 ab	5 ab	8 bc	19 bc
Microfine Sulfur 90W 3lb	Covers											

Averages of four single tree replications, 20 fruit per replicate. Mean separation by Waller-Duncan K-ratio t-test (p=0.05).

Fungicide application dates: 23 March (BS, bud swell, Thiram and Ziram Granuflo and Tenn-Cop only); 2 Apr (P, pink, all treatments); 13 Apr (bloom); 22 Apr (late bloom-petal fall); 1st-5th covers: 5 May, 21 May, 3 June, 22 June, 7 July, 21 July (6th cover Redgold), 3 Aug (2 wk pre-harvest, Redgold), 11 Aug (1 wk pre-harvest, Redgold. Samples harvested 18 Aug.

Apple: *Malus x domestica* ('Rome Beauty')
Apple scab; *Venturia inaequalis*
Cedar-Apple Rust; *Gymnosporangium juniperi-virginianae*
Flyspeck; *Zygophiala jamaicensis*

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EFFICACY OF FUNGICIDE TREATMENTS APPLIED CONCENTRATE FOR DISEASE MANAGEMENT ON APPLE, 1999: Fungicide treatments including two stroby fungicides compared to MBI's, and Milsana, a biochemical product, were evaluated in a mature block of 'Rome Beauty' trees. Trees were well-pruned to a moderate density and a height of 12 ft. Natural inoculum levels of scab and powdery mildew were high, but lack of rainfall limited primary scab infection periods to seven occurring between 9 Apr (green-tip) and 13 Jun (3rd cover). Environmental parameters in the orchard were measured with a Neogen Envirocaster which utilized the Mills Modified apple scab model. Primary apple scab infection periods and their level of severity were identified on 15-16 Apr (low), 6-7 May (high), 8-9 May (low), 22-23 May (moderate), 2-3 Jun (moderate), 10-11 Jun (moderate), and 13 Jun (moderate). While environmental conditions were highly favorable for powdery mildew development, drought conditions between mid-Jun and Sep were highly unfavorable for development of fungal diseases. Cedar-apple galls (2-3) were placed in each tree on 6 May (early-bloom) and served as the inoculum source for rust infections which occurred on 8, 12 (bloom), and 22 May (1st cover). Experimental plots consisted of double trees arranged in a randomized complete block design with four replicates. Sprayed plots were bordered by nontreated plots between and adjacent to the treated. Applications were made at 50 gpa with a Metters Model 36 airblast sprayer operated at 2.5 mph with a manifold pressure of 200 psi under still air and low evaporation conditions to minimize spray drift and improve coverage. The fungicides were applied as complete sprays at 7-8 day intervals between 1/2"-green and 1st cover growth stages and at 12-17 day intervals during the cover sprays. The fungicide programs (combinations) were applied in 12 applications from 1/2"-green through 7th cover sprays as follows: 19 Apr (1/2"-green), 23 Apr (tight-cluster), 1 May (pink), 10 May (bloom), 18 May (petal-fall), 1st through the 7th cover sprays on 26 May, 8, 23 Jun, 6, 23 Jul, 9, and 23 Aug, respectively. Scab, mildew, and rust incidence on terminal leaves was determined on 21 Jul by observing all leaves on 10 vegetative terminals per tree. Disease incidence on fruit was determined by observing 50 fruits/tree (100/replicate) at harvest on 8-11 Oct. The interval between last application and harvest was 48 days allowing sufficient time for flyspeck infection and symptom expression at the time of observations. All data obtained were analyzed by analysis of variance using appropriate transformations and the Tukey-Kramer HSD test for significance ($P = \leq 0.05$).

Moderate incidence and severity on nontreated leaves provided adequate conditions for efficacy evaluation of the treatments for powdery mildew control, but levels of scab and apple rust were too low to measure treatment differences. Mildew symptoms on fruit were not observed in this evaluation. The stroby fungicides, Sovran and Flint, provided about equal levels of control when applied at about the same number of applications per season (Table 1). The level of mildew control increased significantly as the number of applications increased. Both fungicides provided control levels equal to the MBI fungicides, Procure, Indar, and Nova. Milsana was ineffective at both rates tested against apple powdery mildew and appeared to have no effect against scab and apple rust. The Vangard program was not highly effective against powdery mildew, but did significantly reduce incidence and severity on treated trees. Flyspeck incidence was 16% on the nontreated fruit, but was 1% or less on all treatments. There was no phytotoxicity to leaves or fruit observed.

Table 1 . Disease Incidence on Leaves and Fruit of 'Rome Beauty' Apple Treated with Concentrate Sprays in 1999. Penn State FREC, Biglerville, PA. K. D. Hickey, et al.

		Percent Disease on Leaves and Fruit				
		Terminal Leaves Powdery mildew		Fruit		
Fungicide and Rate/A	Application Timing	Incidence	Severity**	A. Scab	A. rust	Flyspeck
1. Nontreated	....	47.8 d ***	47.3 f	2.7 c	4.5 b	15.5 b
2. Sovran 50W 3.0 oz	1/2"-G, TC, PF, 1C					
Nova 40W 3.0 oz + Polyram 80W 3.0 lb	P, B					
Ziram 75DF 4.0 lb	2C, 3C, 4C, 5C					
Ziram 75DF 3.0 lb + Topsin-M 70 WSB 12.0 oz	6C, 7C.........................	23.0 b	3.1 bc	0.3 ab	0.0 a	0.0 a
3. Sovran 50W 3.0 oz	1/2"-G, TC, PF, 1C - 7 C					
Nova 40W 3.0 oz + Polyram 80W 3.0 lb	P, B	11.4 a	1.0 ab	0.0 a	0.0 a	0.0 a
4. Sovran 50W 3.0 oz	1/2"-G thru 5C					
Ziram 75DF 3.0 lb + Topsin-M 70WSB 12.0 oz	6C, 7C	10.8 a	0.7 a	0.3 ab	1.8 ab	0.0 a
5. Vangard 75WG 5.0 oz	1/2"-G, TC					
Vangard 75WG 3.0 oz + Dithane 75DF NT 3.0 lb	P, B, PF					
Captan 50W 2.25 lb + Benlate 50W 9.0 oz	1C - 7C	34.9 c	16.6 d	0.3 ab	0.3 a	0.0 a
6. Penncozeb 75DF 6.0 lb	1/2"-G					
Flint 50W 1.5 oz	TC, P					
Nova 40W 3.0 oz + Penncozeb 75DF 3.0 lb	B, PF, 1C					
Ziram 76DF 5.0 lb	2C, 3C					
Ziram 76DF 3.0 lb + Topsin-M 70WSB 12.0 oz	4C, 5C, 6C, 7C..............	32.5 c	10.4 d	0.0 a	0.0 a	0.0 a
7. Flint 50W 2.0 oz	B*, PF					
Flint 50W 1.5 oz + Captan 50W 2.25 lb	1C - 7C	11.4 a	1.7 abc	0.7 ab	4.3 b	0.3 a
8. Flint 50W 2.0 oz	B*,1C					
Nova 40W 4.0 oz + Dithane 75DF NT 3.0 lb	PF					
Captan 50W 2.25 lb + Benlate 50W 9.0 oz	2C - 6C					
Flint 50W 3.0 oz	7C	22.8 b	4.4 c	0.0 a	0.0 a	0.0 a
9. Procure 50W 8.0 oz + Captan 50W 3.0 lb	1/2"-G thru 2C					
Captan 50W 3.0 lb	3C - 7C					
Benlate 50W 12.0 oz	6C, 7C	20.9 b	1.7 abc	0.0 a	0.0 a	0.5 a
10. Indar 75WSP 2.0 oz + Latron B-1956 16.0 fl oz	1/2"-G thru 7C	21.1 b	4.0 c	0.0 a	0.0 a	0.5 a
11. Milsana (BAS 114 UBF) 1.0% v/v	1/2"-G,TC,P,B,PF,1C,2C,3C					
Ziram 75DF 4.0 lb	4C, 5C					
Ziram 75DF 3.0 lb + Topsin-M 70 WSB 12.0 oz	6C, 7C	46.2 d	42.8 ef	1.0 ab	3.5 ab	1.0 a

Table 1 . Disease Incidence on Leaves and Fruit of 'Rome Beauty' Apple Treated with Concentrate Sprays in 1999. Penn State FREC, Biglerville, PA. K. D. Hickey, et al. (continued)

		Percent Disease on Leaves and Fruit				
		Terminal Leaves				
		Powdery mildew		Fruit		
Fungicide and Rate/A	Application Timing	Incidence	Severity**	A. Scab	A. rust	Flyspeck
12. Milsana (BAS 114 UBF) 0.5% v/v	1/2"-G,TC,P,B,PF,1C,2C,3C					
Ziram 75DF 4.0 lb	4C, 5C					
Ziram 75DF 3.0 lb + Topsin-M 70 WSB 12.0 oz	6C, 7C..........................	49.8 d	37.8 e	1.6 bc	2.3 ab	0.5 a
13. Nova 40W 3.0 oz + Dithane 75DF NT 3.0 lb	1/2"-G thru 2C					
Ziram 75DF 4.0 lb	3C, 4C, 5C					
Ziram 75DF 3.0 lb + Topsin-M 70WSB 12.0 oz	6C, 7C	19.2 b	3.3 bc	0.0 a	0.0 a	0.0 a

* Applied 100 hr after first scab infection period.

** Severity rating established by using the Horsfall-Barratt scale of 0 to 11, then converting to a percentage of the lower surface covered with mildew.

*** Means followed by the same letter(s) are not significantly different, Tukey-Kramer HSD Test ($P = \leq 0.05$).

** Not for Publication **

Apple: *Malus x domestica* ('Cortland', 'Delicious', 'Golden Delicious', 'Rome Beauty', 'Stayman')
Apple scab; *Venturia inaequalis*
Cedar-Apple Rust; *Gymnosporangium juniperi-virginianae*
Powdery mildew; *Podosphaera leucotricha*
Flyspeck; *Zygophiala jamaicensis*

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APPLE DISEASE INCIDENCE WITH NEW FUNGICIDES APPLIED AT TREE-ROW-VOLUME RATES, 1999: Two tree-row-volume (TRV) rates of an early-season (1/2"-green through 1st cover) fungicide program of Sovran/Nova plus Polyram followed by Thiram/Benlate (6C, 7C) in the cover sprays were evaluated in a 14-year-old experimental semi-dwarf orchard. Treatment plots consisted of one tree each of five cultivars grown on M-26 rootstock and planted 10 ft apart in the rows with a 50 ft space between plots. The orchard was five rows wide and contained 80 plots which were equally divided across the rows into two treated areas. Tree-row-volume was determined to be 35% of a "standard" orchard and fungicide rates were adjusted to match the tree size in one treated area compared to a 50% rate applied in the other area. Nontreated plots were located throughout both blocks. Applications were made at 50 gpa with a Metters Model 36 airblast sprayer operated at 2.5 mph and a manifold pressure of 200 psi. Application dates and respective growth stages were: 15 Apr (1/2"-green), 22 Apr (tight-cluster), 30 Apr (pink), 6 May (bloom), 12 May (petal-fall), 1st through the 7th cover sprays on 19 May, 1, 16 Jun, 1, 14, 27 Jul, and 11 Aug, respectively. Environmental parameters in the orchard were measured with a Neogen Envirocaster which utilized the Mills Modified apple scab model. Primary apple scab infection periods and their level of severity were identified on 15-16 Apr (low), 6-7 May (high), 8-9 May (low), 22-23 May (moderate), 2-3 Jun (moderate), 10-11 Jun (moderate), and 13 Jun (moderate). Disease incidence on leaves and fruit was observed on six experimental plots (replicates) strategically located in each treated area and compared to an equal number of nontreated plots in each area. Powdery mildew, apple rust, and scab incidence on leaves was recorded on the most susceptible cultivars by observing on 26 Jul all leaves on each of 15 terminal shoots/replicate. Disease incidence on fruit was recorded at harvest on 100 fruits/replicate as follows: scab (17 Sep, 'Delicious' and 6 Oct, 'Stayman'); and flyspeck (17 Sep, 'Golden Delicious'). The data obtained were analyzed by analysis of variance using appropriate transformations and significance between means was determined by the Tukey-Kramer HSD test ($P = \leq 0.05$).

Apple scab incidence was very low because of drought conditions that occurred between mid-Jun and Sep. Incidence on nontreated leaves of 'Rome Beauty', 'Cortland', and 'G. Delicious' was 4.8, 2.4, and 3.3%, respectively (Table 2). Apple rust on nontreated leaves of 'Cortland' was 3.9%. Scab incidence on nontreated fruit of 'G. Delicious' and 'Rome Beauty' was 3.3 and 1.7%, respectively. Scab infection levels were lower than previously recorded and differences between treatments was not evident. Powdery mildew incidence and severity was moderate on 'Cortland' and 'Rome Beauty'. The 50% TRV rate provided significantly better control of mildew. Differences in flyspeck control was not apparent under the unfavorable conditions for development of sooty blotch and flyspeck. Sooty blotch incidence on nontreated 'G. Delicious' fruit was 4.0% and was not present on nontreated trees.

Table 2. Disease Incidence and Severity on Apple Leaves and Fruit Treated Seasonally with Fungicides Applied at Tree Row Volume Rates with an Airblast Sprayer at 50 GPA in 1999. Penn State Fruit Research & Extension Center, 5-Cultivar Block, Biglerville, PA. K. D. Hickey, et al.

Fungicides and Rate/A	Applic. Timing	Terminal Leaves: Powdery mildew Cortland Incidence	Terminal Leaves: Powdery mildew Cortland Severity*	Terminal Leaves: Powdery mildew 'Rome Beauty' Incidence	Terminal Leaves: Powdery mildew 'Rome Beauty' Severity*	Terminal Leaves: A. Rust 'Rome B'.	Fruit: Scab 'Delicious'	Fruit: Scab 'Stayman'	Fruit: Flyspeck 'G. Del.'
1. Nontreated	--	39.3 c**	17.0 b	27.9 c	11.8 b	5.8 b	4.9 b	4.0 b	13.8 b
2. TRV Rate 50% of Standard									
Sovran 50W 2.0 oz	1/2"-G, TC, PF, 1C								
Nova 40W 1.5 oz + Polyram 80W 1.5 lb	P, B								
Thiram Granuflo 75WDG 1.5 lb	2C - 7C								
Benlate 50W 6.0 oz	6C, 7C	6.5 a	1.6 a	12.0 a	1.9 a	0.9 a	0.0 a	0.0 a	0.0 a
3. TRV Rate 35% of Standard									
Sovran 50W 1.4 oz	1/2"-G, TC, PF, 1C								
Nova 40W 1.05 oz + Polyram 80W 16.8 oz	P, B								
Thiram Granuflo 75WDG 16.8 oz	2C - 7C								
Benlate 50W 4.2 oz	6C, 7C	21.9 b	4.0 a	17.4 b	3.0 a	2.0 a	0.2 a	0.2 a	1.5 a

* Severity rating established by using the Horsfall-Barratt scale of 0 to 11, then converting to a percentage of the lower surface covered with mildew.

** Means followed by the same letter(s) are not significantly different, Tukey-Kramer HSD Test ($P = \leq 0.05$).

** Not for Publication **

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

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DMI/PROTECTANT FUNGICIDE COMBINATIONS FOR DISEASE MANAGEMENT ON APPLE, 1999: Combinations of myclobutanil (Nova 40W) with the protective fungicides mancozeb, thiram, or ziram applied during the early season and followed by the protectants in the summer sprays were evaluated for control of seasonal diseases. The test was conducted in a mature orchard block of trees planted 30 x 36 ft and well-pruned to a height of 15 ft. The test trees were grafted to each of three cultivars which composed approximately 1/3 of the tree. Treatments were arranged in a randomized complete block design with 3-tree replicates (each tree with the three cultivars). Environmental parameters in the orchard were measured with a Neogen Envirocaster which utilized the Mills Modified apple scab model. Primary apple scab infection periods and their level of severity were identified on 15-16 Apr (low), 6-7 May (high), 8-9 May (low), 22-23 May (moderate), 2-3 Jun (moderate), 10-11 Jun (moderate), and 13 Jun (moderate). Fungicide treatments were applied as dilute sprays with a high pressure orchard sprayer operated at 400 psi and equipped with a 9-nozzle boom which delivered 2.8 gal/tree (280 gal/A). Application dates and respective growth stages were: 15 Apr (1/2'-green), 23 Apr (tight-cluster), 6 May (full-bloom), 15 May (petal-fall), 1st through the 7th cover sprays on 26 May, 8, 22 Jun, 6, 21 Jul, 3 and 18 Aug, respectively. Disease observations were made on the center tree of each 3-tree plot. Scab and mildew incidence on leaves were obtained on 10 Aug by observing all leaves on 10 vegetative terminals/replicate. Scab, sooty blotch, and flyspeck were determined at harvest on 100 fruits/tree observed on 30 Sep ('G. Delicious'), 1 Oct ('Delicious'), and 5 Oct ('Rome Beauty'). White rot was not evident at harvest and a 25-fruit sample of symptomless fruit were collected on 30 Sep, placed on paper packing trays, incubated at 76-79^{o} F and 100% relative humidity, and observed for decay after 21 days. The data obtained were analyzed by analysis of variance using appropriate transformations and significance between means was determined by the Tukey-Kramer HSD test ($P = \leq 0.05$).

Drought conditions occurring between mid-Jun and Sep were highly unfavorable for scab and summer disease development. Scab incidence on nontreated leaves of 'Delicious' and 'Rome Beauty' was 11.0 and 4.0%, respectively (Table 3). Differences among treatments were not evident under the low scab pressure in this test. Powdery mildew incidence was relatively low because of low inoculum in the test block. The Nova 40W in the mixtures provided good control allowing only 3-6% infection. Sooty blotch and flyspeck incidence was 43 and 83%, respectively on the nontreated 'Golden Delicious' at harvest. Incidence on treated fruit was relatively low and control was provided by the Benlate in the mixture applied during the 6th and 7th cover sprays. Fruit decay that developed after 21 days incubation was 99% white rot with an occasional fruit showing black rot symptoms. The Thiram Granuflo program provided complete control and was significantly better than the ziram, thiram/captan, or mancozeb/captan programs. Sooty blotch and flyspeck symptoms on the incubated fruit were approximately the same as that observed at harvest. It appeared that these diseases developed on fruit after the beginning of the rain period in early Sep. The last fungicide application was made on 18 Aug, 43 days before fruit observation.

Table 3 . Apple Disease Incidence on Trees Treated Seasonally with Dilute Fungicide Sprays in 1999. Penn State FREC, Grafted Block, Biglerville, PA. K. D. Hickey, et al.

		Percent Disease on Leaves and Fruit						
			Fruit					
		Terminal Lvs. P. mildew	A. scab			Sooty blotch	Fly speck	White Rot
Fungicide and Rate/100 gal	Applic. Timing	'Rome'	'Del.'	'Rome'	'G. Del.'	'G. Del.'	'G. Del.'	'G. Del.'
1. Nontreated	--	12.3 b*	21.5 b	11.0 b	5.0 b	42.8 b	82.5 b	32.0 c
2. Thiram Granuflo 75WDG 1.0 lb + Nova 40W 1.5 oz Thiram Granuflo 75WDG 1.0 lb Benlate 50W 4.0 oz	1/2"-G, OC, P, B, PF, 1C, 2C 3C, 4C, 5C, 6C, 7C 6C, 7C	3.4 a	0.5 a	0.3 a	0.0 a	0.3 a	4.8 a	0.0 a
3. Ziram Granuflo 75WDG 1.0 lb + Nova 40W 1.5 oz Ziram 76WDG 1.0 lb Benlate 50W 4.0 oz	1/2"-G, OC, P, B, PF, 1C, 2C 3C, 4C, 5C, 6C, 7C 6C, 7C	5.8 a	0.8 a	0.3 a	0.0 a	0.3 a	6.8 a	5.0 b
4. Thiram Granuflo 75WDG 1.0 lb + Captan 50W 1.0 lb Thiram Granuflo 75WDG 8.0 oz + Captan 50W 8.0 oz Benlate 50W 4.0 oz	1/2"-G, OC, P, B, PF, 1C, 2C 3C, 4C, 5C, 6C, 7C 6C, 7C	14.9 b	0.8 a	0.5 a	0.0 a	0.3 a	8.8 a	7.0 b
5. Dithane 75DF 1.0 lb + Nova 40W 1.5 oz Captan 50W 1.0 lb Benlate 50W 4.0 oz	1/2"-G, OC, P, B, PF, 1C, 2C 3C, 4C, 5C, 6C, 7C 6C, 7C	6.2 a	1.5 a	0.3 a	0.0 a	0.8 a	18.0 a	11.0 b

* Means followed by the same letter(s) are not significantly different, Tukey-Kramer HSD Test ($P \leq 0.05$).

** Not for Publication **

Apple: *Malus x domestica* ('Golden Delicious', 'Red Delicious', 'Rome Beauty', 'York Imperial')
Apple scab; *Venturia inaequalis*
Flyspeck; *Zygophiala jamaicensis*

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APPLE FUNGICIDE PROGRAMS COMPOSED OF VANGARD, MBI/PROTECTANT, FLINT, AND BENLATE/CAPTAN APPLIED CONCENTRATE, 1999: Two fungicide programs utilizing Vangard and Flint (stroby fungicides) compared to a Nova/Dithane (early-season) and Captan/Benlate (cover sprays) were evaluated for disease control in a 18-year old test orchard. Trees were grown on MM 106 rootstock, planted at 20 ft between rows in rows 22 ft wide, and pruned to a height of 12 ft. The orchard rows contained two sections consisting of six trees each of two cultivars. Eight cultivars were planted in 4-row sections and replicated four times. The fungicide treatments were applied to each section at 50 gal/A with a Metters 36 airblast sprayer operated at 2.5 mph with a manifold pressure of 200 psi. Apple scab and powdery mildew inoculum levels in the orchard were moderate to low and environmental conditions were not favorable for fungal disease development. Environmental parameters in the test site were monitored nearby with a Neogen Envirocaster which utilized the Mills Modified apple scab model. Primary apple scab infection periods and their level of severity were identified on 15-16 Apr (low), 6-7 May (high), 8-9 May (low), 22-23 May (moderate), 2-3 Jun (moderate), 10-11 Jun (moderate), and 13 Jun (moderate). Fungicides were applied in complete sprays on the following applications dates and respective growth stages on: 15 Apr (1/2"-green), 22 Apr (tight-cluster), 28 Apr (pink), 5 May (bloom), 15 May (petal-fall), 1st through 7th cover sprays on 21 May, 3, 17, 29 Jun, 15, 28 Jul, and 12 Aug, respectively. Scab and mildew counts were made on terminal leaves on 29 Jul by observing all leaves on 10 vegetative terminals per replicate (6 replicates). Scab counts on fruit were made on 100 fruits/replicate on 22 Sep ('Golden Delicious'), 23 Sep ('Delicious'), 14 Oct ('York'), and 18 Oct ('Rome'). Incidence of flyspeck and sooty blotch on 'Golden Delicious' at harvest was observed on 22 Sep, 41 days after the last spray application. Data obtained were analyzed by analysis of variance using appropriate transformations and significance between means was determined by the Tukey-Kramer HSD test ($P = \leq 0.05$).

Incidence of apple scab on leaves and fruit was very low because of drought conditions between mid-Jun and Sep. On nontreated trees, the percent of leaves infected with scab on 'Rome Beauty', 'Delicious', and 'York Imperial' was 5.9, 3.9, and 1.3, respectively (Table 4). Powdery mildew on nontreated 'Rome' leaves was 3.1% and was not found on the treated trees. Sooty blotch incidence was lower than flyspeck and on nontreated trees at harvest was: 2.0% ('Golden Delicious', 41 days PHI), 0.8% ('York', 63 days PHI), and 20.3% ('Rome', 67 days PHI). Flyspeck incidence on nontreated 'York' and 'Rome' (not shown in the Table) was 22.8 and 32.8%, respectively. Under the conditions of this test, treatment effects were not apparent.

Table 4 . Apple Scab Incidence on Fruit Treated Seasonally with Fungicides Applied Airblast at 50 GPA in 1999. Penn State FREC, 8-C Block, Arendtsville, PA. K. D. Hickey, et al.

Treatment and Rate/A	Applic. Timing	Percent Apple Scab 'Rome'	'Delicious'	'York'	'G. Del.'	% Flyspeck 'G. Del.'
1. Nontreated	- -	13.3 b*	31.7 b	4.2 b	19.0 b	8.5 b
2. Vangard 75WG 5.0 oz	1/2"-green, TC					
Nova 40W 4.0 oz + Dithane 75DF NT 3.0 lb	Pink, PF					
Flint 50W 2.0 oz	Bloom, 1C					
Benlate 50W 8.0 oz + Captan 50W 3.0 lb	2C-6C					
Flint 50W 3.0 oz	7C	0.0 a	0.0 a	0.5 a	0.0 a	0.2 a
3. Vangard 75WG 5.0 oz	1/2"-G					
Vangard 75WG 3.0 oz + Dithane 75DF NT 3.0 lb	TC					
Flint 50W 1.5 oz + Dithane 75DF NT 3.0 lb	Pink, PF					
Nova 40W 4.0 oz + Dithane 75DF NT 3.0 lb	Bloom					
Flint 50W 2.0 oz	1C					
Benlate 50W 8.0 oz + Captan 50W 3.0 lb	2C-6C					
Flint 50W 3.0 oz	7C	0.5 a	0.0 a	0.0 a	0.0 a	0.2 a
4. Nova 40W 4.0 oz + Dithane 75DF NT 3.0 lb	1/2"-G-2C					
Captan 50W 4.0 lb	3C, 4C, 5C					
Captan 50W 3.0 lb + Benlate 50W 8.0 oz	6C, 7C	0.5 a	0.5 a	0.0 a	0.0 a	0.0 a

* Means followed by the same letter(s) are not significantly different, Tukey-Kramer HSD Test (P = ≤ 0.05).

** Not for Publication **

Apple: *Malus x domestica* ('Rome Beauty', 'Delicious', 'Golden Delicious')
Fire Blight; *Erwinia amylovora*
Fruit Russet

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FIRE BLIGHT INCIDENCE AND FRUIT RUSSET ON APPLE TREES SPRAYED WITH COPPER COMPOUNDS IN 1999: Copper formulations designed to provide increased efficacy and reduced phytotoxicity to apples were evaluated in a mature semi-dwarf experimental orchard planted 30 x 35 ft and pruned to 12 ft high. The experimental plots consisted of three trees of moderate vigor, one of each cultivar planted in a group at each tree site. Copper treatments were arranged in a randomized complete block design with four replicates. The trees had no natural blighted shoots at the time of first application on 27 May (8 days after petal-fall), but five terminal shoots were inoculated during late bloom on 17 May and were beginning to show blight symptoms. These blighted shoots and subsequent inoculated shoots served as inoculum to measure effect of treatments on natural spread to new shoots. Sprays were applied dilute to the point of complete wetness at weekly intervals on 27 May, 2, 10, and 17 Jun. Applications were made with a high-pressure orchard sprayer operated at 400 psi and equipped with a 9-nozzle boom which delivered 2.8 gal/tree (280 gal/A). Following each application after spray had dried, treatment effect on the same treated trees was measured by wound inoculating 2-3 apical leaves on each of five vegetative terminals (shoots)/replicate with *E. amylovora* (1×10^8 cfu/ml). Leaves were injured with very fine (3M-220) sandpaper, then swabbed with inoculum. Observations for fire blight symptoms on inoculated shoots (necrosis, bacterial ooze, and shoot blight) were made 7, 14 (not shown in tables), 23, and 69 days after inoculations on 27 May, 2, 10, and 17 Jun. The number of naturally infected shoots/tree ('Rome Beauty') were recorded on 10 Aug. The level of phytotoxicity caused by the copper treatments in the form of fruit russeting was determined at harvest on 'Golden Delicious' and 'Rome Beauty' by the Barratt-Horsfall rating scale of 0-11 then converted to percentages using the Elanco conversion tables. Data obtained were analyzed by analysis of variance using appropriate transformations and significance between means was determined by the Tukey-Kramer HSD test ($P = \leq 0.05$).

Observations for fire blight symptoms on inoculated shoots were first evident seven days after inoculation. Necrosis on the inoculated leaves (2-3 apical) associated with the sandpaper injury was variable among the treatments after each application. Inoculated shoots showing necrosis without bacterial ooze after seven days ranged from 5-70%, while shoots showing bacterial ooze on the injured leaves ranged between 0 and 95% (Tables 5 & 6). Differences among treatment means were not significant because of wide variation in symptom expression. Blight development on inoculated shoots, usually involving half or more of the shoot, was well developed after 23 days and ranged from 5-50% among the treatments, but treatment means were not significantly different. Blight development after 69 days was generally somewhat higher than at 23 days. Natural blight development on noninoculated shoots on the treated trees ranged from 5.8 to 17.0 blighted shoots/tree but treatment means were not significantly different on 10 Aug (Table 7). Shoot blight levels on most of the treatments were approximately half of that on the nontreated and, although not significantly different, appeared to affect the level obtained. Differences among treatments in fruit russet were significant on 'Golden Delicious', but not on 'Rome Beauty' (Table 7). Kocide 200, GX 569, and GX 270 treatments, consisting of copper hydroxide, produced significantly less russet on 'Golden Delicious' than the Bordeaux plus Maneb, Bordeaux plus Pencozeb or Copper Count-N treatments. The level of russet on the copper hydroxide treatments was not significantly higher than the nontreated fruit. Injury to leaves was minimal with the copper hydroxide treatments, but was more evident on the Bordeaux mixtures.

Table 5 . Fire Blight Incidence on Shoots of 'Rome Beauty' Apple Sprayed Dilute with Copper Treatments (5/27, 6/2) and Inoculated with *Erwinia amylovora* in 1999. Penn State FREC, Young 3-C Block, Biglerville, PA. K. D. Hickey, et al.

	Percent shoots showing necrosis, bacterial ooze, or blight[1]							
	Days after treatment (Inoculation)							
	After First Application				After Second Application			
	7		23	69	7		23	69
Treatment and Rate/100 gal	Nectrosis[2]	Ooze[3]	Blight[4]	Blight[4]	Nectrosis[2]	Ooze[3]	Blight[4]	Blight[4]
1. Nontreated	35.0 a[5]	30.0 a	20.0 a	25.0 a	5.0 a	90.0 a	25.0 a	50.0 a
2. Kocide 2000 54DF (35% cu) 4.3 oz	35.0 a	25.0 a	20.0 a	25.0 a	25.0 a	65.0 a	20.0 a	40.0 a
3. GX-569 46W (30% cu) 5.0 oz	10.0 a	45.0 a	30.0 a	35.0 a	0.0 a	90.0 a	20.0 a	35.0 a
4. GX-569 46W (30% cu) 3.8 oz	20.0 a	55.0 a	45.0 a	55.0 a	30.0 a	70.0 a	40.0 a	50.0 a
5. GX-569 46W (30% cu) 2.5 oz	25.0 a	40.0 a	45.0 a	50.0 a	10.0 a	65.0 a	30.0 a	45.0 a
6. GX-270 32.5DF (20% cu) 3.8 oz	45.0 a	35.0 a	45.0 a	45.0 a	5.0 a	95.0 a	35.0 a	50.0 a
7. Bordeaux (20% cu) 2.67 lb	5.0 a	35.0 a	15.0 a	15.0 a	20.0 a	80.0 a	40.0 a	65.0 a
8. Bordeaux (20% cu) 1.7 lb + Maneb 75DF 4.3 oz	15.0 a	10.0 a	20.0 a	20.0 a	25.0 a	75.0 a	45.0 a	55.0 a
9. Bordeaux (20%) 0.8 lb + Pencozeb 75DF 8.0 oz	25.0 a	35.0 a	45.0 a	50.0 a	15.0 a	70.0 a	30.0 a	60.0 a
10. Copper Count-N (8% cu) 20.0 fl oz	30.0 a	50.0 a	45.0 a	45.0 a	10.0 a	90.0 a	50.0 a	65.0 a

1 Obtained by wound inoculating 2-3 apical leaves on each of 5 vegetative terminals per replicate (4 reps) with *E. amylovora* (1×10^8 cfu/ml) after applicationof each treatment. Leaves injured with very fine sandpaper then swabbed with inoculum.

2 Necrosis of inoculated apical leaves (2-3) or blight development.

3 Presence of bacterial ooze on leaves and stem, with no apparent necrosis.

4 Typical shoot blight from inoculation. Usually involved half or more of the shoot length.

5 Means followed by the same letter(s) are not significantly different, Tukey-Kramer HSD Test ($P = \leq 0.05$)

** Not for Publication **

Table 6 . Fire Blight Incidence on Shoots of 'Rome Beauty' Apple Sprayed Dilute with Copper Treatments (6/10, 6/17) and Inoculated with *Erwinia amylovora* in 1999. Penn State FREC, Young 3-C Block, Biglerville, PA. K. D. Hickey, et al.

	Percent shoots showing necrosis, bacterial ooze, or blight[1]							
	Days after treatment (Inoculation)							
	After Third Application				After Fourth Application			
	7		23	69	7		23	69
Treatment and Rate/100 gal	Nectrosis[2]	Ooze[3]	Blight[4]	Blight[4]	Nectrosis[2]	Ooze[3]	Blight[4]	Blight[4]
1. Nontreated	40.0 a[5]	20.0 a	20.0 a	15.0 a	40.0 a	15.0 a	15. 0 a	15. 0 a
2. Kocide 2000 54DF (35% cu) 4.3 oz	45.0 a	0.0 a	20.0 a	15.0 a	40.0 a	0.0 a	15.0 a	10.0 a
3. GX-569 46W (30% cu) 5.0 oz	25.0 a	5.0 a	5. 0 a	0.0 a	45.0 a	0.0 a	20.0 a	0.0 a
4. GX-569 46W (30% cu) 3.8 oz	25.0 a	0.0 a	10.0 a	15.0 a	70.0 a	0.0 a	5.0 a	20.0 a
5. GX-569 46W (30% cu) 2.5 oz	25.0 a	5.0 a	15.0 a	30.0 a	45.0 a	10.0 a	10.0 a	10.0 a
6. GX-270 32.5DF (20% cu) 3.8 oz	40.0 a	25.0 a	25.0 a	25.0 a	60.0 a	5. 0 a	5. 0 a	5. 0 a
7. Bordeaux (20% cu) 2.67 lb	40.0 a	10.0 a	25. 0 a	15.0 a	45. 0 a	0.0 a	5. 0 a	15. 0 a
8. Bordeaux (20% cu) 1.7 lb + Maneb 75DF 4.3 oz	30.0 a	5. 0 a	5. 0 a	25. 0 a	35. 0 a	0.0 a	10.0 a	0.0 a
9. Bordeaux (20%) 0.8 lb + Pencozeb 75DF 8.0 oz	10.0 a	5. 0 a	5. 0 a	15. 0 a	45. 0 a	0.0 a	20.0 a	5. 0 a
10. Copper Count-N (8% cu) 20.0 fl oz	15.0 a	5. 0 a	5. 0 a	15. 0 a	60.0 a	5. 0 a	0.0 a	15. 0 a

1 Obtained by wound inoculating 2-3 apical leaves on each of 5 vegetative terminals per replicate (4 reps) with *E. amylovora* (1 X 10^8 cfu/ml) after applicationof each treatment. Leaves injured with very fine sandpaper then swabbed with inoculum.
2 Necrosis of inoculated apical leaves (2-3) or blight development.
3 Presence of bacterial ooze on leaves and stem, with no apparent necrosis.
4 Typical shoot blight from inoculation. Usually involved half or more of the shoot length.
5 Means followed by the same letter(s) are not significantly different, Tukey-Kramer HSD Test ($P = \leq 0.05$)

** Not for Publication **

Table 7 . Incidence of Natural Fire Blight Shoot Infections and Fruit Russeting on Apple Trees Treated with Copper Fungicides in 1999. Penn State FREC, Young 3-C Block, Biglerville, PA. K. D. Hickey, et al.

Treatment and Rate/100 gal	No. natural infections per tree[1]	Percent Fruit Russet[2] 'Rome'	'G. Delicious'
1. Nontreated	16.8 a[3]	1.7 a	2.3 a
2. Kocide 2000 54DF (35% cu) 4.3 oz	7.0 a	2.0 a	6.7 abc
3. GX-569 46W (30% cu) 5.0 oz	8.8 a	1.9 a	7.0 abc
4. GX-569 46W (30% cu) 3.8 oz	8.8 a	1.5 a	10.2 bc
5. GX-569 46W (30% cu) 2.5 oz	8.0 a	1.5 a	5.9 abc
6. GX-270 32.5DF (20% cu) 3.8 oz	17.0 a	2.4 a	4.7 ab
7. Bordeaux (20% cu) 2.67 lb	8.0 a	2.3 a	44.4 f
8. Bordeaux (20% cu) 1.7 lb + Maneb 75DF 4.3 oz	5.8 a	2.6 a	32.5 ef
9. Bordeaux (20%) 0.8 lb + Pencozeb 75DF 8.0 oz...........................	11.5 a	2.0 a	15.3 cd
10. Copper Count-N (8% cu) 20.0 fl oz	5.8 a	2.7 a	23.4 de

1 Number of shoots blighted per tree from natural infections observed on 10 Aug.
2 Obtained by use of the Horsfall-Barratt scale of 0 to 11, then converting to percentage of surface affected.
3 Means followed by the same letter(s) are not significantly different, Tukey-Kramer HSD Test ($P = \leq 0.05$)

** Not for Publication **

PEACH CONSTRICTION CANKER
YIELD AND ECONOMIC LOSS

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Constriction canker of peach, also known as Fusicoccum canker, is caused by the fungus *Phomopsis amygdali* (syn. *Fusicoccum amygdali*). The pathogen infects peach twigs through fresh leaf scars in the fall and through buds, bud scale scars, blossoms, and fruit scars in the spring. The resulting symptoms consist of reddish brown elongate cankers centered about twig nodes.

By the following summer, cankers become sunken and tan to silver in appearance, and have completely girdled and killed the shoots. Foliage distal to the canker desiccates quickly, but remains attached, resulting in the characteristic shoot blight phase of the disease. Since infected shoots are the fruit bearing shoots for the current growing season, shoot death results in direct fruit loss. Most fruit on infected shoots shrivel-up and drop off as the shoots desiccate. Shoots having more advanced cankers are often killed prior to or during bloom and fruit set.

Survey. To quantitatively determine loss from constriction canker during 1996-98, the number of fruit lost per infected shoot was estimated as a function of disease incidence in 21 severely infected New Jersey orchards. For each cultivar in 1997 and 1998, the distribution of fruit sizes at harvest and prices at shipping were used to calculate total crop value for typical expected yields. Economic loss was then calculated from yield loss and crop value estimates.

