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Proceedings of the

CUMBERLAND-SHENANDOAH
FRUIT WORKERS CONFERENCE
77TH ANNUAL MEETING

November 15 and 16, 2001
Winchester Holiday Inn
Winchester, Virginia

Conference Chair
Peter W. Shearer
Rutgers, The State University of New Jersey
Rutgers Agricultural Research & Extension Center
Extension Specialist in Tree Fruit Entomology

77th CUMBERLAND-SHENANDOAH FRUIT WORKERS CONFERENCE
November 15-16, 2001
Winchester, VA

Thursday Morning, November 15, 2001 (Apple Blossom I & II)

8:30 Registration

9:00 Welcome and Call of the States

General Session
Moderator – Guido Schnabel

9:30 To Be Announced

9:50 Is It Stink Bug or Cork Spot?—
M.W. Brown, USDA, ARS

10:10 Break

10:30 Is It Stink Bug or Cork Spot? – Follow-up —
M.W. Brown

10:40 Plum Pox in PA from 1999-Present—
Karl Valley, Chief of Division of Plant Protection, PA Dept. of Ag.

11:20 FQPA from an Industry Perspective—
Fred Marmor, Gowan Company

12:00 BUFFET LUNCH (included in registration)

Thursday Afternoon, November 15, 2001

1:00 Breakout Sessions for Individual research paper presentations by discipline (Entomology, Plant Pathology, Horticulture). Paper titles and authors are listed in the following sections.

5:30 DINNER (on your own)

Friday Morning, November 16, 2001

8:00 Continue breakout sessions for research papers

9:00 BREAK

10:25 Discipline Summary Report and Business Meeting (Apple Blossom I & II)

11:30 Adjourn

Breakout Session – Entomology (Apple Blossom II)
November 15, 2001

Thursday Afternoon **Moderator – Dean Polk**

1:00 Pheromone Disruption With and Without Insecticide Applications to Control Peachtree Borers in Peaches—Agnello, D. Kain, NYSAES

1:12 Tech/USDA Dogwood Borer Program: More Questions Than Answers from 2001 Field Research—J.C. Bergh, T.C. Leskey, S. Wright, J. Engelman, Virginia Tech, USDA AFRS

1:24 Methods for Rearing Dogwood Bores in the Laboratory—Tracy C. Leskey, Starker E. Wright, USDA-ARS AFRS, J. Christopher Bergh, Virginia Tech

1:36 Borer Problems and Their Control in Dwarf Apple Trees-2001 Update—
D. Kain, R. W. Straub, A. Agnello, NYSAES

1:48 Aphids in Commercial Peach Orchards-Abundance and Species Composition—
Greg Krawczyk, Larry A. Hull, Penn State Univ., FREC

2:00 Research Update on the Woolly Apple Aphid Predator, *Heringia* (Neocnemodon) calcarata—J.C. Bergh, B.D. Short, VA Tech AHS AREC

2:12 Evaluation of Apple Maggot Control and an Organic Insecticide Program—
David Combs, Harvey Reissig, Cornell University, NYSAES

2:24 Influence of Natural Sources of Olfactory & Visual Stimuli on Adult Plum Curculio Responses to Baited Traps—Tracy C. Leskey, Starker E. Wright, USDA-ARS AFRS

2:36 Three Summers of Trapping Plum Curculio in Virginia Orchards—
Michelle McClanan, Joella Killian, Doug Pfeiffer, Virginia Tech

2:48 Large Block Mating Disruption of the Oriental Fruit Moth in Peaches with Hand Applied Dispensers and Paraffin Emulsion—
Shawn Robertson, Larry Hull, Penn State Fruit Research & Extension Center

3:00 Comparison of Mating Disruption Technologies for Control of the Oriental Fruit Moth—
Atanas Atanassov, Peter Shearer, George Hamilton, Dean Polk, Rutgers University,

3:12 Break

3:30 Pheromone Disruption and Egg Hatch of Oriental Fruit Moth in Peaches - 2001—
A. Agnello, NYS AES

3:42 The Potential of Paraffin-based Pheromone Dispensing Systems in the Mating Disruption of Oriental Fruit Moth, Grapholita molesta (Busck) —
F.M. deLame, J.R. Miller, L.J. Gut, Dept. of Entomology, Michigan State University
C.A. Atterholt, Dept. of Chemistry and Physics, Western Carolina University