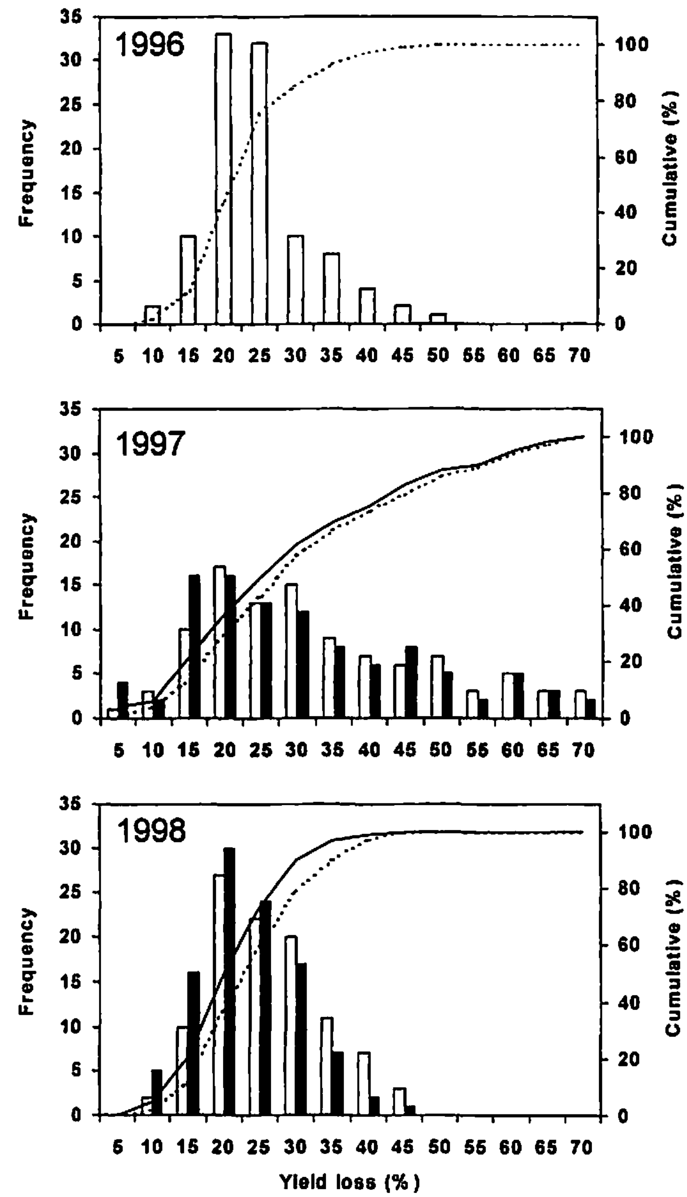

Fig. 1. Frequency (bar) and cumulative (line) yield loss distributions for peach trees having moderate to severe constriction canker in 17 commercial NJ orchards. Yield loss estimates were derived from six trees that were assessed in the same orchard blocks in each year of the study, for a total of 102 observations per year. Adjusted estimates (solid bars and lines) assume fruit below cankers on bearing shoots will be harvested, while unadjusted estimates (open bars, dashed lines) assume these fruit will be lost to disease.

Table 1. Estimated economic loss in U.S. dollars / ha from constriction canker for expected yields[a] (Y_E) in severely infected commercial New Jersey peach orchards

County Site	Cultivar	Economic Loss ($ / ha) 1997 Y_{E1}	1997 Y_{E2}	1997 Y_{E3}	1998 Y_{E1}	1998 Y_{E2}	1998 Y_{E3}
Cumberland							
C1-1	Jerseyglo	2781	4635	5562	1684	2807	3369
C1-2	Encore	1640	2733	3279	1963	3272	3927
C1-3	Biscoe	3980	6634	7961	---[b]	---[b]	---[b]
C2-1	Harcrest	1053	1754	2105	1221	2035	2442
C2-2	Jerseyglo	1122	1871	2245	1710	2850	3420
Camden							
A1-1	Autumnglo	5320	8867	10640	1586	2643	3171
A1-2[c]	Jerseyglo	3292	5487	6584	2018	3363	4036
A2-1	Cresthaven	1335	2224	2669	1366	2277	2732
A2-2	Redhaven	624	1040	1248	1038	1730	2076
Burlington							
B1-1	Autumnglo	3864	6440	7728	2397	3994	4793
B1-2	Biscoe	4333	7221	8666	2761	4601	5522
Gloucester							
G1-1	Encore	1826	3043	3651	1459	2432	2919
G1-2	Redhaven	2480	4134	4961	1800	3000	3600
G2-1	Jerseyland	2572	4287	5145	1508	2513	3016
G2-2	Redhaven	1799	2998	3597	1816	3027	3632
G3-1	Loring	1577	2628	3153	1192	1987	2385
G3-2	Redhaven	1289	2149	2579	1386	2311	2773

[a] Expected yields used to simulate low, moderate, and high cropping seasons, were respectively, Y_{E1} = 8406, Y_{E2} = 14010, and Y_{E3} = 16812 kg/ha (7500, 12500, and 15000 lb/A).
[b] Orchard removed after 1997.
[c] Site A1-2 was an abandoned orchard included for comparison.

Results. The percent yield loss mean across all sites and cultivars, unadjusted for fruit remaining on infected shoots, was 22.2, 30.7, and 23.7% for 1996, 1997, and 1998, respectively. The frequency of these losses were not normally distributed (Fig. 1) according to the Wilk-Shapiro test and the nonparametric Friedmans test indicated that yield loss was significantly different among years. Assuming the remaining fruit on infected shoots were harvested, yield losses for 1997 and 1998 were on average 28.5 and 21.0%, which translated into economic losses of $4,009 and 2,803 / ha, respectively, for a yield level of 14,010 kg/ha (Table 1). These loss values justify control measures for management of constriction canker in severely infected orchards.

Peach: *Prunus persica* ('Redhaven', 'Sunhigh')
Nectarine: *Prunus persica var nectarina* ('Summer Beaut')
Brown rot; *Monilinia fructicola*
Scab; *Cladosporium carpophilum*

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INCIDENCE OF BROWN ROT AND PEACH SCAB ON PEACH/NECTARINE SPRAYED DILUTE WITH FUNGICIDES, 1999: Fungicide treatments were evaluated in a 13-year old orchard planted 30 ft between rows in an experimental orchard consisting of 3-tree plots (one each of 'Redhaven' and 'Sunhigh' peach and one 'Summer Beaut' nectarine). Trees were planted at 10 ft in the row with the nectarine planted between the peach. Treatments were arranged in a randomized complete block design with four replicates. Brown rot and peach scab inoculum in the block was low to moderate and environmental conditions were unfavorable for brown rot development after the first of Jun. Environmental parameters were monitored in the orchard with a Neogen Envirocaster. Fungicide treatments were applied as dilute sprays using 2 gal/tree (200 gal/A) with a high pressure sprayer equipped with a six-nozzle boom and operated at 400 psi. The treatments were applied during the bloom, shuck-fall, and harvest periods as follows: 19 Apr (bloom), 18 May (shuck-fall), 1 Jun (14 days after shuck-fall), 28 Jul (7 day PHI - 'Redhaven', 12 day PHI - 'Summer Beaut'), 4 Aug (harvest - 'Redhaven'), 9 Aug (harvest - 'Summer Beaut', 7 day PHI - 'Sunhigh'), and 13 Aug (harvest - 'Sunhigh'). Brown rot and scab incidence was determined on 20-fruit samples/replicate which were uniformly "firm ripe" and harvested after the last spray application had dried. Samples were collected randomly around the tree on 4 Aug ('Redhaven'), 9 Aug ('Summer Beaut'), and 13 Aug ('Sunhigh'), placed stem-end down on fruit packing trays and inoculated by atomizing with conidia of *Monilinia fructicola* (1 X 10^5 conidia/ml) within eight hours after the last spray. Observations for presence of brown rot and peach scab were made before inoculation. Brown rot and Rhizopus rot development was monitored at 5, 7, and 10 days after incubation under polyethylene tarp at 77° F and 99% relative humidity. Infected fruits showing sporulation of either disease were removed after each observation to prevent additional inoculum and spread. The data were analyzed by the analysis of variance using appropriate transformations and significance between means was determined by the Tukey-Kramer HSD test ($P \leq = 0.05$).

No brown rot was evident on 'Redhaven' or 'Sunhigh' on the day of harvest, but a few infected fruit of 'Summer Beaut' nectarine was found. On the inoculated fruit, brown rot was present on 23% of the nontreated 'Redhaven' 7 days after inoculation and increased signficantly at 10 days (Table 8). The levels of infection was higher on 'Sunhigh' and 'Summer Beaut' nectarine. Treatment effects were generally not significant at 7 days, but better separation among means was found at 10 days. TM 402 (Elevate) was moderately effective against brown rot and the level of control was generally not improved significantly when used in combinations with captan, ziram, or Orbit. Incidence of brown rot on fruit treated with the MBI fungicides, Orbit, and Indar was lower than with TM 402 but not statistically significant. The incidence of peach scab was variable throughout the orchard and no statistical separation among treatment means was found. Scab levels on the treatments, except Orbit, were appreciably lower than the nontreated.

Table 8 . Brown Rot and Scab Incidence on Peach/NectarineSprayed with Dilute Fungicide Treatments in 1999. Penn State FREC Peach/Nectarine Block, Block. Biglerville, PA. K. D. Hickey, et al.

	Percent Disease on Fruit						
	Brown Rot After Incubation Days						
	'Redhaven'		'Sunhigh'		'Summer Beaut'		
Fungicide and Rate/100 gal	7	10	7	10	7	10	Peach Scab*
1. Nontreated	22.5 a**	42.5 b	40.0 b	60.0 c	62.5 c	83.8 c	27.5 a
2. TM 402 50WDG (Elevate) 6.4 oz	12.5 a	21.3 ab	8.8 ab	38.8 bc	30.0 bc	42.5 abc	7.5 a
3. TM 402 50WDG (Elevate) 6.4 oz + Captan 50W 2.0 lb	6.3 a	13.8 ab	15.0 ab	26.3 abc	16.3 ab	26.3 abc	3.8 a
4. Captan 50W 2.0 lb	10.0 a	25.0 ab	8.8 ab	16.3 ab	23.8 bc	45.0 bc	3.8 a
5. TM 402 50WDG (Elevate) 6.4 oz + Ziram 76DF 2.0 lb	2.5 a	6.3 ab	8.8 ab	21.3 abc	12.5 ab	21.3 ab	0.0 a
6. Ziram 76DF 2.0 lb	17.5 a	36.3 ab	18.8 ab	31.3 abc	41.3 bc	67.5 bc	3.8 a
7. TM 402 50WDG (Elevate) 6.4 oz + Orbit 3.6E 1.5 fl oz	5.0 a	10.0 ab	6.3 a	15.0 ab	10.0 ab	27.5 ab	7.5 a
8. Orbit 3.6E 1.5 fl oz	1.3 a	5.0 a	6.3 a	11.3 ab	12.5 ab	18.8 ab	20.0 a
9. Rovral 41.6F 10.0 fl oz + Latron B-1956 16.0 fl oz	2.5 a	5.0 a	5.0 a	13.8 ab	18.8 abc	32.5 abc	0.0 a
10. Indar 75WSP 0.8 oz + Latron B-1956 16.0 fl oz	1.3 a	6.3 a	1.3 a	5.0 a	1.3 a	5.0 a	0.0 a

* Observed on 'Summer Beaut' nectarine at harvest on 9 Aug.

** Means followed by the same letter(s) are not significantly different, Tukey-Kramer HSD Test (P = ≤ 0.05).

** Not for Publication **

Peach: *Prunus persica* ('Loring', 'Redskin')
Nectarine: *Prunus persica var nectarina* ('Sunglo')
Brown rot; *Monilinia fructicola*

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EFFICACY OF FUNGICIDE TREATMENTS ON PEACH/NECTARINE FOR CONTROL OF BROWN ROT, 1999: The efficacy of fungicide treatments for control of brown rot was evaluated in a 9-year old experimental orchard with trees planted 10 ft in rows 30 ft wide. Experimental plots consisted of three trees, one each of 'Loring' and 'Redskin' peach, and 'Sunglo' nectarine which were arranged in a randomized complete block design with four replicates. Brown rot inoculum was low and environmental conditions in the field were unfavorable for rot development. Fungicide treatments were applied with a high pressure orchard sprayer equipped with a 6-nozzle boom and operated at 400 psi. Sprays were applied to "complete wetness" using 2.0 gal of spray mixture/tree (200 gal/A). Spray applications were timed during the bloom, shuck-fall, and pre-harvest periods. Early season sprays were as follows: 21 Apr (bloom), 19 May (shuck-fall), 2 Jun (first cover). Spray dates and pre-harvest intervals (PHI) between sprays and harvest were: 'Loring' (17 Aug, 7-da PHI, and 23 Aug, 0-da PHI); 'Sunglo' (10 Aug, 7-da PHI, and 17 Aug, 0-da PHI); and 'Redskin' (30 Aug, 7-da PHI, and 3 Sep, 0-da PHI). The thiram program was as follows: thiram alone in bloom, shuck-fall, and 1 da PHI (16 Aug, 'Sunglo'; 2 Sep, 'Loring' and 'Redskin'); thiram plus sulfur in first cover (16 Jun), second cover (1 Jul), third cover (14 Jul); sulfur in 4-da PHI (19 Aug, 'Loring'); sulfur in 7-da PHI (10 Aug, 'Sunglo' and 30 Aug 'Redskin'). Brown rot incidence on inoculated fruit after harvest was determined by observing 20 uniformly "firm ripe" fruit/replicate collected after the harvest spray had dried. Fruits were inoculated by uniformly atomizing conidia of *Monilinia fructicola* (1 X 10^5 conidia/ml) over the fruit surfaces after being placed stem-end down on fruit packing trays. Incubation was for 5, 7, and 10 days under polyethylene tarp at 76^o F and 100% relative humidity. Fruits showing symptoms were removed after each observation period to prevent secondary spread. Data obtained were analyzed by analysis of variance using appropriate transformations and significance between means was determined by the Tukey-Kramer HSD test, ($P = \leq 0.05$).

Drought conditions and low inoculum levels were unfavorable for blossom blight or natural brown rot development in the orchard. Nontreated inoculated fruit showed 35 to 53% brown rot after five days, 70% after 10 days, and most treatments were significantly different from the nontreated (Table 9). Brown rot levels on treated trees were similar among the peach and nectarine cultivars and significant differences occurred on trees sprayed with Elite 45DF or Indar 75WSP when used alone or in combination with TM 402 50WDG. Thiram provided brown rot control equal to Captan which was similar to TM 402 or the Sovran 50W plus Nova 40W combination.

Table 9 . Brown Rot Incidence on Peach/Nectarine Sprayed with Dilute Fungicide Treatments in 1999. Penn State FREC Peach/Nectarine Block. Arendtsville, PA. K. D. Hickey, et al.

	Fungicide and Rate/100 gal	Percent Brown Rot After Incubation (Post-Inoculation Days)					
		'Loring'		'Sunglo'		'Redskin'	
		7	10	7	10	7	10
1.	Nontreated	40.0 b*	70.0 c	35.0 c	68.8 d	52.5 c	70.0 c
2.	TM 402 50WDG (Elevate) 6.4 oz	15.0 ab	37.5 bc	33.8 bc	45.0 cd	10.0 a	18.8 ab
3.	TM 402 50WDG (Elevate) 6.4 oz + Captan 50W 2.0 lb	17.5 ab	37.5 bc	16.3 abc	33.8 bcd	8.8 a	18.8 ab
4.	Captan 50W 2.0 lb	18.8 ab	38.7 bc	20.0 abc	43.8 cd	8.8 a	20.0 ab
5.	TM 402 50WDG (Elevate) 6.4 oz + Elite 45DF 2.0 oz	3.8 a	11.3 a	5.0 a	11.3 a	5.0 a	12.5 ab
6.	Elite 45DF 2.0 oz	2.5 a	18.8 ab	5.0 a	11.3 a	8.8 a	15.0 ab
7.	TM 402 50WDG (Elevate) 6.4 oz + Indar 75WSP 0.8 oz + Latron B-1956 16.0 fl oz	5.0 a	15.0 ab	11.3 ab	23.8 abc	5.0 a	16.3 ab
8.	Indar 75WSP 0.8 oz + Latron B-1956 16.0 fl oz	2.5 a	8.8 a	11.3 ab	16.3 ab	2.5 a	3.8 a
9.	Thiram Granuflo 75WDG 2.0 lb** Thiram Granuflo 75WDG 1.0 lb + Wettable Sulfur 93W 3.0 lb Wettable Sulfur 93W 5.0 lb	15.0 ab	26.3 ab	10.0 a	28.8 abc	23.8 bc	35.0 b
10.	Sovran 50W 1.0 oz + Nova 40W 2.0 oz	12.5 ab	30.0 ab	6.3 a	21.3 abc	12.5 a	23.8 ab

* Means followed by the same letter(s) are not significantly different, Tukey-Kramer HSD Test ($P = \leq 0.05$).

** See text for thiram spray schedule.

** Not for Publication **

Cherry: Red Tart *Prunus cerasus* ('Montmorency')
Brown rot; *Monilinia fructicola*
Cherry leaf spot; *Blumeriella jaapii*

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CONTROL OF BROWN ROT AND CHERRY LEAF SPOT WITH FUNGICIDE TREATMENTS, 1999: Fungicide treatments were evaluated in a 5-year old bearing orchard where trees were planted 30 ft X 30 ft. Inoculum levels for brown rot and leaf spot were very low. Drought conditions were unfavorable for disease development in the orchard. Leaf spot development was slow before harvest, but developed in the summer after rain periods occurred in late Aug. Treatments were arranged in a randomized complete block design. Applications were made as dilute sprays with a high pressure (400 psi) sprayer equipped with a 6-nozzle boom which delivered 2.0 gal (200 gal/A) . Application dates and respective growth stages were: 4 May (bloom), 15 May (shuck-fall), 7 Jun (14 days after shuck-fall), 22 Jun (28 days after shuck-fall), 29 Jun (8 days pre-harvest), 9 Jul (first harvest), and 16 Jul (second harvest). At the harvest time on 9 and 16 Jul, a random sample of 100 fruits/replicate were collected one hour after the harvest application had dried. The fruit were placed stem-end down on styrofoam plates and one tray/replicate was inoculated by atomizing with conidia of *Monilinia fructicola* at 1 X 10^5 spores/ml. The inoculated samples were incubated for 5-17 days at 75^{o} F and 100% relative humidity under a polyethylene tarp. The percent soluble solids of fruit at harvest was determined with an Atago PR-1 refractometer for a 50-fruit composite sample/replicate. Fruit size was determined by counting the number of fruit in a 1.0 kg sample from each replicated tree. Cherry leaf spot incidence was determined by observing all leaves on 10 terminals shoots/replicate on 30 Jul and 13 Oct. The data obtained were analyzed by the analysis of variance using appropriate transformations and significance between means was determined by the Tukey-Kramer HSD test ($P = \leq 0.05$).

There was no significant effect among treatments on fruit quality. The number of fruit/1.0 kg sample ranged from 228 to 267. Soluble solids ranged from 14.9 to 16.5%. Brown rot was not evident on fruit at harvest and incidence on inoculated nontreated fruit incubated for 16-17 days was only 9.0% on the first (9 Jul) and 15.5% on the second (16 Jul) harvest dates (Table 10). All treatments provided very good protection and differences were generally significant. The effect of drought conditions was also evident in the development of leaf spot. At the end of Jul nontreated trees showed only 4.9% leaf spot, but increased to 100% with 60.4% defoliation by 13 Oct. All treatments provided control of leaf spot but differences among means were generally not significant. Phytotoxicity to leaves or fruit was not evident.

Table 10 . Incidence of Brown Rot and Leaf Spot on 'Montmorency' Cherry Sprayed Seasonally with Dilute Fungicide Treatments in 1999. Penn State Fruit Research & Extension Center, Biglerville, PA . K. D. Hickey, et al.

Fungicide and Rate/100 gal	Percent Fruit Infected: Brown Rot Test 1 Inoculation days 8	16	Brown Rot Test 2 Inoculation Days 7	12	17	Percent Leaf Spot: Incidence 30 Jul	Incidence 13 Oct	Defoliation 13 Oct
1. Nontreated	4.8 b*	9.0 b	3.8 b	8.5 c	15.5 c	4.9 b	100.0 f	60.4 c
2. TM 402 50WDG (Elevate) 6.4 oz	0.8 ab	2.0 ab	2.5 ab	5.5 bc	16.5 bc	0.2 a	88.3 def	12.2 b
3. TM 402 50WDG (Elevate) 6.4 oz + Captan 50W 2.0 lb	0.3 a	0.8 a	0.0 a	0.0 a	0.0 a	0.2 a	75.3 cde	12.1 ab
4. Captan 50W 2.0 lb	0.0 a	0.5 a	0.3 a	0.8 ab	1.3 a	0.3 a	72.9 cd	3.9 ab
5. TM 402 50WDG (Elevate) 6.4 oz + Ziram 76DF 2.0 lb	0.0 a	0.8 a	0.3 a	0.5 ab	0.8 a	0.0 a	89.5 ef	5.9 ab
6. Ziram 76DF 2.0 lb	0.8 ab	2.0 ab	1.0 ab	1.5 ab	2.5 ab	0.0 a	89.3 ef	8.4 ab
7. TM 402 50WDG (Elevate) 6.4 oz + Elite 40DF 2.0 oz	0.0 a	0.5 a	0.0 a	0.0 a	0.5 a	0.2 a	56.4 bc	5.3 ab
8. Elite 40DF 2.0 oz	0.0 a	0.3 a	0.0 a	0.3 ab	0.8 a	0.2 a	40.9 ab	2.5 a
9. Rovral 50W 8.0 oz + Latron B-1956 16.0 fl oz	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.5 a	28.6 a	2.6 a

* Means followed by the same letter(s) are not significantly different, Tukey-Kramer HSD Test (P = ≤ 0.05).

** Not for Publication **

(Not for publication or distribution, 1999 CSFWC)

The Influence of Apogee and Combinations with Ethephon, Chemical Thinners, Cations, and Adjuvants for Apple Tree Growth Control and Return Bloom

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Abstract. In 1998, 3 applications of Apogee (63 ppm) or ethephon (135 ppm) did not affected shoot growth of 'Fuji/M.9 trees at these low rates. Combinations of Apogee and ethephon gave good control of tree growth. Flowering and fruit set were not promoted by any of these applications.

The 10% and the 27.5% Apogee formulations gave similar shoot growth inhibition when applied with Regulaid or Oil plus L-77. The addition of CaCl to the 27.5% Apogee (125ppm) formulation caused poorer growth control, but the addition of NH4SO4 restored the effectiveness of the mixture. When using hard well water, Apogee plus NH4SO4 promoted better activity. The additives, NH4SO4, Ca Cl, Regulaid, and Oil plus L-77, alone had no effect on tree growth. Apogee plus L-77 plus Oil provided additional growth suppression when compared to Apogee plus Regulaid.

Apogee caused a significant increase in fruit set from the control when applied at 250 ppm in 3 applications. Alone Vydate, Carbaryl+Oil compared to Carbary+Accel+Oil caused fruit thinning, but ethephon or shading 3 days did not cause significant thinning. Apogee did not have an effect on the fruit thinning when chemical thinners were applied after the first Apogee application.

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 growth in the current season or in non-pruned years 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) dealing with many of these compounds indicate that most have effects of greater commercial value than control of vegetative growth.

The objectives of the experiments reported here were to evaluate the effects of prohexadione-calcium (3-oxido-4-propionyl-5-oxo-3-cyclohexenecarboxylate), formulated as BAS-125 ("Apogee"™)1) to determine if combinations of Apogee and Ethrel would provide better control of tree growth than either alone, 2) to determine the effectiveness of Apogee formulations, 3) to determine the influence of hard water, Calcium Chloride, ammonium sulfate, and adjuvants on effectiveness of Apogee, and 4) to determine if Apogee affected fruit set or the results of chemicals applied for fruit thinning.

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 1998, forty-eight 4-year-old 'Fuji'/M.9 trees (6 blocks) were selected for 8 treatments (Table 1). Prohexadione-calcium was applied alone to drip in 3 applications to the same trees at 63 ppm at PF, PF+14, and PF+28 days or PF+28, PF+42, and PF+56 days. In addition, ethephon was applied alone 135 ppm at PF, PF+14, and PF+28 days or PF+28, PF+42, and PF+56 days. A combination of ethephon applied at PF, PF+14, and PF+28 days plus Apogee applied PF+28, PF+42, and PF+56 days; or a combination of Apogee was applied at PF, PF+14, and PF+28 days plus ethephon applied PF+28, PF+42, and PF+56 days. In the dormant season, average shoot length of the longest top two shoots, length of the five longest scaffold shoots, total length of shoots longer than 30 cm, weight and basal and terminal shoot diameters of these scaffold shoots, nodes/cm of the basal 40 cm, nodes/cm of the upper 30 cm of shoots, and time required to prune each tree, number of cuts/tree, and pruning weights/cm^2 trunk cross-sectional area (TCSA) per tree were recorded.

Prohexadione-calcium formulated as Apogee (27.5%) plus Regulaid® (a surfactant mixture, polyoxyethylenepolypropoxypropanol, alkyl 2-ethoxethanol, and dihydroxy propane 0.125% (v/v)) was used with all prohexadione-calcium treatments.

Expt. 2. In 1999, one hundred and two 5-year-old 'Fuji'/M.9 trees (6 blocks) were selected for 17 treatments (Table 2). Apogee applied 3 times (at 125 ppm each) was tested for efficacy using hard water, Calcium Chloride, ammonium sulfate, adjuvants L-77 plus Oil, Regulaid, and two Apogee formulations as listed in table 2. Shoot length of the longest 4 scaffold shoots were measured on 15 June 99. Additional data will be taken in the dormant season.

Expt. 3. In 1999, seventy two 5-year-old 'Fuji'/M.9 trees (6 blocks) were selected for 12 treatments (Table 3). Apogee was applied 3 times at 250 ppm at PF, PF+24, and PF+45. *Thinning* chemicals were applied at approximately 10 mm fruit diameter 7 days after the first Apogee application (PF+ 14 days).

Results and Discussion

Expt. 1. In 1998, 3 applications of Apogee (63 ppm) or ethephon (135 ppm) did not suppress shoot growth of 'Fuji/M.9 trees at these low rates (Table 1, Figure 1). Combinations of Apogee and ethephon (trt#s 6, 7, and 8) gave good control of tree growth. Flowering and fruit set were not promoted by any of these applications.

Expt. 2. The 10% and the 27.5% Apogee formulations gave similar shoot growth supression when applied with Regulaid or Oil plus L-77 (Table 2, Figure 2). The addition of CaCl to the 27.5% Apogee (125ppm) formulation caused poorer growth control (trt #s 4,5,6 vs 7,10,14), but the addition of NH4SO4 restored the effectiveness of the mixture (trt #s 7,10,14, vs 8, 11,15). When using hard well water, Apogee plus NH4SO4 promoted better activity (trt #s 4,5,6 vs 8,11,15). The additives, NH4SO4, Ca Cl, Regulaid, and Oil plus L-77, alone had no effect on tree growth (1vs16; 1vs17). Apogee plus L-77 plus Oil provided additional growth suppression when compared to Apogee plus Regulaid (trt #s 2,5,12 vs, 3,6,13).

Expt. 3. Apogee caused a significant increase in fruit set compared to the control when applied at 250 ppm in 3 applications (Table 3). Alone NAA, Carbaryl+Oil, Carbary+Accel+Oil caused fruit thinning, but ethephon or shading 3 days did not cause significant thinning. Apogee did not have an effect on the fruit thinning when chemical thinners were applied after the first Apogee application (trt #s 3,4,5,6,7 vs 8,9,10,11,12).

Acknowledgements

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References

Faust, M. (ed.). 1984 International workshop on controlling vigor in fruit trees. Acta Hort. 146.

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.

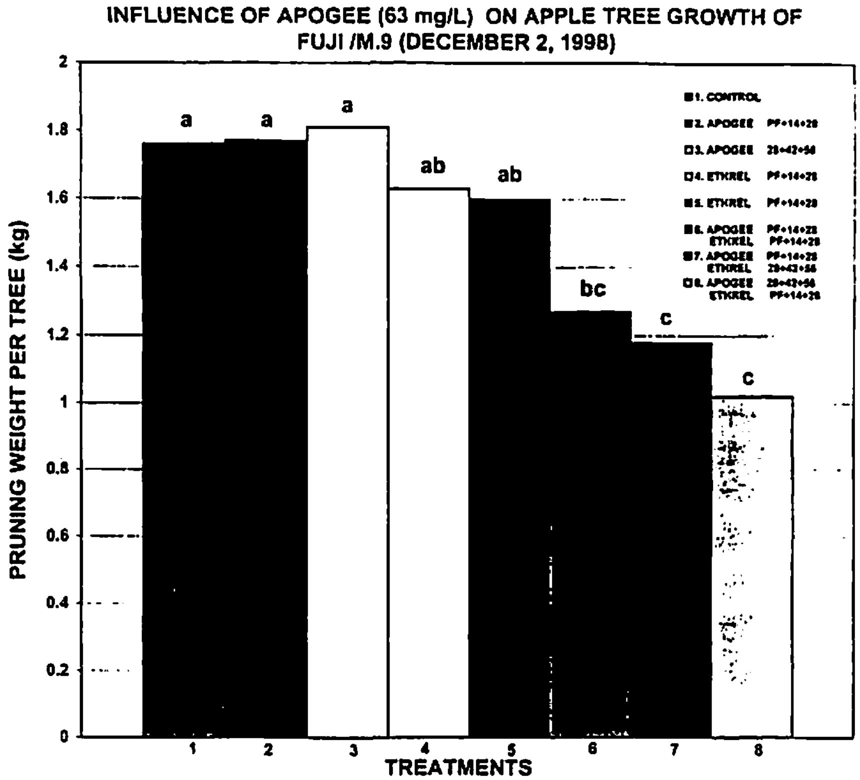

Figure 1. The influence of Apogee (63 mg/L) and Ethephon (135 mg/L) on apple tree growth of Fuji/M.9. Treatments were applied in the spring of 1998, and data collected in the dormant season (December 2, 1998).

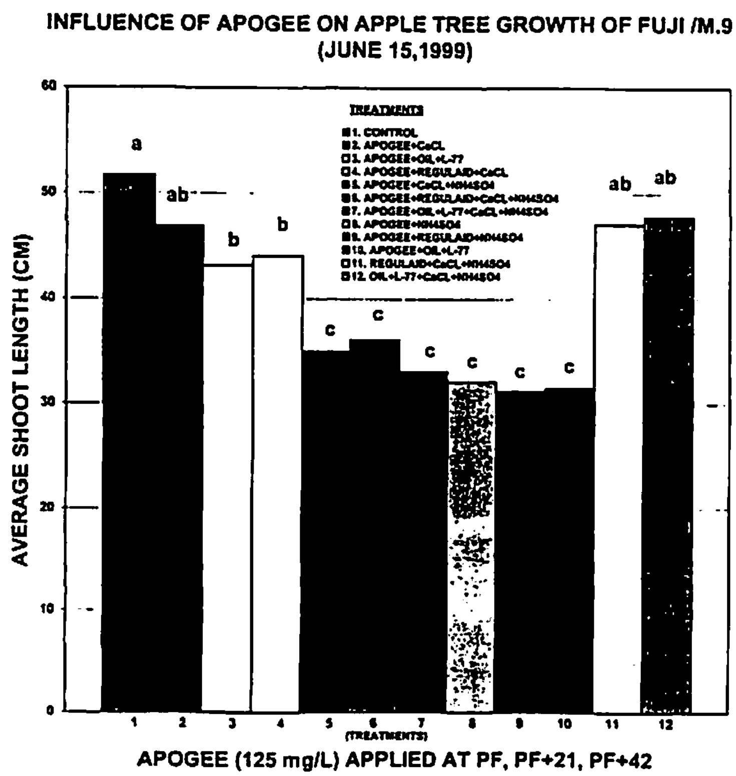

Figure 2. The Influence of Apogee (6 mg/L) and Cations, and Adjuvants on apple tree growth of Fuji/M.9. Treatments were applied in the spring of 1999, and data collected in the summer of the same year (June 15, 1999).

Table 1A. Effect of Appogee (BAS 125 10W) on 'Fuji'/M.9 apple tree growth applied in 1998.

No.	Color	Treatment[zy]	Rate ppm	Rate/ 100 gal	Rate/ 3.5 liter	Application time/date	Avg. shoot length of longest top 2 shoots (cm) 2 Dec 98	Avg. shoot length of longest 5 scaffold shoots (cm) 2 Dec 98	Weight of top 2 shoots (g) 2 Dec 98	Weight of 5 scaffold shoots (g) 2 Dec 98	Avg. basal diameter of 5 longest scaffold shoots (cm) 2 Dec 98	Change in cm² trunk cross sectional area from 6 Apr 98 to 2 Dec 98	Number of cuts/cm² cross sectional area of tree 2 Dec 98	Time required to prune 1 tree (minutes) 2 Dec 98	Number of cuts per tree 2 Dec 98	Pruning weight per tree (kg) 2 Dec 98
1.	W	Control					104.5 a	89.2 a	159.8 a	204.7 a	1.247 a	13.828 a	2.71 ab	3.32 abc	86.2 ab	1.76 a
2.	R	BAS 125 (27.5%)	63, 63 , 63	86g	0.796g	PF, +14, +28	108.0 a	83.2 abc	160.6 a	181.8 ab	1.213 ab	12.431 ab	2.70 ab	3.81 a	85.7 ab	1.77 a
3.	B	BAS 125 (27.5%)	63, 63 , 63	86g	0.796g	+28, +42, +56	101.3 a	85.8 ab	143.8 ab	190.5 a	1.148 bc	12.071 ab	2.92 a	3.83 a	91.3 a	1.81 a
4.	FO	Ethrel (21.7%)	135, 135 , 135	1/2pt.	2.177ml	PF, +14, +28,	98.3 ab	80.5 abc	135.6 ab	165.3 abc	1.135 bcd	11.666 ab	2.65 ab	3.49 ab	82.2 abc	1.63 ab
5.	HP	Ethrel	135, 135 , 135	1/2pt.	2.177ml	+28, +42, +56	95.8 ab	81.2 abc	141.6 ab	177.2 ab	1.155 abc	11.344 ab	2.57 ab	3.22 abc	79.0 abc	1.60 ab
6.	DG	BAS 125 (27.5%) + Ethrel	63, 63 , 63 135, 135 , 135	86g 1/2pt.	0.796g 2.177ml	PF, +14, +28 PF, +14, +28	99.3 ab	70.7 bc	143.8 a	136.0 bc	1.093 cd	10.462 b	2.36 b	2.71 c	68.0 c	1.27 bc
7.	RD	BAS 125 (27.5%) + Ethrel	63, 63 , 63 135, 135 , 135	86g 1/2pt.	0.796g 2.177ml	PF, +14, +28 +28, +42, +56	94.2 ab	78.1 abc	122.6 ab	158.5 abc	1.154 abc	9.757 b	2.43 b	2.84 bc	67.8 c	1.18 c
8.	BD	BAS 125 (27.5%) + Ethrel	63, 63 , 63 135, 135 , 135	86g 1/2pt.	0.796g 2.177ml	+28, +42, +56 PF, +14, +28	85.0 b	69.7 c	103.4 b	123.0 c	1.051 d	10.645 ab	2.37 b	2.88 bc	71.5 bc	1.02 c

Contrasts:	Comparisons:	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F
1 vs 2	Control vs PF, +14, +28 (BAS 125)	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
1 vs 3	Control vs +28, +42, +56 (BAS 125)	ns	ns	ns	ns	*	ns	ns	ns	ns	ns
1 vs 4	Control vs PF, +14, +28 (ethrel)	ns	ns	ns	ns	*	ns	ns	ns	ns	ns
1 vs 5	Control vs +28, +42, +56 (ethrel)	ns	ns	ns	ns	*	ns	ns	ns	ns	ns
1 vs 6	Control vs PF, +14, +28 (BAS 125+ethrel)	ns	*	ns	**	***	*	ns	ns	*	*
1 vs 7	Control vs PF, +14, +28 (BAS 125) +28, +42, +56 (ethrel)	ns	ns	ns	*	*	**	ns	ns	*	**
1 vs 8	Control vs +28, +42, +56 (BAS 125)+ PF, +14, +28 (ethrel)	**	**	**	***	***	*	ns	ns	*	***
2 vs 3	PF, +14, +28 (BAS 125) vs +28, +42, +56 (BAS 125)	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
2 vs 4	PF, +14, +28 (BAS 125) vs PF, +14, +28 (ethrel)	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
2 vs 5	PF, +14, +28 (BAS 125) vs +28, +42, +56 (ethrel)	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
2 vs 6	PF, +14, +28 (BAS 125) vs PF, +14, +28 (BAS 125+ethrel)	ns	ns	ns	*	**	ns	ns	ns	*	*
2 vs 7	PF, +14, +28 (BAS 125) vs PF, +14, +28 (BAS 125) +28, +42, +56 (ethrel)	ns	ns	ns	ns	ns	ns	ns	**	*	**
2 vs 8	PF, +14, +28 (BAS 125) vs +28, +42, +56 (BAS 125)+ PF, +14, +28 (ethrel)	**	ns	**	*	***	ns	ns	**	ns	***
3 vs 4	+28, +42, +56 (BAS 125) vs PF, +14, +28 (ethrel)	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
3 vs 5	+28, +42, +56 (BAS 125) vs +28, +42, +56 (ethrel)	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
3 vs 6	+28, +42, +56 (BAS 125) vs PF, +14, +28 (BAS 125+ethrel)	ns	*	ns	*	ns	ns	**	**	**	**
3 vs 7	+28, +42, +56 (BAS 125) vs PF, +14, +28 (BAS 125) +28, +42, +56 (ethrel)	ns	ns	ns	ns	ns	ns	*	**	**	**
3 vs 8	+28, +42, +56 (BAS 125) vs. +28, +42, +56 (BAS 125)+ PF, +14, +28 (ethrel)	*	*	*	**	*	ns	**	**	**	***
2,3 vs 4,5	BAS 125 vs ethrel	ns	ns	ns	ns	ns	ns	ns	*	ns	ns
2,3 vs 6,7,8	BAS 125 vs BAS 125+ethrel	**	*	*	**	**	*	**	***	***	***
4,5 vs 6,7,8	ethrel vs BAS 125+ethrel	ns	ns	ns	ns	ns	ns	ns	*	*	***

[z]Full bloom occurred 15 April 1998. Data taken on treatments Dec 2,1998.

[y] Treatments were applied with a low pressure handwand sprayer. Fruit size on spray dates May 6, May 20, June 3, June 17 were 7.9, 22.5, 36.0, 46.4 mm .

[x]Mean separation within columns by Duncan's new multiple range test; ($P \leq 0.05$).

Byers # 5

Table 1B. Effect of Appogee (BAS 125 10W) on 'Fuji'/M.9 apple tree growth applied in 1998.

No.	Color	Treatment[zy]	Rate ppm	Rate/ 100 gal	Rate/ 3.5 liter	Application time/date	Flower bud rating (%) 12 Apr 1999	Flowering clusters/ cm² cross sectional area limb 27 Apr 1999	Flowering clusters/cm on annual growth (5 shoots) 27 Apr 1999	Fruit/ cm² cross sectional area limb 30 July 1999
1.	W	Control					61.7 ab[x]	5.18 a	0.057 a	4.86 a
2.	R	BAS 125 (27.5%)	63, 63 , 63	86g	0.796g	PF, +14, +28	48.3 bc	5.80 a	0.066 a	5.11 a
3.	B	BAS 125 (27.5%)	63, 63 , 63	86g	0.796g	+28, +42, +56	46.7 c	6.01 a	0.076 a	4.87 a
4.	FO	Ethrel (21.7%)	135, 135 , 135	1/2pt.	2.177ml	PF, +14, +28,	51.7 abc	5.83 a	0.096 a	4.13 a
5.	HP	Ethrel (21.7%)	135, 135 , 135	1/2pt.	2.177ml	+28, +42, +56	43.3 c	5.75 a	0.095 a	4.84 a
6.	DG	BAS 125 (27.5%)	63, 63 , 63	86g	0.796g	PF, +14, +28	63.3 a	6.63 a	0.098 a	4.31 a
		+ Ethrel	135, 135 , 135	1/2pt.	2.177ml	PF, +14, +28				
7.	RD	BAS 125 (27.5%)	63, 63 , 63	86g	0.796g	PF, +14, +28	51.7 abc	6.44 a	0.057 a	5.14 a
		+ Ethrel	135, 135 , 135	1/2pt.	2.177ml	+28, +42, +56				
8.	BD	BAS 125 (27.5%)	63, 63 , 63	86g	0.796g	+28, +42, +56	65.0 a	8.75 a	0.097 a	4.91 a
		+ Ethrel	135, 135 , 135	1/2pt.	2.177ml	PF, +14, +28				

Contrasts:	Comparisons:	Pr>F	Pr>F	Pr>F	Pr>F
1 vs 2	Control vs PF, +14, +28 (BAS 125)	*	ns	ns	ns
1 vs 3	Control vs +28, +42, +56 (BAS 125)	*	ns	ns	ns
1 vs 4	Control vs PF, +14, +28 (ethrel)	ns	ns	ns	ns
1 vs 5	Control vs +28, +42, +56 (ethrel)	**	ns	ns	ns
1 vs 6	Control vs PF, +14, +28 (BAS 125+ethrel)	ns	ns	ns	ns
1 vs 7	Control vs PF, +14, +28 (BAS 125) +28, +42, +56 (ethrel)	ns	ns	ns	ns
1 vs 8	Control vs +28, +42, +56 (BAS 125)+ PF, +14, +28 (ethrel)	ns	ns	ns	ns
2 vs 3	PF, +14, +28 (BAS 125) vs +28, +42, +56 (BAS 125)	ns	ns	ns	ns
2 vs 4	PF, +14, +28 (BAS 125) vs PF, +14, +28 (ethrel)	ns	ns	ns	ns
2 vs 5	PF, +14, +28 (BAS 125) vs +28, +42, +56 (ethrel)	ns	ns	ns	ns
2 vs 6	PF, +14, +28 (BAS 125) vs PF, +14, +28 (BAS 125+ethrel)	*	ns	ns	ns
2 vs 7	PF, +14, +28 (BAS 125) vs PF, +14, +28 (BAS 125) +28, +42, +56 (ethrel)	ns	ns	ns	ns
2 vs 8	PF, +14, +28 (BAS 125) vs +28, +42, +56 (BAS 125)+ PF, +14, +28 (ethrel)	*	ns	ns	ns
3 vs 4	+28, +42, +56 (BAS 125) vs PF, +14, +28 (ethrel)	ns	ns	ns	ns
3 vs 5	+28, +42, +56 (BAS 125) vs +28, +42, +56 (ethrel)	ns	ns	ns	ns
3 vs 6	+28, +42, +56 (BAS 125) vs PF, +14, +28 (BAS 125+ethrel)	*	ns	ns	ns
3 vs 7	+28, +42, +56 (BAS 125) vs PF, +14, +28 (BAS 125) +28, +42, +56 (ethrel)	ns	ns	ns	ns
3 vs 8	+28, +42, +56 (BAS 125) vs. +28, +42, +56 (BAS 125)+ PF, +14, +28 (ethrel)	**	ns	ns	ns
2,3 vs 4,5	BAS 125 vs ethrel	ns	ns	ns	ns
2,3 vs 6,7,8	BAS 125 vs BAS 125+ethrel	**	ns	ns	ns
4,5 vs 6,7,8	ethrel vs BAS 125+ethrel	**	ns	ns	ns

[z]Full bloom occurred 15 April 1998.

[y] Treatments were applied with a low pressure handwand sprayer. Fruit size on spray dates May 6, May 20, June 3, June 17 were 7.9, 22.5, 36.0, 46.4 mm .

[x]Mean separation within columns by Duncan's new multiple range test; ($P \leq 0.05$).

Table 2A. Effect of Apogee on 'Fuji'/M.9 on apple tree growth applied in 1999.

No.	Color	Treatment Apogee (ppm)[z,y]	Salt	Formulation	Avg. shoot length of longest 4 scaffold shoots (cm) 15 June 99	Avg. shoot length of longest top 2 shoots	Avg. shoot length of longest 5 scaffold shoots	Weight of top 2 shoots (g)	Weight of 5 scaffold shoots (g)	
1.	W	Control			51.7 a[x]					
2.	Y	125, 125, 125	4.375g	10%	36.2 c					
		Regulaid	4.4ml							
3.	BK	125, 125, 125	4.375g	10%	32.6 c					
		+ Oil	8.8ml							
		+ L-77	1.1ml							
4.	YS	125, 125, 125	1.591g	27.5%	43.6 b					
5.	GS	125, 125, 125	1.591g	27.5%	36.3 c					
		Regulaid	4.4ml							
6.	PBKS	125, 125, 125	1.591g	27.5%	34.5 c					
		+ Oil	8.8ml							
		+ L-77	1.1ml							
7.	OBKS	125, 125, 125	1.591g	27.5%	46.9 ab					
		CaCl (1.5lb)	6.3g							
8.	HPS	125, 125, 125	1.591g	27.5%	32.1 c					
		NH4SO4	6.3g							
9.	RCK	125, 125, 125	1.591g	27.5%	35.0 c					
		+ CaCl (1.5lb)	6.3g							
		+ NH4SO4	6.3g							
10.	OCK	125, 125, 125	1.591g	27.5%	44.1 b					
		Regulaid	4.4ml							
		CaCl	6.3g							
11.	HPCK	125, 125, 125	1.591g	27.5%	31.2 c					
		Regulaid	4.4							
		NH4SO4	6.3g							
12.	YRS	125, 125, 125	1.591g	27.5%	36.1 c					
		Regulaid	4.4ml							
		+ CaCl (1.5lb)	6.3g							
		+ NH4SO4	6.3g							
13.	OBKD	125,125,125	1.591	27.5%	33.1 c					
		+ Oil	8.8ml							
		+ L-77	1.1ml							
		+ CaCl (1.5lb)	6.3g							
		+ NH4SO4	6.3g							
14.	PBKD	125, 125, 125	1.591g	27.5%	43.2 b					
		+ Oil	8.8ml							
		+ L-77	1.1ml							
		CaCl (1.5lb)	6.3g							
15.	RBKD	125, 125, 125	1.591g	27.5%	31.5 c					
		+ Oil	8.8ml							
		+ L-77	1.1ml							
		NH4SO4	6.3g							
16.	GD	Regulaid	4.4ml		47.1 ab					
		+ CaCl (1.5lb)	6.3g							
		+ NH4SO4	6.3g							
17.	OD	+ Oil	8.8ml		47.8 ab					
		+ L-77	1.1ml							
		+ CaCl (1.5lb)	6.3g							
		+ NH4SO4	6.3g							
Contrasts:		**Comparisons:**			Pr>F	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F
2 vs 5		Formulation 10% vs 27.5%			ns					
2,3 vs 5,6		Formulation 10% vs 27.5%			ns					
4 vs 5		Regulaid vs none(27.5%)			**					
2,5,12 vs 3,6,13		Regulaid vs oil+L-77			*					
7,10,14 vs 8,11,15		CaCl vs NH_4SO_4			***					
7,10,14 vs 9,12,13		CaCl vs CaCl+NH_4SO_4			***					
4,5,6 vs 7,10,14		CaCl vs none			***					
4,5,6 vs 8,11,15		NH4SO4 vs none			***					
16 vs 1		Additives vs none			ns					
17 vs 1		Additives vs none			ns					
ANOV		(Factorial)		Pr>F	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F	
		CaCl								
		NH4SO4								
		Surfactant								

[z]Full bloom occurred April 30 1999.
[y]Treatments were applied at PF, PF+21, PF+42 days with a low pressure hand-wand sprayer.
Chemical rates were as follows: Apogee = 0.125 g/L (125 mg/L);
NH_4SO_4 = 1.257 g/L; CaCl = 1.8 g/L; Regulaid = 1.257 ml/L; L-77 = 0.314 ml/L; Oil = 2.514ml/L.
[x]Mean separation within columns by Duncan's New Multiple Range Test; ($P \leq 0.05$).

Table 2B. Effect of Apogee on 'Fuji'/M.9 on apple tree growth applied in 1999.

No.	Color	Treatment Apogee (ppm)[ZY]	Salt	Formulation	Avg. shoot length of longest 4 scaffold shoots (cm) 15 June 99	Fruit diameter (cm) (Oct 7)	Length/ diameter ratio (Oct 7)	Fruit firmness (lb) (Oct 7)	Soluble solids (Oct 7)	Starch (0-8) (Oct 7)	Fruit color (Oct 7)	Single fruit weight (g) (Oct 7)
1.	W	Control			51.7 a[X]	7.33 a	0.838 a	16.7 a	14.3 a	6.76 a	70.2 a	169.6 a
11.	HPCK	125, 125, 125	1.591g	27.5%	31.2 b	7.25 a	0.840 a	16.9 a	14.0 a	6.91 a	74.2 a	166.8 a
		Regulaid	4.4									
		NH4SO4	6.3g									

[Z]Full bloom occurred April 30 1999.

[Y]Treatments were applied at PF, PF+21, PF+42 days with a low pressure hand-wand sprayer. Chemical rates were as follows: Apogee=0.125 g/L (125 mg/L); NH_4SO_4=1.257 g/L; CaCl=1.8 g/L; Regulaid=1.257 ml/L.

[X]Mean separation within columns by t test; ($P \leq 0.05$).

Byers # 8

Table 3A. Effect of Apogee on fruit set and thinning of Fuji/M.9 on apple tree growth applied in 1999.

No.	Color	Treatment Apogee (ppm)^{zy} PF, 21,42	Thinner at 10mm May 14, 1999	Fruit/cm cross sectional area limb June 9, 1999
1.	W	Control		5.12 b^{x}
2.	Y	250, 250, 250 + NH4SO4 + L-77		7.33 a
3.	BK	250, 250, 250 + NH4SO4 + L-77	Carbaryl + Oil	4.06 bc
4.	YS	250, 250, 250 + NH4SO4 + L-77	Carbaryl + Accel + Oil	1.37 e
5.	GS	250, 250, 250 + NH4SO4 + L-77	Ethrel	6.71 a
6.	PBKS	250, 250, 250 + NH4SO4 + L-77	Vydate + Accel	4.29 bc
7.	OBKS	250, 250, 250 + NH4SO4 + L-77	Shade 3 days	3.63 bc
8.	HPS		Carbaryl + Oil	2.96 cd
9.	RCK		Carbaryl + Accel + Oil	1.72 de
10.	OCK		Ethrel	6.74 a
11.	HPCK		Vydate + Accel	3.29 c
12.	YRS		Shade 3 days	3.55 bc

ANOV	(Factorial)	Pr>F

Contrasts:	Comparisons:	Pr>F
1 vs 2	BASF vs none	*
3,4,5,6,7 vs 8,9,10,11,12	BASF + thinners vs thinners alone	ns
2 vs 3,4,5,6,7	BASF vs BASF + thinners	***

^{z}Full bloom occurred Apr 30 1999. Petal fall occurred May 7, 1999.

^{y}Treatments were applied at PF, PF + 24, PF + 45 days with a low pressure hand-wand sprayer. Chemical rates were as follows: Apogee = 0.250 g/L (250 mg/L); Carbaryl XLR = 1.257 ml/L (600 ml/L); Accel = 2.75 ml/L (50 mg/L); Vydate = 1.257 ml/L (300 mg/L); NH_4SO_4 = 0.909 g/L; L-77 = 1.257 ml/L; Oil = 5.00 ml/L.

^{x}Mean separation within columns by Duncan's New Multiple Range Test; ($P \leq 0.05$).

Byers # 9

Table 3B. Effect of Apogee on fruit set and thinning of Fuji/M.9 on apple tree growth applied in 1999.

No.	Color	Treatment Apogee (ppm)[z][y] PF, 21,42	Salt	Adjuvant	Thinner at 10mm (14 May 99)	Fruit/cm cross sectional area limb (5 Oct 99)	Fruit diameter (cm) (5 Oct 99)	Length/ diameter ratio (5 Oct 99)	Fruit firmness (lb) (5 Oct 99)	Soluble solids (5 Oct 99)	Starch (0-8) (5 Oct 99)	Color (%) (5 Oct 99)	Number of fruit/tree (5 Oct 99)	Average single fruit weight(g) (5 Oct 99)	Average total weight per tree(kg) (5 Oct 99)
1.	W	Control				12.9 a[x]	6.90 b	0.839 a	16.6 b	14.3 b	7.0 ab	74 a	351.29 a	147.03 b	52.3 a
7.	OBKS	250, 250, 250 + NH4SO4 + L-77			Shade 3 days	8.9 b	7.01 b	0.846 a	17.3 a	14.0 b	7.5 a	75 a	214.00 b	148.72 b	31.5 b
12.	YRS				Shade 3 days	6.3 b	7.38 a	0.836 a	16.5 b	15.4 a	6.7 b	80 a	154.14 b	198.92 a	29.9 b

[z]Full bloom occurred Apr 30 1999. Petal fall occurred May 7, 1999.

[y]Treatments were applied at PF, PF + 24, PF + 45 days with a low pressure hand-wand sprayer. Chemical rates were as follows: Apogee = 0.250 g/L; NH_4SO_4 = 0.909 g/L; L-77 = 1.257 ml/L

[x]Mean separation within columns by Duncan's New Multiple Range Test; ($P \leq 0.05$).

Byers # 10

EFFECTS OF RESIDUES OF DIURON, SIMAZINE, AND TERBACIL ON NEWLY PLANTED APPLE AND PEACH TREES

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In mature fruit orchards weeds are controlled to reduce competition, improve access to trees, and eliminate habitat of crop-damaging insects. Several experiments have demonstrated that herbicides applied to soil can adversely affect peach and apple tree growth. Herbicide toxicity can vary with soil conditions such as soil texture and percent organic matter, environmental conditions such as precipitation, and past management practices such as herbicide incorporation. Diuron (N'-(3,4-dichlorphenyl)-N,N-dimethylurea), simazine (6-chloro-N,N'-diethyl-1,3,5-triazine-2,4-diamine), and terbacil (5-chloro-3-(1,1-dimethylethyl)-6-methyl-2,4(1H,3H)-pyrimidinedione) have been available for nearly thirty years and have been applied repeatedly for weed control in fruit orchards in widely different environments. These herbicides can persist in soil for more than one year in quantities sufficient to cause damage to plants. The objective of this experiment was to determine the effect of past long-term use of different herbicides, applied at different rates and combinations on survival and growth of young apple and peach trees.

Combinations of diuron, simazine, and terbacil were applied every year over 15 and 16 years to the same plots. Apple and peach trees then were planted one and two years following the last herbicide application. In general, apple tree growth was not affected but peach tree growth was reduced by some herbicide treatments. The greatest reduction in peach tree growth occurred in plots previously treated with 4 kg ha^{-1} diuron plus 2 kg ha^{-1} terbacil. This herbicide combination also reduced weed growth the most over 15 years and, consequently, soil organic matter was lowest on these plots. Time of last herbicide treatment had no effect on apple or peach tree growth. The results indicate that reduced fruit tree growth was a consequence of reduced organic matter rather than residual toxic effects of the herbicides.

Not For Citation

THE EFFECT OF PREHARVEST AVG AND POSTHARVEST MCP APPLICATIONS ON PEACH MATURITY AND STORAGE LIFE

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Ethylene is involved in a number of ripening-related processes in fruit. The plant growth regulator, AVG or ReTain (Abbott Labs) reduces ethylene biosynthesis and thus delays ripening. The plant growth regulator, 1-methylcyclopropene (MCP) or EthylBloc (Biotechnologies for Horticulture), inhibits ethylene action by blocking the ethylene receptor. While both compounds act on the ethylene system in plants, the mode of action is different. The objective of these experiments was to study the response of peaches to preharvest applications of AVG (ReTain) and/or postharvest MCP (EthylBloc)gassing following harvest and cold storage.

MATERIALS AND METHODS

Preharvest AVG applications were made to 7 year-old 'Contender'/ 'Lovell' peach trees at the Sandhills Research Station in Jackson Springs, NC. Applications were made with a mist blower delivering approximately 935 l/ha of water. AVG treatments were made based upon the number of days before the first anticipated harvest. It also must be mentioned that fruit harvested in subsequent harvests would have had the AVG applied for a longer duration. MCP treated fruit were gassed after harvest with 1 ul/l for approximately 16 hours at 4.4°C. The experiment was a randomized complete block design with 6-1 tree replicates with a 5 fruit sample evaluated at each storage duration. Trees were harvested 4 times and yield was measured for each treatment. Fruit evaluated in this study were those from the first two harvests. Maturity indices measured included fruit diameter, ethylene evolution, flesh firmness (8 and 11 mm tips), and soluble solids content. Fruit were evaluated at harvest and 1,2, and 3 weeks after harvest. The fruit evaluated at harvest were evaluated the day after the harvest due to the time required to harvest all treatments. Fruit evaluated 1 week after harvest were placed at 0°C for 4 days and then at 22°C for 3 days to try to simulate conditions that a peach would receive until used by the consumer. Fruit held for 2 and 3 weeks were placed in cold storage at 0°C and removed to 22°C and evaluated when fruit were at ambient temperature.

The treatments evaluated were:

1. Untreated Control
2. ReTain, 25 g/acre @ 3 days before first harvest
3. ReTain, 50 g/acre @ 3 days before first harvest
4. ReTain, 25 g/acre @ 5 days before first harvest
5. ReTain, 50 g/acre @ 5 days before first harvest
6. ReTain, 25 g/acre @ 7 days before first harvest

7. ReTain, 50 g/acre @ 7 days before first harvest
8. ReTain, 25 g/acre @ 10 days before first harvest
9. ReTain, 50 g/acre @ 10 days before first harvest
10. ReTain, 50 g/acre @ 3 days before first harvest + MCP gassing @ 1 ul/l for 16 hrs at 4.4°C
11. ReTain, 50 g/acre @ 7 days before first harvest + MCP gassing @ 1 ul/l for 16 hrs at 4.4°C
12. MCP only

Harvest Dates:

–First Harvest - 7/19
–Second Harvest - 7/22
–Third Harvest - 7/26
–Fourth Harvest - 7/30

RESULTS AND DISCUSSION

The preharvest applications of AVG did not significantly alter the percentage of fruit harvested during the first 3 harvests. However, for the fourth and final harvest, AVG applications did result in a greater percentage of fruit being harvested. This delay in harvest, although somewhat small, was also seen in large scale EUP grower trials conducted in NC this year.

At the first harvest, AVG applied 5 days before first harvest at 50 g or 7 days at 25 or 50 g resulted in fruit that were firmer than the untreated fruit. However, this effect was not detected at the second harvest, 3 days later. At the third harvest, 6 days after the first harvest, the fruit were more mature and fruit treated at both the 25 and 50 g rate were firmer than the untreated fruit.

After one week of storage (4 days at 0°C and 3 days at 22°C), fruit flesh firmness was greatly reduced and only the large tip was used. For both harvest 1 and harvest 2, fruit treated 5 or 7 days before the first harvest at the 50 g rate were significantly firmer than the untreated fruit. No significant increases in fruit firmness were measured for both harvests for fruit held for 2 weeks. However, for the fruit held for 3 weeks the flesh firmness for fruit from the first harvest and treated 7 days before the first harvest at both the 25 and 50 g rate were significantly firmer than the untreated fruit.

Fruit treated with MCP, with and without AVG, in this study did not appear to result in firmer fruit than untreated fruit. In two instances the fruit treated with AVG before first harvest at the 50 g rate and treated with MCP resulted in fruit firmer than untreated fruit. However, the fruit treated only with AVG 7 days before first harvest at the 50 g rate were firmer that the untreated fruit. MCP in other studies has been shown to result in firmer fruit than those untreated. However, the fruit in this study were harvested at a more advanced stage of maturity similar to commercial operations in NC. It may also be that the 'Contender' cultivar is one that once maturity has been initiated it is not possible to delay the process with MCP.

In conclusion, it appears that the use of AVG may slightly delay harvest and shift a greater percentage of fruit to the last harvest. It also appears that AVG may result in firmer fruit, both at harvest and after storage when applied 5-7 days before the first harvest. However, the timing of the preharvest applications still needs to be determined. Although the 25 g rate provided firmer fruit in some instances, the 50 g rate resulted in greater flesh firmness for fruit being held in storage.

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Pre-harvest Fruit Drop Studies, Harvest Quality, and Cold Storage of 'Golden Delicious' and 'Rome' Apples

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Abstract. Combinations of Aminoethoxyvinylglycine (AVG, ReTain) and NAA gave better control of fruit drop of 'Golden Delicious' than either alone. When the full rate of ReTain (50g/A) was compared to a reduced rate of ReTain (35g/A) plus NAA, equivalent control of fruit drop of 'Golden Delicious' resulted. ReTain delayed softening and starch depletion of 'Golden Delicious' fruit. NAA in some cases promoted earlier fruit maturity; but when used in combination with ReTain, maturity was similar to ReTain treated fruit. Fruit with the best firmness and starch came out of cold storage in the best condition.

Neither 1-Methylcyclopropene (MCP, EthylBlock) or NAA inhibited fruit drop of 'Golden Delicious' fruit when applied at harvest; but previous ReTain and NAA data indicate that late applications are frequently much less effective than if applied 4 weeks before harvest. Ethephon spray treatments caused more rapid and extensive fruit drop than the control. Trees gassed or sprayed with EthylBlock before ethephon sprays also dropped rapidly. Shading trees with 92% polypropylene shade material for 3 or 7 days caused more rapid fruit abscission at 7 days than 3 days and both were greater than the control. Further study of earlier applications of EthylBlock may be needed to get fruit drop control. 'Golden Delicious' fruit on the tree were dramatically maintained firmer by the EthylBlock gas, and to a lesser extent by EthylBlock sprays by 4.3 lbs. and 2.3 lbs. firmness, respectively. Starch was maintained by the EthylBlock gas, but not by the sprays. These data indicated that EthylBlock was applied in a manner that did have a physiological affect but did not control fruit drop. Fruit diameter, soluble solids and color did not appear to be affected.

NAA plus Silwet L-77 inhibited fruit drop of 'Law Rome', but none of the EthylBlock sprays inhibited fruit drop when applied at harvest. Previous data with ReTain and NAA indicated that late applications are frequently much less effective than if applied 4 weeks before harvest. Ethylblock sprays applied 21 Oct. dramatically maintained fruit firmness tested on 3 November. Starch was not maintained by the EthylBlock gas, but starch had almost disappeared by the application time on 21 Oct. Fruit diameter, soluble solids and color did not appear to be affected. Further study of earlier applications of EthylBlock may be needed to get fruit drop control.

Introduction

Aminoethoxyvinylglycine (AVG, ReTain) is an ethylene-biosynthesis inhibitor (Yu and Yang, 1979, Shafer et al., 1995) that suppresses ethylene production in apples (Malus domestica Borkh.) (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).

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 into a powder with the trade name EthylBloc that releases the 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).

The objectives of these experiments were to investigate ReTain, NAA, and their combinations for pre-harvest fruit drop control, fruit quality, and cold storage of harvested fruit and MPC for pre-harvest fruit drop control, fruit quality.

Materials and Methods

Trees were selected for uniformity and were blocked according to row and terrain into six blocks for the number of treatments listed in each table. Specific information about tree size, spray application dates, chemical rates, stage of development, and temperatures are reported in each table where applicable.

Expt. 1. In 1998, fifty-four 23-year-old 'Golden Delicious'/MM.106 trees (6 blocks) were used for 9 treatments (Table 1). NAA or ReTain was applied to each treatment on 5 Aug, 12 Aug, or 26 Aug (5, 4, or 2 weeks before the optimum estimated maturity date; 9 Sept.). The sprays were applied with a Swanson 3-pt hitch airblast sprayer with both fans adjusted to one side to double air output. Trees were considered 75% Tree-Row-Volume (TRV) dilute.

Three limbs/tree (approximately 50 fruits/tree) were selected and tagged for determining fruit drop . At intervals of about 7 days, fruit on limbs were counted and the percentage fruit drop was calculated based on fruit remaining on the five limbs/tree. Fruit remaining on each limb were counted on 29 Oct. In addition, a sample of 10 fruit was collected from each tree on 3 Sept., 2 Oct., 19 Oct for determining fruit firmness, % soluble solids concentration (SSC), and ratings for watercore, starch, and fruit color.

In addition, fruit samples from the 3 Sept. and 2 Oct. harvest dates were stored in a commercial cold storage at 32 F and was tested 13 January 1999.

Expt 2. In 1999, sixty-six 4-year-old 'Golden Delicious'/MM.111 trees (6 blocks) were used for 11 treatments (Table 2). On Sept 23 large plastic bags were placed over trees for gassing trt #s 4,7 with EthylBlock from 6 pm to 8:00 am To prevent heating from sunlight, trees were gassed over the night period. On Sept 24, spray treatments of NAA, ReTain, Ethrel, and EthylBlock were applied as indicated in Table 1A.

Expt 3. In 1999, thirty 15-year-old ' Law Rome'/MM.111 trees (6 blocks) were used for 5 treatments (Table 3). On October 21, NAA plus Silwet L-77 or EthylBlock plus Silwet L-77 + Oil plus either buffer # 1 or # 2 was applied as sprays (Table 3).

Results and Discussion

Expt. 1. NAA provided unacceptable control of fruit drop. ReTain (50 g/A) provided better control drop than NAA (10 ppm)(trt#s 2vs4). ReTain (35 g/A)+ NAA (10 ppm) reduced fruit drop of 'Golden Delicious'/MM111 better than 10 ppm NAA (trt#s 9vs2, or trt#s 8vs2)(Table 1A) or AVG (35g) alone (trt#s 6,7 vs 8,9). ReTain at the 50g rate was slightly more effective than 35g rate(trt#s 4,5 vs 6,7); but no differences were found between the 50g ReTain and the 35g ReTain + NAA (10ppm). (Table 1A).

Fruit quality and maturity of Golden Delicious/MM106 is reported in table 1B. There was a considerable increase in fruit size from Sept 3 to Oct 2 in all the treatments. Fruit firmness of the 35g ReTain + NAA (trt#s 8,9) on Sept 3 was higher than NAA alone (trt 2) and similar to the 35g ReTain treatments (trt#s 6,7). The same was true for starch levels on Oct 2. Better color was obtained by all treatments in the later pickings; 50 g ReTain (trt# 4) caused the greatest delay in starch and fruit coloring on Sept 3, Oct 2, and Oct 19.

Fruit harvested Sept 3 and stored until Jan 12 had lost considerable firmness (Table 1C). NAA alone (trt 2) was less firm than all other treatments. The combination of NAA + ReTain (trt#s 8, 9) did not cause a reduction of fruit firmness when compared to ReTain alone (trt#s 6,7).

Fruit harvested Oct. 2 and stored until Jan 12 had lost considerable firmness (Table 1C). NAA alone (trt 2) and the control was less firm on Jan 13 than other treatments that had ReTain. The combination of NAA + ReTain (trt#s 8, 9) did not cause a reduction of fruit firmness when compared to ReTain alone (trt#s 6,7).

Expt 2. In 1999, neither EthylBlock or NAA inhibited fruit drop of 'Golden Delicious' fruit (Table 2A). Previous data with ReTain and NAA indicate that late applications are frequently much less effective than if applied 4 weeks before harvest.All ethephon spray treatments caused more rapid and extensive fruit drop than the control (trt #s 6,7,8) Trees gassed (trt # 7) or sprayed (trt # 8) with EthylBlock before ethephon sprays also dropped rapidly. Shading trees with 92% polypropylene shade material for 3 or 7 days caused more rapid fruit abscission at 7 days than 3 days (trt #s 1, 9,10,11) and both greater than the control. Further study of earlier applications of EthylBlock may be needed to get fruit drop control.

'Golden Delicious' fruit on the tree were dramatically maintained firmer by the Ethylblock gas (trt# 4), and to a lesser extent by EthylBlock sprays (trt#s 3, 5) by 4.3lbs and 2.3 lbs firmness, respectively on 28 October (Table 2B). Starch was maintained by the EthylBlock gas (trt# 4), but not by the sprays (trt#s 3,5). These data indicated that EthylBlock was applied in a manner that did have a physiological affect but did not control fruit drop. Fruit diameter, soluble solids and color did not appear to be affected.

Expt 3. NAA plus Silwet L-77 inhibited fruit drop of 'Law Rome' (trt#2), but none of the EthylBlock sprays inhibited fruit drop (trt#s 3,4,5) (Table 3A). Previous data with ReTain and NAA indicate that late applications are frequently much less effective than if applied 4 weeks before harvest.

Ethylblock sprays applied 21 Oct. dramatically maintained fruit firmness (trt#s 3,4,5) tested on 3 November (Table 3B). Starch was not maintained by the EthylBlock gas, but starch had almost disappeared by application time on 21 Oct. Fruit diameter, soluble solids and color did not appear to be affected. Further study of earlier applications of EthylBlock may be needed to get fruit drop control.

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References

Byers, R. E. 1997a. Peach and Nectarine Fruit Softening Following Aminoethoxyvinylglycine (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. Blakenship, and J. P Mattheis. 1999. 1 Methylcyclopropene inhibits apple ripening. J. Amer. Soc. Hort. Sci. 124: (in press).

Sisler, E. C. and M. Serek. 1997. Inhibitors of ethylene responses in plants at the receptor level: Recent developments. Physiol. Plant. 100:577-582.

Table 1A. Effect of ReTain and NAA on fruit drop of 'Golden Delicious'/111 (1998).

No.	Color	Treatment[Z,Y]	Rate (g/acre) (gallons/acre)	Rate/ 50 gal	Date of application	Aug 4	Aug 12	Sept 2	Sept 9	Sept 16	Sept 23	Sept 30	Oct 7	Oct 14	Oct 21	Oct 28
						% Fruit Drop										
1.	W	Control				0.0 a[x]	0.3 a	0.7 ab	1.0 ab	1.4 a	2.7 a	5.9 a	9.0 ab	20.4 a	63.0 a	80.1 a
2.	R	NAA (10ppm)	366g/100	183g	Aug 12	0.0 a	0.0 a	0.3 ab	1.2 ab	1.5 a	2.6 a	3.4 ab	5.8 ab	13.6 ab	45.0 b	57.9 b
		+ ABG-7011 (0.1%)		189.5 ml												
3.	B	ReTain (15%)	50g/100	167 g	Aug 5	0.0 a	0.0 a	0.3 ab	0.6 ab	0.6 a	1.9 a	1.9 b	4.3 b	9.0 b	35.3 bc	52.7 bc
		+ ABG-7011 (0.1%)		189.5 ml												
4.	FO	ReTain (15%)	50g/100	167 g	Aug 12	0.0 a	0.3 a	0.9 ab	1.6 a	1.9 a	4.3 a	4.6 ab	5.6 b	8.3 b	25.4 c	38.2 c
		+ ABG-7011 (0.1%)		189.5 ml												
5.	HP	ReTain (15%)	50g/100	167 g	Aug 26	0.0 a	0.3 a	0.3 ab	0.9 ab	0.9 a	1.8 a	2.9 ab	6.4 ab	9.0 b	26.2 c	43.5 c
		+ ABG-7011 (0.1%)		189.5 ml												
6.	FOBKS	ReTain (15%)	35g/100	117 g	Aug 12	0.0 a	0.0 a	0.0 b	0.0 b	0.3 a	3.4 a	5.2 a	8.4 ab	14.5 ab	32.4 bc	44.9 bc
		+ ABG-7011 (0.1%)		189.5 ml												
7.	PBKS	ReTain (15%)	35g/100	117 g	Aug 26	0.0 a	0.0 a	0.3 ab	1.0 ab	2.1 a	3.7 a	6.4 a	11.8 a	16.6 ab	35.3 bc	51.4 bc
		+ ABG-7011 (0.1%)		189.5 ml												
8.	RD	ReTain (15%)	35g/100	117 g	Aug 12	0.0 a	0.3 a	1.6 a	1.9 a	1.9 a	2.8 a	4.1 ab	5.9 ab	8.6 b	20.2 c	33.7 c
		+ ABG-7011 (0.1%)		189.5 ml												
		+ NAA (10ppm)	366g/100	183g	Aug 12											
9.	BD	ReTain (15%)	35g/100	117g	Aug 26	0.0 a	0.0 a	0.3 ab	0.3 ab	0.3 a	2.0 a	2.6 ab	4.5 b	8.7 b	21.8 c	38.0 c
		+ ABG-7011 (0.1%)		189.5 ml												
		+ NAA (10ppm)	366g/100	183g	Aug 26											

Contrasts	Comparisons	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F
1 vs 2	Control vs NAA	ns	ns	ns	ns	ns	ns	ns	ns	ns	*	*
1 vs 3	Control vs 50g ReTain (Aug 5)	ns	ns	ns	ns	ns	ns	*	ns	**	**	**
1 vs 4	Control vs 50g ReTain (Aug 12)	ns	ns	ns	ns	ns	ns	ns	ns	**	***	***
1 vs 5	Control vs 50g ReTain (Aug 26)	ns	ns	ns	ns	ns	ns	ns	ns	**	***	***
2 vs 3	NAA vs 50g ReTain (Aug 5)	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
2 vs 4	NAA vs 50g ReTain (Aug 12)	ns	ns	ns	ns	ns	ns	ns	ns	ns	*	*
2 vs 5	NAA vs 50g ReTain (Aug 26)	ns	ns	ns	ns	ns	ns	ns	ns	ns	*	ns
2 vs 8	NAA vs 35g ReTain + NAA (Aug 12)	ns	ns	*	ns	ns	ns	ns	ns	ns	**	**
2 vs 9	NAA vs 35g ReTain + NAA (Aug 26)	ns	ns	ns	ns	ns	ns	ns	ns	ns	**	*
3 vs 4	ReTain 50g (Aug 5 vs Aug 12)	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
3 vs 5	ReTain 50g (Aug 5 vs Aug 26)	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
4,5 vs 6,7	ReTain 50g vs ReTain 35g (Aug 12,26 vs Aug 12,26)	ns	ns	ns	ns	ns	ns	ns	*	*	ns	ns
4,5 vs 8,9	ReTain 50g vs ReTain 35g + NAA (Aug 12,26 vs Aug 12,26)	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
4 vs 5	ReTain 50g (Aug 12 vs Aug 26)	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
4 vs 6	ReTain 50g (Aug 12) vs ReTain 35g (Aug 12)	ns	ns	ns	*	ns	ns	ns	ns	ns	ns	ns
5 vs 7	ReTain 50g (Aug 26) vs ReTain 35g (Aug 26)	ns	ns	ns	ns	ns	ns	*	*	ns	ns	ns
6,7 vs 8,9	ReTain (NAA vs none)	ns	ns	ns	ns	ns	ns	*	**	*	*	*
6 vs 8	ReTain 35g (Aug 12) vs ReTain 35g + NAA (Aug 12)	ns	ns	**	**	ns	ns	ns	ns	ns	ns	ns
7 vs 9	ReTain 35g (Aug 26) vs ReTain 35g + NAA (Aug 26)	ns	ns	ns	ns	*	ns	*	**	*	ns	ns
8 vs 9	ReTain 35g + NAA (Aug 12) vs ReTain 35g + NAA (Aug 26)	ns	ns	*	*	ns	ns	ns	ns	ns	ns	ns

[Z]All treatments were applied with an airblast machine at 100 gals/acre. Tree size was considered to be 75% TRV.
[Y]Estimated optimum harvest date: Sept 3, 1998.
[X]Mean separation within columns by Duncan's New Multiple Range Test;(P≤ 0.05).

Byers # 5

Table 1B. Effect of ReTain and NAA on fruit quality and maturity of 'Golden Delicious'/111 harvested Sept 3, Oct 2, and Oct 19 (1998).

No.	Treatment[z]	Rate (g/acre) (gallons/acre)	Rate/ 50 gal	Date of application	Fruit diameter (cm) Sept[y] 3	Fruit diameter (cm) Oct 2	Fruit diameter (cm) Oct 19	Length/ diameter ratio Sept 3	Length/ diameter ratio Oct 2	Length/ diameter ratio Oct 19	Fruit firmness (lb.) Sept 3	Fruit firmness (lb.) Oct 2	Fruit firmness (lb.) Oct 19	Soluble solids (%) Sept 3	Soluble solids (%) Oct 2	Soluble solids (%) Oct 19	Starch (1-8 rating) Sept 3	Starch (1-8 rating) Oct 2	Starch (1-8 rating) Oct 19	Color (0-5) Sept 3	Color (0-5) Oct 2	Color (0-5) Oct 19
1.	Control				7.13 a[x]	7.71 ab	7.63 ab	0.900 a	0.904 a	0.918 a	19.0 bc	15.6 b	11.5 d	13.11 bcd	16.2 a	17.7 a	2.57 bcd	6.44 a	7.74 abc	2.77 a	3.12 a	4.00 a
2.	NAA (10ppm) + ABG-7011 (0.1%)	366g/100	183g 189.5 ml	Aug 12	7.13 a	7.67 ab	7.71 ab	0.920 a	0.892 a	0.904 a	18.5 c	17.1 a	11.2 d	12.93 cd	15.5 b	17.1 ab	3.23 a	6.33 a	7.90 a	2.57 ab	3.05 a	3.98 a
3.	ReTain (15%) + ABG-7011 (0.1%)	50g/100	167 g 189.5 ml	Aug 5	7.13 a	7.63 ab	7.67 ab	0.902 a	0.893 a	0.907 a	20.4 a	17.1 a	13.7 bc	12.88 d	16.1 ab	16.9 ab	2.12 d	5.53 abc	7.25 cd	2.65 a	3.02 a	3.93 ab
4.	ReTain (15%) + ABG-7011 (0.1%)	50g/100	167 g 189.5 ml	Aug 12	7.20 a	7.81 a	7.79 a	0.911 a	0.901 a	0.913 a	19.9 a	17.5 a	15.5 a	12.98 cd	15.5 b	17.1 ab	1.53 e	4.87 c	6.82 d	2.38 b	2.95 a	3.75 c
5.	ReTain (15%) + ABG-7011 (0.1%)	50g/100	167 g 189.5 ml	Aug 26	7.15 a	7.60 b	7.67 ab	0.916 a	0.905 a	0.910 a	20.1 a	17.4 a	13.3 c	13.28 abcd	15.7 ab	16.7 b	3.10 ab	6.03 ab	7.25 cd	2.67 a	3.23 a	3.87 ab
6.	ReTain (15%) + ABG-7011 (0.1%)	35g/100	117 g 189.5 ml	Aug 12	7.24 a	7.64 ab	7.71 ab	0.904 a	0.891 a	0.904 a	19.8 ab	17.5 a	13.8 bc	13.23 abcd	15.6 ab	16.9 ab	2.22 cd	5.28 bc	7.47 abc	2.58 ab	3.08 a	3.87 ab
7.	ReTain (15%) + ABG-7011 (0.1%)	35g/100	117 g 189.5 ml	Aug 26	7.15 a	7.63 ab	7.68 ab	0.907 a	0.901 a	0.906 a	20.1 a	17.2 a	13.8 bc	13.65 ab	16.0 ab	17.1 ab	2.70 abcd	5.73 abc	7.38 bc	2.72 a	3.15 a	3.93 ab
8.	ReTain (15%) + ABG-7011 (0.1%) + NAA (10ppm)	35g/100 366g/100	117 g 189.5 ml 183g	Aug 12 Aug 12	7.08 a	7.52 b	7.59 b	0.903 a	0.903 a	0.900 a	19.6 ab	17.1 a	14.3 b	13.47 abc	15.6 ab	16.8 b	2.78 abc	5.68 abc	7.80 ab	2.52 ab	3.07 a	3.80 bc
9.	ReTain (15%) + ABG-7011 (0.1%) + NAA (10ppm)	35g/100 366g/100	117g 189.5 ml 183g	Aug 26 Aug 26	7.08 a	7.54 b	7.61 b	0.908 a	0.899 a	0.916 a	20.2 a	17.3 a	13.9 bc	13.72 a	16.0 ab	17.2 ab	2.73 abcd	5.97 ab	7.53 abc	2.73 a	3.18 a	3.90 ab
Contrasts	Comparisons				Pr>F	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F
1 vs 2	Control vs NAA				ns	ns	ns	ns	ns	ns	ns	•••	ns	ns	•	ns	•	ns	ns	ns	ns	ns
1 vs 3	Control vs 50g ReTain (Aug 5)				ns	ns	ns	ns	ns	ns	•••	•••	•••	ns	ns	•	ns	ns	•	ns	ns	ns
1 vs 4	Control vs 50g ReTain (Aug 12)				ns	ns	ns	ns	ns	ns	•	•••	•••	ns	•	ns	••	•••	•••	••	ns	•••
1 vs 5	Control vs 50g ReTain (Aug 26)				ns	ns	ns	ns	ns	ns	••	•••	•••	ns	ns	••	ns	ns	•	ns	ns	•
2 vs 3	NAA vs 50g ReTain (Aug 5)				ns	ns	ns	ns	ns	ns	•••	ns	•••	ns	ns	ns	•••	ns	••	ns	ns	ns
2 vs 4	NAA vs 50g ReTain (Aug 12)				ns	ns	ns	ns	ns	ns	•••	ns	•••	ns	ns	ns	•••	•••	•••	ns	ns	•••
2 vs 5	NAA vs 50g ReTain (Aug 26)				ns	ns	ns	ns	ns	ns	•••	ns	•••	ns	ns	ns	ns	ns	••	ns	ns	ns
2 vs 8	NAA vs 35g ReTain + NAA (Aug 12)				ns	ns	ns	ns	ns	ns	••	ns	•••	•	ns	ns	ns	ns	ns	ns	ns	••
2 vs 9	NAA vs 35g ReTain + NAA (Aug 26)				ns	ns	ns	ns	ns	ns	•••	ns	•••	••	ns	ns	ns	ns	ns	ns	ns	ns
3 vs 4	ReTain 50g (Aug 5 vs Aug 12)				ns	•	ns	ns	ns	ns	ns	ns	•••	ns	ns	ns	ns	ns	•	•	ns	••
3 vs 5	ReTain 50g (Aug 5 vs Aug 26)				ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	••	ns	ns	ns	ns	ns
4,5 vs 6,7	ReTain 50g vs ReTain 35g (Aug 12,26)				ns	ns	ns	ns	ns	ns	ns	ns	•	ns	ns	ns	ns	ns	•	ns	ns	•
4,5 vs 8,9	ReTain 50g vs ReTain 35g + NAA (Aug 12,26)				ns	••	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	•	ns	•••	ns	ns	ns
4 vs 5	ReTain 50g (Aug 12 vs Aug 26)				ns	•	•	ns	ns	ns	ns	ns	•••	•	ns	ns	•••	••	•	•	ns	ns
4 vs 6	ReTain 50g (Aug 12) vs ReTain 35g (Aug 12)				ns	ns	ns	ns	ns	ns.	ns	ns	•••	ns	ns	ns	•	ns	••	ns	ns	ns
5 vs 7	ReTain 50g (Aug 26) vs ReTain 35g (Aug 26)				ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
6,7 vs 8,9	ReTain (NAA vs none)				•	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
6 vs 8	ReTain 35g (Aug 12) vs ReTain 35g + NAA (Aug 12)				ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
7 vs 9	ReTain 35g (Aug 26) vs ReTain 35g + NAA (Aug 26)				ns	ns	ns	ns.	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
8 vs 9	ReTain 35g + NAA (Aug 12) vs ReTain 35g + NAA (Aug 26)				ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns

[z] All treatments were applied with an airblast machine at 100 gals/acre. Tree size was considered to be 75% TRV.
[y] Estimated optimum harvest date: Sept 3, 1998.
[x] Mean separation within columns by Duncan's New Multiple Range Test;($P \leq 0.05$).