3:54 Sprayable Pheromones and Puffers: An Update on Their Efficacy Against OFM in Pennsylvania in 2001—
N.H. Ellis, L. A. Hull, Penn State University Fruit Research and Ext. Center,

4:06 Mating Disruption of Grape Berry Moth - 2001—
Doug G. Pfeiffer, Virginia Tech, Blacksburg, VA

4:18 Mating Disruption of Internal Feeders in Apple - 2001—
Doug G. Pfeiffer, M.H. Rhoades, M.E. McClaran, C. Bergh, Virginia Tech

4:30 Efficacy of Disruption Formulations that Combine Pheromone Blends—
Larry Gut, Peter McGhee, Mike Haas, Carlos Garcia-Salazar, Michigan State University

4:42 Sprayable Pheromone for Control of Lepidopteran Pests in Apple—
Larry Gut, David Epstein, Daniel Waldstein, Michigan State University

4:54 Management of the Obliquebanded Leafroller and Insecticide Resistance with Soft Insecticides in Western New York Apple Orchards, 1999-2001—
Harvey Reissig, C. Smith, D. Combs, Cornell University, NYSAES

5:06 Within Canopy Variation in Efficacy of Methoxyfenozide Applied to Apple With an Airblast Sprayer—
Dan Borchert, Jim Walgenbach, North Carolina State University

5:18 Alternative Codling Moth Control Trials—
M.W. Brown, USDA, ARS, AFRS

Breakout Session – Plant Pathology (Apple Blossom I)
November 15, 2001

Thursday Afternoon **Moderator – Norman Lalancette**

1:00 Resistance of Geneva Apple Rootstocks to *Erwinia Amylovora* When Grown as Vegetative Shoots and Orchard Trees—
Jay Norelli, USDA-ARS Appalachian Fruit Research Station, Kearneysville, WV,
H.S. Aldwinckle, H.T. Holleran, T.L. Robinson, W.C. Johnson, Cornell University

1:20 Blueberry Scorch Disease: An Emerging Regional Problem—
P.V. Oudemans, A. DeMarsay, S. Polavarapu, B.I. Hillman, Rutgers University

1:40 Review of Evidence on the Etiology of Peach Rusty Spot—
N.Lalancette, L.A. Furman, J. F. White, Rutgers University

2:00 Disease Control in Apples Using Surround WP and Sulfur Minerals Update—
P. Gundrum, D.M. Glenn, G. Puterka, USDA-ARS AFRS

2:20 Effect of Apogee Dose Level on Fire Blight Shoot Infection in Young 'Gala' and 'York' Apple Trees—
Jay Norelli, Steven Miller, USDA-ARS AFRS

2:40 Demonstration of Effectiveness of Apogee for Fire Blight Shoot Blight Suppression in Commercial Apple Orchards—
K.S. Yoder, A.R. Biggs, J.L. Norelli, R.P. Marini, Virginia Tech, WVU, USDA-AFRS

3:00 Break

3:20 Efficacy of Apogee for Fire Blight Control on Young Apple Trees in 2001—
K. D. Hickey, N.O. Halbrendt, J.W. Travis, Penn State University, FREC

3:40 Evaluation of Apogee and Messenger for Control of Fire Blight Shoot Infection on Apple in 2001—
K. D. Hickey, N.O. Halbrendt, J.W. Travis, Penn State University, FREC

4:00 Stone Fruit Fungicide and Bactericide Efficacy Studies—
N.Lalancette, K.A. Foster, L.A. Furman, Rutgers University

4:20 Highlights of 2001 Peach Fungicide Tests—
K.S. Yoder, A.E. Cochran II, W.S. Royston, Jr., S.W. Kilmer, Virginia Tech

4:40 Highlights of 2001 Apple Fungicide Tests—
K.S. Yoder, A.E. Cochran II, W.S. Royston, Jr., S.W. Kilmer, Virginia Tech AREC

5:00 Results from Orchard Apple Disease Management Evaluations in 2001—
K. D. Hickey, J.W. Travis, J. May, N.O. Halbrendt, Penn State University, FREC

Breakout Session – Horticulture (Apple Blossom III)
November 15, 2001

Thursday Afternoon **Moderator – Robert D. Belding**

1:10 Two-year Response of Apple and Peach Trees to Scoring and Restriction of Trunks—
Tom Tworkoski, Stephen Miller, USDA-ARS AFRS