Byers # 6

Table 1C. Effect of ReTain and NAA on fruit quality and maturity of 'Golden Delicious'/111 harvested Sept 3 and stored at 0° C until Jan 12,1999 (1998).[Y]

No.	Treatment[Z]	Rate (g/acre) (gallons/acre)	Rate/ 50 gal	Date of application	Fruit firmness (lb.) Sept 3	Fruit firmness (lb.) Jan 12	Soluble solids (%) Sept 3	Soluble solids (%) Jan 12	Starch (1-8 rating) Sept 3	Starch (1-8 rating) Jan 12
1.	Control				19.0 bc	11.2 c	13.11 bcd	14.62 ab	2.57 bcd	---
2.	NAA (10ppm)	366g/100	183g	Aug 12	18.5 c	10.6 d	12.93 cd	13.73 c	3.23 a	---
	+ ABG-7011 (0.1%)		189.5 ml							
3.	ReTain (15%)	50g/100	167 g	Aug 5	20.4 a	12.3 ab	12.88 d	14.48 ab	2.12 d	---
	+ ABG-7011 (0.1%)		189.5 ml							
4.	ReTain (15%)	50g/100	167 g	Aug 12	19.9 a	12.5 ab	12.98 cd	14.93 a	1.53 e	---
	+ ABG-7011 (0.1%)		189.5 ml							
5.	ReTain (15%)	50g/100	167 g	Aug 26	20.1 a	11.9 b	13.28 abcd	14.17 bc	3.10 ab	---
	+ ABG-7011 (0.1%)		189.5 ml							
6.	ReTain (15%)	35g/100	117 g	Aug 12	19.8 ab	12.2 ab	13.23 abcd	14.95 a	2.22 cd	---
	+ ABG-7011 (0.1%)									
7.	ReTain (15%)	35g/100	117 g	Aug 26	20.1 a	12.2 ab	13.65 ab	14.77 ab	2.70 abcd	---
	+ ABG-7011 (0.1%)									
8.	ReTain (15%)	35g/100	117 g	Aug 12	19.6 ab	12.4 ab	13.47 abc	14.53 ab	2.78 abc	---
	+ ABG-7011 (0.1%)		189.5 ml							
	+ NAA (10ppm)	366g/100	183g	Aug 12						
9.	ReTain (15%)	35g/100	117g	Aug 26	20.2 a	12.8 a	13.72 a	14.93 a	2.73 abcd	---
	+ ABG-7011 (0.1%)		189.5 ml							
	+ NAA (10ppm)	366g/100	183g	Aug 26						

Contrasts	Comparisons	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F
1 vs 2	Control vs NAA	ns	*	ns	**	*	---
1 vs 3	Control vs 50g ReTain (Aug 5)	***	**	ns	ns	ns	---
1 vs 4	Control vs 50g ReTain (Aug 12)	*	***	ns	ns	**	---
1 vs 5	Control vs 50g ReTain (Aug 26)	**	*	ns	ns	ns	---
2 vs 3	NAA vs 50g ReTain (Aug 5)	***	***	ns	ns	***	---
2 vs 4	NAA vs 50g ReTain (Aug 12)	***	***	ns	***	***	---
2 vs 5	NAA vs 50g ReTain (Aug 26)	***	***	ns	ns	ns	---
2 vs 8	NAA vs 35g ReTain + NAA (Aug 12)	**	***	*	**	ns	---
2 vs 9	NAA vs 35g ReTain + NAA (Aug 26)	***	***	**	***	ns	---
3 vs 4	ReTain 50g (Aug 5 vs Aug 12)	ns	ns	ns	ns	ns	---
3 vs 5	ReTain 50g (Aug 5 vs Aug 26)	ns	ns	ns	ns	**	---
4,5 vs 6,7	ReTain 50g vs ReTain 35g (Aug 12,26 vs Aug 12,26)	ns	ns	ns	ns	ns	---
4,5 vs 8,9	ReTain 50g vs ReTain 35g + NAA (Aug 12,26 vs Aug 12,26)	ns	ns	ns	ns	*	---
4 vs 5	ReTain 50g (Aug 12 vs Aug 26)	ns	ns	*	*	***	---
4 vs 6	ReTain 50g (Aug 12) vs ReTain 35g (Aug 12)	ns	ns	ns	ns	*	---
5 vs 7	ReTain 50g (Aug 26) vs ReTain 35g (Aug 26)	ns	ns	ns	*	ns	---
6,7 vs 8,9	ReTain (NAA vs none)	ns	ns	ns	ns	ns	---
6 vs 8	ReTain 35g (Aug 12) vs ReTain 35g + NAA (Aug 12)	ns	ns	ns	ns	ns	---
7 vs 9	ReTain 35g (Aug 26) vs ReTain 35g + NAA (Aug 26)	ns	ns	ns	ns	ns	---
8 vs 9	ReTain 35g + NAA (Aug 12) vs ReTain 35g + NAA (Aug 26)	ns	ns	ns	ns	ns	---

[Z]All treatments were applied with an airblast machine at 100 gals/acre. Tree size was considered to be 75% TRV.
[Y]Estimated optimum harvest date: Sept 3, 1998.
[X]Mean separation within columns by Duncan's New Multiple Range Test;($P \leq 0.05$).

Byers # 7

Table 1D. Effect of ReTain and NAA on fruit quality and maturity of 'Golden Delicious'/111 harvested Oct 2 and stored at 0° C until Jan 13,1999 (1998).[Y]

No.	Treatment[Z]	Rate (g/acre) (gallons/acre)	Rate/ 50 gal	Date of application	Fruit firmness (lb.) Oct 2	Fruit firmness (lb.) Jan 13	Soluble solids (%) Oct 2	Soluble solids (%) Jan 13	Starch (1-8 rating) Oct 2	Starch (1-8 rating) Jan 13
1.	Control				15.6 b	10.4 c	16.2 a	16.4 a	6.44 a	---
2.	NAA (10ppm)	366g/100	183g	Aug 12	17.1 a	10.5 c	15.5 b	15.6 b	6.33 a	---
	+ ABG-7011 (0.1%)		189.5 ml							
3.	ReTain (15%)	50g/100	167 g	Aug 5	17.1 a	11.3 b	16.1 ab	15.9 ab	5.53 abc	---
	+ ABG-7011 (0.1%)		189.5 ml							
4.	ReTain (15%)	50g/100	167 g	Aug 12	17.5 a	12.0 a	15.5 b	16.2 ab	4.87 c	---
	+ ABG-7011 (0.1%)		189.5 ml							
5.	ReTain (15%)	50g/100	167 g	Aug 26	17.4 a	11.0 bc	15.7 ab	15.8 ab	6.03 ab	---
	+ ABG-7011 (0.1%)		189.5 ml							
6.	ReTain (15%)	35g/100	117 g	Aug 12	17.5 a	11.5 ab	15.6 ab	16.1 ab	5.28 bc	---
	+ ABG-7011 (0.1%)									
7.	ReTain (15%)	35g/100	117 g	Aug 26	17.2 a	11.6 ab	16.0 ab	16.5 a	5.73 abc	---
	+ ABG-7011 (0.1%)									
8.	ReTain (15%)	35g/100	117 g	Aug 12	17.1 a	11.4 ab	15.6 ab	15.7 ab	5.68 abc	---
	+ ABG-7011 (0.1%)		189.5 ml							
	+ NAA (10ppm)	366g/100	183g	Aug 12						
9.	ReTain (15%)	35g/100	117g	Aug 26	17.3 a	11.4 ab	16.0 ab	16.0 ab	5.97 ab	---
	+ ABG-7011 (0.1%)		189.5 ml							
	+ NAA (10ppm)	366g/100	183g	Aug 26						

Contrasts	Comparisons	Fruit firmness Oct 2 Pr>F	Fruit firmness Jan 13 Pr>F	Soluble solids Oct 2 Pr>F	Soluble solids Jan 13 Pr>F	Starch Oct 2 Pr>F	Starch Jan 13 Pr>F
1 vs 2	Control vs NAA	***	ns	*	*	ns	---
1 vs 3	Control vs 50g ReTain (Aug 5)	***	*	ns	ns	ns	---
1 vs 4	Control vs 50g ReTain (Aug 12)	***	***	*	ns	***	---
1 vs 5	Control vs 50g ReTain (Aug 26)	***	ns	ns	ns	ns	---
2 vs 3	NAA vs 50g ReTain (Aug 5)	ns	*	ns	ns	ns	---
2 vs 4	NAA vs 50g ReTain (Aug 12)	ns	***	ns	*	***	---
2 vs 5	NAA vs 50g ReTain (Aug 26)	ns	ns	ns	ns	ns	---
2 vs 8	NAA vs 35g ReTain + NAA (Aug 12)	ns	ns	ns	ns	ns	---
2 vs 9	NAA vs 35g ReTain + NAA (Aug 26)	ns	**	ns	ns	ns	---
3 vs 4	ReTain 50g (Aug 5 vs Aug 12)	ns	*	ns	ns	ns	---
3 vs 5	ReTain 50g (Aug 5 vs Aug 26)	ns	ns	ns	ns	ns	---
4,5 vs 6,7	ReTain 50g vs ReTain 35g (Aug 12,26 vs Aug 12,26)	ns	ns	ns	ns	ns	---
4,5 vs 8,9	ReTain 50g vs ReTain 35g + NAA (Aug 12,26 vs Aug 12,26)	ns	ns	ns	ns	ns	---
4 vs 5	ReTain 50g (Aug 12 vs Aug 26)	ns	**	ns	ns	**	---
4 vs 6	ReTain 50g (Aug 12) vs ReTain 35g (Aug 12)	ns	ns	ns	ns	ns	---
5 vs 7	ReTain 50g (Aug 26) vs ReTain 35g (Aug 26)	ns	ns	ns	*	ns	---
6,7 vs 8,9	ReTain (NAA vs none)	ns	ns	ns	*	ns	---
6 vs 8	ReTain 35g (Aug 12) vs ReTain 35g + NAA (Aug 12)	ns	ns	ns	ns	ns	---
7 vs 9	ReTain 35g (Aug 26) vs ReTain 35g + NAA (Aug 26)	ns	ns	ns	ns	ns	---
8 vs 9	ReTain 35g + NAA (Aug 12) vs ReTain 35g + NAA (Aug 26)	ns	ns	ns	ns	ns	---

[Z]All treatments were applied with an airblast machine at 100 gals/acre. Tree size was considered to be 75% TRV.
[Y]Estimated optimum harvest date: Sept 3, 1998.
[X]Mean separation within columns by Duncan's New Multiple Range Test;($P \leq 0.05$).

Byers # 8

Table 2A. Effect of ReTain, NAA, Ethyl Block, Ethrel, and shading on fruit drop of 'Golden Delicious'/MM.111 (1999).

No.	Color	Treatment[zy]	Rate/ gallon	Application method	% Fruit Drop					
					9/26	9/30	10/7	10/14	10/21	10/28
1.	W	Control			2.5 cd[x]	26.2 d	33.5 e	43.7 e	51.2 d	57.9 d
2.	R	NAA (10ppm) K-200	0.73 ml	(spray)	8.5 ab	43.4 bcd	45.8 cde	57.1 cd	61.4 cd	64.7 cd
		+ ABG-7011 (0.1%)	3.785 ml							
3.	B	ReTain (15%)(150ppm)	3.785 g	(spray)	7.9 abc	45.4 bcd	55.2 bcd	80.5 b	82.5 b	84.8 b
		+ ABG-7011 (0.1%)	3.785 ml							
4.	FO	Ethyl Block	3 g	(gas)	3.3 bcd	39.2 bcd	41.1 de	54.0 cde	63.8 c	69.4 cd
		+ Buffer	60 ml							
5.	HP	Ethyl Block	3 g	(spray)	6.1 abcd	35.2 cd	39.8 de	49.1 de	56.5 cd	67.6 cd
		+ Oil (0.2%)	60 ml							
		+ Buffer	30 ml							
6.	LG	Ethrel 400 ppm	6.96 ml	(spray)	10.0 abcd	87.2 a	97.9 a	99.7 a	99.7a	100 a
		+ ABG-7011 (0.1%)	3.5 ml							
7.	Y	Ethrel 400 ppm	6.96 ml	(spray)	6.7 abcd	80.9 a	95.8 a	98.8 a	98.8 a	98.8 a
		+ ABG-7011 (0.1%)	3.5 ml							
		+ ABG-7011 (0.1%)	3.785	(gas)						
		+ Ethyl Block	3 g							
		+ Buffer	60 ml							
8.	BK	Ethrel 400 ppm		(spray)	8.1 ab	87.6 a	99.8 a	100 a	100 a	100 a
		+ ABG-7011 (0.1%)	3.5 ml							
		Ethyl Block	3 g	(spray)						
		+ Oil (0.2%)	7.57ml							
		+ Buffer	60 ml							
9.	OBKS	Shade 3 days (92%)			7.9 abc	47.7 bc	53.4 bcd	65.2 c	67.7 c	73.3 c
10.	PBKS	Shade 7 days (92%)			4.2 bcd	56.6 b	64.2 b	88.2 ab	92.0 ab	94.0 ab
11	RYS	Shade 7 days (92%)			1.5 d	45.2 bcd	57.5 bc	88.1 ab	93.4 ab	95.6 ab

[zy]All treatments were applied with a low pressure hand-wand sprayer. Ethyl Block applied on Sept. 23 (trts. 4,7); sprays applied on Sept. 24 (trts. 2,3,5,6,7,8).

[x]Mean separation within columns by Duncan's New Multiple Range Test;($P \leq 0.05$).

Byers # 9

Table 2B. Effect of ReTain NAA, Ethyl Block, Ethrel, and shading on maturity of 'Golden Delicious'/MM.111 (1999).

No.	Color	Treatment[zy]	Rate/ gallon	Application method	Fruit maturity*									
					Fruit firmness		Starch		Fruit diameter		Soluble solids		Fruit color	
					7 Oct	28 Oct	7 Oct	28 Oct	7 Oct	28 Oct	7 Oct	28 Oct	7 Oct	28 Oct
1.	W	Control			16.0 c	14.0 d	6.73 de	7.75 a	7.06 a[x]	7.06 a	16.6 ab	17.2 a	3.78 a	4.00 a
2.	R	NAA (10ppm) K-200 + ABG-7011 (0.1%)	0.73 ml 3.785 ml	(spray)	16.5 c	13.8 d	6.91 bcde	7.83 a	6.77 abc	6.85 abc	16.8 a	17.5 a	3.90 a	3.86 ab
3.	B	ReTain (15%)(150ppm) + ABG-7011 (0.1%)	3.785 g 3.785 ml	(spray)	17.5 b	16.6 b	6.78 cde	7.51 a	6.95 ab	6.92 ab	16.5 ab	17.0 a	3.54 ab	3.94 ab
4.	FO	Ethyl Block + Buffer	3 g 60 ml	(gas)	18.7 a	18.3 a	5.78 f	7.41 a	6.78 abc	6.58 c	16.3 ab	17.6 a	3.50 ab	3.85 ab
5.	HP	Ethyl Block + Oil (0.2%) + Buffer	3 g 60 ml 30 ml	(spray)	17.8 b	15.9 c	6.70 e	7.78 a	6.76 abc	6.70 bc	16.1 b	17.2 a	3.28 b	3.76 b
6.	LG	Ethrel 400 ppm + ABG-7011 (0.1%)	6.96 ml 3.5 ml	(spray)	16.0 c	--	7.40 ab	--	6.65 bc	--	16.0 b	--	3.51 ab	--
7.	Y	Ethrel 400 ppm + ABG-7011 (0.1%) + ABG-7011 (0.1%) + Ethyl Block + Buffer	6.96 ml 3.5 ml 3.785 3 g 60 ml	(spray) (gas)	16.4 c	--	7.33 abc	--	6.63 bc	--	16.7 ab	--	3.44 ab	--
8.	BK	Ethrel 400 ppm + ABG-7011 (0.1%) Ethyl Block + Oil (0.2%) + Buffer	 3.5 ml 3 g 7.57ml 60 ml	(spray) (spray)	15.9 c	--	7.86 a	--	6.42 c	--	16.4 ab	--	3.53 ab	--
9.	OBKS	Shade 3 days (92%)			16.3 c	--	7.30 abcd	--	6.75 abc	--	16.4 ab	--	3.58 ab	--
10.	PBKS	Shade 7 days (92%)			16.0 c	--	7.50 ab	--	6.74 abc	--	16.5 ab	--	3.70 ab	--
11	RYS	Shade 7 days (92%)			16.3 c	--	7.28 abcde	--	6.89 ab	--	16.1 b	--	3.63 ab	--

[zy]All treatments were applied with a low pressure hand-wand sprayer. Ethyl Block applied on Sept. 23 (trts. 4,7); sprays applied on Sept. 24 (trts. 2,3,5,6,7,8).
[x]Mean separation within columns by Duncan's New Multiple Range Test;($P \leq 0.05$).
*Maturity sample at start of experiment: Fruit firmness = 18.5; Starch = 3.25; Fruit diameter = 6.60 cm; Soluble solids = 16.5; Fruit color = 3.7.

Byers # 10

Table 3A. Effect of NAA and Ethyl Block (MCP) on fruit drop of 'Law Rome'/MM.111 (1999).

No.	Color	Treatment[zY]	Rate/ gallon	*PH of solutions*	% Fruit Drop 10/29	11/5	11/12
1.	W	Control			31.4 a[x]	93.4 a	97.6 a
2.	PBKS	NAA (10ppm) K-200	0.73 ml	7.2-7.3	22.8 a	73.8 b	78.6 b
		+ Silwet L-77 (0.1%)	3.785 ml				
3.	HPBKS	Ethyl Block	6 g	7.3	22.9a	92.0 a	97.3 a
		+ Silwet L-77 (0.1%)	3.785 ml				
4.	RYS	Ethyl Block	7.57 ml	7.3	24.6 a	89.2 a	96.0 a
		+ Silwet L-77 (0.1%)	6 g				
		+ Oil (0.2%)	3.785 ml				
		+ Buffer #1 Company	7.57 ml				
5.	YBKS	Ethyl Block	3.785 ml	6.2	23.2 a	89.5 a	98.3 a
		+ Silwet L-77 (0.1%)	6 g				
		+Oil (0.2%)	3.785 ml				
		+Buffer #2 Miller Aid	7.57 ml				

[zY]All treatments were applied with a wand sprayer. Treatments were applied Oct 21, 1999.

[x]Mean separation within columns by Duncan's New Multiple Range Test;($P \leq 0.05$).

Byers # 11

Table 3B. Effect of Ethyl Block (MCP) on fruit maturity of 'Law Rome'/111 (1999)*.

No.	Color	Treatment[ZY]	Rate/ gallon	*PH of solutions*	Fruit firmness (lb) 3 Nov 99	Starch (0-8) 3 Nov 99	Fruit diameter (cm) 3 Nov 99	Soluble solids 3 Nov 99	Fruit Color (%) 3 Nov 99
1.	W	Control			12.6 d	8.00 a	8.00 b[x]	11.9 ab	93.9 a
2.	PBKS	NAA (10ppm) K-200	0.73 ml	7.2-7.3	13.0 cd	8.00 a	8.08 ab	11.5 b	94.1 a
		+ Silwet L-77 (0.1%)	3.785 ml						
3.	HPBKS	Ethyl Block	6 g	7.3	13.6 bc	8.00 a	8.17 a	12.1 ab	93.7 a
		+ Silwet L-77 (0.1%)	3.785 ml						
4.	RYS	Ethyl Block	7.57 ml	7.3	14.8 a	7.95 a	8.19 a	12.6 a	95.5 a
		+ Silwet L-77 (0.1%)	6 g						
		+ Oil (0.2%)	3.785 ml						
		+ Buffer #1 Company	7.57 ml						
5.	YBKS	Ethyl Block	3.785 ml	6.2	14.1 ab	8.00 a	8.11 ab	11.9 ab	94.7 a
		+ Silwet L-77 (0.1%)	6 g						
		+ Oil (0.2%)	3.785 ml						
		+ Buffer #2 Miller Aid	7.57 ml						

[ZY]All treatments were applied with a wand sprayer. Treatments were applied Oct 21, 1999.
[x]Mean separation within columns by Duncan's New Multiple Range Test;($P \leq 0.05$).
*Maturity sample at start of experiment: Fruit diameter = 7.65 cm; Fruit firmness = 18.7 lbs.; Soluble solids = 12.2; Starch = 7.0; Fruit color = 97.6%.

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YIELD AND QUALITY ATTRIBUTES OF PROMISING APPLE CULTIVARS IN WEST VIRGINIA[1]

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Interest in new apple cultivars has increased among fruit growers and consumers during the last decade (Ballard, 1995; Miller, 1991; Norton, 1997). 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 Appalachian Fruit Research Station (AFRS), as a cooperator in this project, has two plantings, one dedicated to horticultural evaluations and one for use in evaluating pest susceptibility. A preliminary report on the horticultural performance of the selected apple cultivars over the first four growing seasons has been presented (Miller, 1998).

The present report focuses on the yields and fruit quality of 23 apple cultivars during the first 5 growing seasons in the orchard. Data will be presented from both the horticultural (H) planting and the pest (P) planting and the most promising cultivars will be identified.

Materials and Methods

Details on planting and early cultural management for the H and P plantings has been reported (Miller, 1998). Additional pruning was required during the 1998-1999 dormant season to restrict lateral growth and open up some of the more densely canopied trees to light. Pruning consisted primarily of thinning cuts. At planting and continuing through 1998 a reduced pest control program was employed for the P planting. A complete pest control schedule, based on local recommendations for commercial orchards, was followed for both plantings in 1999. Disease ratings for foliar and fruit diseases were discontinued in the P planting in 1999 since a complete pest control schedule was followed. Chemical thinner, NAA (10 ppm K-Salt) was applied to all trees on 18 May at about the 10 mm stage of fruit growth. Trees were hand thinned after "June drop" to

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

space remaining fruits approximately 15 cm apart. Drip irrigation was used to supplement rainfall with application timing based on soil irrometer readings.

Fruit were harvested at the estimated optimum maturity (starch index rating of 4 to 6), counted, and weighed (in kilograms) on a per tree basis each year beginning in 1996 and continuing through 1999. Preharvest fruit drops were counted at the time of harvest in 1999. Fruit measuring 3.8 cm in diameter or less were classified as "pygmy" fruits and were not included in the final fruit count and weight. Trunk circumference was recorded for each tree at a marked spot 30 cm above the graft union at the end of the growing season. Trunk cross sectional area (TCSA) was calculated from trunk circumference and used to compute cumulative yield efficiency (kg/cm^2).

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. Data collected included: fruit weight, diameter, and length, flesh firmness, soluble solids concentration (SSC), and starch index (SI) rating. Greene (1998) and Miller (1998) describe the methods used for fruit analysis. Sensory evaluation was performed on a 5-apple sample selected from each replicated tree as described above. The following factors were rated on a 1 to 5 rating scale developed by the NE-183 Fruit Quality Subcommittee: color, attractiveness, shape, skin toughness, flesh crispness and firmness, juiciness, sweetness, acidity, astringency, flavor, and desirability. As an example of the rating system, attractiveness was rated as follows: 1= dislike, 2= somewhat attractive, 3= acceptable, 4= above average attractiveness, and 5= very attractive. Acidity was rated as follows: 1= none detected (bland), 2= weakly acidic, 3= slightly tart, 4= tart, and 5= very tart. During the tasting process notes were taken from observations of percent surface red color (or blush), fruit maladies (corking, russet, etc.) lenticel condition, pedicel and calyx characteristics, and impressions of specific sensory attributes. Based on data and observations collected from the time of planting in 1995 until the end of harvest in 1999, a list of the most promising cultivars, those with average potential, and those of limited potential was developed.

Results and Discussion

Horticultural Planting –

Yield, Fruit Size, and Biennial Bearing: Five cultivars had a cumulative yield of 70 kg/tree or greater: 'Enterprise', 'Fuji', 'Gala Supreme', 'Golden Supreme', and 'Golden Delicious'/M.9 (Table 1). 'Enterprise' had the highest cumulative yield at 100.4 kg/tree. Cumulative yields for 'Honeycrisp', 'Pristine', and 'Sansa' were less than 30 kg/tree. 'Gala Supreme' and 'Fortune' had the highest cumulative yield efficiency among the 22 cultivars evaluated at 2.13 and 2.12 kg/cm^2 TCSA respectively. Five additional cultivars showed a cumulative yield efficiency of 2.0 kg/cm^2 TCSA or greater (Table 1). Two cultivars had cumulative yield efficiencies of less than 1.0 kg/cm^2 TCSA: 'Pristine' (0.91) and 'Sansa' (0.79). All cultivars produced their highest single season yield/tree in 1999, the fifth leaf. Cropping records from 1997 through 1999 indicate that 'Golden

Supreme', 'Suncrisp', 'GoldRush', and 'Yataka' have tendencies toward biennial bearing.

'Honeycrisp' had the largest mean fruit weight (243 g), followed by 'Fortune' (236 g) and 'Ginger Gold' (217 g) (Table 2). The smallest fruit were harvested from 'Pristine' and NY75414-1, at 102 g and 103 g, respectively. Most of the cultivars evaluated exhibit a strong tendency toward an oblate fruit shape with L/D ratios generally less than 0.90 (Table 2). Reduced fruit elongation is probably a result of the warmer growing conditions common to this area during early stages of fruit growth.

Fruit Quality and Preharvest Drop: 'Braeburn', 'GoldRush', and 'Arlet' had the firmest fruit at harvest (Table 3). High flesh firmness may be associated with smaller fruit size, but in this case the firmest fruit were not among the smallest fruit. Conversely, large fruit are often softer, but 'Gala Supreme' showed good flesh firmness given its larger fruit size (204 g). 'Yataka' fruit were the softest at harvest, however, the fruit were over mature (SI = 7.9 or 8.0). Flesh firmness was considered low [< 66.7 N (15.0 lbs.)] in seven additional cultivars (Table 3). The lower flesh firmness for 'Suncrisp' is probably associated with an advanced stage of maturity (SI = 7.2) (Table 3). Six cultivars had a SSC greater than 13.0 % at harvest (Table 3). 'GoldRush', an apple with a tart (acid) flavor had the highest mean SSC (14.7 %) at harvest. The high SSC combined with high flesh firmness suggest 'GoldRush' may have processing potential. In addition to those cultivars harvested overmature, five cultivars were harvested below the optimum mean maturity level (SI = 4 to 6) including 'Ginger Gold', 'Fortune', NY75414-1, 'Orin', and 'Sansa'. Two cultivars exhibited unusually high levels of fruit cracking near harvest: 'GoldRush' (19%) and NY75414-1 (82%). The level of cracking in 'GoldRush' was less than in previous years (mean of about 30%). This was the first time in three cropping years that cracking was observed on NY75414-1. No chemical treatments were applied to retard preharvest fruit drop. 'Golden Supreme' exhibited severe preharvest fruit drop (32.9 %) as did NY75414-1 (25 %) (Table 4). Much of the fruit drop on NY75414-1 was associated with cracked fruit. 'Orin' and 'Gala Supreme' had the lowest level of preharvest fruit drop (2.0% and 2.6% respectively).

Pest Planting –

Yield,Fruit Size, and Biennial Bearing: A yield of 19 kg/tree or greater was considered reasonable for these 4-year-old trees. Except for four cultivars among the 26 in the planting all cultivars yielded an average of 19 kg/tree or more in 1999 (Table 1). 'Honeycrisp', 'Sansa', 'Braeburn'/Mark, and NY75414-1 had the lowest yields in 1999 (all < 19 kg/tree) and also the lowest cumulative yields. 'Suncrisp' had the highest yield in 1999 (55.4 kg/tree) and the largest cumulative yield (68.6 kg/tree) for the planting. Three additional cultivars had cumulative yields above 60 kg/tree: 'Fortune', 'Golden Delicious'/M.9 , and 'Cameo'. Yields per tree in 1999 were greater than in any of the 3 previous cropping years for all cultivars except 'Braeburn'/M.9 which, ironically, had the highest cumulative yield efficiency (2.58 kg/cm^2 TCSA) (Table 1). Only one other cultivar in the pest planting, 'GoldRush', had a cumulative yield efficiency above 2.0 (2.05 kg/cm^2 TCSA). Eight cultivars had yield efficiencies below 1.0 kg/cm^2 TCSA with 'Enterprise' having the lowest efficiency (0.60 kg/cm^2 TCSA). Yield records from 1996 through 1999 suggested tendencies toward biennial bearing for 'Suncrisp', 'Fuji', and 'GoldRush'.

Yields of 'Enterprise' in the P planting were affected by an, as yet, unexplained disorder observed soon after bloom in both 1998 and 1999. In both years about 7 days after full bloom the young leaves and fruitlets on shoots throughout the canopy showed signs of desiccation and began to shrivel. Affected fruitlets stopped growth and dropped. The lack of leaf expansion was particularly noticeable. The condition appeared to originate on the peripheral shoots and move progressively toward the center of the tree's canopy. Within 3 to 4 weeks there was a regeneration of new shoots along scaffolds and on older shoots that progressed toward the periphery of the canopy. Few of the original affected shoots died in 1998 but about 30% died in 1999. The new shoots grew normally and filled the canopy by mid-July. Isolations from the bark of diseased trees in 1999 provided no evidence of a pathogen. The condition is thought to be soil related and likely associated with a nutrient imbalance. Soil and foliar samples have been taken from affected trees and healthy trees in another location for analysis.

'Shizuka' produced the largest size fruit (244 g), based on weight, followed by 'Fortune' (236 g) and 'Ginger Gold' (225 g) (Table 2). 'Pristine' produced the smallest fruit at an average of 103 g/fruit. Fruit shape for most cultivars tended to be more oblate (flat) than oblong or conic based on L/D ratio. NY75414-1 had the lowest L/D ratio (0.757) among all cultivars (Table 2).

Fruit Quality and Preharvest Drop: Flesh firmness above 80 N (18 lbs.) was considered excellent at harvest. Three cultivars had mean flesh firmness above 80 N at harvest: 'Arlet' (83.2 N), 'Braeburn'/Mark (83.2 N), and 'GoldRush' (82.6 N) (Table 3). Six cultivars had low flesh firmness levels [< 66.7 N (15.0 lbs.)] at harvest with 'Pristine' and 'Yataka' having the lowest firmness. The fruit on the latter two cultivars was slightly to overmature (SI = 6.2 or 7.8 respectively). Four cultivars had SSC above 14.0 % at harvest and eleven cultivars had SSC between 13.0 and 13.9 % at harvest (Table 3). 'PioneerMac' had the lowest SSC at harvest, 10.8%. Based on the SI rating 'Yataka,' 'Pristine', and 'Creston' were harvested past optimum maturity (SI> 6.0) in 1999 (Table 3). 'Golden Delicious'/M.9 was the least mature (SI = 2.9) when harvested. Preharvest fruit drop was most severe for 'Golden Supreme' (23.3%) Table 4). Preharvest fruit drop exceeded 10% for seven additional cultivars in the pest planting. The higher fruit drop levels for 'Pristine' and 'Yataka' may be associated with the advanced maturity. Fruit cracking likely contributed to the high preharvest fruit drop levels in 'GoldRush' and NY75414-1 since cracked fruit often rot and fall to the ground before harvest. Fifty-seven percent of the NY75414-1 fruit showed cracking at harvest and 25% of the 'GoldRush' fruit exhibited some level of skin cracking. 'Orin' and 'Gala Supreme' had the least amount of preharvest fruit drop (2.0% and 2.8% respectively)

Specific Fruit Observations and Potential

Above Average Potential (listed in order of maturity):

1. **Sunrise** – a small to medium size apple that ripens in early August. Fruit are round to oblate with an attractive red over green/yellow color. The flesh is moderately firm, crisp, and juicy, with a tart to mildly acid flavor, but with detectable sweetness at SI 4.0 or above. 'Sunrise' will store reasonably well in regular storage for 3 to 4 weeks. 'Sunrise' trees bloom somewhat early, are precocious, but only moderately productive, and an annual bearer. The tree is moderately vigorous, spurry, and spreads nicely with cropping. 'Sunrise' appears to have good tolerance to powdery mildew and fire blight. This cultivar appears to be a good early red apple for local retail marketing.

2. **Ginger Gold** – a medium to large apple that matures in early to mid-August. Fruit shape is round to oblate, and color is greenish yellow to lemon yellow (at full maturity). The flesh is firm, juicy, and moderately crisp. The flavor of 'Ginger Gold' is sub-acid to mildly tart with some sweetness at SI above 5.0. Fruit can be picked over a 7 to 10 day period since early starch breakdown is slow. Fruit are resistant to russet. Fruit will store moderately well for about 8-10 weeks in regular storage but soften rapidly when removed. The tree is vigorous, spreading, productive, and fairly easy to manage but the wood is somewhat brittle. 'Ginger Gold' is highly susceptible to fire blight and susceptible to scab and powdery mildew. This is the best early yellow apple, with both fresh and processing potential.

3. **Honeycrisp** – a medium to large apple that matures in late August. Fruit shape is round to oblong sometimes slightly conic. Color is orange/red striped over a green/yellow ground color. 'Honeycrisp' colors poorly in this region but can have an attractive color when conditions favor cool nights and warm days. The lenticels are numerous, prominent and often slightly sunken giving the surface a "dimpled" appearance. The flesh is moderately firm, very juicy, with a distinct crispness even in large fruit. The flavor is acid to tart at lower SI (2) but is sprightly acidic at SI 5 to 6. Fruit stores for 4 months or longer in regular storage retaining high crispness. Fruit are susceptible to watercore and bitter pit. 'Honeycrisp' blooms late. The tree is weak, moderately productive, semi-upright, and has a rather poor quality leaf that exhibits a mottled appearance . 'Honeycrisp' is susceptible to mite injury and has shown susceptibility to fire blight at this location. Fruit are best suited for fresh consumption, and may have both local and limited retail market potential for the region.

4. **Golden Supreme** - an attractive medium to larger sized, smooth skinned yellow fruit that matures in early September and has some resemblance to 'Golden Delicious'. 'Golden Supreme' may have a pink blush covering 10 to 30% of its surface that enhances appearance. The flesh is firm, moderately crisp, and juicy. Fruit have a mild sweet flavor at SI 5 or above. 'Golden Supreme' is very prone to preharvest fruit drop and may require multiple harvests. Fruits store for 4 – 5 months in regular storage, but have a short shelf life. The tree blooms late, is vigorous, upright, and productive, but not precocious. It has good resistance to

cedar apple rust. The cultivar appears to be prone to alternate bearing. Fruit may have both fresh and processing potential.

5. **Fortune** – a very large round to oblong apple originally tested as NY429. Fruit matures in mid-September. The color is pink to light red over green. 'Fortune' colors rather poorly in this region with only 30-40% red color on most fruits. Fruits have a medium to heavy "bloom" that must be rubbed to expose the bright finish. Fruits are subject to scarfskin that can be severe at times which detracts from the appearance. The flesh is only moderately firm but crisp and juicy and the flavor is mildly acid with a good balance of acid and sugar at SI rating of 5 or above. 'Fortune' appears to have moderate storage potential (4-5 months), and fruits are subject to Ca related disorders such as corking and bitter pit. The tree is vigorous, but is easy to manage, as the canopy is partially spreading with good limb and spur structure. 'Fortune has had good productivity, and has good yield efficiency at this site. Trees are susceptible to fire blight but have good resistance to cedar apple rust and scab. 'Fortune' probably has limited fresh market potential, but should be considered for processing.

6. **Cameo** – a medium to larger fruit with a prominent red stripe over green that matures in early to mid-October. This apple was originally named 'Carousel'. Fruits are generally round or oblong, but may be more conic. 'Cameo' colors poorly in most seasons, but hangs on the tree quite well, maintaining firmness and crispness while color improves. At early stages of maturity the fruit have been likened to the original 'Delicious' in appearance. 'Cameo' has prominent and numerous tan to nearly white lenticels, that may be slightly raised, giving the fruit a slightly rough feel. The skin is subject to scarfskin that may be severe, and fruit may exhibit minor russeting. The flavor is acid at SI 4 but quickly changes to sweet-tart at SI 6. Fruit store reasonably well. The tree is somewhat upright in habit, moderately vigorous and with a rather dense canopy. 'Cameo' appears to be precocious and has had good productivity at this site. Fruits should be considered for local fresh market with some wholesale potential.

7. **Fuji BC Type 2** – a medium sized oblate often angular or ribbed ("5-sided") apple that matures in early to mid-October. The color of 'Fuji' is pinkish red. In most seasons color is poor unless fruit are allowed to hang on the tree until late maturity. Fruit hang on the tree quite well. Lenticels are often large, tan and irregular, and may be slightly raised, which can detract from the appearance. A net-like russet may be common in some seasons on the surface of fruits. The flesh is firm and juicy. 'Fuji' has a sweet flavor that may be somewhat weak (bland) at the earliest harvest. Fruits have a very high sugar content and low acid content. 'Fuji' has excellent storage and shelf life, but a tendency for watercore. The tree is moderately vigorous to vigorous, productive, but difficult to thin and is prone to alternate bearing. The canopy spreads well once cropping begins. The tree is susceptible to fire blight and scab. 'Fuji' has both fresh and processing potential.

8. **Braeburn** – also known as 'Southern Rose'. 'Braeburn' is a medium size fruit that matures in early October. The fruit are round to somewhat conic, with an attractive reddish-orange color over a green/yellow ground color. (Recent selections of this cultivar have more red color). Fruit are prone to scarfskin that at times may be severe. The flesh of 'Braeburn' is very firm, crisp, and juicy with a fine texture. The flavor is tart at harvest, but improves to a pleasant sweet-tart after about 6 to 8 weeks storage. Fruits are highly susceptible to low Ca disorders, but the apple appears to store well in regular storage. Fruit allowed to hang on the tree may exhibit a greasy skin and are likely to have watercore. The tree is weak, especially on more dwarfing rootstocks, blooms early, is precocious, and may flower profusely, but set poorly. The canopy is spreading, with good spur development; the trees are highly susceptible to mite injury and fire blight. 'Braeburn' appears to be best suited for the fresh market.

9. **Enterprise** – a large round to oblate scab-resistant cultivar (originally Co-op 30) that matures in early to mid-October. Color is dull red over a yellow-green ground color. Fruit show 80% or better red color in this region. The surface of the fruit has a moderate "bloom" and may show some scarfskin, but fruit are not subject to russeting. The flesh is firm and moderately crisp, and the flavor is tart, but improves to mild-acidic after 4 – 6 weeks in storage. 'Enterprise' has a high soluble solids level (> 14.0%) at harvest that is masked in sensory evaluation by the high acid level at harvest. The skin is tough and somewhat chewy. 'Enterprise' appears to be very susceptible to low Ca disorders. The tree is vigorous, spreading, and productive. There is evidence that 'Enterprise' is susceptible to low soil pH and may show internal bark necrosis (apple measles). The tree has excellent resistance to powdery mildew and cedar apple rust. 'Enterprise' may have promise as a processing apple.

10. **Suncrisp** - first tested as NJ55. A medium size round to conic fruit that matures in early to mid-October. The color is yellow-green to lemon yellow at full maturity with an attractive orange-red blush. Fruit are prone to develop a fine-textured net-like russet that detracts somewhat from the appearance. The blushed area is often marked by scarfskin. 'Suncrisp' is subject to sunburn and may be prone to preharvest fruit drop. The flesh is moderate in firmness, crispness, and juiciness. The flavor is initially tart, but becomes spicy sub-acid after 6 – 8 weeks in storage. Fruit generally have a high soluble solids level that is masked by the high acid level. The tree blooms late, is moderately vigorous and upright and appears to be alternate bearing and subject to preharvest fruit drop. 'Suncrisp' has been very productive at this test site but biennial. This cultivar may have processing potential.

11. **GoldRush** – a scab resistant cultivar, originally tested as Co-op 38, that matures in late October. Fruits are medium sized, round to oblate, and with a dark yellow color. Fruit may have a pink or bronze blush. The lenticels are often large, irregular, rough and russeted . The flesh is very firm, crisp, and juicy. The flavor of 'GoldRush' at harvest is very tart, which masks the high soluble solids content.

However, the flavor improves to mildly acidic after several months in storage. Fruit store very well. 'GoldRush' has exhibited severe fruit cracking, similar to "Stayman cracking", in each season at this test site. Fruit can hang on the tree very well without loss in firmness. The tree is moderately vigorous, semi-spreading and fairly productive, but tends to be biennial bearing especially if over-cropped. 'GoldRush' appears to have both processing and fresh market potential.

Average Potential:

1. **Sansa** – a small to medium size fruit with attractive pink/cherry-red color that matures in early to mid-August. Fruit ripens non-uniformly over a period of 1 to 2 weeks. Russets severely in wet years. Susceptible to low Ca related disorders. Unusual mild acid/sweet, somewhat spicy flavor.
2. **Creston** – medium size oblong to conic apple that matures about the 2nd week in September. Color is usually very poor, but in some seasons the orange-red stripe over green is attractive. Flesh is crisp and very juicy but flavor is variable from mild acidic to sweet.
3. **Shizuka** – a large yellow-green fruit that is very similar to 'Mutsu' (same parents). Matures late September just before 'Mutsu'. A vigorous triploid variety that has been precocious and productive.
4. **Yataka** – a medium to larger sized sport of 'Fuji' that ripens in mid-September. Not as firm as 'Fuji' with shorter shelf life. May have better flavor off the tree than 'Fuji'.
5. **Gala Supreme** – a medium size oblate apple with good surface red color that matures in late September. This apple is not a 'Gala' strain as the name suggests. Fruit have large, irregular, rough lenticels that detract from appearance. Fruit are also susceptible to russet and scarfskin. The skin tends to be tough.
6. **Orin** – small to medium conic shaped green apple ripening in late September. Lenticels may be smooth but are often raised and rough. Flavor is mild sweet and flesh is firm but only moderately juicy.

Limited Potential:

1. **Pristine** – a very early medium sized yellow scab resistant apple maturing in late July. Flavor is very tart at SI 1 to 4 and sub-acid at SI 6 to 8. Must be spot picked, and bruises easily at maturity. Fruit have little to no shelf life. Probably limited to local fresh market or backyard growers.
2. **Senshu** – a medium sized apple that ripens toward the end of August. Color is light pink to red stripe on green and is generally of poor appearance. Flavor is tart, but often weak; flesh is not crisp and only moderately firm.

3. **Arlet** – also known as 'Swiss Gourmet'. A medium sized conic apple that matures mid- to late August. This apple russets severely even in dry years. The flavor is very tart, except at SI 7 to 8 and the skin is tough. Fruit show some susceptibility to corking.
4. **NY75414-1** – a small dark purplish-red oblate apple with a heavy "bloom" that ripens in mid- to late September. Lenticels are often large, irregular, and rough. Fruit shows severe scarfskin and is prone to russeting. Fruit cracking is severe in some years, with losses of 25 to 50% or more. Flavor is tart to sub-acid.

Conclusions

During the five seasons these cultivars have grown and developed, much has been learned concerning growth, productivity, pest susceptibility, and fruit quality. No cultivar is "perfect". Each of the 24 "newer" cultivars evaluated has some positive characteristic(s) and probably a place in fruit growing from processing to fresh fruits or even as a "dooryard apple". Several cultivars have qualities that suggest potential as dual purpose (processing and fresh market) apples. Additional time is needed to fully assess this potential as well as the preharvest drop characteristics, storage and shelf life, long-term quality, annual bearing capabilities, and pest susceptibility characteristics of these cultivars in order to make strong recommendations to apple growers in the Mid-Atlantic Region.

Literature Cited

Ballard, J. 1995. Testing new apple varieties is a never-ending project. Proc. 91st Washington State Horticultural Association, pp.145-147

Greene, D.W. 1998. Promising high quality apples evaluated in New England. Fruit Var. Journal 52(4):190-199.

Miller, S.S. 1991. Apple cultivars - current situation and trends around the world. An introduction. Fruit Var. Journal 45:75-76.

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.

Norton, R.A. 1997. Apples for the 21st century. Good Fruit Grower 48(17):39-43.

Table 1. Mean annual and cumulative yield of apple cultivars in the two 1995 NE-183 Regional Apple Cultivar Evaluation Project plantings at the Appalachian Fruit Research Station, Kearneysville, WV after 5 growing seasons.

Horticultural Planting

Cultivar/Rootstock	Mean yield, kg/tree: 1996	1997	1998	1999	Cumulative	Cumul. Yd. Efficiency (kg/cm^2 TCSA)
Enterprise/M.9	0	3.9	32.6	(2)* 63.9	100.4	2.06
Fuji BC Type 2/M.9	0	5.2	9.3	(4) 64.8	79.3	2.08
Gala Supreme/M.9	0	2.0	28.6	(1) 47.6	78.2	2.13
Golden Supreme/M.9	0	3.9	1.2	(2) 70.6	75.7	1.94
Golden Delicious/M.9	0.3	2.9	3.3	(4) 67.2	73.7	1.97
Suncrisp/M.9	0.3	6.3	3.3	(2) 59.8	69.7	2.06
Fortune/M.9	0	0.4	10.9	(1) 58.2	69.5	2.12
GoldRush/M.9	0.3	11.2	0.1	(3) 52.2	63.8	1.98
Golden Delicious/Mark	0	9.4	8.2	(3) 42.8	60.3	1.96
Yataka/M.9	0	7.2	0.1	(4) 53.0	60.3	1.70
Arlet/M.9	0.1	7.6	16.4	(2) 36.0	60.1	1.56
Ginger Gold/M.9	0	0.1	13.9	(1) 38.3	52.3	1.21
Cameo/M.9	0.3	1.5	9.6	(2) 39.6	51.0	1.53
Braeburn/M.9	0	1.5	15.0	(3) 28.2	44.7	2.07
Yataka/Mark	0	4.7	1.7	(3) 37.9	44.3	1.26
NY75414-1/M.9	0	1.8	12.2	(4) 28.4	42.4	1.70
Braeburn/Mark	0	1.7	18.2	(1) 21.3	41.2	2.00
Sunrise/M.9	0.2	1.0	5.2	(4) 31.0	37.2	1.06
Orin/M.9	0	4.3	1.5	(3) 27.8	33.6	1.37
Honeycrisp/M.9	0	2.9	0.6	(2) 23.3	26.8	1.46
Pristine/M.9	0	0.5	3.2	(1) 20.9	24.6	0.91
Sansa/M.9	0	1.2	0.8	(5) 13.8	15.8	0.79
Creston/M.9 No trees in this planting						
Senshu/M.9 No trees in this planting						
Shizuka/M.9 No trees in this planting						

Pest Planting

Cultivar/Rootstock	Mean yield, kg/tree 1996	1997	1998	1999	Cumulative	Cumul Yd. Efficiency
Suncrisp/M.9	0	13.2	0	(4)* 55.4	68.6	1.89
Fortune/M.9	0	3.0	22.9	(4) 41.0	66.9	1.69
Golden Delicious/M.9	0	4.3	8.4	(5) 48.5	61.2	1.66
Cameo/M.9	0	3.9	8.9	(5) 48.3	61.1	1.77
Fuji BC Type 2/M.9	0.1	4.4	0.2	(4) 45.5	50.1	1.51
Shizuka/M.9	0.1	1.2	3.8	(5) 44.9	50.0	0.95
Golden Supreme/M.9	0	0.4	3.5	(5) 44.2	48.1	1.26
Creston/M.9	0.1	3.1	9.1	(5) 34.2	46.5	1.37
Braeburn/M.9	0.2	1.8	22.5	(5) 21.1	45.6	2.58
GoldRush/M.9	0.6	7.7	1.8	(5) 35.4	45.5	2.05
Ginger Gold/M.9	0.1	4.2	13.4	(5) 27.0	44.7	1.43
Orin/M.9	0.1	1.6	9.4	(5) 33.6	44.7	1.30
Enterprise/M.9	0	1.8	14.9	(4) 27.8	44.5	0.60
Gala Supreme/M.9	0	3.6	6.3	(5) 33.1	43.0	1.39
Golden Delicious/Mark	0	5.4	5.2	(5) 29.8	40.4	1.62
Yataka/M.9	0	2.1	2.6	(5) 35.2	39.9	1.28
Arlet/M.9	0.1	1.2	7.9	(5) 29.4	38.6	0.93
Yataka/Mark	0	2.6	2.0	(4) 32.7	37.3	1.34
Sunrise/M.9	0.2	3.0	7.7	(4) 22.1	33.0	0.92
Pristine/M.9	0	2.1	3.9	(4) 26.4	32.4	1.07
Senshu/M.9	0	0.6	3.1	(5) 22.1	25.8	0.78
PioneerMac/M.9	0	3.7	1.8	(5) 19.6	25.1	0.86
NY75414-1/M.9	0	0.9	8.7	(5) 15.4	25.0	1.14
Braeburn/Mark	0.1	0.6	7.3	(5) 13.7	21.6	1.15
Sansa/M.9	0.1	1.2	3.0	(5) 8.0	12.2	0.66
Honeycrisp/M.9	0	0.1	2.5	(5) 8.6	11.2	0.70

* number of trees included in mean yield for 1997 – 1999 seasons

Table 2. Mean fruit size and length/diameter (L/D) ratio of apple cultivars in the two 1995 NE-183 Regional Apple Cultivar Evaluation Project plantings at the Appalachian Fruit Research Station, Kearneysville, WV, 1999. Cultivars ranked according to fruit weight.

Horticultural Planting

Cultivar/Rootstock	Fruit weight (g)	Fruit diameter (cm)	L/D ratio
Honeycrisp/M.9	243	8.77	0.812
Fortune/M.9	236	9.05	0.842
Ginger Gold/M.9	217	8.62	0.858
Enterprise/M.9	213	8.30	0.832
Cameo/M.9	212	8.04	0.874
Gala Supreme/M.9	204	8.05	0.780
Yataka/M.9	183	8.02	0.789
Braeburn/M.9	179	7.77	0.841
Fuji, BC Type 2/M.9	178	7.75	0.807
Braeburn/Mark	171	7.65	0.856
Golden Delicious/M.9	163	7.43	0.895
GoldRush/M.9	162	7.36	0.899
Suncrisp/M.9	157	7.60	0.876
Yataka/Mark	150	7.39	0.809
Orin/M.9	145	7.06	0.889
Arlet/M.9	144	7.24	0.869
Sansa/M.9	140	7.11	0.832
Sunrise/M.9	128	7.12	0.850
Golden Supreme/M.9	127	7.62	0.907
Golden Delicious/Mark	125	6.76	0.899
NY75414-1/M.9	103	7.62	0.757
Pristine/M.9	102	6.91	0.770

Pest Planting

Cultivar/Rootstock	Fruit weight (g)	Fruit diameter (cm)	L/D ratio
Shizuka/M.9	244	8.53	0.876
Fortune/M.9	236	8.93	0.824
Ginger Gold/M.9	225	8.45	0.836
Fuji, BC Type 2/M.9	195	7.97	0.803
Creston/M.9	194	7.95	0.882
Honeycrisp/M.9	192	8.31	0.796
Cameo/M.9	191	8.06	0.843
Enterprise/M.9	185	8.47	0.779
Yataka/Mark	180	8.09	0.813
Braeburn/M.9	180	7.52	0.824
GoldRush/M.9	179	7.37	0.877
Golden Delicious/M.9	178	7.55	0.881
Gala Supreme/M.9	175	7.97	0.787
Yataka/M.9	174	8.23	0.802
Orin/M.9	165	7.30	0.872
Suncrisp/M.9	165	7.60	0.886
Braeburn/Mark	165	7.72	0.835
Golden Supreme/M.9	157	7.56	0.910
Arlet/M.9	146	7.24	0.848
Sansa/M.9	142	7.36	0.818
Sunrise/M.9	141	7.08	0.854
PioneerMac/M.9	140	7.65	0.777
Golden Delicious/Mark	140	7.04	0.888
Senshu/M.9	139	7.07	0.794
NY75414-1/M.9	121	7.49	0.757
Pristine/M.9	103	6.97	0.766

Table 3. Mean flesh firmness, soluble solids concentration (SSC), and starch index (SI) rating of apple cultivars in the two NE-183 Regional Apple Cultivar Evaluation Project plantings at the Appalachian Fruit Research Station, Kearneysville, WV, 1999. Cultivars ranked according to flesh firmness.

Horticultural Planting			
Cultivar/Rootstock	Flesh firmness (N)	SSC (%)	SI [z] (1 – 8)
Braeburn/Mark	81.4	13.3	5.1
GoldRush/M.9	80.5	14.7	4.3
Arlet/M.9	78.7	13.8	5.6
Braeburn/M.9	77.4	12.6	5.5
Orin/M.9	73.2	12.7	3.6
Gala Supreme/M.9	72.7	12.9	4.0
Golden Supreme/M.9	72.4	11.9	4.8
Ginger Gold/M.9	72.3	12.2	2.7
Fortune/M.9	70.0	13.5	3.3
Golden Delicious/M.9	68.3	12.7	4.3
Golden Delicious/Mark	68.2	12.3	5.0
Fuji, BC Type 2/M.9	67.2	11.6	6.2
Honeycrisp/M.9	67.1	12.9	5.4
Enterprise/M.9	65.1	13.2	5.3
Sansa/M.9	64.5	12.6	3.8
Cameo/M.9	64.0	11.7	4.6
Suncrisp/M.9	63.8	11.8	7.2
Sunrise/M.9	62.0	11.3	5.0
Pristine/M.9	61.7	11.9	4.2
NY75414-1/M.9	60.6	13.1	3.4
Yataka/Mark	57.6	12.2	8.0
Yataka/M.9	56.5	11.9	7.9

Pest Planting			
Cultivar/Rootstock	Flesh firmness (N)	SSC (%)	SI [z] (1 – 8)
Arlet/M.9	83.2	13.6	4.2
Braeburn/Mark	83.2	13.5	5.8
GoldRush/M.9	82.6	14.4	4.0
Braeburn/M.9	78.7	12.4	5.7
Golden Supreme/M.9	77.6	12.8	4.2
Gala Supreme/M.9	75.3	12.7	4.2
Ginger Gold/M.9	74.8	12.8	3.2
Orin/M.9	74.4	13.2	3.8
Golden Delicious/M.9	70.8	13.1	2.9
Fortune/M.9	70.5	13.2	3.2
Honeycrisp/M.9	70.2	13.3	4.8
Golden Delicious/Mark	69.7	13.8	4.1
PioneerMac/M.9	69.3	10.8	3.9
Suncrisp/M.9	68.9	14.0	6.0
Sunrise/M.9	68.8	12.2	4.0
Shizuka/M.9	68.0	13.6	4.8
Sansa/M.9	68.0	13.7	3.4
Fuji, BC Type 2/M.9	67.5	12.1	5.9
Creston/M.9	67.5	12.8	6.1
Senshu/M.9	66.8	12.2	4.8
Enterprise/M.9	66.4	14.1	5.3
NY75414-1/M.9	64.9	13.9	3.3
Cameo/M.9	64.3	12.4	4.3
Yataka/Mark	58.5	14.3	7.8
Yataka/M.9	56.4	13.5	7.8
Pristine/M.9	55.3	11.8	6.2

[z] Starch index (SI) ratings: 1 to 3 = imature; 4 to 6 = mature; and 7 to 8 = over mature

Table 4. Mean number and percent of preharvest fruit drop per tree for apple cultivars in the NE-183 Regional Apple Cultivar Evaluation Project Horticultural (H) and Pest (P) plantings at the Appalachian Fruit Research Station, Kearneysville, WV in 1999. Cultivars ranked according to percent fruit drop in the H planting.

	Preharvest fruit drop per tree			
	H Planting		P Planting	
Cultivar/Rootstock	(%)	No.	(%)	No.
Golden Supreme/M.9	32.9	127	23.3	55
NY75414-1/M.9	25.0	52	12.2	14
Pristine/M.9	14.8	26	14.0	31
Fortune/M.9	13.1	28	7.5	12
Suncrisp/M.9	11.2	38	14.6	42
Honeycrisp/M.9	9.3	6	10.0	4
Braeburn/M.9	7.6	11	6.4	7
Yataka/M.9	6.9	19	12.7	22
Ginger Gold/M.9	6.7	11	3.6	4
Yataka/Mark	6.6	16	9.6	16
GoldRush/M.9	6.4	20	10.2	19
Sunrise/M.9	6.4	15	3.3	5
Sansa/M.9	6.4	6	3.6	2
Braeburn/Mark	5.9	7	13.7	10
Golden Delicious/Mark	4.9	16	3.4	7
Cameo/M.9	4.4	8	6.8	16
Arlet/M.9	4.2	10	3.6	7
Golden Delicious/M.9	4.0	16	1.9	5
Enterprise/M.9	3.8	11	7.3	9
Fuji, BC Type 2/M.9	3.7	13	3.4	8
Gala Supreme/M.9	2.6	6	2.8	5
Orin/M.9	2.0	4	2.0	4
PioneerMac/M.9	--	--	7.8	10
Senshu/M.9	--	--	5.3	8
Shizuka/M.9	--	--	4.5	8
Creston/M.9	--	--	4.0	7

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Bloom and Post-Bloom Apple and Peach Thinning Studies (1998/1999)

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<u>Abstract.</u> Effectiveness of pollination/fertilization inhibitors for flower thinning depends highly on the precise timing of sprays within 24 to 36 hours after flower opening. In 1999, cool weather delayed the application of hormone thinners which were intended for comparison with pollination/fertilization thinners at bloom. Pollination inhibitors applied in bloom and hormone thinners applied at petal fall or 8 mm fruit diameter caused good fruit thinning.

Fruit injury caused by carbaryl was almost non-existant in 1999 in two tests which compared different formulations. Some very slight, non-significant injury, may have occurred with 3 of 9 formulations tested when trees were shaded. Shading trees for one day in conjunction with carbaryl sprays also did not promote injury (previously shading promoted carbaryl injury). The addition of Oil to all formulations as a tank mix caused about 3 to 8% of the fruit to show injury. However, in an adjoining block, Sevin + Accel + Regulaid caused injury to over 50% of the fruit applied the same day as the experiments.

Ethephon applied in bloom did not cause thinning of 'Empire' fruit, but Sevin + Accel + Oil caused good fruit thinning when applied in bloom. Sevin + Accel + Oil increase fruit diameter and did not affect fruit russet (Table 5). Ethephon applied at 22 mm fruit diameter at water rates of 100 gal/acre or 400 gal/acre and chemical rates of 2.5 pt/acre or 5 pt/acre did not cause significant fruit thinning.

In 1998, pollination inhibitors and growth regulators caused flower and fruit thinning of 'Starkrimson'/MM111/106 trees. Good thinning occurred with both pollination inhibitors and ethephon treatments; but Sevin + Accel + oil was not as effective. Thinex caused the most side russet. Treatments that thinned generally caused increased fruit diameter. In 1999, return bloom was promoted by early thinning, but ethephon did not appear to promote return bloom beyond the thinning effect.

In 1998, endothall caused good thinning of 'York'/MM.111 with a minimum of foliage injury. Fruit diameter was increased. Thinning with endothall greatly increased return bloom in 1999, but trees were considered over thinned in 1998.

In 1998, some thinning to 'Fuji'/M.27 may have been caused by ethephon at Pink and by Sevin+Accel+oil at 10mm; but generally very little thinning occurred in this experiment. Fruit diameter generally was increased where thinning occurred. Those treatments that caused thinning also increased return bloom in 1999, but ethephon did not appear to promote return bloom beyond the thinning effect.

In 1998, some thinning to 'Golden Delicious'/M.27 may have been caused by Ethrel+Accel+oil at 10mm; but no thinning occurred at Pink, Bloom, or Petal Fall in this experiment. Ethephon caused increased flowering in 1999 where thinning occurred.

Introduction

Due to the recent cancellation of Elgetol in the Northwestern U.S.A., considerable interest has developed in pollination and fertilization inhibitors for thinning. In 1996, Wilthin was registered for thinning apple and peach trees in bloom, and Thinex was registered for thinning apple trees. In addition, several other chemical companies have had an interest in registration of pollination and fertilization inhibitors for bloom thinning. In 1994, a federal registration was obtained by Abbott Labs for Accel (6-BA + low rate of GA_{4+7}); and in 1996, Dupont obtained a registration for thinning apples with Vydate. Since the FQPA may influence the registrations and availability of Carbaryl and Vydate for thinning purposes, experience with alternative thinning combinations may be needed.

The objectives of the experiments reported here were 1) to further investigate hormone-type chemical combinations for flower and early fruit thinning, 2) to observe chemical injuries to fruit and foliage, and 3) to compare the effectiveness of chemical thinner combinations without the use of Carbaryl or Vydate

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 tests were randomized complete block experiments. Apple 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 cross sectional area limb, CD) was determined by counting fruit on 3 pre-selected limbs per tree; or on whole trees (fruit/cm^2 cross sectional area trunk, CD). Three limbs per tree were tagged during late pink; 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 after unfertilized fruit dropped. Crop density (CD) on sample limbs was expressed as fruit•cm^2 cross-sectional area limb(LCSA). In the event that all the fruit on a tree was counted crop density was expressed as fruit•cm^2 cross-sectional area trunk (TCSA). Past experience has indicated that when using these techniques that the desirable crop load is approximately 4 to 6 fruit•cm^2 cross-sectional area limb (or trunk) 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 fruit maturity for quality evaluations, which included flesh firmness, soluble solids concentration, starch staining, percentage red color, fruit scaring and/or russet, and incidence of water core. Flesh firmness of apple fruit 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 for each replicate of each treatment. Each apple fruit was cut in half transversely, and severity of water core was rated on a scale of 0 to 8 (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 5 where 1 = staining of the entire cut surface and 8 = absence of starch (Poapst et al., 1959).

In 1999, airblast applications to peach trees were applied to blocks 3 rows wide and data was taken from the center 6 trees within the row so that drift from adjacent rows increased the deposit on the count row when trees were in bloom. Previous published and unpublished data indicate approximately 40 to 70% of the deposit on peach trees from an airblast spray at bloom time will come from adjacent rows (Byers, et al. 1985). Peach crop density (fruit/cm^2 cross sectional area limb, CD) was determined similar to the apple experiments.

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 and pre-planned single-degree of freedom contrasts of interest. The experimental designs for all experiments were randomized complete block and were block by location within rows.

Expt. 1. Eighty eight 11-year-old 'Ace Delicious'/MM.111 trees (8 blocks) were used for 16 treatments (Table 1). Since pollination inhibitors require precise timing with flower opening and may cause foliage and/or fruit injury, hormone thinners were compared to pollination inhibitors for fruit thinning, quality, and appearance. Since temperatures were rather cool in bloom, hormone thinner applications were delayed until Petal fall.

Expt. 2. Ninty 22-year-old 'Redspur Delicious'/MM.111 trees (6 blocks) were used for 15 treatments (Table 3). Four formuations of Carbaryl, with or without 1 day of 92 percent artificial shading, and with or without a 70 second superior spray oil, were compared for thinning and fruit injury.

Expt. 3 Sixty-six 22-year-old 'Redspur Delicious'/MM.111 trees (6 blocks) were used for 11 treatments (Table 3). Nine formuations of Carbaryl were compared for thinning and fruit injury. Formulations used were old materials still in the Winchester Laboratory inventory.

Expt. 4 Six-five 22-year-old 'Golden Delicious'/MM.106 trees (13 blocks) were used for 5 treatments (Table 4). Ethephon was applied at two chemical rates at 2.5pt/acre and 5pt/acre and two water rates at 100gal/acre and 400gal/acre to determine if either had a major effect on thinning and fruit injury.

Expt. 5. Forty 10-year-old 'Empire'/MM.111 trees (10 blocks) were used for 4 treatments (Table 5). Ethephon applied at two chemical rates were compared to Carbaryl + Accel + Oil for thinning and fruit injury.

Expt. 6. In 1998,seventy-two 11-year-old 'Starkrimson Delicious'/MM.111/106 trees (9 blocks) were used for eight treatments (Table 6). Since pollination inhibitors require precise timing for flower opening and may cause foliage and/or fruit injury, hormone thinners were compared to pollination inhibitors for fruit thinning, quality, and appearance.

Expt. 7. In 1998, fourteen 11-year-old 'York'/MM.111 trees (7 blocks) were used for two treatments (Table 7). Since pollination inhibitors in 1997 caused considerable foliage injury and over thinning, 'York'/MM.111 trees were sprayed with endothall to observe foliage injury and fruit thinning.

Expt. 8. In 1998, seventy-eight 7-year-old 'Fuji'/M.27 trees (6 blocks) were used for thirteen treatments (Table 8). Since early thinning may promote a better return bloom of Fuji, strong growth regulator combinations were chosen for comparison at Pink, Bloom, Petal Fall, and 10 mm. In addition, these treatments were chosen not to contain Vydate or Carbaryl, since these chemicals may be lost in the FQPA registration review. Return bloom was observed 1999.

Expt. 9. Thirty 7-year-old 'Golden Delicious'/M.27 trees (6 blocks) were used for five treatments (Table 9). Since early thinning may promote a better return bloom, strong growth regulator combinations were chosen for comparison at Pink, Bloom, Petal Fall, and 13 mm. In addition, these treatments were chosen not to contain Vydate or Carbaryl, since these chemicals may be lost in the FQPA registration review. Return bloom was observed 1999.

Expt. 10. Sixty 7-year-old 'Starkrimson Delicious'/Mark trees (6 blocks) were used for ten treatments (Table 10). Applications of ethephon, or accel+oil, or carbaryl+oil were made at 6AM, 2 PM and 8PM when temperatures were 57F, 92F and 66F, respectively in an attempt to determine if application temperature influenced thinning. Return bloom was observed 1999.

Expt. 11. In 1999, a single block 8-year-old 'Bisco' peach trees, 6 rows wide and 32 trees long, were used for 4 treatments (Table11). Nine trees per treatment were monitored for fruit set. Spray treatments listed in Table 1 were applied on 8 April after approximately 50-75% of the flowers had opened. Vegetative shoot injury was rated on

21 April. The number of fruit on each tree was counted on 27 May, 47 days after 50-75% bloom and expressed as CD. Ten fruit were harvested from each tree on 20 Aug. for determining fruit diameter.

Expt. 12. In 1999, a single block 8-year-old 'Redhaven' peach trees, 6 rows wide and 32 trees long, used for 4 treatments (Table12). Eight trees per treatment were monitored for fruit set. Spray treatments listed in Table 1 were applied on 9 April after approximately 50-75% of the flowers had opened. Vegetative shoot injury was rated on 21 April. The number of fruit on each tree was counted on 27 May, 47 days after 50-75% bloom and expressed as CD. Ten fruit were harvested from each tree on 22 July for determining fruit diameter.

Expt. 13. In 1999, a single block 8-year-old 'Cresthaven' peach trees, 6 rows wide and 32 trees long, were used for 4 treatments (Table13). Sixteen trees per treatment were monitored for fruit set. Spray treatments listed in Table 1 were applied on 10 April after approximately 50-75% of the flowers had opened. Vegetative shoot injury was rated on 21 April. The number of fruit on each tree was counted on 27 May, 47 days after 50-75% bloom and expressed as CD. Ten fruit were harvested from each tree on 20 Aug. for determining fruit diameter.

Results and Discussion

Expt. 1. In 1999, cool weather delayed the application of hormone thinners which were intended for comparison with pollination/fertilization thinners at bloom. Pollination inhibitors applied in bloom and hormone thinners applied at petal fall or 8 mm fruit diameter caused good fruit thinning (Table 1). Fruit injury was very low with only small differences in net side russet. Trees bloomed very well, but fruit set was poor due to cool temperatures during and after bloom.

Expt. 2. In 1999, fruit injury was almost non-existant. None of the formulations caused injury when applied alone. The addition of shading for one day also did not promote injury (previously shading promoted carbaryl injury). The addition of Oil to all formulations as a tank mix caused about 3 to 8% of the fruit to show injury. These fruit were removed on 22 June.

Figure 1. In an adjoining block, Sevin + Accel + Regulaid caused injury to over 50% of the fruit applied the same day as experiment 2.

Expt. 3. In 1999, some very slight, non-significant injury, may have occurred with 3 of 9 formulations tested when trees were shaded (Table 3).

Expt. 4. In 1999, ethephon at all the rates and timings did not cause significant fruit thinning applied at 22 mm fruit diameter (Table 4). Fruit diameter may have been slightly depressed, but trees sprayed with ethephon visually had slightly higher crop loads. Side and stem-end russet did not appear to be affected.

Expt. 5. In 1999, ethephon did not cause thinning of 'Empire' fruit, but Sevin + Accel + Oil caused good fruit thinning when applied in bloom. Sevin + Accel + Oil increase fruit diameter but and did not affect fruit russet (Table 5).

Expt. 6. In 1998, pollination inhibitors and growth regulators caused flower and fruit thinning of 'Starkrimson'/MM.111/106 trees (Table 6). Good thinning occurred with both pollination inhibitors and ethephon treatments; but Sevin + Accel + oil was not as effective. Thinex caused the most side russet and treatments that thinned generally caused increased fruit diameter (data not shown). In 1999, return bloom was promoted by early thinning, but ethephon did not appear to promote return bloom beyond the thinning effect.

Expt. 7. In 1998, endothall caused good thinning of 'York'/MM.111 with a minimum of foliage injury (Table 7). Fruit diameter was increased. Thinning with endothall greatly increased return bloom in 1999, but trees were considered over thinned in 1998.

Expt. 8. In 1998, ethephon caused some thinning to 'Fuji'/M.27 at Pink and by Sevin+Accel+oil at 10mm; but generally very little thinning occurred in this experiment (Table 8). Fruit diameter generally was increased where thinning occurred. Those treatments that caused thinning also increased return bloom in 1999, but ethephon did not appear to promote return bloom beyond the thinning effect.

Expt. 9. In 1998, some thinning to 'Golden Delicious'/M.27 may have been caused by Ethrel+Accel+oil at 13 mm; but no thinning occurred at Pink, Bloom, or Petal Fall in this experiment (Table 9). Ethephon caused increased flowering in 1999 where thinning occurred (trt# 5).

Expt. 10. In 1998, time of day and temperature did not alter the thinning of ethephon, accel+oil, or carbaryl+oil even though spray temperatures were 57F, 92F, and 66F at 6AM, 2 PM and 8PM, respectively (Table 10). These results are similar to those of a previous year on 'Empire'. The return bloom by carbaryl + oil appeared to be related to the amount of thinning. Ethephon applied in 1998 did not increase flowering in 1999.

Expt. 11. Wilthin + Regulaid applied on April 8 when trees were 50% to 75% in bloom caused flower thinning and increased fruit size, but neither Endothall or Armothin caused thinning in this experiment (Table 11).

Expt. 12. None of the sprays caused fruit thinning or increased fruit diameter (Table 12).

Expt. 13. Wilthin + Regulaid, Endothall, or Armothin applied on April 10 when trees were 50% to 75% in bloom caused flower thinning (Table 13); but only Wilthin + Regulaid increased fruit diameter.

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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.

Table 1. Effect of various chemicals on thinning of Ace Delicious/MM.111 (1999).

No.	Color	Treatment[zy]	Rate/acre /100 gal	Rate/ 25 gal	Spray Timing	Fruit/cm² cross sectional area limb (June 1)	% fruit injury /cm² cross sectional area limb (June 1)	Fruit diameter (cm) (Aug 30)	Length/ diameter ratio (Aug 30)	Net fruit side russet rating[x] (0-5) (Aug 30)
1.	W	Control			--	4.83 a[w]	0.00 a	6.98 b	0.934 bcd	0.45 cd
2.	R	Endothal	4 pt	473	Bloom	3.07 cdef	0.00 a	7.08 ab	0.927 cdef	0.54 abc
3.	HP	Wilthin	16 pt	1888	Bloom	3.13 cdef	0.00 a	7.21 a	0.923 def	0.56 ab
		+ Regulaid	1 pt	118						
4.	B	ATS	6 gal	5664	Bloom	2.46 ef	0.00 a	7.22 a	0.932 bcde	0.52 abcd
5.	FO	Ethrel 400 ppm	3 pt	355	PF	3.67 bcd	0.00 a	7.09 ab	0.915 fg	0.46 cd
6.	LG	Ethrel 600 ppm	4.5pt	532	PF	3.13 cdef	0.00 a	7.21 a	0.900 g	0.48 bcd
7.	Y	Sevin XLR	2 pt	236	PF	2.16 f	0.00 a	7.19 ab	0.955 a	0.47 bcd
		+ Accel 30g	1578	395						
		+ Oil 1qt	1/2 gal	473						
8.	RYS	Fruitone-N 7.5ppm	183.2	46	8 mm	3.71 bcd	0.00 a	7.16 ab	0.934 bcd	0.45 cd
9.	PBKS	Fruitone-N 7.5ppm	183.2	46	8 mm	3.58 bcd	0.00 a	7.00 ab	0.916 efg	0.48 bcd
		+ Ethrel 400 ppm	3pt	355						
10.	OBKS	Fruitone-N 7.5 ppm	183.2g	46	8 mm	3.43 bcde	0.00 a	7.12 ab	0.941 abc	0.43 d
		+ Sevin XLR	2 pt	236						
11.	PBKD	901 7.5 ppm	183.2g	46	8 mm	3.05 cdef	0.00 a	7.11 ab	0.934 bcd	0.43 d
		+ Sevin XLR	2 pt	236						
12.	OBKD	Sevin XLR	2 pt	236	8 mm	4.01 abc	0.00 a	6.98 b	0.945 ab	0.43 d
		+ Oil 1qt	1/2 gal	473						
13.	RD	Sevin XLR	2 pt	236	8 mm	2.81 def	0.00 a	7.11 ab	0.943 abc	0.45 cd
		+ Accel 30g	1578	395						
		+ Oil 1qt	1/2 gal	473						
14.	BD	Vydate	2 pt	236	8 mm	4.45 ab	0.00 a	6.99 b	0.943 abc	0.45 cd
15.	CKR	Vydate	2 pt	236	8 mm	3.47 bcde	0.00 a	7.11 ab	0.918 def	0.44 cd
		+ NAA 7.5ppm	183.2g	46						
16.	CKO	Vydate	2 pt	236	8 mm	2.86 def	0.00 a	7.06 ab	0.941 abc	0.58 a
		+ Accel	1578	395						

[z]Full bloom occurred 28 Apr 99 (90% open); petal fall (3 May 99)

[y]Treatments were applied in bloom (28 Apr 99), petal fall (3 May 99), and 8 mm (11 May 99). The average daytime high temperatures for the 2 day period after application was 63°,71°,71° F, and the night time low was 45°,60°,61°F for Bloom, Petal fall, and 8 mm. Treatments were applied with an airblast sprayer at 100 gal water/A. Airblast sprayer was calibrated for trees spaced 20 ft between rows, 10 ft tree wideth, and 14 ft tree height which was equivalent to 50% TRV.

[x]Side russet rating: 0 = no net side russet; 5 = heavy net russet.

[w]Mean separation within columns by Duncan's New Multiple Range Test($P \leq 0.05$).

Byers # 8

Table 2. Effect of 1999 Carbaryl formuations on fruit injury and fruit set of Redspur Delicious/M.111 (1999).

No.	Color	Treatment[zy]	Rate /3.5 liter	Spray Timing	Shading 1 day	Fruit/cm^2 cross sectional area limb (22 June 99)	% fruit injury/ cm^2 cross sectional area limb[x] (22 June 99)	Fruit diameter (cm) (10 Sept 99)	Length/ diameter ratio (10 Sept 99)
1.	W	Control	--	--		7.12 a[w]	0.00 c	5.97 ab	0.963 ab
2.	R	Sevin 50 WP	12.6 g	10mm		5.25 bcd	0.00 c	5.74 b	0.970 ab
3.	B	Sevin 80 WP	7.88 g	10mm		5.45 bc	0.00 c	5.94 ab	0.973 ab
4.	HP	Sevin XLR	13.2 ml	10mm		3.95 cde	0.00 c	5.72 b	0.979 a
5.	FO	Sevin 4 F	13.2 ml	10mm		4.66 bcde	0.00 c	5.83 ab	0.977 a
6.	LG	Sevin 50 WP	12.6 g	10mm	x	5.48 bc	0.00 c	5.82 ab	0.977 a
7.	Y	Sevin 80 WP	7.88 g	10mm	x	4.67 bcde	0.00 c	6.02 ab	0.968 ab
8.	BK	Sevin XLR Plus	13.2 ml	10mm	x	4.26 cde	0.00 c	5.68 b	0.972 ab
9.	PBKS	Sevin 4 F	13.2ml	10mm	x	4.26 cde	0.00 c	5.91 ab	0.962 ab
10.	OBKS	Sevin 50WP	12.6 g	10mm	x	3.67 e	5.96 ab	5.77 ab	0.963 ab
		+ Oil	17.50 ml						
11.	RYS	Sevin 80 WP	7.88 g	10mm	x	3.46 e	3.21 bc	5.93 ab	0.969 ab
		+ Oil	17.50 ml						
12.	RS	Sevin XLR	13.2 ml	10mm	x	3.58 de	7.83 a	5.72 b	0.972 ab
		+ Oil	17.50 ml						
13.	BS	Sevin 4F	13.2 ml	10mm	x	4.28 cde	3.58 b	5.72 b	0.983 a
		+ Oil	17.50 ml						
14.	YS	Oil	13.2 ml	10mm	x	4.78 bcde	0.00 c	5.98 ab	0.976 a
15.	OS	Shade	none	10mm	x	6.09 ab	0.00 c	6.16 a	0.950 b

Contrasts:	Comparisons:	Pr>F	Pr>F	Pr>F	Pr>F
2,3,4,5 vs 6,7,8,9	Sevin vs Sevin + shade	ns	ns	ns	ns
2,3,4,5 vs 10,11,12,13	Sevin vs Sevin + shade + oil	ns	***	ns	ns
6,7,8,9 vs 10,11,12,13	Sevin + shade vs Sevin + shade + oil	*	***	ns	ns
2 ,6,10 vs 3,7,11	50WP vs 80WP	ns	ns	ns	ns
2,6,10 vs 4,8,12	50WP vs XLR	ns	ns	ns	ns
2,6,10 vs 5,9,13	50WP vs 4F	ns	ns	ns	ns
1 vs 14	Control vs Oil	**	ns	ns	ns
1 vs 15	Control vs Shade	ns	ns	ns	ns
1 vs 2,3,4,5	Control vs Sevin formulations	***	ns	ns	ns

[z]Full bloom occurred 27 Apr 99; petal fall (3 May 99)

[y]Treatments were applied at 10 mm (12 May 99). All rates are equivalent ai to 3 lb/100 gal of a 50%WP formulation. The average daytime high temperatures for the 2 day period after application was 62°,59° F, and the night time low was 59°,56°F. Treatments were applied with a low pressure hand wand sprayer.