1:30 Environmental Modification for Strawberry Plasticulture Using a Weather Forecasting Service—
R.J. Rouse, M. Newell, University of Maryland, WYE Res. & Education Center

1:50 The Effect of Continuous and Periodic Shade on the Performance of Ginger Gold'/M.9 Apple Trees—
Stephen S. Miller, USDA-ARS, AFRS

2:10 Return Bloom and Fruit Set as Influenced by Subsequent Season(s) Gibberellin, Ethephon, Foliar Nutrient, and Fruit Thinning Sprays (1997-2001) —
R.E. Byers, D. H. Carbaugh, L. D. Combs, T. D. Stern, VPI & SU, AHS-AREC

2:30 The Influence of Chemical Sprays for Control of Apple Fruit Drop and Fruit Dips for Inhibition of Peach and Apple Maturity in Regular Cold Storage, at Room Temperature, or On-the-Tree—
R.E. Byers, D. H. Carbaugh, L. D. Combs, T. D. Stern, VPI & SU, AHS-AREC

3:10 Fruit Maturation and Cracking Susceptibility in Gala Apples—
C.S. Walsh, S.A. Altman, D. Lai, K.W. Hunt, J. Hu, University of Maryland

3:30 The Effect of Rootstock on the Maturity of Gala Apples—
Michael L. Parker, Sylvia Blankenship, North Carolina State University

3:50 Influence of Chemicals, Adjuvants, and Temperature on Apple Fruit Thinning, Fruit Size, Shape, Color, Injuries, and Appearance and Peach Thinning Results in 2001—
R.E. Byers, D. H. Carbaugh, L. D. Combs, T. D. Stern, VPI & SU, AHS-AREC

4:10 2001 'York Imperial' Apple Thinning Trial—
George M. Greene, PSU Fruit Research & Extension Center

4:30 Use of PGRs to Regulate Cropping in 'York Imperial' Apples—
George M. Greene, PSU Fruit Research & Extension Center, Biglerville, PA,
Stephen S. Miller, USDA Appalachian Fruit Research Station, Kearneysville, WV,
Ross E. Byers, VPI & SU, AHS-AREC

4:50 Whole Canopy Photosyntheses Studies in 2001-Summary—
D.M. Glenn, P. Gundrum, G. Puterka, USDA-ARS AFRS

November 16, 2001

Friday Morning **Moderator – Robert D. Belding**

8:20 Apple Training System Trials with Fresh and Processing Cultivars—
R.M. Crassweller, D.E. Smith, Dept. of Horticulture, Penn State University

8:40 The Influence of Apogee and Its Combinations with Ethephon, Hydrogen Ion Concentration, Cations, Adjuvants on Apple Tree Growth Control, Fruit Cracking, and Return Bloom—
R.E. Byers, D. H. Carbaugh, L. D. Combs, T. D. Stern, VPI & SU, AHS-AREC

9:00 'Blake's Pride': A New Fire Blight Resistant Pear Cultivar—
Richard L. Bell, T. van der Zwet, USDA, ARS Appalachian Fruit Research Station, Kearneysville, WV, Roland Blake, USDA, ARS, OARDC

9:20 Sooty Blotch Susceptibility From an Apple's Perspective—
Robert Belding, Gail Lokaj, Rutgers University

Breakout Session – Entomology (Apple Blossom I & II)
November 16, 2001

Friday Morning **Moderator – Dean Polk**

8:00 Identification of the Internal Feeders Causing Rejection of Apples by Virginia Processors—
J.C. Bergh, J.P. Engelman, VA Tech AHS AREC

8:12 Arthropod Pest Susceptibility of New Apple Cultivars—
Henry W. Hogmire, W. Virginia University, Kearneysville, WVA, Stephen S. Miller, USDA AFRS

8:24 Measuring the Impact of Apple Arthropod Foliage Feeders Using Whole Plant and Single Leaf Photosynthesis Measurements—
J.P. Nyrop, A.N. Lakso, NYSAES, Cornell Univ

8:36 RAPDs and Wolbachia in Plum Curculio, *Conotrachelus*—
Michelle McClanan, Shirley Luckhart, Doug Pfeiffer, Virginia Tech

8:48 Impact of Peach Extrafloral Nectar on Key Biological Characteristics of *Trichogramma minutum* (Hymenoptera: Trichogrammatidae) —
Atanas Atanassov, Peter Shearer, Rutgers University