[x]Percent of fruit with caylx-end injury (typical of Sevin injury) and removed 22 June and rated again 10 Sept..

[w]Mean separation within columns by Duncan's New Multiple Range Test($P \leq 0.05$).

Byers # 9

Table 3. Effect of old Carbaryl formulations on fruit injury and fruit set of Redspur Delicious/M.111 (1999).

No.	Color	Treatment[z,y]			Rate /3.5 liter	Spray Timing	Shading 1 day	Fruit/cm^2 cross sectional area limb (22 June 99)	% fruit injury/ cm^2 cross sectional area limb (22 June 99)	Caylx-end injury[x] (% of fruit) (8 Sept 99)	Fruit diameter (cm) (8 Sept 99)	Length/ diameter ratio (8 Sept 99)
1.	W	Control		--	--			8.86 a[w]	0.000 a	0.0 a	6.04 a	0.976 a
2.	GS	Form #5	XLR 61105202	94	13.2 ml	10mm	x	5.19 bc	0.000 a	0.0 a	5.95 a	0.975 a
3.	BD	Form #6	XLR 60316802	98	13.2 ml	10mm	x	6.84 abc	0.366 a	2.5 a	6.01 a	0.979 a
4.	PBKD	Form #7	XLR 60625202	93	13.2 ml	10mm	x	4.91 c	0.000 a	0.8 a	5.85 a	0.982 a
5.	OBKD	Form #8	XLR 60924102	?	13.2 ml	10mm	x	6.40 abc	0.635 a	1.7 a	5.76 a	0.986 a
6.	RBKD	Form #9	XL60506402R	96	13.2 ml	10mm	x	5.54 c	0.472 a	2.5 a	5.87 a	0.976 a
7.	RD	Form #10	TD 4079045	94	12.6 g	10mm	x	5.27 bc	0.000 a	0.0 a	5.82 a	0.969 a
8.	GD	Form #11	E 04222052	96	12.6 g	10mm	x	8.14 ab	0.000 a	0.0 a	5.74 a	0.990 a
9.	CKP	Form #12	TD 2151119	?	12.6 g	10mm	x	5.70 bc	0.000 a	0.0 a	5.86 a	0.967 a
10.	CKR	Form #13	F 09087053	98	7.88 g	10mm	x	5.03 bc	0.000 a	0.0 a	5.75 a	0.975 a
11.	CKO	Shading	none		None	10mm	x	8.94 a	0.000 a	1.7 a	6.11 a	0.989 a

[z]Full bloom occurred 27 Apr 99; petal fall (3 May 99)

[y]Treatments were applied in 13 May 99 at 10 mm.
The average daytime high temperatures for the 2 day period after application was 59°,70° F. and the night time low was 56°,52°F . Treatments were applied with a low pressure hand wand sprayer.

[x]Percent of fruit with caylx-end injury (typical of Sevin injury) and removed 22 June and rated again 8 Sept..

[w]Mean separation within columns by Duncan's New Multiple Range Test($P \leq 0.05$).

Byers # 10

Table 4. Effect of ethephon on fruit thinning of 'Golden Delicious' /MM.106 (1999).

No. Color	Treatment[zy]	Water volume /acre	Chemical Rate/ acre	Rate/ 100 gal	Fruit/cm^2 cross sectional area limb (31 May)	Visual crop load estimate (%) (9 Aug)	Fruit diameter (cm) (7 Sept)	Length/ diameter ratio (cm) (7 Sept)	Net fruit side russet rating (0-5)[x] (7 Sept)	Stem-end russet rating (0-5)[x] (7 Sept)
1. W					7.57 a[w]	240 ab	6.05 a	0.924 a	0.76 ab	1.36 a
2. R	ethephon	100	2.5 pt	1182.5	8.69 a	229 b	5.85 bc	0.913 ab	0.70 bc	1.23 a
3. B	ethephon	400	2.5 pt	296	8.49 a	252 a	5.96 ab	0.909 b	0.63 c	1.11 a
4. HP	ethephon	100	5 pt	2365	7.52 a	233 b	5.87 bc	0.914 ab	0.86 a	1.30 a
5. FO	ethephon	400	5 pt	591.25	9.13 a	242 ab	5.81 c	0.916 ab	0.67 bc	1.10 a
Contrasts:	Comparisons:				Pr>F	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F
2,3 vs 4,5	Ethephon rate (2.5pt vs 5 pt)				ns	ns	ns	ns	*	ns
2,4 vs 3,5	Water rate (100 gal vs 400 gal/acre)				ns	**	ns	ns	**	ns

[z]Full bloom occurred 28 April 1999 .

[y]Treatments were applied May 26, 1999 when fruit diameter was 22 mm. Trees were 24 feet between rows, tree width was 13 feet, and tree height was 18 ft (75% TRV).

[x]Russet rating: 0 = no russet; 5 = heavy net russet.

[w]Mean separation within columns by Duncan's new multiple range test; ($P \leq 0.05$).

Byers # 11

Table 5. Effect of various chemicals on thinning of Empire/MM.111 (1999).

No.	Color	Treatment[z,y]	Rate/acre /100 gal (200 gal base /acre)	Rate/ 25 gal	Spray Timing	Fruit/cm^2 cross sectional area limb (June 1)	Fruit diameter (cm) (Sept 3)	Length/ diameter ratio (Sept 3)	Net fruit side russet rating[x] (0-5) (Sept 3)
1.	W	Control			--	7.42 a[w]	6.56 b	0.829 a	0.25 b
2.	RBKS	Ethrel 400 ppm	3 pt	355	Bloom	6.60 a	6.48 b	0.825 a	0.25 b
3.	BBKS	Ethrel 600 ppm	4.5pt	532	Bloom	6.15 a	6.62 b	0.811 b	0.25 b
4.	YBKS	Sevin XLR	2 pt	236	Bloom	2.78 b	7.10 a	0.832 a	0.50 a
		+ Accel 30g	1578	395					
		+ Oil 1qt	1/2 gal	473					

Contrasts:	Comparisons:	Pr>F	Pr>F	Pr>F	Pr>F
1 vs 2,3	Control vs Ethrel	ns	ns	*	ns
1 vs 4	Control vs Sevin+Accel+Oil	***	***	ns	***
2,3 vs 4	Ethrel vs Sevin+Accel+Oil	***	***	**	***

[z]Full bloom occurred 15 Apr 99; petal fall (21 Apr 99)

[y]Treatments were applied in Pink (8 Apr 99),Bloom (15 Apr 99), petal fall (21 Apr 99), and 10 mm (4 May 99). The average daytime high temperatures for the 2 day period after application was 56°,77°,65°,72° F, and the night time low was 40°,50°,40°,50°F for Pink, Bloom, Petal fall, and 10 mm. Treatments were applied with an airblast sprayer at 100 gal water/A. Airblast sprayer was calibrated for trees spaced 20 ft between rows, 10 ft tree wideth, and 14 ft tree height which was equivalent to 50% TRV.

[x]Side russet rating: 0 = no net side russet; 5 = heavy net russet.

[w]Mean separation within columns by Duncan's New Multiple Range Test($P \leq 0.05$).

Table 6. Effect of growth regulators on fruit set of 'Starkrimson Delicious' /MM.111/106 (1998-99).

No.	Color	Treatment[z,y]	Rate/acre 100 gal/ acre	Rate/ 25 gal	Spray timing (15 Apr 1998)	Fruit/cm^2 cross sectional area limb (14 May 1998)	Visual crop load estimate (%) (4 Aug 1998)	Flowering clusters/cm^2 cross sectional area limb (14 Apr 1999)	Spurs flowering (visual bloom rating, 0-100%) (16 Apr 1999)
1.	W	Control				8.69 a[x]	103 a	1.33 d	35 b
2.	B	Endothall	4 pt	473	Bloom	3.88 c	68 b	4.12 bc	66 a
3.	R	Wilthin	18 pt	2,129	Bloom	2.01 c	41 cd	6.62 a	73 a
		+ Regulaid	1 pt	118					
4.	BS	Thinex	12pt.	1,419	Bloom	3.98 c	32 d	7.05 a	81 a
		+ Regulaid	1pt.	118					
5.	FO	Sevin XLR	3 pt.	355	Bloom	6.15 b	79 b	2.07 cd	48 b
		+ Accel	30 g	395					
		+ oil	2 pt	236					
6.	Y	Sevin XLR	3 pt.	355	Bloom	3.03 c	58 bc	7.73 a	73 a
		+ Ethrel	3 pt.	355					
7.	BK	Ethrel	3pt	355	Bloom	3.84 c	68 b	6.69 a	71 a
		+ Accel	30g	395					
		+ Oil	2pt	236					
8.	RS	Ethrel	4 pt.	473	Bloom	3.99 c	61 bc	5.12 ab	76 a

[z]Full bloom occurred 15 April 1998 (90-95% open).

[y]Treatments were applied at bloom. Airblast sprayer was calibrated for 100 gal/acre. Trees were 24 feet between rows, tree width was 12 feet, and tree height was 14 ft (50% TRV).

[x]Mean separation within columns by Duncan's New Multiple Range Test; ($P \le 0.05$).

Table 7. Effect of growth regulators on fruit set of 'York' /MM.111 (1998).

No.	Color	Treatment[zy]	Rate/acre 100 gal/ acre	Rate/ 25 gal	Spray timing (15 Apr)	Fruit/cm^2 cross sectional area limb (14 May)	Petal Injury rating (0-5)[x] (17 Apr)	Foliage injury rating (0-5)[x] (17 Apr)	(23 Apr)	(1 May)	Visual crop load estimate (%) (4 Aug.)	Fruit diameter (cm) (13 Oct)	Length/ diameter ratio (cm) (13 Oct)	Side[w] russet rating (0-5) (13 Oct)	Visual bloor rating(spurs flowering, 0-100%) (26 Apr 99)
1	W	Control				10.3 a[v]	0.00 a	0.00 a	0.00 b	0.00 b	91 a	6.86 b	0.794 a	0.13 b	00.1 b
2	B	Endothall	4 pt	473	Bloom	3.74 b	0.50 b	0.00 a	0.50 a	0.47 a	64 a	7.41 a	0.778 a	2.50 a	54.0 a

[z]Full bloom occurred 15 April 1998 (90-95% open).
[y]Treatments were applied at bloom (Airblast sprayer was calibrated for 100 gal/acre (trees were 24 feet between rows, tree width was 12 feet, and tree height was 14 ft (50% TRV).
[x]Petal and foliage rating: 0 = no injury, 5 = severe injury.
[w]Russet rating: 0 = no russeting, 5 = severe russeting.
[v]Mean separation within columns by T Test; ($P \leq 0.05$).

Byers # 14

Table 8. Effect of various chemicals on fruit set of Fuji/M.27 (1998).

No.	Color	Treatment[zy]	Rate /3.5 liter	Spray Timing	Fruit/cm² cross sectional area limb (June 3)	Fruit diameter (cm) (Sept 23)	Length/ diameter ratio (Sept 23)	Net fruit side russet rating[x] (0-5) (Sept 23)	Spurs flowering (visual bloom rating, 0-100%) (26 Apr 99)
1.	W	Control	--	--	16.4 ab[w]	6.91 cd	0.859 de	0.14 b	12.3 cde
2.	R	Sevin + Accel + Oil	4.40 ml 9.63 ml 17.50 ml	Pink	16.2 abc	7.18 abc	0.875 cd	0.18 b	14.8 cde
3.	B	Ethrel 500 ppm + Accel + Oil	8.04 ml 9.63 ml 17.50 ml	Pink	12.3 bcd	7.10 abcd	0.879 ab	0.08 b	39.1 bc
4.	FO	Ethrel 500 ppm	8.04 ml	Pink	12.9 bcd	7.33 a	0.843 f	0.13 b	45.0 ab
5.	HP	Sevin + Accel + Oil	4.40 ml 9.63 ml 17.50 ml	Bloom	15.9 abc	7.03 bcd	0.890 a	0.13 b	3.3 e
6.	Y	Ethrel 500 ppm + Accel + Oil	8.04 ml 9.63 ml 17.50 ml	Bloom	16.20 abc	7.02 bcd	0.881 ab	0.08 b	26.8 bcde
7.	BD	Ethrel 500 ppm	8.04 ml	Bloom	14.3 abcd	7.07 abcd	0.858 de	0.12 b	34.0 bcd
8.	RD	Sevin + Accel + Oil	4.40 ml 9.63 ml 17.50 ml	Petal Fall	13.8 abcd	7.13 abcd	0.868 bcd	0.30 a	33.3 bcd
9.	RS	Ethrel 500 ppm + Accel + Oil	8.04 ml 9.63 ml 17.50 ml	Petal Fall	15.3 abc	6.94 cd	0.863 cd	0.09 b	28.0 bcde
10.	BS	Ethrel 500 ppm	8.04 ml	Petal Fall	17.6 a	6.86 d	0.858 de	0.10 b	9.0 de
11.	BK	Sevin + Accel + Oil	4.40 ml 9.63 ml 17.50 ml	10 mm	10.5 d	7.31 ab	0.867 bcd	0.15 b	66.7 a
12.	DG	Ethrel 500 ppm + Accel + Oil	8.04 ml 9.63 ml 17.50 ml	10 mm	13.1 bcd	7.15 abcd	0.873 bcd	0.11 b	28.8 bcde
13.	OS	Ethrel 500 ppm	8.04 ml	10 mm	15.9 abc	6.90 cd	0.846 ef	0.16 b	12.0 cde
Contrasts:		Comparisons:			Pr>F	Pr>F	Pr>F	Pr>F	Pr>F
1 Vs 2		Control Vs Pink (Sevin + Accel + Oil)			ns	*	*	ns	ns
1 Vs 3		Control Vs Pink (Ethrel + Accel + Oil)			*	ns	**	ns	*
1 Vs 4		Control Vs Pink (Ethrel)			*	**	*	ns	**
1 Vs 5		Control Vs Bloom (Sevin + Accel + Oil)			ns	ns	***	ns	ns
1 Vs 6		Control Vs Bloom (Ethrel + Accel + Oil)			ns	ns	**	ns	ns
1 Vs 7		Control Vs Bloom (Ethrel)			ns	ns	ns	ns	ns
1 Vs 8		Control Vs Petal Fall (Sevin + Accel + Oil)			ns	ns	ns	*	ns
1 Vs 9		Control Vs Petal Fall (Ethrel + Accel + Oil)			ns	ns	ns	ns	ns
1 vs 10		Control vs Petal Fall (Ethrel)			ns	ns	ns	ns	ns
1 vs 11		Control vs 10 mm (Sevin + Accel + Oil)			***	**	ns	ns	***
1 vs 12		Control vs 10 mm (Ethrel + Accel + Oil)			ns	ns	*	ns	ns
1 Vs 13		Control vs 10 mm (Ethrel)			ns	ns	*	ns	ns
2,3,4 vs 5,6,7		Pink vs Bloom (All materials)			ns	*	**	ns	ns
2,3,4 vs 8,9,10		Pink vs Petal Fall (All materials)			ns	**	ns	ns	ns
2,3,4 vs 11,12,13		Pink vs 10 mm (All materials)			ns	ns	ns	ns	ns
5,6,7 vs 8,9,10		Bloom (All materials) vs Petal Fall (All materials)			ns	ns	***	ns	ns
5,6,7 Vs 11,12,13		Bloom vs 10mm			*	ns	***	ns	*
8,9,10 vs 11,12,13		Petal Fall vs 10 mm (All materials)			*	ns	**	ns	ns

[z]Full bloom occurred 15 Apr 98; petal fall (21 Apr 98)

[y]Treatments were applied in Pink (8 Apr 98),Bloom (15 Apr 98), petal fall (21 Apr 98), and 10 mm (4 May 98). The average daytime high temperatures for the 2 day period after application was 56°,77°,65°,72° F, and the night time low was 40°,50°,40°,50°F for Pink, Bloom, Petal fall, and 10 mm. Treatments were applied with a low pressure hand wand sprayer.

[x]Side russet rating: 0 = no net side russet; 5 = heavy net russet.

[w]Mean separation within columns by Duncan's New Multiple Range Test($P < 0.05$).

Table 9. Effect of various chemicals on fruit set of Golden Delicious/M.27 (1998).

No.	Color	Treatment[z,y]	Rate /3.5 liter	Spray Timing	Fruit/cm^2 cross sectional area limb (June 3)	Fruit diameter (cm) (5 Sept)	Length/ diameter ratio (cm) (5 Sept)	Fruit Firmness (lb) (5 Sept)	Soluble solids (5 Sept)	Starch (0-8) (5 Sept)	Net fruit side russet rating[x] (0-5) (5 Sept)	Yellow color rating (5 Sept)	Spurs flowering (visual bloom rating, 0-100%) (22 Apr 99)
1.	Y	Control	--	--	21.7 a[w]	7.09 a	0.894 a	18.40 b	15.1 a	4.2 a	2.02 a	3.13 a	46.7 bc
2.	BD	Ethrel 500 ppm + Accel + Oil	8.04 ml 9.63 ml 17.50 ml	Pink	20.2 a	7.18 a	0.894 a	19.25 ab	15.1 a	3.4 c	2.23 a	3.02 a	63.3 b
3.	RD	Ethrel 500 ppm + Accel + Oil	8.04 ml 9.63 ml 17.50 ml	Bloom	20.6 a	6.98 a	0.892 a	19.23 ab	15.3 a	3.9 ab	2.20 a	3.08 a	33.3 c
4.	BS	Ethrel 500 ppm + Accel + Oil	8.04 ml 9.63 ml 17.50 ml	Petal Fall	19.2 a	7.06 a	0.894 a	19.32 a	15.0 a	3.6 bc	1.93 a	3.07 a	58.3 bc
5.	RS	Ethrel 500 ppm + Accel + Oil	8.04 ml 9.63 ml 17.50 ml	13 mm	11.2 b	7.08 a	0.911 a	19.85 a	15.6 a	3.5 bc	2.25 a	3.10 a	88.3 a

Contrasts:	Comparisons:	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F
1 Vs 2	Control Vs Pink	ns	ns	ns	*	ns	**	ns	ns	ns
1 Vs 3	Control Vs Bloom	ns	ns	ns	*	ns	ns	ns	ns	ns
1 Vs 4	Control Vs Petal Fall	ns	ns	ns	*	ns	*	ns	ns	ns
1 Vs 5	Control Vs 13 mm	***	ns	ns	**	ns	**	ns	ns	**

[z]Full bloom occurred 15 Apr 1998.

[y]Treatments were applied in Pink (8 Apr 98),Bloom (15 Apr 98) petal fall (21 Apr 98) and 13 mm (13 May 98).The average daytime high temperatures for the 2 day period after application was 56°,77°,65°,86° F, and the night time low was 40°,50°,40°,51°F for Pink, Bloom, Petal fall, and 13mm. Treatments were applied with a low pressure hand wand sprayer.

[x]Side russet rating: 0 = no net side russet; 5 = heavy net russet.

[w]Mean separation within columns by Duncan's New Multiple Range Test($P \leq 0.05$).

Byers # 16

Table 10. Effect of application time on fruit thinning of 'Starkrimson'/Mark by ethephon, accel + oil, and carbaryl (Sevin XLR) + oil (1998).

No.	Treatment[y]	Application time[z] (15 May)	Fruit/cm² cross sectional area trunk (1 June)	Temperature (°F) (15 May)	Relative humidity (%) (15 May)	Fruit length (cm) (15 Sept)	Fruit diameter (cm) (15 Sept)	Length/ diameter ratio (cm) (15 Sept)	Fruit firmness (lb) (15 Sept)	Soluble solids (15 Sept)	Starch (0-8) (15 Sept)	Spurs flowering (visual bloom rating, 0-100%) (26 Apr 99)
1.	Control	---	10.44 a[x]	—	--	6.89 cd	7.37 b	0.936 a	16.5 ab	13.9 ab	6.45 ab	32 abc
2.	ethephon	6:00 AM	9.38 ab	57	99	6.87 cd	7.34 b	0.936 a	16.7 a	13.6 b	6.18 b	30 bc
3.	ethephon	2:00 PM	7.58 ab	92	37	6.84 d	7.39 ab	0.926 a	16.2 ab	13.4 b	6.65 ab	34 abc
4.	ethephon	8:00 PM	8.97 ab	66	61	6.87 cd	7.42 ab	0.926 a	16.3 ab	13.3 b	6.48 ab	34 abc
5.	accel+ oil	6:00 AM	7.68 ab	57	99	7.05 abcd	7.43 ab	0.950 a	16.2 ab	13.3 b	6.63 ab	28 c
6.	accel+ oil	2:00 PM	7.61 ab	92	37	7.04 bcd	7.39 ab	0.954 a	16.2 ab	13.4 b	6.60 ab	36 abc
7.	accel+ oil	8:00 PM	8.24 ab	66	61	7.09 abc	7.49 ab	0.947 a	16.4 ab	13.3 b	6.60 ab	38 abc
8.	carbaryl + oil	6:00 AM	7.43 b	57	99	7.27 a	7.64 a	0.952 a	16.3 ab	13.5 b	6.50 ab	57 abc
9.	carbaryl + oil	2:00 PM	7.10 b	92	37	7.19 ab	7.59 ab	0.947 a	15.9 ab	13.5 b	6.50 ab	64 ab
10.	carbaryl + oil	8:00 PM	6.85 b	66	61	7.09 abc	7.53 ab	0.942 a	15.7 b	14.3 a	6.98 a	66 a

		Fruit/cm²
ANOV(P>0.05)		ns
Factorial (less the control)		ns
	Chem	ns
	Time	ns
	Chem x Time	ns

Contrasts:	Comparisons:	Pr>F (Fruit/cm²)	Pr>F (Fruit length)	Pr>F (Fruit diameter)	Pr>F (Length/diameter)	Pr>F (Fruit firmness)	Pr>F (Soluble solids)	Pr>F (Starch)	Pr>F (Spurs flowering)
1 vs 2,3,4,5 ,6,7,8,9,10	Control vs all trts	**	ns	ns	ns	ns	ns	ns	ns
1 vs 2,3,4	Control vs ethephon	ns	ns	ns	ns	ns	*	ns	ns
1 vs 5,6,7	Control vs accel+ oil	*	ns	ns	ns	ns	*	ns	ns
1 vs 8,9,10	Control vs carbaryl+ oil	**	***	*	ns	ns	ns	ns	*
2,5,8 vs 3,6,9	57 vs 96 (all trts)	ns	ns	ns	ns	ns	ns	ns	ns
3,6,9 vs 4,7,10	57 vs 66 (all trts)	ns	ns	ns	ns	ns	ns	ns	ns
2,5,8 vs 4,7,10	57 vs 66 (all trts)	ns	ns	ns	ns	ns	ns	ns	ns
1 vs 2	Control vs ethephon	ns	ns	ns	ns	ns	ns	ns	ns
1 vs 3	Control vs ethephon	*	ns	ns	ns	ns	ns	ns	ns
1 vs 4	Control vs ethephon	ns	ns	ns	ns	ns	*	ns	ns
1 vs 5	Control vs accel+ oil	*	ns	ns	ns	ns	*	ns	ns
1 vs 6	Control vs accel+ oil	*	ns	ns	ns	ns	ns	ns	ns
1 vs 7	Control vs accel+ oil	ns	*	ns	ns	ns	*	ns	ns
1 vs 8	Control vs carbaryl+ oil	*	***	*	ns	ns	ns	ns	ns
1 vs 9	Control vs carbaryl+ oil	*	**	*	ns	ns	ns	ns	ns
1 vs 10	Control vs carbaryl+ oil	**	*	ns	ns	ns	ns	ns	ns
2 vs 3	57 vs 96 (ethephon)	ns	ns	ns	ns	ns	ns	ns	ns
3 vs 4	96 vs 66 (ethephon)	ns	ns	ns	ns	ns	ns	ns	ns
2 vs 4	57 vs 66 (ethephon)	ns	ns	ns	ns	ns	ns	ns	ns
5 vs 6	57 vs 96 (accel+oil)	ns	ns	ns	ns	ns	ns	ns	ns
6 vs 7	96 vs 66 (accel+oil)	ns	ns	ns	ns	ns	ns	ns	ns
5 vs 7	57 vs 66 (accel+oil)	ns	ns	ns	ns	ns	ns	ns	ns
8 vs 9	57 vs 96 (carbaryl+oil)	ns	ns	ns	ns	ns	ns	ns	ns
9 vs 10	96 vs 66 (carbaryl+oil)	ns	ns	ns	ns	ns	**	ns	ns
8 vs 10	57 vs 66 (carbaryl+oil)	ns	ns	ns	ns	ns	**	ns	ns

[z]Full bloom occurred April 15, 1998. Applications were made on May 15, 1998 when fruit diameter was 19.2 mm.

[y]Spray treatments concentrations were: carbaryl 600mg/L; accel 50mg/L; ethephon 270mg/L; oil 0.25%.

[x]Mean separation within columns by Duncan's New Multiple Range Test, P≤0.05.

Byers # 17

Table 11. Effect of airblast chemical thinning treatments on 'Bisco' (young block) fruit set and diameter sprayed 8 April 1999).

No.	Color	Treatment[zy]	Rate/ 50 gal (block rate)	Rate/ 100 gal (block rate)	Fruit/cm² cross sectional area limb 27 May	Vegetative shoot injury rating (0-10) 21 Apr	Fruit diameter (inches) 20 Aug
1.	W	Control			17.3 a[x]	0.00 b	2.62 b
2.	B	Endothall (100 gal/acre)	710 ml	3 pt	16.7 ab	0.31 b	2.72 b
3.	R	Wilthin (100 gal/acre)	3784ml	16 pt	12.5 b	1.10 a	2.83 a
		+ Regulaid	236 ml	1 pt			
4.	Y	Armothin	1420 ml	6 pt	17.5 a	0.00 b	2.71 b

[z]Full Bloom: 10 April—50-75% flowers open. Whole blocks were sprayed and the water rate was held constant at 100 gal/acre.

[y]All treatments including the control were hand thinned June 2-7.

[x]Mean separation within columns by Duncan's New Multiple Range Test, P≤0.05.

Table 12. Effect of airblast chemical thinning treatments on 'Redhaven' (young block) fruit set and diameter sprayed 9 April 1999).

No.	Color	Treatment[zy]	Rate/ 50 gal (block rate)	Rate/ 100 gal (block rate)	Fruit/cm² cross sectional area limb 28 May	Vegetative shoot injury rating (0-10) 21 Apr	Fruit diameter (inches) 22 July
1.	W	Control			10.9 a[x]	0.00 b	2.64 a
2.	B	Endothall (100 gal/acre)	710 ml	3 pt	11.9 a	0.69 a	2.59 a
3.	R	Wilthin (100 gal/acre)	3784ml	16 pt	10.1 a	0.50 a	2.66 a
		+ Regulaid	236 ml	1 pt			
4.	Y	Armothin	1420 ml	6 pt	10.1 a	0.00 b	2.64 a

[z]Full Bloom: 10 April—50-75% flowers open. Whole blocks were sprayed and the water rate was held constant at 100 gal/acre.

[y]All treatments including the control were hand thinned June 2-7.

[x]Mean separation within columns by Duncan's New Multiple Range Test, P≤0.05.

Table 13. Effect of airblast chemical thinning treatments on 'Cresthaven' (young block) fruit set and diameter sprayed 10 April 1999).

No.	Color	Treatment[zy]	Rate/ 50 gal (block rate)	Rate/ 100 gal (block rate)	Fruit/cm² cross sectional area limb 27 May	Vegetative shoot injury rating (0-10) 21 Apr	Fruit diameter (inches) 20 Aug
1.	W	Control			14.6 a[x]	0.00 c	2.68 b
2.	B	Endothall (100 gal/acre)	710 ml	3 pt	12.5 b	0.24 b	2.66 b
3.	R	Wilthin (100 gal/acre)	3784ml	16 pt	9.2 c	0.83 a	2.89 a
		+ Regulaid	236 ml	1 pt			
4.	Y	Armothin	1420 ml	6 pt	10.6 c	0.01 c	2.70 b

[z]Full Bloom: 10 April—50-75% flowers open. Whole blocks were sprayed and the water rate was held constant at 100 gal/acre.

[y]All treatments including the control were hand thinned June 2-7.

[x]Mean separation within columns by Duncan's New Multiple Range Test, P≤0.05.

1999 Apple Thinning Trials in Pennsylvania

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Biennial bearing remains a production problem causing significant losses in the Mid-Atlantic region. One way to overcome this with some varieties is to have an aggressive thinning program so that excessive fruit numbers are reduced thereby allowing adequate return bloom that will result in a good crop the next year.

For years the Pacific Northwest growers used Elgetol at full bloom followed by subsequent fruitlet thinners as needed. This strategy allowed them to reduce fruit numbers where bloom was excellent, and that was usually the case, and then to come back with a fruitlet thinner when fruit numbers were still excessive. This strategy worked well but with the loss of Elgetol serious problems resulted from over cropping. The objectives of the studies conducted this year were to aid in the development of both blossom and fruitlet thinners that might be useful for eastern fruit growers.

Materials and Methods

All sprays were applied with an airblast sprayer. The Durand-Wayland AF100-32 3-point hitch sprayer was mounted on a John Deere 5400 N orchard tractor. The basic calibration for this tractor and sprayer for sprays at the Fruit Res. and Ext. Center was: row width 20 ft., gallonage 100 gal/A, speed 2.07 mph, 8.6 gal/minute. These experiments were conducted in two blocks at the Mapleton Farm of Crestmont Orchards, Inc. I extend my sincere appreciation to Chester J. Tyson III for his cooperation in letting me use his orchards. The trees in both blocks were the same size. The tree row volume calculations were : tree width = 18 ft., row width = 24 ft., tree height = 15 ft., tree row volume = 85.9%. At 400 GPA times 85.9% a full dilute spray would be 343.6 GPA. However, a factor of 70% is used for tree openness so a dilute spray at this time of year would be 240 GPA. Since the row spacing in these blocks was 24 ft. rather than 20 ft. the tractor was operated at 1.69 mph rather than 2.07 mph thereby applying 102 gal/A.

A blossom thinning experiment was conducted in the Barn Block. Since Treatments 4 and 5 were to be applied at 200 gallons per acre tractor speed was slowed to 0.87 MPH so that the sprays were applied at 198 gallons per acre. In 1999 full-bloom was much more variable than it had been in the past. On May 2nd most king blossoms were in full bloom. On May 5, 58% of the flowers were in full-bloom, 32% were pink, and 10% were in petal-fall. However, some individual branches had as many as 79% of the flowers in pink or as much as 24% of the flowers in petal-fall. This made timing of the applications problematic. Treatments selected for blossom thinning are listed in Table 1. Treatments consisted of two treatments of an Elf Atochem experimental thinner TD-2337-03 and a low and high rate of WILTHIN. For the WILTHIN sprays the tractor speed was slowed to 0.87 MPH making the water rate 198 gallons per acre. The first application for Treatment 3 was made at 6:30 AM on May 5th and a miscalculation resulted in a lower rate of the chemical being used than is listed in Table 1. All other treatments were applied between 6:30 and 11 AM on May 6th. A 24 apple fruit sample was harvested in the fall and consisted of fruit from the following locations: 8 upper, outer and 8 lower, outer (2 from the north, south, east and west) and 4 upper, inner and 4 lower, inner (1 from the north, south, east and west).

A fruitlet thinning experiment was conducted in the Tyson Hill Block at the Mapleton Farm. Treatments selected for this experiment are listed in Table 2. These treatments consisted of an untreated check, a hand-thinning check, and then various combinations of ethephon and sevin with additional materials such as oil, Fruitone N or both of these materials. Other treatments included the substitution of Vydate for sevin and the substitution of Vydate for sevin plus Fruitone N and oil, and one additional treatment that was applied five days after the initial treatments. On May 26th a random sample of fruit clusters was harvested and the mean fruit size was 15.1 mm with a range of 7-20 mm but most were 12-19 mm. On May 28th applications were made between 6:30 and 10:00 AM. Conditions were calm and sunny with a temperature of 48 F at 6:30 AM. On June 2nd thinning sprays were applied between 6:30 and 7:40 AM. At that time it was cloudy then sunny with a temperature of 68F at 6:30 AM with no wind. Hand thinning was performed on June 23rd for Treatment 2. A 24 apple fruit sample was harvested in the fall and consisted of fruit from the following locations: 8 upper, outer and 8 lower, outer (2 from the north, south, east and west) and 4 upper, inner and 4 lower, inner (1 from the north, south, east and west).

All data was entered in a Macintosh computer and was analyzed with the appropriate statistical analysis of variance program in the SuperANOVA accessible General Linear Modeling program made by Abacus Concepts, Inc. of Berkeley, CA.

Results and Discussion

Results from the blossom thinning experiment are shown in Table 3. .It can be seen that on May 25 the two TD-2337 treatments had caused a significant reduction in a number of fruit per blossom cluster. The significant effect carried over through July 1 and Aug. 6. There was no difference between the two TD 2337-03 treatments but it should be remembered that a mistake was made and the first spray was made at a rate below that listed. On the other hand, neither of the WILTHIN treatments caused significant thinning in this experiment.

Results for the fruitlet thinning experiment are shown in Table 4. June drop removed 28% of the fruitlets, on the other hand, hand thinning removed nearly 80% of the initial fruitlets. Ethephon and sevin removed about 45% of the fruitlets while the addition of oil slightly increased the fruitlet removal to 58% but not significantly so. However, the addition of oil appeared to make the thinning response occur in a more rapid manner. An additional fruit removal occurred when Fruitone N was added to ethephon and sevin. This treatment removed 72% of the fruitlets. A 4 way combination of ethephon, sevin, Fruitone N and oil removed approximately 80% of the fruit which is very close to the number removed by hand thinning. If Vydate was added to the ethephon plus Fruitone N combination 63% of the fruitlets were removed indicating that Vydate was just about as effective as sevin in enhancing the efficacy of ethephon and Fruitone N in removing fruits.

A 4 way combination of ethephon, Vydate, Fruitone N and oil removed 80% of the fruit indicating that Vydate was just about as effective as sevin in enhancing the efficacy of ethephon and Fruitone N and oil in removing fruits. Delaying the application of the four way combination thinning treatment of ethephon, sevin, Fruitone N and oil until June 2nd significantly reduced the ability of that combination to remove fruit compared to the same combination that had been applied on May 28th. This later application removed about 60% of the fruit compared to the earlier application that removed about 80% of the fruit. Perhaps the application on May 28th was made near the end of the period when the fruit were at a high level of susceptibility to fruit thinners.
Several treatments involved various combinations of thinners with and without oil as an adjuvant. An analysis of this effect is shown in Table 5. Oil significantly enhanced the thinning of fruit from June 1 to July 1. However, if looking at the number of fruitlets removed from July 1 to July 30 the oil treatment removed significantly fewer fruit which indicated that the oil enhanced the efficacy of thinners and made the thinning occur more rapidly. From June 1 to July 30 oil significantly increased the thinning response.

These results with blossom and fruitlet thinners should aid in the development of effective programs for thinning apples in the mid-Atlantic region both at full bloom and when fruitlets have past the old "optimum" size of 10 mm.

Table 1. List of treatments for the 1999 York Imperial blossom thinning experiment (MS99ATOA).

Trmt. No.	Treatment Name	Timing	Chemical	Rate	Method
1.	Check	--	--	--	--
2.	TD-2337-03, 0.4S, 1.5 pt. / 100 gallons	60-80% Full Bloom	TD-2337-03 0.4S	1.5 pt./100 gal. dilute equiv.	Airblast, 100 GPA
3.	TD-2337-03, 0.4S, 1.25 pt. / 100 gallons, twice	40% Full Bloom	TD-2337-03 0.4S	1.25 pt./100 gal. dilute equiv.	Airblast, 100 GPA
		90% Full Bloom	TD-2337-03 0.4S	1.25 / 100 gal.. dilute equiv.	Airblast, 100 GPA
4.	WILTHIN 3 pt.. / 100 gallons	60-80% Full Bloom	WILTHIN	3 pt./100 gal. dilute equiv.	Airblast, 200 GPA
5.	WILTHIN, 4.5 pt. / 100 gallons	60-80% Full Bloom	WILTHIN	4.5 pt./100 gal. dilute equiv.	Airblast, 200 GPA

Table 2. List of treatments for the 1999 York Imperial fruitlet thinning experiment (MS99THIN).

Trmt. No.	Treatment Name	Timing	Chemical	Rate	Method
1.	Check	--	--	--	--
2.	Hand Thin	June 23	--	--	--
3.	ethephon + Sevin	May 28	Sevin XLR ethephon	1 qt. per 100 gallons equivalent 1.5 pt. per 100 gallons equiv.	Airblast @ 100 GPA
4.	ethephon + Sevin + Oil	May 28	Sevin XLR ethephon Oil	1 qt. per 100 gallons equivalent 1.5 pt. per 100 gallons equiv. 1 gallon per acre	Airblast @ 100 GPA
5.	ethephon + Sevin + Fruitone N	May 28	Sevin XLR ethephon Fruitone N	1 qt. per 100 gallons equivalent 1.5 pt. per 100 gallons equiv. 15 ppm dilute equivalent	Airblast @ 100 GPA
6.	ethephon + Sevin + Oil + Fruitone N	May 28	Sevin XLR ethephon Oil Fruitone N	1 qt. per 100 gallons equivalent 1.5 pt. per 100 gallons equiv. 1 gallon per acre 15 ppm dilute equivalent	Airblast @ 100 GPA
7.	ethephon + Vydate + Fruitone N	May 28	Vydate ethephon Fruitone N	4 pts. per acre 1.5 pt. per 100 gallons equiv. 15 ppm dilute equivalent	Airblast @ 100 GPA
8.	ethephon + Vydate + Fruitone N + Oil	May 28	Vydate ethephon Fruitone N Oil	4 pts. per acre 1.5 pt. per 100 gallons equiv. 15 ppm dilute equivalent 1 gallon per acre	Airblast @ 100 GPA
9.	ethephon + Sevin + Oil + Fruitone N	June 2	Sevin XLR ethephon Oil Fruitone N	1 qt. per 100 gallons equivalent 1.5 pt. per 100 gallons equiv. 1 gallon per acre 15 ppm dilute equivalent	Airblast @ 100 GPA
10.	Fruitone N	June 16	Fruitone N	5 ppm dilute equivalent	Airblast @ 100 GPA
11.	Fruitone N	June 16, 30,	Fruitone N	5 ppm dilute equivalent	Airblast @ 100 GPA
12.	Fruitone N	June 16, 30, July 14	Fruitone N	5 ppm dilute equivalent	Airblast @ 100 GPA
13.	Fruitone N	June 16, 30, July 14, 28	Fruitone N	5 ppm dilute equivalent	Airblast @ 100 GPA
14.	Fruitone N	June 2, 16, 30, July 14, 28	Fruitone N	5 ppm dilute equivalent	Airblast @ 100 GPA

Table 3. The influence of blossom thinners on the fruit per 100 blossom clusters of 'York Imperial' apples (MS99ATOA).

Treatment Name	Fruit count per 100 blossom clusters 5/25	7/1	8/6
Check	33.7 b [z]	31.8 b	29.7 b
TD-2337-03, 0.4S, 1.5 pt/100 gallons	12.3 a	12.1 a	11.7 a
TD-2337-03, 0.4S, 1.25 pt/100 gallons, twice	9.6 a	9.6 a	9.4 a
WILTHIN, 3.0 pt/100 gallons	31.6 b	27.3 b	24.9 b
WILTHIN, 4.5 pt/100 gallons	26.2 b	24.5 b	23.2 b
AOV Prob. Value Table			
Rep.	.5913	.6009	.7550
Trmt.	.0009	.0008	.0017

[z]Means followed by the same letter(s) are not significantly different according to the Duncan New Multiple Range Test at the 5% level of probability.

Table 4. The influence of thinning treatments on the percent of 'York Imperial' apples removed (MS99THIN).

Trmt. No.	Treatment Name	Percent of 6/1 Fruit Removed 6/1-7/1 %	7/1-7/30 %	6/1-7/30 %
1	Check	25.5 a	3.0 ab	28.4 a
2	Hand thin 6/23	74.6 cd	3.8 ab	78.3 ef
3	ethephon + Sevin 5/28	32.5 a	13.9 c	46.4 bc
4	ethephon + Sevin + Oil 5/28	54.4 b	3.8 ab	58.1 cd
5	ethephon + Sevin + Fruitone N 5/28	70.6 bcd	1.4 a	72.0 def
6	ethephon + Sevin + Oil + Fruitone N 5/28	79.2 d	1.6 ab	80.9 f
7	ethephon + Vydate + Fruitone N 5/28	60.3 bc	2.7 ab	63.0 cde
8	ethephon + Vydate + Oil + Fruitone N 5/28	79.7 d	.2 a	80.0 ef
9	ethephon + Sevin + Oil + Fruitone N 6/2	54.4 b	5.0 ab	59.4 cd
10	Fruitone N 6/16	18.5 a	10.0 bc	28.5 a
11	Fruitone N 6/16, 6/30	17.7 a	3.9 ab	21.6 a
12	Fruitone N 6/16, 6/30, 7/14	21.9 a	5.4 ab	27.3 a
13	Fruitone N 6/16, 6/30, 7/14, 7/28	24.1 a	5.0 ab	29.1 a
14	Fruitone N 6/2, 6/16, 6/30, 7/14, 7/28	27.0 a	4.2 ab	31.2 ab
AOV Probability Value Table				
Block		.4653	.0726	.8011
Treatment		.0001	.0351	.0001

[z]Means followed by the same letter(s) are not significantly different according to the Duncan New Multiple Range Test, 5% level.

Table 5. The influence of oil as an adjuvant to increase the thinning potential of treatments on the percent of York Imperial apples removed. (MS99THIN).

Treatment Name	Percent of 6/1 fruit removed 6/1-7/1 (%)	7/1-7/30 (%)	6/1-7/30 (%)
No oil	54.4 a[z]	6.0 a	60.4 a
Oil	71.1 b	1.9 b	73.0 b
AOV Prob. Table			
Treatment	.0009	.0483	.0072

[z]Means followed by the same letter(s) are not significantly different according to the Analysis of Variance Test at least the 5% level of probability.

Ethephon, Foliar Nutrient, and Gibberellin Sprays on Subsequent Season(s) Return Bloom and Fruit Set (1997-1999)

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Abstract. Heavily cropping 'York'/M.27 trees sprayed with seven multiple low doses of ethephon (135 ppm each) did not cause greater return bloom in 1999 unless foliar fertilizers (either 18-18-18 or Ca No3) were added to the ethephon sprays. Foliar fertilizer sprays alone did not promote return bloom.

'York'/M.7 trees selected for very little bloom in 1997 ("off year" of the beinnal 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). Trees sprayed in 1997 ("off year") with GA_3 return bloom and cropped in 1999; but trees in the "off year" in 1997 that were not sprayed with GA_3, trees did not crop in 1999. Sprays of GA3 provided some control of alternate bearing of 'York'/M.7 trees when applied in the "off year" of the biennial bearing cycle.

Leaves taken from Braeburn/M.27 trees in 70F rooms evolved ethylene through out the 12 days of the test. A moderate ethylene peak occurred on about day 5 and 6. Leaves from trees in the 40F room did not evolve detectable ethylene levels until trees were put in another 70F room on day 6. Ethylene levels were approximately the same from day 6 through day 12 for all treated trees at 70F. Non-treated control trees in rooms at 40F or 70F did not produce detectable ethylene levels during the experiment (except for a very small amount detected only on day 2 from leaves seal for 24 hours at 70F.

Introduction

Ethephon has been used in the apple industry as a thinning agent; flower promoter, and color enhancer (Abeles 1992). Olien and Bukovac (1978) have reported that temperature may greatly influence ethylene evolution in cherry leaves. Weekly, low dose, multiple applications of ethephon have been used to promote return bloom of apple while avoiding fruit abscission from higher rates during the thinning period (Byers 1993). Since flower bud induction by ethephon occurs during the same period as when the fruit are susceptible to fruit abscission by ethylene, it is important to know how long the ethylene evolution continues after each single application in order to reduce the chance of fruit thinning. Since ethephon can induce fruit abscission at application rates above 500 mg/L, multiple low dose sprays (160 mg/L to 320 mg/L) may have the potential for fruit abscission if ethephon breakdown continues longer than a week and/or if ethephon induces significant autocatalytic ethylene from the plant tissues. Jones and Koen (1985) found that, in growth chambers, application and post application temperatures greatly contribute to increased fruit abscission.

The objectives of the experiments reported here were 1) to investigate foliar nutrient sprays, multiple applications of ethephon, and hand thinning for increasing return bloom and fruiting of heavily set York trees, 2) to follow the return bloom and fruiting of biennial "off year" cropping 'York/M.7 trees sprayed with GA3 in 1997, and 3) to determine ethylene evolution from apple tree leaves when trees were placed in 40F and 70F controlled temperature rooms for several days.

Materials and Methods

Chemicals were applied to whole trees with a low-pressure hand-wand sprayer or with a high pressure hand gun. All experiments were randomized complete block experiments. Apple 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.

Flower clusters or crop density (fruit or flower/cm^2 cross sectional area limb, CD) was determined by counting flower clusters or fruit on 3 pre-selected limbs per tree; or on whole trees (fruit/cm^2 cross sectional area trunk, CD). Three limbs per tree were tagged during late pink; 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 after unfertilized fruit dropped. Crop density (CD) on sample limbs was expressed as fruit•cm^2 cross-sectional area limb(LCSA). In the event that all the fruit on a tree was counted crop density was expressed as fruit•cm^2 cross-sectional area trunk (TCSA). Past experience has indicated that when using these techniques that the desirable crop load is approximately 4 to 6 fruit•cm^2 cross-sectional area limb (or trunk) after thinning (Byers and Carbaugh 1991; Byers, 1997).

Data for flowering or crop density were analyzed with SAS (Sas Institute, Cary, N. C.), general linear model (GLM procedures) to evaluate the linear and quadratic effects and pre-planned single-degree of freedom contrasts of interest, or Duncan's Multiple range tests. The experimental designs for all experiments were randomized complete block and were block by location within rows.

Expt. 1. Seventy-two 8-year-old 'York'/M.27 trees (8 blocks) were selected for 90 to 100 % spurs flowering and used for 9 treatments (Table 1). Seven multiple low doses of ethephon were applied alone or in combination with Ca N03 or Millers 18-18-18 foliar nutrient spray (which includes several minor elements) in the period from petal fall to 48.6 mm fruit diameter. All trees were hand thinned at 17.3 mm fruit diameter except for treatments 2 & 3 which were thinned (8 trees) or defruited (8 trees) at bloom and treatment 10 and 11 which were trees (8 trees each) selected for only 0 to 10% flowering or 60% to 70% flowering in 1998.

Expt. 2. In 1997, forty 8-year-old 'York'/MM. 7 trees (10 blocks) were used for four treatments in a study to evaluate various treatments that might encourage return bloom (Table 2). Trees were not hand or chemically thinned in 1997. Trees selected for the test had 0 to 20 visual estimate of % spurs flowering except for one of the control treatments that had 90 to 100 % of the spurs flowering. Trees were either sprayed with GA_3 at 160 ppm, 320 ppm, or non-sprayed. In 1997, the number of fruit on limbs that were pre-tagged at bloom were counted and expressed as FCSA limb. The % of spurs flowering in 1998 were visually estimated and fruit set on limbs tagged in 1997 were counted in 26 May 1998. In 1999, visual estimates of spurs flowering and flower clusters and fruit were counted on 2 representative limbs per tree. Trees were over sprayed with chemical thinners in 1998 and 1999.

Expt. 3. In 1999, six Braeburn/M.27 trees grown in the field in root bags were excavated and placed in 5-gallon buckets and sprayed with ethephon on August 9. Additional six trees served as controls. After sprays were dry, 3 treated and 3 control trees were moved into either 40F or 70F rooms for 11 days in the dark. Ten leaves were collected from each tree each day for 11 days and leaf samples were place in glass jars and sealed in the room. Ethylene samples were drawn from each jar after 3 hours and 24 hours and injected into a Gas Chromatograph. Leaves were weighted and ethylene levels were expressed in ul/g/hour.

Results and Discussion

Expt. 1. Seven multiple low doses of ethephon, Ca N03, or Millers 18-18-18 (which includes several minor elements) did not increase flowering or fruit set in 1999 (trt#5, #8, #9). Only the combination of ethephon plus Ca N03 or Millers 18-18-18 in the period from petal fall to 48.6 mm fruit diameter in 1998 dramatically increased flowering and fruiting in 1999. All trees were hand thinned at 17.3 mm fruit diameter except for trt #s 2 & 3 which were thinned (8 trees) at bloom or defruited (8 trees) at bloom, and treatments 10 and 11 which were (8 trees) selected for only 0 to 10% or 60-70% flowering in 1998.

Trees defruited at bloom flowered and cropped heavily in 1999 (trt#2). Hand thinning at 17.5 mm statistically did not increase flowering or fruiting in 1999 (trt#3). Trees selected for only 10% bloom in 1998, flowered and cropped heavily in 1999 (trt#11). Trees selected for 60 to 70% flowering in 1998, flowered and had sufficient fruit set for a full crop (trt#10).

Expt. 2. '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 2) . 'York' trees selected for very little bloom in 1997 ("off year" of the beinnal 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. Trees sprayed in 1997 ("off year") with GA_3 return bloom and cropped in 1999; but trees in the "off year" in 1997 that were not sprayed with GA_3, trees did not crop in 1999. Sprays of GA3 provided some control of alternate bearing of 'York'/M.7 trees when applied in the "off year" of the biennial bearing cycle.

Expt. 3. Leaves taken from Braeburn/M.27 trees in 70F rooms evolved ethylene throughout the 12 days of the test. A moderate ethylene peak occurred on about day 5 and 6 (Figures 1 & 3). Leaves from trees in the 40F room did not evolve detectable ethylene levels until trees were put in another 70F room on day 6 (Figures 2 & 4). Ethylene levels were approximately the same from day 6 through day 12 for all treated trees at 70F

(Figures 1, 2, 3, & 4). Non-treated control trees in rooms at 40F or 70F did not produce detectable ethylene levels during the experiment (except for a very small amount detected only on day 2 from leaves seal for 24 hours at 70F (Figure 7).

Individual trees in either the "on year" or the "off year" of the biennial bearing cycle can be sprayed with either ethephon + a foliar N source to promote flowering in the "off year" or sprayed with GA_3 to reduce flowering of trees in the "on year". Annual observation and spraying of individual trees may provide higher yields of marketable fruit for cultivars that typically bear biennially.

Acknowledgements

Appreciation to David Carbaugh, Leon Combs, Seth Combs, Heath Combs, Maurice Keeler, Harriet Keeler, for data collection and technical assistance.

References

Abeles, F. B. 1992. Ethylene in plant biology. Academic Press, New York.

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.

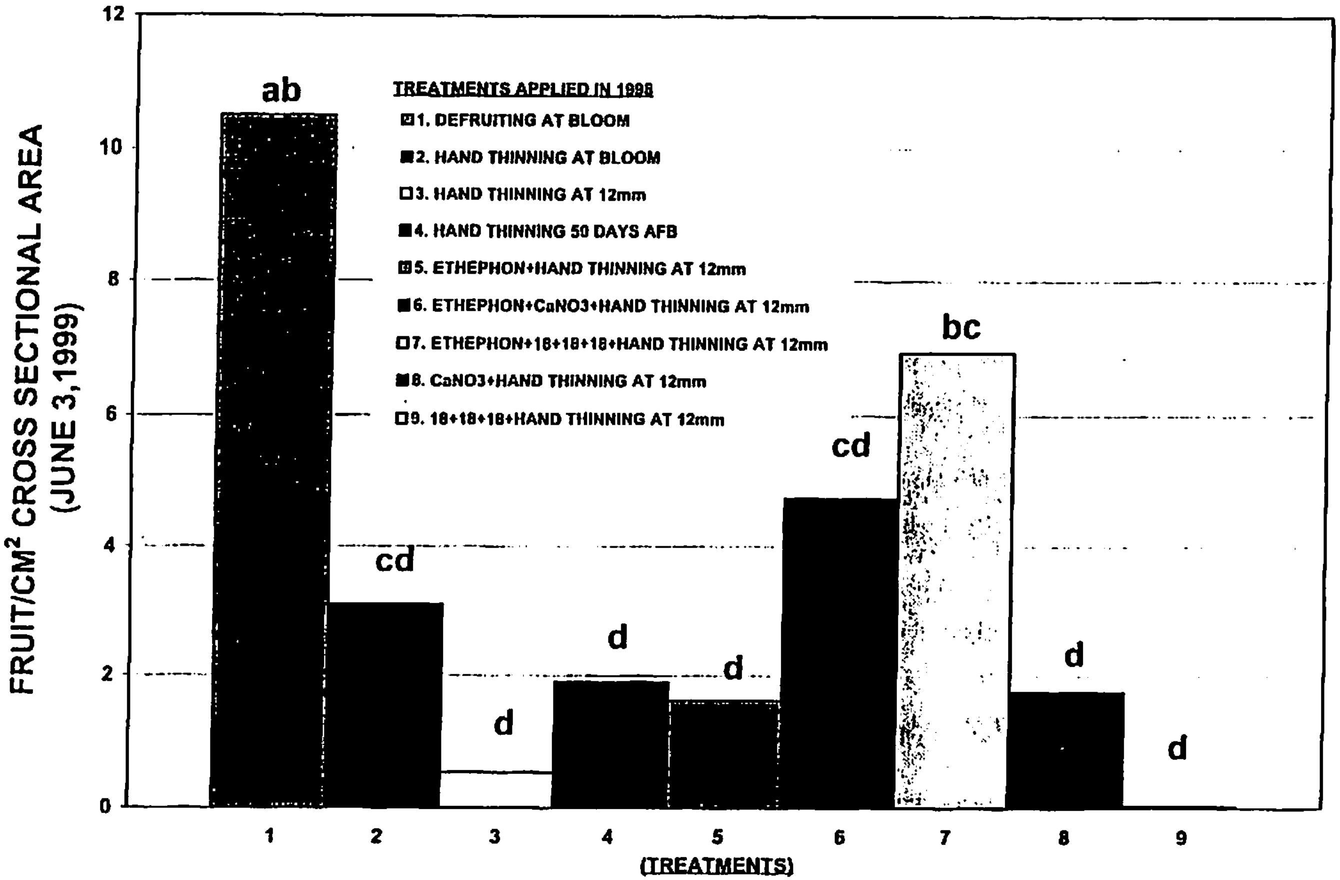
Byers, R.E. 1993. Controlling growth of bearing apple trees with ethephon. Hort. Sci. 28 (11) : 1103-1105.

Jones, K. M. and T.B. Koen. 1985. Temperature effects on ethephon thinning of apples. J. Hort. Sci. 60 (1) : 21-24.

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.

INFLUENCE OF VARIOUS 1998 TREATMENTS ON RETURN FRUIT SET OF YORK /M.27 (JUNE 3,1999)
(All trees 90 to 100% spurs flowering in 1998)



SEVEN SPRAY APPLICATIONS FROM PF TO 49mm IN 1998
(All treatments hand-thinned in 1998)

Byers # 5

Figure 1. The influence of Ethephon, Foliar fertilizers, and hand thinning applied in the spring of 1998 on Fruit/cm² trunk cross sectional area in 1999.

Table 1. Effect of various factors on return bloom of 'York'/M.27 (1998-99).

No.	Color	Treatment[z,y]	Spurs Flowering (%) 1998	Rate /100 gal	Rate 3.5 liter	PF Apr 21	8.5 mm May 1	17.3 mm May 13	23.9 mm May 21	33.6 mm May 31	41.7 mm June 12	48.6 mm June 22	Fruit /cm² cross sectional area trunk before thinning 13 May 1998	Fruit /cm² cross sectional area trunk after thinning 13 May 1998	% spurs flowering (estimated) 21 April, 1999	Spurs flowering /cm² cross sectional area limb 26 April 1999	Fruit /cm² cross sectiona area limb 3 June 1999
1.	W	Control–hand thinning 50 days AFB	90 to 100								T		33.35 ab	6.14 a	15.0 cde	1.16 bc	1.90 d
2.	R	Defruiting at bloom --	90 to 100			T							0.15 c	0.00 c	98.3 a	30.9 a	10.50 ab
3.	FO	Hand Thinning at bloom	90 to 100			T							27.06 ab	5.99 a	28.3 bcde	4.14 bc	3.10 cd
4.	HP	Hand Thinning at 17.3 mm	90 to 100					T					33.22 ab	6.02 a	5.0 e	0.50 c	0.53 d
5.	Y	Ethephon 135 ppm + H. Thinning at 17.3 mm	90 to 100	237 ml	2.19ml	x	x	xT	x	x	x	x	30.17 ab	5.99 a	18.3 cde	1.16 bc	1.62 d
6.	RD	Ethephon 135 ppm + Ca NO3 + H. Thinning at 17.3 mm	90 to 100	237 ml 6 lb (2518g)	2.19ml 25.2g	x x	x x	xT x	x x	x x	x x	x x	30.49 ab	6.01 a	40.0 bcd	4.03 bc	4.75 cd
7.	BD	Ethephon 135 ppm + 18-18-18 + H. Thinning at 17.3 mm	90 to 100	237 ml 5 lb (2270g)	2.19ml 21g	x x	x x	xT x	x x	x x	x x	x x	28.88 ab	6.01 a	50.0 b	6.29 bc	6.93 bc
8.	DG	Ca NO3 + Thinning at 17.3 mm	90 to 100	6 lb (2518g)	25.2g	x	x	xT	x	x	x	x	31.48 ab	6.03 a	16.7 cde	0.94 bc	1.76 d
9.	BK	18-18-18 + H. Thinning at 17.3 mm	90 to 100	5. lb (2270g)	21g	x	x	xT	x	x	x	x	33.66 a	6.00 a	0.0 e	0.02 c	0.03 d
10.	RS	Control + H. Thinning at 17.3 mm	60 to 70					T					25.50 b	6.02 a	43.3 bc	8.04 b	6.86 bc
11.	BS	Control	0 to 10										0.48 c	0.48 b	98.3 a	28.7 a	12.34 a

[z](T) = Thinning will be by hand.
[y]Full bloom = April 16 1998.
[x]Mean separation within columns by Duncan's New Multiple Range Test;(P ≤ 0.05).

Dyers # 6

Table 2. Effect of GA3 on return bloom of 'York'/M.7 (1997-1999).

No.	Color	Treatment[z]	Spurs flowering (visual estimate, 0-100%)	Flower clusters/ cm^2 cross sectional area of limb	Fruit/ cm^2 cross sectional area of limb	Visual estimate of crop load (%)
			1997 (Apr 27)	1997 (Apr 27)	1997 (June 17)	
1.	W	Control - no treatment	0 to 20	0.7 b[Y]	0.483 b	
5.	LG	GA3 160 ppm at 10 mm	0 to 20	1.1 b	1.423 b	
6.	DP	GA3 320 ppm at 10 mm	0 to 20	1.8 b	1.065 b	
7.	W2	Control – no treatment	90 to 100	28.7 a	6.513 a	
			1998	1998	1998 (May 26)	
1.	W	Control - no treatment	99 a		12.7 a	
5.	LG	GA3 160 ppm at 10 mm	61 b		8.4 b	
6.	DP	GA3 320 ppm at 10 mm	46 b		5.9 b	
7.	W2	Control – no treatment	3 c		0.4 c	
			1999 (Apr 15)	1999 (Apr 15)	1999 (June 23)	1999 (Aug 3)
1.	W	Control - no treatment	0.2 c	0.0 c	0.00 c	0.00 b
5.	LG	GA3 160 ppm at 10 mm	24.0 b	3.2 c	2.92 b	41.0 b
6.	DP	GA3 320 ppm at 10 mm	34.0 b	8.7 b	3.78 b	42.0 b
7.	W2	Control – no treatment	97.0 a	20.0 a	6.12 a	216.0 a

[z]Full Bloom occurred 16 April 1998.Treatments were applied on 30 April, 1997.
[Y]Mean separation within columns by Duncan's New Multiple Range Test, $P \leq 0.05$.

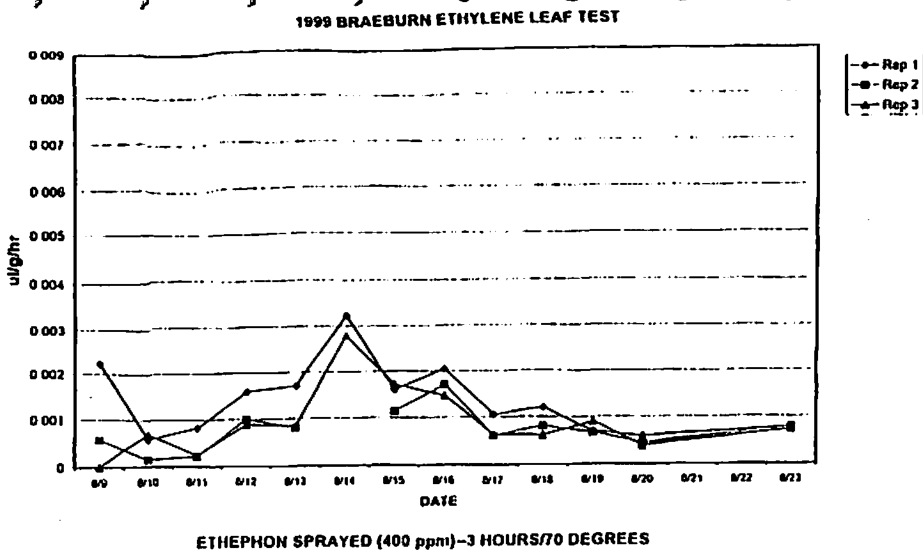


Fig. 1. Ethylene evolution from leaves of 'Braeburn'/M.27 trees sprayed with ethephon (400 mg/L) August 9 (3 hour sample, 70F).

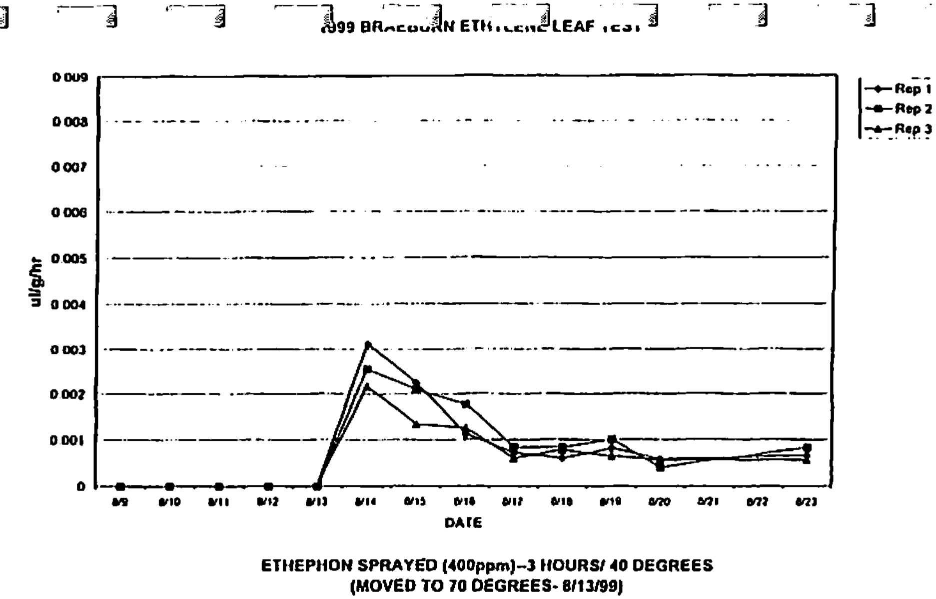


Fig. 2. Ethylene evolution from leaves of 'Braeburn'/M.27 trees sprayed with ethephon (400 mg/L) August 9 (3 hour sample, 40F) then moved to 70F August 13. Ethylene evolution (ul/L/hr/g) was based on analysis of a headspace gas sample.

Byers # 8

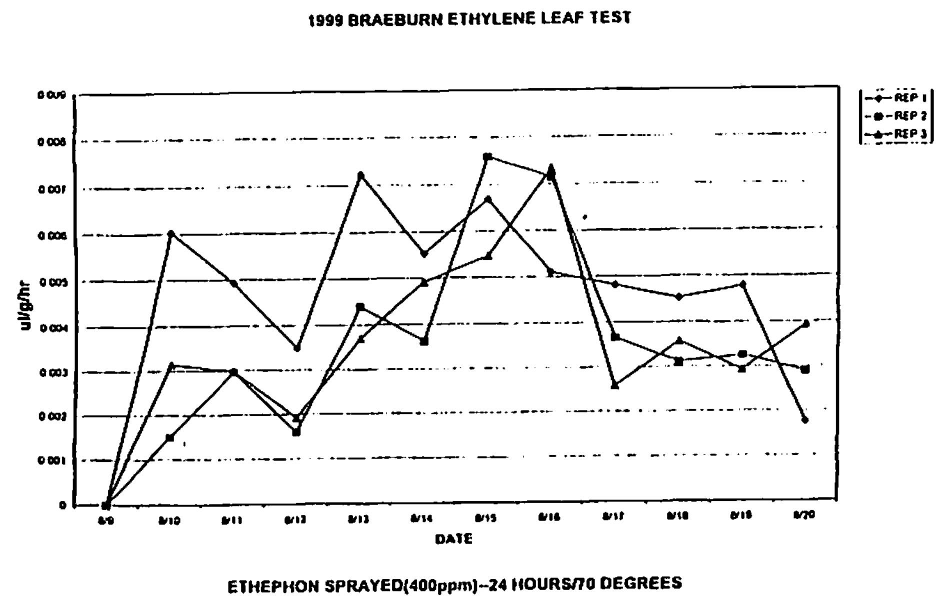


Fig. 3. Ethylene evolution from leaves of 'Braeburn'/M.27 trees sprayed with ethephon (400 mg/L) August 9 (24 hour sample, 70F). Ethylene evolution (ul/L/hr/g) was based on analysis of a headspace gas sample.

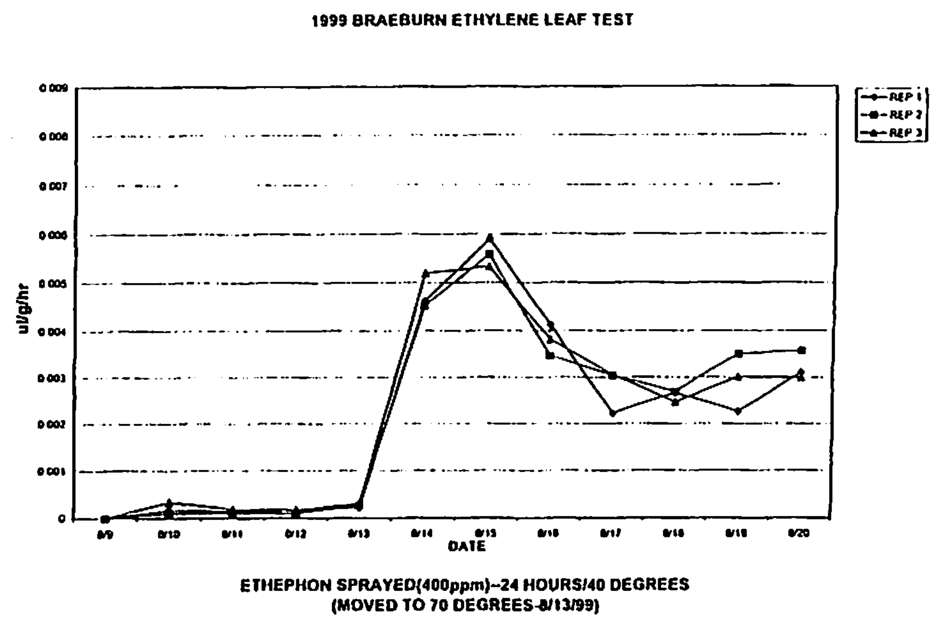


Fig. 4. Ethylene evolution from leaves of 'Braeburn'/M.27 trees sprayed with ethephon (400 mg/L) August 9 (24 hour sample, 40F) then moved to 70F August 13. Ethylene evolution (ul/L/hr/g) was based on analysis of a headspace gas sample.

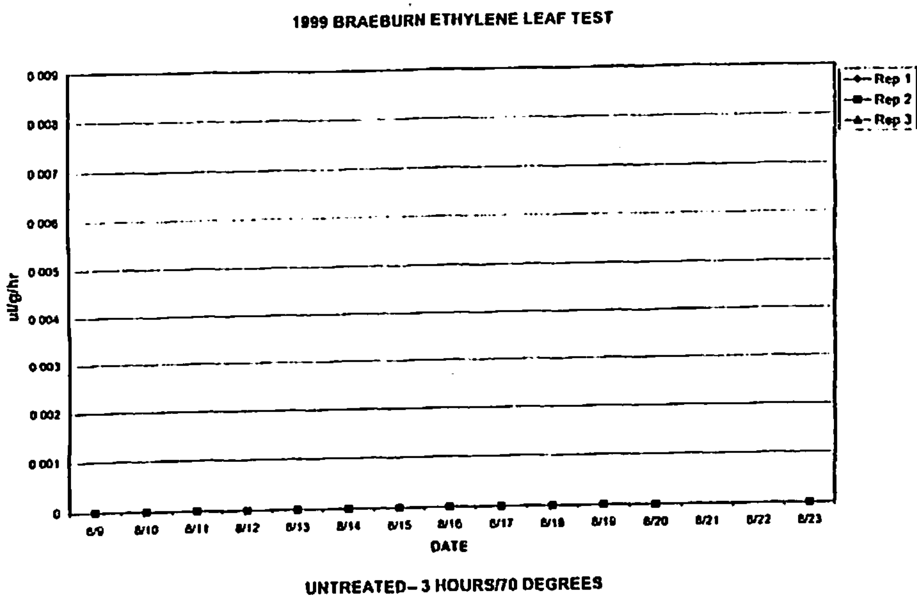


Fig. 5. Ethylene evolution from leaves of 'Braeburn'/M.27 trees not sprayed with ethephon (3hour sample, 70F). Ethylene evolution (ul/L/hr/g) was based on analysis of a headspace gas sample.

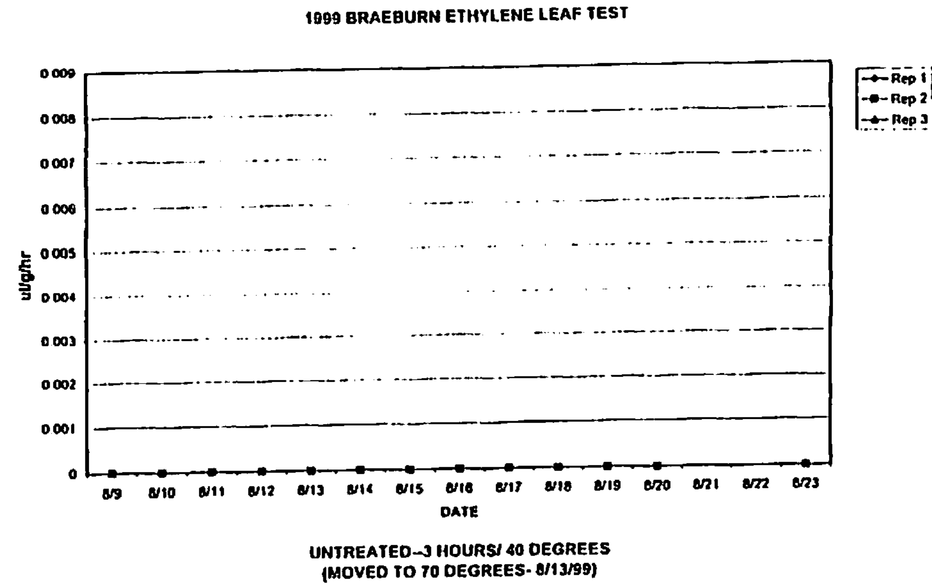


Fig. 6. Ethylene evolution from leaves of 'Braeburn'/M.27 trees not sprayed with ethephon (3 hour sample, 40F) then moved to 70F August 13. Ethylene evolution (ul/L/hr/g) was based on analysis of a headspace gas sample.

Byers # 9

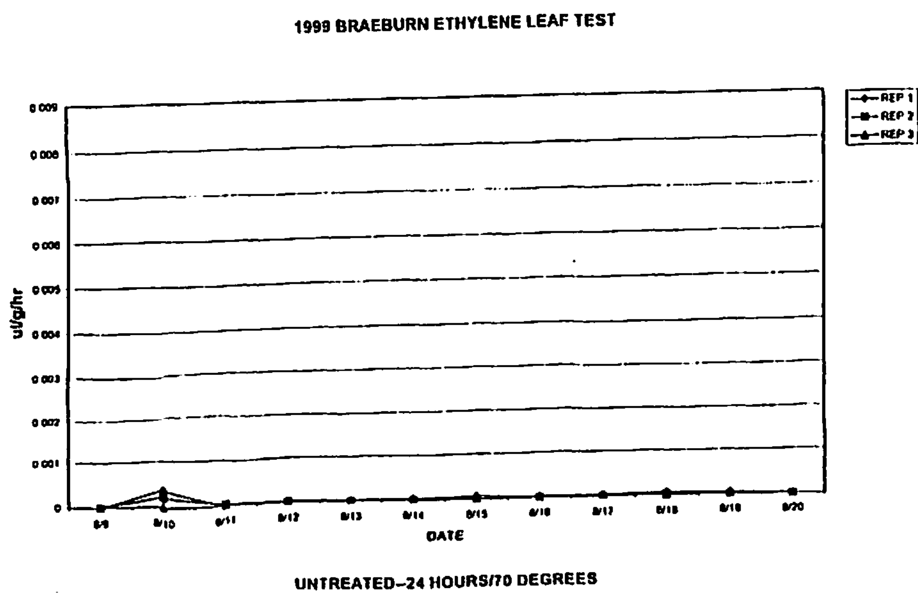


Fig. 7. Ethylene evolution from leaves of 'Braeburn'/M.27 trees not sprayed with ethephon (24 hour sample, 70F). Ethylene evolution (ul/L/hr/g) was based on analysis of a headspace gas sample.

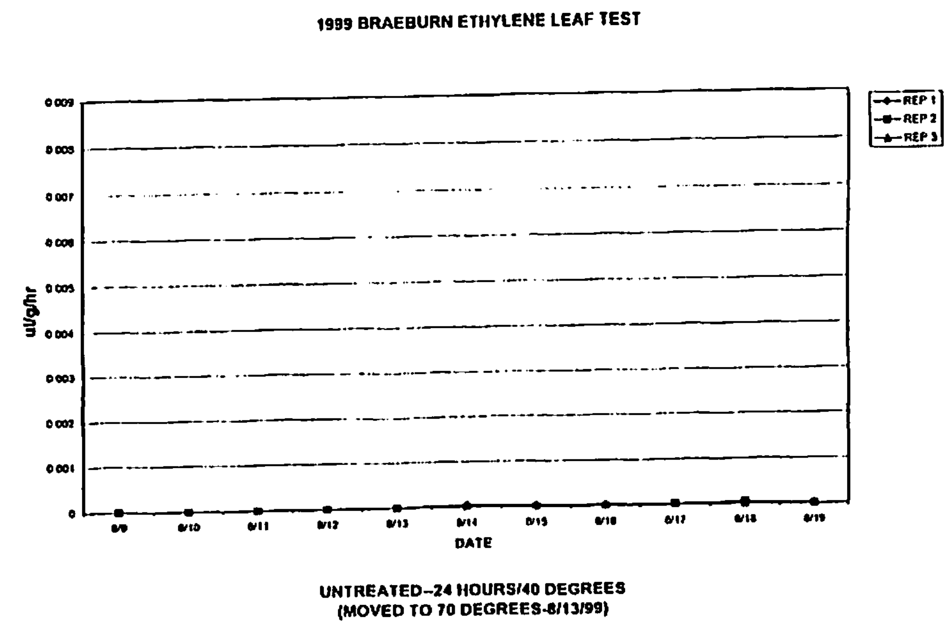


Fig. 8. Ethylene evolution from leaves of 'Braeburn'/M.27 trees not sprayed with ethephon (24 hour sample, 40F) then moved to 70F August 13. Ethylene evolution (ul/L/hr/g) was based on analysis of a headspace gas sample.

THE NEGATIVE INTERACTION OF CHEMICAL THINNERS WITH SPRAY OIL USED IN CONJUNCTION WITH AGRI-MEK IN A PESTICIDE COVER SPRAY AN OBSERVATION.

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In the spring of 1999, fruit size measurements indicated appropriate timing of thinner application on several cultivars (Gala, Early Red One, Red Delicious, Stark Spur Red Delicious, Empire and Fuji) two days before "First Cover" pesticide application. Thinners used varied from Sevin with Surfactant, Sevin with NAA and Sevin with low rates of Ethrel.

Smoothee Golden Delicious were thinned with NAA @ 10 ppm the day after first cover pesticide application.

Seven to ten days after first cover application (before thinner response) "typical" marginal spray burn of young expanding leaves was observed. As thinner response commenced (17-21 days) it became apparent that most thinner applications applied before first cover grossly over thinned. The response of NAA on Smoothee seemed to be very slow and ended with a reduced thinning response due to a tremendous fruit stunting or pygmy development. Smoothee Golden Delicious fruit size for 9, 20 bu. bins of fruit averaged 339.6 fruit per bushel. On a bushel basis, 75% of the fruit volume was less than 2.5" with a lot of grape sized fruit at harvest. All of these thinners used were those with proven appropriate thinning response over the past several years on these same orchards. One block of Std. Golden and Redchief (Mercier) Red Delicious, which was being used in cooperation with entomological data collection on 'Apogee', did not receive Agri-Mek and spray oil and the response was normal and as expected from previous years response.

These are <u>only</u> observations between the one non Agri-Mek treated orchard and the atypical nature of the thinning response in the other blocks. Based on previous experience and the known impact of spray oils on increased thinner response, I am highly suspect of this factor as the culprit in the inappropriate thinner responses observed. A warning to be aware of additives in cover spray application in proximity to thinner application such as "Agri-Mek and Oil" will be in our orchard management guide next year.

PRIMOCANE MANAGEMENT STUDY FOR EASTERN THORNLESS BLACKBERRIES ON ROTATABLE CROSS-ARM TRELLIS. II. FLOWERING AND FRUITING.