9:00 Commercial Use of Reduced Risk Practices and Mating Disruption in New Jersey Peach Production—
Dean Polk, Peter Shearer, Atanas Atanassov, George Hamilton, Robin Brumfield, David Schmitt, Rutgers University

9:12 The Impact of Two Pest Management Practices on Peach Pesticide Residues—
George Hamilton, Peter W. Shearer, Dean Polk, Rutgers University, Roy Meyers, Ann Rush, NJDEP

9:24 Particle Film Technology for Sharpshooter and Leafhopper Control in Grapes—
Gary J. Puterka, USDA-ARS, AFRS

9:36 Does Apogee Treatment Affect Injury Levels of Potato Leafhopper on Apple? —
Kathleen Leahy, Duane Greene, Wesley Autio, University of Massachusetts

9:48 Update on an OFM Egg Model for Peaches and Apples—
Larry Hull, Greg Krawczyk, Penn State Univ., FREC

10:00 The Effects of Host Plant on the Development of Oriental Fruit Moth (*Grapholita molesta*)—
Clayton T. Myers, Larry A. Hull, Penn State University Fruit Research and Ext. Center

10:12 Evaluation of Reduced Risk Insect Management Programs on Apples—
Jim Walgenbach, Charles Thayer, North Carolina State University

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77th Cumberland-Shenandoah Fruit Workers Conference
Program Highlights and Business Meeting

The 77th meeting of the Cumberland-Shenandoah Fruit Workers Conference was hosted by Rutgers, The State University of New Jersey and Clemson University, South Carolina and held at the Holiday Inn in Winchester, VA. The meeting was held on Thursday and Friday, November 15-16, 2001with 85 registered participants and 60 presented papers. Registration was $50 to cover the costs of the proceedings, breaks, and Thursday lunch. Peter Shearer was the general chair and secretary and Steve Miller served as the treasurer. Guido Schnabel organized and chaired the general session, Norman Lalancette was chair of the Plant Pathology Session, Robert Belding was chair of the Horticulture Session, and Dean Polk and Peter Shearer were chairs of the Entomology Session.

The Thursday morning session started with the "Call of the States" which provided a brief report of the crop, weather, and pest conditions for the 2001 season. This was followed by the General session which included excellent and informative presentations by Mark Brown on stink bug/cork spot injury, an update on the Plum Pox virus in Pennsylvania presented by Karl Valley, PA. Dept. of Ag., and a presentation about the FQPA from an industry perspective by Fred Marmor, Gowan Company. Following lunch, the meeting broke up into 3 concurrent sessions (Entomology, Horticulture, and Plant Pathology).

The business meeting was called to order by Peter Shearer. Reports of the concurrent sessions were provided by Peter Shearer, Keith Yoder, and Robert Belding. Steve Miller gave the treasurer's report. Total income in 2000/2001 from the carryover balance, registrations, interest, and sale of 2000 Proceedings was $4,438.07. Expenses attributed to the 2000 meeting, printing and postage costs for the 76th Proceedings and materials amounted to $3669.70. The CSFWC account balance at the time of the 2001 meeting was $768.37. Registration receipts for the 2001 meeting were $4,325.00. Sale of Proceedings represented income of $60.00. Meeting costs, including room rental, noon meal, and refreshments were $2,453.93. The CSFWC Account had a balance of $2,699.44 at the conclusion of the 77th meeting. The treasurer presented information on facilities and printing costs beginning with the 1997 meeting through the 2000 meeting. Facilities costs reported: 1997-$1,617.15; 1998 - $1,624.40; 1999 - $1,916.78; and 2000 - $2,134.64. Printing costs (including covers): 1997 - $946.58; 1998 - $867.55; 1999 - $888.77; and 2000 - $1,461.67. Motion was made George Greene seconded by Ross Byers and approved to accept the treasurer's report. Peter Shearer expressed his appreciation to Steve Miller for his continuing to serve as CSFWC treasurer and to Henry Hogmire for his chairing of last year's meeting and putting out the proceedings in a very timely manner.

Other business included a vote on whether Industry can send more than one representative to the meeting. The CSFWC members voted in favor to allow 2 representatives per company. The members also voted in favor of an industry sponsored social to take place on Thursday evening of the next meeting. Due to conflicts with the Annual Meeting of the Entomological Society of America, the next meeting will be held on December 5-6, 2002 at the Holiday Inn in Winchester, VA.

Future Meetings and Host States:

2002 – Virginia
2003 – Maryland/Delaware
2004 – North Carolina
2005 - USDA
2006 – Pennsylvania
2007 – West Virginia
2008 – New Jersey/South Carolina

Respectfully submitted,
Peter W. Shearer, General Chair, Secretary
Stephen S. Miller, Treasurer

Report for Massachusetts and central New England 2001

Reporting: Kathleen Leahy, Polaris Orchard Management, IPM consulting

Overall Crop: The winter of 2000-2001 was mild but extremely snowy; substantial snow cover persisted in most locations into mid-April, making pruning and clearing brush difficult. A few very hot days in early May brought conditions back to "normal". A freeze occurred during bloom on May 7, where the temperature went down to the low 20's in some locations (high teens in Rhode Island), but in Massachusetts, the final crop estimate is down only about 20%. Some varieties were harder hit than others; Cortlands were notably sensitive, and Liberty and Red Delicious showed considerable russetting.

General conditions were fairly dry during the growing season, but there was sufficient ground water and intermittent rainfall that drought stress was not a problem, and most growers seem fairly happy with fruit quality. Market conditions also seem good, at least in the early part of the season, for retail and especially for pick-your-own operations.

Diseases: Primary scab began on May 22 and ended on June 3 - the shortest and the easiest scab season most people can remember. Some growers did get caught short by the large releases on the 22nd, after many false alarms in the weather forecast. Where it occurred at all, scab was confined to the fruit shoot and terminal growth, though by midsummer, unsprayed trees did show considerable scab on both fruit and foliage.

Maryblyte showed a high risk for blossom blight for May 4; some areas did receive a brief wetting on that day; in addition, the freeze on the 7th created some concern as a possible trauma event. The growers who were at risk had already applied Strep on the 4th, and no fire blight was seen in sprayed orchards in MA. Connecticut reported considerable fire blight, perhaps owing to the freeze.

Sooty blotch, flyspeck, and other summer diseases were virtually nonexistent. Some rust was seen in orchards that do not typically have a problem with rust. More powdery mildew than usual was also noted

Insects: Overall, insect activity was average or below average. Leafminers generally were low, though a few hot-spots generated an amazing amount of activity; Chris Maier reported an orchard in Connecticut with 1 mine per leaf at petal fall. Potato leafhoppers were below normal and occurred primarily in the Connecticut River Valley. Pear thrips and green pug moth, our "new" insect pests, were less abundant this year. Tarnished plant bug did put in an appearance prebloom in some apple orchards; this insect had been at very low levels for several years. Mites were well below average, two-spotted mites were especially notable for their absence, given the dry conditions this year. One orchard had a problem with organophosphate-resistant oblique-banded leafrollers, which have not previously been seen in Massachusetts.

One note on small fruits - black vine weevil was extraordinarily high this year; in NH, Alan Eaton commented that some growers had left the strawberry business as a result.

A major outbreak of fall armyworm greatly amused some orchardists by eating all the grass in the understory and saving them a round of mowing.

CALL OF THE STATES REPORT FOR NY

As far as generalizations go, 2001 was a fairly uneventful season for arthropod pests; they weren't absent, certainly, and some were problematic, but in general, populations occurred and progressed about as expected, once the weather was taken into account. A gradually warming early spring developed into three weeks of hot days starting the last week of April (disrupting the bloom progression, as usual), and then cooling towards normal by late May, culminating in some damaging hailstorms on Memorial Day. True summer weather moved in about mid-June, with scattered storms, and then turned warmer again at the end of the month and into July, from which point we entered the long hot and dry pattern that persisted through August.

The key pests offered few surprises. **European red mite** control seemed to be good during the early season, with a number of predictable outbreaks (plus a few of **twospotted mites**) provoked by the midsummer heat. **Plum curculio** entered just as the bloom heat wave subsided, and exhibited another protracted oviposition period that didn't finish in western N.Y. until the middle of June, so a full protectant program of 2-3 sprays was indicated in most orchards. **Obliquebanded leafroller** appeared on schedule, and generally responded well to treatment in orchards with a presumptive high population. However, some growers were misled by an apparent absence of July larval populations that ended up as fruit damage later on. In fact, terminal infestations were relatively scarce, but only because the dry weather truncated the production of new foliar growth. Under those conditions, OBLR larvae tend to feed on the undersides (along the midveins and edges) of protected younger leaves without noticeably rolling them, so they are often undetected until they move to the developing fruits.