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The Rotatable Cross Arm (RCA) Trellis was developed to improve the machine harvestability of eastern thornless blackberries, such as 'Chester Thornless'. As a modified "Y" trellis, it allows for the formation of a divided canopy of floricanes and primocanes. During the growing season, primocanes are bent and tied to develop horizontally and unidirectionally along a training wire approximately 1 m above the ground. Once the primocanes extend to the adjacent plant, they are tipped to help promote lateral development. In the winter, canes are transferred to a wire on the opposite side of the trellis and laterals are tied to the rotatable cross arm. A series of studies have been initiated at the Appalachian Fruit Research Station to study training techniques to maximize production while minimizing labor. The objective of the current study was to study the effects of floricane numbers on the flowering characteristics and productivity of 'Chester Thornless' blackberry.

Eight, four-plant sections of tissue cultured 'Chester Thornless' blackberry established in 1991 were randomly chosen in 1998 to retain 2, 4, or 6 primocanes per plant. In the spring of 1999, four plants of each treatment were selected to count total node numbers and cluster numbers per plant. In addition, six clusters per floricane were counted to determine the number of primary, secondary, tertiary, and quaternary flowers per cluster. Between 19 July and 30 August, plant sections were harvested twice a week with the USDA-ARS over-the-row bramble harvester. Total yields, estimated red:black fruit ratios, and 20 berry weights were recorded for each harvest. Every two weeks drops were counted to determine ground loss.

Plants with 2 floricanes per plant possessed 74% of the nodes and produced 78% of the clusters of plants with 6 floricanes. The percentage of nodes that produced fruit clusters were similar for all treatments. Plants with 2 floricanes contained greater flower numbers per inflorescence compared to other treatments. Plants with 2 floricanes possessed 10% more secondary flowers, 40% more tertiary flowers, and 50% more quaternary flowers compared to plants with 6 floricanes.

Overall, plants with 2 floricanes and 6 floricanes produced 8.7 kg per plant and 10.3 kg per plant, respectively. Both treatments possessed similar total yields, ground losses, red losses, and average berry weights per plant. Productivity per cane was increased with lower floricane numbers. Plants with 2 floricanes yielded 57% more per floricane than plants with 6 floricanes per plant.

In summary, plants with 2 floricanes had fewer nodes and flower clusters per plant, more flowers per cluster, similar berry weights, similar productivity per plant, and greater productivity per floricane as compared to plants with 6 floricanes. Plants with 2 floricanes produced adequate yields and reduced labor inputs such as training and floricane removal time substantially.

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[1] Research Horticulturist and Agricultural Research Technician, respectively.
We thank Donald L. Peterson and Scott Wolford for their cooperation and use of the USDA-ARS over-the-row bramble harvester. We also thank Eric LeMasters and G. Michael Ball for their technical assistance.

Accel® (PGR) Concentration and Timing Adjustments to Evaluate Thinning and Size Responses in 'Liberty' Apple

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Rutgers University, New Jersey Agricultural Experiment Station

The Plant Growth Regulator Accel® (6-benzyladenine (BAP) + Gibberellins A_4A_7, Abbott Laboratories) for thinning and sizing characteristics, in a randomized and replicated field study. Determine the effect multiple applications of a low concentration of Accel® will have on final fruit size as a dependant variable of it's thinning properties, as well as independent of it's thinning response.

Introduction:

Increasing size and packout is an annual challenge with small fruited apple varieties such as 'Liberty'. Proper cultural practices can only attain a grower a determinant amount of size in most years, and the proper use of certain Plant Growth Regulators may substantially aid in a positive response to final fruit size. Understanding how and when to apply certain compounds will be necessary for their efficient use in orchard management practices in the future.

Effective chemical thinning is one of the most difficult aspects of apple production to master. Every year is unique and adds a new variable to the thinning regime. One aspect of thinning that has been intensely researched, and is well documented, is the correlation between early thinning and the increase in overall fruit size. Although the benefits of reducing the trees fruit load early are well understood, the current commercial availability of materials and annual variation in climatical conditions makes an aggressive approach to crop reduction during the bloom and petal fall stages of fruit development, before fruit set is known, risky (4).

Accel® is a commercially available Plant Growth Regulator that is predominately used for its chemical thinning properties, but reportedly also has the ability to enhance fruit size by increasing cell division (1). Alternately, when used at rates below the thinning threshold (i.e. 10 gm(ai)/A), an increase in cell division has been documented without any crop load adjustment caused by the materials thinning effect (2). A trial was conducted in 1998 at the Rutgers University, Snyder Research and Extension Farm in Pittstown, NJ to investigate these findings. The trial was established to investigate any size enhancing characteristics Accel® may possess that are independent of its thinning properties. In the trial, the Accel® treatments produced a significant increase in fruit size, weight and diameter, as compared to the untreated control, but the certainty of the direct action is in question. Our target application rate for Accel® was 10 gm(ai)/A, but a calibration error led to the application of 15.75 gm(ai)/A per treatment. Also, the first treatment application was applied on 29 April, one day following the Carbaryl thinning application. A possible interaction of the two thinning agents may have combined to create an aggressive thinning combination that overthinned these treatments.

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A third possibility that could have lead to the excessive defruiting of the treatments was the compact (5 days between treatments) application schedule. It was apparent that the two treatments containing Accel® produced a dramatic thinning effect that was not intended and significantly impacted crop load (3).

The trial conducted in 1999 was established to evaluate two of the three scenarios that were presented from last year's trial. Tree limitations allowed for us to only evaluate two of the parameters, and not all three.

Multiple doses of Accel® were applied in concentrations that are not expected to produce a thinning response. The main objective of these rates, and the overall trial, is to improve cell division of the fruitlet, and therefore increase final fruit size. A thinning response was noticed, with multiple low rates, in the trial that was conducted last year. This year the trial was expanded to not only evaluate the sizing effect of multiple low rates, but also the thinning effect multiple low rates and their timing may have on apples.

Establishment:

A ten year old block of 'Liberty' apples on M26 trained to a central leader system was used to conduct this experiment at the Rutgers University, Snyder Research and Extension Farm in 1999. This trial was conducted in a randomized complete block design containing four replications with multiple branches on single tree treatments. Although the variety Empire was used to conduct the 1998 trial, we felt the highly precocious, difficult to thin, and inherently small fruited nature of Liberty made it a cultivar that would clearly express any treatment affect.

Materials and Methods:

Extremely mild temperatures during February and into the month of March caused the trees to break bud about two weeks early this spring. Below average temperatures were then experienced during most of the month of April and May, which slowed bud advancement, and allowed bloom to settle into the traditional window for our region. Bloom was heavy on Liberty's in 1999, due partially to their highly precocious nature. A sufficient bloom period (+7 days) produced only 1 day of adequate sunlight (75% full) containing warm temperatures (+65°F).

Prior to the application of the bloom treatments, the treatment trees were properly selected and randomized. After the trees were randomized, three representative limbs per tree were selected, marked, and their circumference was measured at the limbs point of initiation off the central leader. After the limbs were selected and marked bloom counts were made (5 May), so the thinning effect of the treatments could be quantified.

No other materials with known thinning characteristics, or Plant Growth Regulators were applied to the trial other than a uniform application of ReTain™ (4 weeks pre-harvest) during the 1999 growing season. All treatments were applied with the spreader/activator Regulaid® (Kalo, Inc.) at 8 oz/100.

The only fungicides applied to this block in 1999, were for summer diseases, and were the protectant type fungicides of Captan 50WP, Ziram 76DF, Topsin®-M WSB, and Benlate® 50WP, in combinations. Insecticide sprays were maintained with the Rutgers IPM pest control schedule as determined by weekly scouting, on-site weather and Skybit® predictions.

Table 1: Treatments

TREATMENT #1 - Untreated control

TREATMENT #2 - Accel® - 10 gm(ai)/a apply at Petal Fall and every 5 days for 6 applications
Note: **(Not adjusted for TRV)**
6 applications = 60 gm(ai)/a total

TREATMENT #3 - Accel® - 10 gm(ai)/a apply at Bloom and every 7 days through 2nd cover
Note: **(Not adjusted for TRV)**
6 applications = 60 gm(ai)/a total

TREATMENT #4 - Accel® - 15 gm(ai)/a apply at Bloom and every 10 days through 2nd cover
Note: **(Not adjusted for TRV)**
4 applications = 60 gm(ai)/a total

TREATMENT #5 - Accel® - 15 gm(ai)/a apply at Petal Fall and every 7 days through 2nd cover
Note: **(Not adjusted for TRV)**
4 applications = 60 gm(ai)/a total

Applications for two of the treatments commenced on 6 May, which correlated to full bloom. The first application for the other two treatments began 6 days later at petal fall. Tree row volume (TRV) was established at 250 gallons per acre dilute (5). The treatments were applied at 1.5x concentrate (165.3 gpa) using a 400 gallon Rears model Pull-Blast airblast sprayer retrofitted with a 10' tower, that utilized 15 nozzles per side, to apply the treatments. Ceramic TeeJet D2 and D4 disks with size 25 cores were alternated along the spray manifold to produce a uniform spray pattern from top to bottom. The sprayer is equipped with a constant velocity centrifugal pump that operates at 170 psi. Output of the nozzles at this constant pressure was calibrated to 0.712 gpm per nozzle for the D4/25's and 0.395 gpm per nozzle for the D2/25's. Forward ground speed of the tractor was calibrated to 2.56 mph, and the travel time for each tree was 3.2 seconds per side, for a total of 6.4 seconds/tree per application. High operating pressures and ball valves in the nozzle bodies assured proper nozzle shut-off, which prevented possible, overspray contamination between treatments. Treatments were applied at their scheduled intervals throughout the cell division period.

One of the principal objectives of this trial was to evaluate Accel's® ability to increase fruit size that was due to its promotion of cell division in a fashion that is independent of its thinning properties. The best method to do this, it was determined, was to analyze and record the remaining crop load after June Drop had been completed, then thin each tree evenly, down to one fruit per cluster. A further analysis of this method indicates it making good horticultural and scientific sense. After cell division is complete and final fruit size has been physiologically determined, as long as all treatments are treated equally for the remainder of the trial (ie. irrigation, fertilizer, etc.), the absence of hand thinning to equally adjust the crop load of all treatments would administer varying crop loads between treatments. This crop variation would continue to put uneven stress on trees, and give us results that were as much dependent on tree stress (due to overcropping) as they were from treatment variation. Hand thinning ensured the authenticity of data analyzing Accel's® ability to increase fruit size was due to its promotion of cell division in a fashion that is independent of its thinning properties.

In cooperation with this determination, hand thinning was done in July (after June Drop), after fruit counts were completed (19 July) to thin fruit clusters down to 1 per spur. This thinning was done to assure uniformity in final crop load between all treatments, which will show accurate results when comparing treatment effect and final fruit size.

After the roller coaster spring, we then experienced a season long drought, which became the second driest summer in recorded history. Due to this drought, season long irrigation was utilized on a weekly schedule throughout the growing season, beginning on 18 May.

As was previously noted, ReTain™ was applied uniformly over the entire block on 16 August. This coincided roughly with 4.5 weeks prior to anticipated harvest.

Treatments were harvested on 7 October. Each treatment limb was harvested, counted and weighed. Each treatment was then placed in conventional cold storage (33°F, 95% RH) until grade evaluations could be conducted on 24 October. Data points collected at harvest and packout included: count and weight of fruit at harvest, packout of fruit at harvest between grades 2.75", 3.00", 3.25" and 3.5", as well as a stem-end crack rating, L/D ratios and yield efficency.

Results and Discussion:

Table 2: Effect of Treatments on thinning

Treatment	Number of applications	Number of fruit/100 clusters[z]	Total yield - kg
UTC	0	105.9 b[y]	75.1
Accel 15 BL, 10, 2nd cv	4	45.2 a	83.0
Accel 15 PF, 7, 2nd cv	4	53.9 a	93.7
Accel 10 PF, 5, 6x	6	54.1 a	86.1
Accel 10 BL, 7, 2nd cv	6	55.2 a	74.6

[z]based on June count

[y]means separation by Fisher's LSD, 5% level

Table 3: Effect of Treatments on fruit size

Treatment	Avg. fruit wgt-gm	Number 2.75" fruit	Number 3.0" fruit	Number 3.25" fruit	Number 3.5" fruit
UTC	156.9 a[z]	58 c[z]	50 c[z]	26 a[z]	3 a[z]
Accel 15 BL, 10, 2nd cv	200.2 c	20 a	28 a	53 b	35 c
Accel 15 PF, 7, 2nd cv	167.4 ab	47 bc	39 b	42 b	9 ab
Accel 10 PF, 5, 6x	184.3 bc	31 ab	33 ab	54 b	19 b
Accel 10 BL, 7, 2nd cv	186.9 bc	29 ab	30 ab	54 b	23 bc

[z]means separation within column by Fisher's LSD, 5% level

Compared to the UTC:

1) All Accel treatments thinned fruit.
2) Accel treatments did not affect total yield by weight.
3) Average fruit weight was increased by all Accel treatments except the 15 gm applied at petal fall.
4) More large fruit were produced on the Accel treated trees. Applications begun at bloom were more effective in producing 3.5" fruit than applications begun at petal fall. Treatment rate for the same application initiation timing did not affect number of 3.5" fruit.

References:

1. Abbott Laboratories 1994, Accel Technical Report.

2. Abbott Laboratories, Dr. Greg Clark, Personal Communication

3. Compton, J.M., Cowgill Jr., W.P., Tietjen, W.H. 1998. Effect of Size Influencing Compounds on 'Empire' Apple. Proceedings: 74th Cumberland-Shenandoah Fruit Workers Conference.

4. Schwallier, Philip. 1996 Apple Thinning Guide. Great Lakes Publishing Company. 13 pages

5. Unrath, C.R., et al. A Tree Row Volume Model for Determining Proper Spray Rates in Apple Orchards. North Carolina State University Agricultural Research and Extension Service. Publication No. 001, 7 pages

Apogee™ (BAS-125W) for Vegetative Growth Suppression in Apple

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Evaluate the plant growth regulator Apogee™ (Prohexadione calcium, BASF Corporation) for vegetative growth suppression, in a randomized and replicated field study. Determine the effect of multiple standard applications of Apogee™ on vegetative growth control of a highly vigorous, mature apple cultivar under Northeast region growing conditions.

Introduction:

Maintaining the balance between vegetative and reproductive growth in apple trees is essential for optimizing an orchard production system. This balance is extremely difficult to attain, since the balance is influenced by many factors, including conditions the grower can control as well as those the orchardist cannot regulate. Maintaining this balance is essential for influencing all factors that effect optimum fruit quality in the current season, increased spray deposition within the canopy of the tree, increased air movement within the orchard and return bloom the following year. The growing conditions of the Northeast region favor the development of vegetative growth that adversely affects fruit production. This growth results in an increase in management costs (i.e. pruning and harvest) and a reduction in yields and fruit quality.

With the loss of Alar in the late 1980's, the growers ability to reduce vegetative growth using Plant Growth Regulators (PGR) became extremely hindered. Presently, the only compounds that chemically alter vigor are Ethephon and NAA. Both compounds provide limited activity against vegetative growth control.

Apogee™ is a unique PGR compound currently in the latter stages of the Environmental Protection Agency's (EPA) product registration process. Apogee™ has the ability to greatly alter orchard management techniques with regards to the vegetative vs. reproductive processes. Apogee™ has a unique mode of action that inhibits the biosynthesis of gibberellin. Gibberellins are natural plant hormones that regulate cell elongation. This cell elongation is the direct component of vegetative shoot growth. Therefore, prohibiting the biosynthesis of gibberellins directly reduces vigorous vegetative shoot growth.

The direct vegetative growth controlling properties Apogee™ provides may correlate to many beneficial side effects. Research of these aspects is still preliminary, but the results are proving favorable. Apogee™ applications may provide added benefit with regards to; reduction of dormant and summer pruning, improved fruit color, a reduction in the incidence of fireblight (shoot blight), reduction of many diseases, insects and horticultural problems as well as increased spur health and a reduction in June Drop.

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Research conducted by BASF Corporation and the Northeast Plant Growth Regulator Working Group over the past several years have focused on optimum rates and timing of Apogee™ for optimum growth control. The research has indicated that rates and number of applications will vary and depend highly on orchard location, vigor of cultivar and length of growing season. Research has also confirmed that the timing of the first application is critical to the success of the product.

Establishment:

A ten year old block of 'Freedom' apples on M26 trained to a central leader system was used to conduct this experiment at the Rutgers University, Snyder Research and Extension Farm in Franklin Township, Hunterdon County during the 1999 growing season. This trial was conducted in a randomized complete block design containing six replications with double tree treatments. A guard tree separated the two treatments within each replication. The cultivar 'Freedom' was selected due to its inherent highly vigorous nature and the light crop expected for the 1999 growing season. These factors together would allow for a definitive analysis of the efficacy of Apogee™. Although the use of Apogee™ may effect and alter many facets of a trees physiological and cultural aspects, only the reduction of vegetative growth as it correlates to vegetative shoot reduction was analyzed in this trial.

Materials and Methods:

Extremely mild temperatures during February and into the month of March caused the trees to break bud about two weeks early this spring. Below average temperatures were then experienced during most of the month of April and May, which slowed bud advancement, and allowed bloom to settle into the traditional window for our region. Bloom was moderate to light on Freedom in 1999, due partially to an excessive crop load in 1998. A sufficient bloom period (+7 days) produced only 1 day of adequate sunlight (75% full) containing warm temperatures (+65°F).

Prior to the initial application of the Apogee™ treatment, treatment trees were properly selected and randomized. After randomization, five representative shoots per tree were selected, marked, and their length was measured at the shoot initiation point (14 May). Bourse shoots and other reproductive wood was avoided, as only those shoots in the vegetative mode were the ones targeted for control.

A single application of Sevin® XLR Plus (Carbaryl, Rhone-Poulenc) at 1 qt/a combined with Accel® (N-1H-purine-6-amine + Gibberellins A_4A_7, Abbott Labs.) at 20 gm(ai)/a during the early fruit set stage (6-10 mm) was the only thinning spray applied to this trial. Other than the single application of Accel®, no other plant growth regulating materials were applied to the trial during the 1999 growing season.

The entire block was treated uniformly regarding standard commercial production practices. Spray schedules for insect and disease pressure was maintained via the Rutgers IPM monitoring schedule as determined by weekly scouting, on-site weather and Skybit® predictions. Irrigation was utilized on a weekly schedule throughout the growing season, beginning on 18 May. All trees were pruned during the 1998-99 dormant season and managed in a uniform manner.

Table 1: Treatments

TREATMENT #1 - Untreated control

TREATMENT #2 – Apogee™ (6 oz / 100 dilute equivalent based on TRV)

Research has indicated the importance of proper timing for the first application of Apogee™ to be targeted to 1-3" of new shoot growth. Treatment applications commenced on 15 May, which correlated to 5 days after petal fall and an average of 2$^{1/2}$" of new shoot growth. Although the initial application fell within the recommended timeframe, it was applied during the later stages of the target window. Due to this delay in the initial application, three applications were deemed necessary for season long growth control. The second application was applied on 27 May (12 days after the first), and the third application was made on 9 June (13 days after the second). All applications were made during early morning hours to assure slower drying conditions. The spreader/activator Regulaid® (1 oz/25 gal) was added to the tank mix as per the 1999 BASF Study Protocol.

Tree row volume (TRV) was established at 250 gallons per acre dilute. The treatments were applied at 1.5x concentrate (165.3 gpa) using a 400 gallon Rears model Pull-Blast airblast sprayer retrofitted with a 10' tower, that utilized 15 nozzles per side, to apply the treatments. Ceramic TeeJet D2 and D4 disks with size 25 cores were alternated along the spray manifold to produce a uniform hollow cone spray pattern from top to bottom. The sprayer is equipped with a constant velocity centrifugal pump that operates at 170 psi. Output of the nozzles at this constant pressure was calibrated to 0.712 gpm per nozzle for the D4/25's and 0.395 gpm per nozzle for the D2/25's. Forward ground speed of the tractor was calibrated to 2.56 mph, and the travel time for each tree was 3.2 seconds per side, for a total of 6.4 seconds/tree per application. High operating pressures and ball valves in the nozzle bodies assured proper nozzle shut-off, which prevented possible overspray contamination between treatments.

In accordance to the study protocol, subsequent measurements of the five shoots per tree were again measured at consecutive intervals of 4 weeks after the final application (9 July), 8 weeks after the final application (3 August), and at harvest (3 November).

Treatments were harvested during the final week of October and the first week of November. Each tree was harvested and total yield weighed. Picking time per tree was also collected and recorded in order to determine any time reduction that may occur in the harvest process due to better visibility of the fruit.

Results and Conclusions

Table 2

Treatment	Shoot length 1 cm	Shoot length 2 cm	Shoot length 3 cm	Shoot length 4 cm	Yield lb	Time minutes
UTC	42.9	72.5 b^z	73.7 b^z	75.3 b^z	107.8	20.2
Apogee	40.9	51.6 a	52.5 a	56.8 b	124.6	20.7

^{z}separation of means within column by Fisher's LSD, 5% level

Results with Apogee as compared to the UTC in Table 2 are as follows:

1) Shoot length 2 was reduced by Apogee treatment. The difference was also evident in subsequent shoot measurements.
2) Yield was not significantly different for Apogee treated trees
3) The time to harvest Apogee treated trees was not significantly different.

Additional Observations and Discussion

Multiple applications of Apogee™ (BAS-125W) proved to significantly reduce season long vegetative growth on the highly vigorous cultivar of Freedom. The results of our trial those being attained by other research in the Northeast region with regards to vegetative growth suppression. Apogee™ is a localized, contact material with no systemic activity. This mode of action produced highly visible observations on the guard trees of this trial. It is visually possible to pinpoint the exact location the sprayer was turned on and off. Future product studies on Apogee™'s mode of action will evaluate its use to control localized sections of a tree's canopy. Although other research has suggested a reduction in actual harvest time could occur with the use of Apogee™, our trial's results showed no statistical difference between the Apogee™ treated trees and the untreated control.

Although all variables were not analyzed in the Snyder Farm trial, observations of this trial and additional research conducted throughout the Northeast region indicate Apogee™ is capable of providing production benefits in our area by:

1) Increasing sunlight penetration on high vigor cultivars and allow all benefits that correspond with increased sunlight (better fruit color, greater fruit set, increased flower bud initiation)
2) Controlling excessive vigor following heavy pruning or in light crop years
3) Reducing pruning intensity
4) Fireblight (shoot blight) suppression

A definitive date has not been given by the EPA as to when Apogee™ will gain full product registration. EPA officials estimate Apogee™ to be granted a federal label somewhere between March and June of 2000. It is hoped that product registration will be granted early in this timeframe, otherwise distribution and product usage for the 2000 growing season will be problematic.

1999 New Jersey Procure® 50WS Evaluations in Apple

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Experiment 1

Rutgers University Field Study, Snyder Research and Extension Farm
Evaluate the efficacy of early season disease control and possible size influencing characteristics of Procure® 50WS fungicide in a comparative study against new classes of fungicides, in a randomized, replicated study.

Experiment 2:

Commercial Grower Trial, Best Fruit Farm
Evaluate size gradients and commercial packouts of a commercial demonstration trial with Procure® 50WS. Procure® 50WS, combined with an industry standard EBDC fungicide in an early season disease control program was compared against a grower standard program utilizing the same EBDC fungicide combined with an alternate sterol inhibitor class fungicide applied under commercial conditions.

Introduction:

Control of early season diseases in apples has always been a challenge to growers throughout history. Apple scab is the most economically important disease to growers throughout the northeastern United States, followed closely by powdery mildew. Other early season fungal diseases of concern to northeastern United States growers include cedar apple rust and quince rust. Effective control of these early season diseases to date has been obtained with the inclusion of a sterol inhibitor (SI) class fungicide in a spray program (4). Although the SI's have excellent eradicative and protective action against many of the fungal diseases that infect apples, observations in numerous trials have indicated a potential adverse effect on fruit size due to their mode of action (2,3,7).

Triflumizole (Procure® 50WS, Uniroyal Chemical) is a recent introduction into the SI family that has been evaluated in numerous university and grower trials as compared to the other SI fungicides (1,5).

Sovran® 50W (kresoxim-methyl, BASF Corporation) and Flint™ 50W (Trifloxystrobin, Novartis) are two new strobilurin class fungicides that possess broad-spectrum protective and curative activities against many of the diseases that effect pome fruits. Although its activity against scab and mildew is highly effective, Sovran® 50W is not quite as effective against rusts as the sterol inhibitors (9, 10,11). Flint™ 50W is not labeled for control against the rust diseases that affect apples (12).

Vangard™ 75WG (cyprodinil, Novartis) is a new anilinopyrimidine (AP) class fungicide that is labeled on apples for protective and curative activity against scab, but does not possess a label for the

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rust diseases or powdery mildew (8).

In a 1998 trial conducted at the Rutgers, Snyder Research and Extension Farm, Procure® 50WS treatments increased size significantly when compared to Nova® 40W and the untreated control in packout of fruit between 3.00" and 3.25". These results confirm reports that by utilizing Procure® 50WS for early season disease control may result in a shift of packout grades to the larger grades (1).

Materials and Methods:

Experiment 1

Table 1: Treatments for the Snyder Farm Study

TREATMENT #1 -	Untreated control	
TREATMENT #2 -	Procure® 50WS PLUS Manzate® 200DF	@10 oz/a @1 lb/100
TREATMENT #3 -	Sovran® 50W	@3.2 oz/a
TREATMENT #4 -	Flint™ 50W	@2 oz/a
TREATMENT #5 -	Vanguard™ 75W	@5 oz/a

A ten-year-old block of Empire apples, on M26, trained to a central leader system was used to conduct this experiment at the Rutgers University, Snyder Research and Extension Farm in 1999 (photo 1). This trial was conducted in a randomized complete block design with seven replications and single tree treatments.

Photo 1. 10 yr. Old Empire/M26 used in Snyder Farm Experiment

Tree row volume (TRV) was established at 250 gallons per acre dilute (6). The treatments were applied at 1.5x concentrate (165.3 gpa) using a 400 gallon Rears model Pull-Blast airblast sprayer retrofitted with a 10' tower, that utilized 15 nozzles per side to apply the treatments. Ceramic TeeJet D2 and D4 disks with size 25 cores were alternated along the spray manifold to produce a uniform spray pattern from top to bottom. The sprayer was equipped with a constant velocity centrifugal pump that operates at 170 psi. Output of the nozzles at this constant pressure was calibrated to 0.712 gpm per nozzle for the D4/25's and 0.395 gpm per nozzle for the D2/25's.

Forward ground speed of the tractor was calibrated to 2.56 mph, and the travel time for each tree was 3.2 seconds per side, for a total of 6.4 seconds/tree per application. High operating pressures and ball valves in the nozzle bodies assured proper nozzle shut-off, which prevented possible overspray contamination between treatments.

The Untreated Control received no early season fungicide covers.

The only fungicides applied for summer diseases to the entire block through the remainder of the season were protectant type fungicides (Captan 50WP, Ziram 76DF, Topsin® M WSB, and Benlate® 50WP) in combinations. Insecticide sprays were maintained with the Rutgers IPM pest control schedule as determined by weekly scouting, on-site weather and Skybit® predictions.

Extremely mild temperatures during February and into the month of March caused the trees to break bud about two weeks early. The first application for all treatments commenced on 8 April, which correlated to the 1/2" green stage of growth, and continued on a 10 day schedule through the primary scab season. All treatments contained the spreader/sticker APSA® 80 (Amway) at the labeled rate of 3 oz/100.

Below average temperatures were experienced during most of the months of April and May, which slowed bud advancement and allowed bloom to settle into the traditional window for our region. Bloom was moderate to light on Empire in 1999, due partially to a heavy crop in 1998. A sufficient bloom period (+7 days) produced only 1 day of adequate sunlight (75% full) containing warm temperatures (+65°F). Pollination of the block was a concern, and chemical thinning at Petal Fall (12 May) was done with 30gm(ai)/A Accel® (Abbott Labs) until fruit set was determined. Once further thinning was indicated, a follow up application of 20gm(ai)/A Accel® plus 1 qt/A Sevin® XLR Plus (Rhone-Poulenc) was made 9 days later (21 May) during the 6mm - 10 mm fruit stage.

The roller coaster spring, was followed by a season long drought, which became the second driest summer in recorded history. Due to this drought, season long irrigation was utilized on a weekly schedule throughout the growing season, beginning on 18 May.

Treatments concluded on 1 June, which coincided traditionally with the 2nd cover spray in our region and the end of primary scab season. Each treatment tree received a total of five applications of the respective treatment chemical throughout the primary scab season.

Table 2: Application Timings for the Snyder Farm Study.

Application Date	Stage of Growth	Days since last spray	Number of infection periods between sprays
8-April	1/2" Green	-	5
19-April	Tight Cluster	11	5
5-May	Bloom	14	7
17-May	Late Petal Fall	12	5
1-June	1st Cover	15	6

Infection period data was based on Skybit® Inc. IPM apple disease calculations. These calculations combine; accumulated degree hours from green tip, accumulated leaf wetness during infection period and average temperature during infection period.

Experiment 2:

This trial was conducted on two separate blocks of a commercial orchard on two different cultivars. Located at Best's Fruit Farm in Independence Township, Warren County, New Jersey, one demonstration block consisted of 20 year old Hilltop MacSpur® on MM 106. The other block was 20 year old Starkrimson® Red Delicious on seedling rootstock. The Starkrimson's® were planted at 20' x 30' and the trees are approximately 23' tall. The spacing on the MacSpur® block is 15' x 20' with the trees roughly 17' in height. Treatment areas were 1 acre in size for both blocks, and applications were made to treatments in single replication, demonstration style solid rows, with an untreated buffer row between each treatment.

In both trials Nova® 40W (myclobutanil, Rohm and Haas) was the alternate sterol inhibitor fungicide with which Procure® 50WS was being evaluated against. Both treatments contained Polyram® 80DF

(United Agri Products, Inc.) as the EBDC protectant fungicide. Treatments were applied with a 400-gallon diesel powered FMC airblast sprayer calibrated to 117 gallons per acre. Based on tree row volume calculations this block of trees computed at 300 gallon per acre. However the grower always reduces his dilute volume to 117 GPA with historical success. Because of his excellent pruning techniques combined with good air drainage due to site location, relatively low disease pressure was present. As a result the standard spray schedule followed for the growing season by our grower cooperator had reduced application rates by nearly two fold.

Table 3: Treatments for Best Fruit Farm Study.

TREATMENT #1	Procure® 50WS	10 oz/a
	PLUS	
	Polyram® 80DF	2 lb/100 @ 117 gpa = 2.34 lb/a
TREATMENT #2	Nova® 40W	2 oz/100 @ 117 gpa = 2.34 oz/a
	PLUS	
	Polyram® 80DF	2 lb/100 @ 117 gpa = 2.34 lb/a

Applications began on 30 April for both trials, and continued throughout the primary scab season. No fungicides were applied to the either trial prior to this date. The final spray was applied on 29 May, which correlated to 2nd cover in the Warren County area and the end of primary scab season. Four applications were applied for both treatments. All treatment applications contained Nitrogen (N-Sure, 1 pint/100), Boron (Borasol, 1 pint/100), and Zinc (Zinc Chelate, 1 pint/100) to maintain tree nutrition.

Table 4: Application Timings for Best Fruit Farm Study.

Application	Application Date	Stage of Growth
Application #1	30-April	Pink
Application #2	10-May	Petal Fall
Application #3	21-May	1st Cover
Application #4	29-May	2nd Cover

The only fungicides applied for summer diseases to the entire block through the remainder of the season were the protectant fungicides Ziram 76DF and Topsin® M WSB in combinations. Insecticide sprays and summer covers were maintained with the Rutgers IPM pest control schedule as determined by weekly scouting and Skybit® predictions.

A single application of 50 ppm NAD (Amid Thin W, Amvac Chemical) was used on 16 May to thin the MacSpur's® when they were at the 9 mm stage. Due to a light fruit set, no chemical thinning treatments were applied to the Starkrimson's® in 1999.

Results and Discussion

Experiment 1

A 200 fruit subsample per single tree replication was harvested. Fruit were randomly selected from the center 2/3's of each tree harvested, as measured form top to bottom. Fruit was then placed in cold storage (33°F, 95% RH) until evaluated on 28 October. Data collected included: total yield, packout grades, stem-end split ratings, percent fruit infection of powdery mildew and scab, and average fruit diameter. A foliar rating of scab and powdery mildew infections were conducted during the summer, after the disease cycles for both diseases were over for the season.

Table 5. Effect of treatments on total yield and fruit size, Snyder Farm study

treatment	total yield, lb	%[y] 2.75" diam	%[y] 3.0" diam	%[y] 3.25" diam	%[y] 3.5" diam
untreated control	163.9 a[z]	16.9	34.5	35.1	13.5
Flint	170.6 a	9.1	31.3	31.0	28.4
Vanguard	173.0 a	14.9	26.5	41.7	17.0
Sovran	200.9 ab	20.0	31.6	38.1	10.3
Procure	220.3 b	8.6	34.5	46.4	16.1

[z] means separation by Fisher's LSD, 5% level
[y] by number of fruit

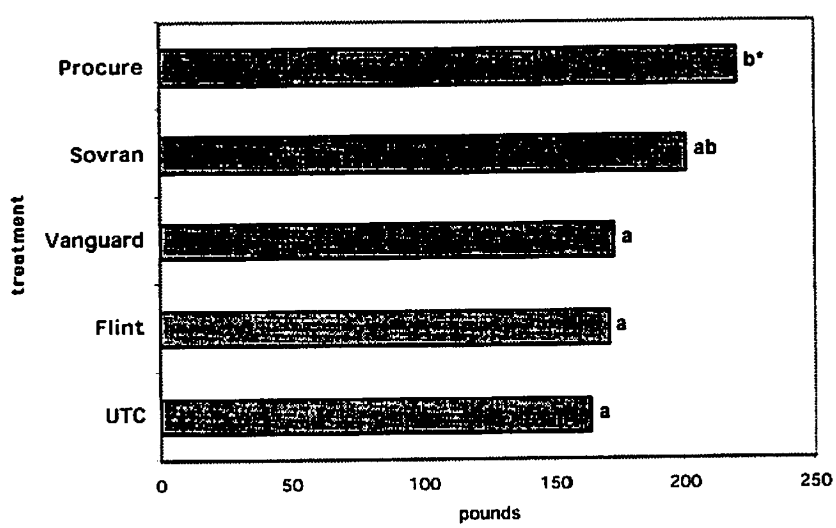
Table 6. Effect of treatments on foliar and fruit disease, Snyder Farm study

treatment	foliar scab[z]	foliar mildew[z]	%[y] fruit scab	%[y] fruit mildew
untreated control	0	0	1.4 b[x]	0.1
Flint	0	0	0.2 a	0.2
Vanguard	0	0	0.8 ab	0.3
Sovran	0	0	0 a	0.1
Procure	0	0	0.3 a	0.1

[z] visual rating of tree 0 to 5, none to severe
[y] by number of fruit affected
[x]means separation by Fisher's LSD, 5% level

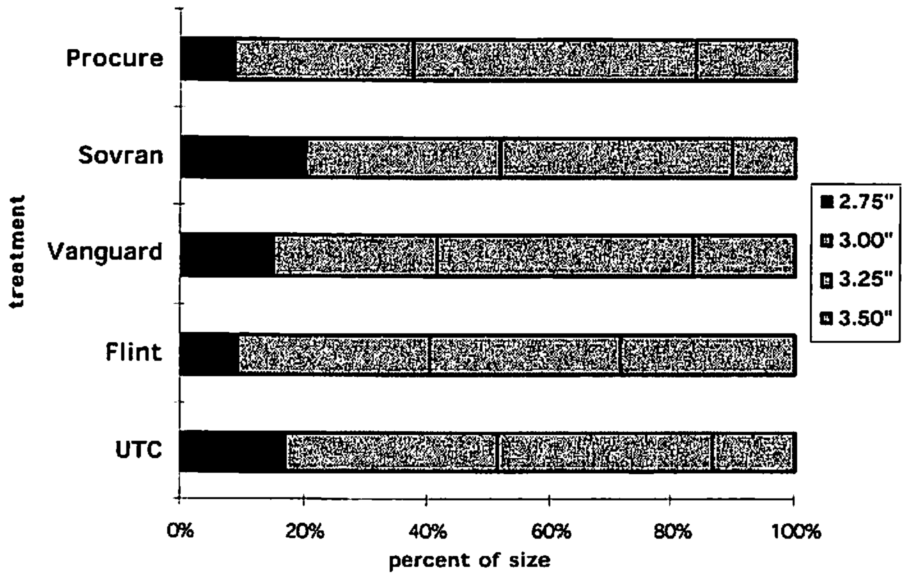
Procure® 50WS significantly increased total fruit yield over the untreated control and all other treatments except for Sovran (see Table 5 and Figure 1). There were no significant differences on the effect of fruit size (see Table 5 and Figure 2). Statistical differences in grade size were not detected at the 5% or 10% levels due to a very variable crop load on the single tree replications.

Figure 1. Effect of treatments on total yield, Snyder Farm study



*Means separation by Fisher's LSD, 5% level

Figure 2. Effect of treatments on fruit size, Snyder Farm study



Experiment 2-MacSpur®

The block was harvested on 20 September and held in conventional cold storage (32° F and 95% RH) until they could be graded and sorted on 14 December. At harvest, two bins (20 bushel) of each treatment were separately harvested and stored for data collection. A commercial Durand-Wayland belt grader was used to determine packout. The grader was set to 5 grade variants and tested for accuracy prior to the commencement of data collection. The grade variants were determined utilizing ring sizers with 20 bushels of "test" fruit run over the grader to certify accuracy.

Table 7: MacSpur gradeout for Best Fruit Farm Trial

Number of 1 bushel boxes falling into each size category at packout					
Treatments	Culls(> 2.5")	2.5"	2.75"	3.0"	3.25"
Procure® 50WS	2	9.75	11.5	4.5	9
Nova® 40W	1.5	9.25	12	4.25	9.25

There was no significant difference at any grade between the two treatments when evaluated for packout.

Experiment 2-Starkrimson®

Due to miscommunication between our grower cooperator and the harvest crew, treatment fruit were not harvested and stored for evaluation. Visual observations during the growing season were made. The foliage on the Procure® 50WS treated trees appeared larger and healthier. Growers' statement "I thought foliage was better on all Procure treated trees", was consistent with our observations.

Several factors appear to have impacted the results of this experiment. The trees in this non irrigated block were drought stressed throughout the growing season. A light crop set in 1999 may have effected the results as well. The significant reduction in Nova® 40W rates throughout the primary scab season by the grower may also have effected the treatment results.

References:

1. Compton, J.M., Cowgill Jr., W.P., Tietjen, W.H. 1998. Effect of Size Influencing Compounds on Empire Apple. Proceedings: 74th Cumberland-Shenandoah Fruit Workers Conference.
2. Fruehling Communications. 1998. Fight Disease, Increase Size. American Fruit Grower Vol. 118 No. 4: P 40
3. Galas Show Size Boost in Fungicide Trial. 1997, American Fruit Grower. American Fruit Grower Vol 117 No, 3
4. Jones, A.L., Aldwinckle, H.S., eds. Compendium of Apple and Pear Diseases. APS Press, St. Paul, MN. 1999
5. Rosenberger, D.A., Englr-Ahlers, C.A., Meyer, F.W. Effects of DMI Fungicides on Fruit Set, Fruit Size, Yield, and Fruit Firmness, 1998. Unpublished Results, 7 pages
6. Unrath, C.R., et al. A Tree Row Volume Model for Determining Proper Spray Rates in Apple Orchards. North Carolina State University Agricultural Research and Extension Service. Publication No. 001, 7 pages
7. Summary 1997 Apple Sizing Trials. Uniroyal Chemical Company, Inc. 1997, 13 pages
8. Vangard™ Use Guide 1998 Novartis Crop Protection Inc. Greensboro, NC, 33 pages
9. Kresoxim-methyl-Products. BASF Corporation. Research Triangle Park, NC
10. BASF Corporation, Dr. Gar Thomas, BASF Field Biologist, Personal Communication
11. Sovran® 50W Product Label 1999 BASF Corporation. Research Triangle Park, NC, 7 pages
12. Flint™ 50W Product Label 1999 Novartis Crop Protection Inc. Greensboro, NC, 5 pages