The dry weather also had its effect on foliar feeders such as **aphids, leafhoppers** and **leafminers,** which were increasingly hard to find as the summer wore on. **Apple maggot** felt the pinch as well, arriving a bit later than usual, and remaining at generally low numbers outside of a few localized spots.

In the category of running concerns, the state's **oriental fruit moth** population seemed to be at its normal size and level of incidence this year, particularly in the stone fruit orchards in the Niagara region. Flights were very healthy, with fruit infestations a real threat in cases where sufficient mating disruption and/or insecticidal coverage wasn't employed. There were once again an uncomfortable number of reports of **internal worms** at harvest that couldn't be immediately explained, and which will undoubtedly drive many of our research efforts next season. Also, we seemed to hear a bit more about **dogwood borers** in apples this season than has usually been the case, although this may be more a reflection of an increased awareness of their ongoing occurrence. **Tarnished plant bugs** initially didn't appear too numerous, but late season warm weather seemed to bring out large numbers during the harvest period.

A few pests didn't make themselves very apparent this year, although it's always possible we weren't looking in the right places. **Pear psylla, San Jose scale** and **Comstock mealybug** appeared to be either low or else well controlled. **Mirid bugs** and their damage weren't particularly numerous, but these tend to have on and off years in response to weather patterns.

Call of the States- New Jersey

Bob Belding
Rutgers University

The apple crop for 2001 reached 55 million pounds, which was a high for the past 3 years. The value of New Jersey's apple crop was reported to be $6.3 million, down from $6.4 in 2000. The peach crop was 75 million pounds a high for the past three years (65-75 million pounds). Despite the large crop, receipts for peaches were down 5%.

Peach bloom was delayed ~8 days due to cool spring weather that was setting us up with a reduced risk of crop loss from spring frosts or freezes. Many growers were primed to increase blossom thinning efforts when late freezes occurred April 19th, 26, and 28. Because of the potential for crop losses, many growers backed away from blossom thinning in favor of the later season hand thinning option. Because of this and over cropping, fruit size was down and with that, reduced prices. There was sporadic occurrence of a lack of bloom on less hardy cultivars this spring in some orchards. Locations near to the damaged blocks reported no such lack of bloom. One theory was the temperatures we had as the trees entered dormancy caused bud death, but the cause was not determined.

Warm rains occurred during bloom on peaches causing blossom blight in many blocks. Those blocks did have notably higher incidence of brown rot at harvest. A hot dry spell during mid summer contributed to thrips outbreaks in nectarines. This year we had the first occurrence of Pansy Spot, a result of thrips laying eggs on apple during bloom. Tufted apple budmoth caused higher than normal injury on apples and late peaches and resulted in a high number of culls. Catfacing injury in peaches was higher in 2001 than normal.

Temperatures were generally cooler throughout most of the growing season with air temperatures only rising above 80°F ten times from April to November. Except for a 28 day dry period from 22 April to 19 May, rainfall occurred frequently throughout the spring and summer.

Blossom blight was light at the research center, only 6% canker on unsprayed trees. Brown rot infection was moderate to high due to the consistent rain pattern. Peach Rusty Spot incidence was low to moderate depending on cultivar and location, often 50% less than that of 2000. Bacterial Spot infection was minimal, mostly due to the low temperatures and lack of rainfall during the critical period after shuck split. More foliar infections occurred later in mid-June when conditions favored infection. Peach Scab Pressure was particularly severe, especially for late maturing cultivars that had to endure the wet summer's infection periods. Over wintering lesions made control difficult. Rhizopus rot was observed in some blocks, but despite the rains, little rot was observed in postharvest studies.

2001 Cumberland Shenandoah Fruit Workers Conference
Call of the States - North Carolina

The peach and apple crop in North Carolina were significantly reduced due to spring freeze events just prior or during bloom. The peach crop was somewhere around 30-40% and apples somewhere around 50% of an average crop. Movement of peaches was very good and there is an increasing interest in peaches across the state with many smaller acreage plantings being established, i.e. 2-5 acres. Several of the varieties from the NCSU breeding program are high chill and show promise for helping to maintain consistent cropping even with spring frost/freeze events.

For apples, the early part of the growing season was very dry and as a consequence scab was the lightest it has been in several years. The early-season dry weather also significantly reduced the severity of fire blight, black rot and frogeye leaf spot, and Brooks fruit spot. Cool weather in May and June inhibited the development of bot rot and bitter rot and the diseases were generally not as severe as in past years. Glomerella leaf spot on Gala, first found in an orchard in NC last year, was not reported from any other orchards in 2001. However, there was a large orchard in Georgia that had extensive leaf infection and some fruit infection.

A number of insect pests were of concern on North Carolina apples in 2001. Early season problems with rosy apple aphid continue to be problem for many growers, with prebloom pyrethroids no longer providing adequate control in most locations. Plum curculio damage was also somewhat higher than normal. Secondary pest problems were of relatively minor concern, with leafminer and mite populations quite low throughout the state. Problems with internal feeding worms, including codling moth and oriental fruit moth, were primarily confined to those blocks adjacent to packing houses and bin storage areas. For the first time in memory, we did experienced some serious problems with apple maggot. The relatively wet growing season contributed to an early and sustained emergence of flies. The increased number of abandoned orchards, the extended spray intervals employed by many growers because of the light crop, and the reduction in the use of organophosphates all contributed to the problem.

Is it Stink Bug or Cork Spot?

M. W. Brown
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Cork spot and bitter pit are disorders of apple often, but not always, related to calcium deficiency. Cork spot is characterized by spherical spots of dead tissue in the apple flesh, superficially resembling cork. Bitter pit resembles cork spot but is associated with fruit skin lesions and normally occurs during storage. Damage from stink bugs (Pentatomidae) also appears as cork-like spots in the fruit underneath a depressed, discolored area on the fruit skin. A study was conducted in West Virginia at the Appalachian Fruit Research Station to describe stink bug damage to apple and demonstrate that this particular type of damage is not attributable to calcium deficiency.

Two 1 ha orchards of mixed apple ('Granny Smith'/EMLA26, and 'Royal Empire'/M9/EMLA111) and peach ('Loring'/'Lovell'), planted in 1997, were used for the study. One of the orchards received foliar calcium chloride applications (44 kg/ha 'Empire' and 53 kg/ha 'Granny Smith') in cover sprays from May to September. At harvest, 1200 fruit per orchard were sampled, 20 fruit from each of 60 randomly selected trees, half from each cultivar. Fruit from the orchard with added calcium had significantly more stink bug damage than the untreated orchard (based on 95% confidence intervals). 'Empire' had 25.3% damaged fruit with calcium and 18.8% damage without calcium. "Granny Smith' had 5.0% damaged fruit with calcium and 2.7% damage without calcium. Sixty branches with a minimum of 5 fruit per branch were caged on 19 July. The cages were divided equally into five treatments: 2 stink bugs enclosed from 6 to 8 weeks before harvest, 2 stink bugs enclosed from 4 to 6 weeks before harvest, 2 stink bugs enclosed from 2 to 4 weeks before harvest, 2 stink bugs enclosed 0 to 2 weeks before harvest, and no stink bugs enclosed. The control cages without stink bugs did have some damaged fruit (15-18%) due to feeding on apples through the screen cage, but the damage was less than that in any of the treatments with stink bugs. Most of the stink bugs that were caged on the fruit were *Euschistus servus euschistoides*, but *Acrosternum hilare* and *E. tristigmus* were also used and caused the same damage. The most stink bug damage occurred from 4 to 8 weeks prior to harvest with 50 to 60% of the fruit in the cages being damaged. Survival of stink bugs in the cages was greatest (100%) at 2 to 4 weeks before harvest. The decline in stink bug damage within 4 weeks of harvest may be due to either a lower susceptibility of the fruit to damage, or an inability of the fruit to manifest damage symptoms at that degree of maturity.

Microscopic examination of feeding sites and damage to apple flesh was done with a dissecting scope at 100X to 600X. All suspected stink bug damaged fruit that were examined had one or more holes in the skin of the type that would be made by insertion of stink bug mouthparts. Some of the feeding sites were visible without magnification, but some were only visible at 200X. Damage to the fruit cortex showed areas within the "corky" area with varying degrees of breakdown. Published photos of physiological cork spot indicate that the "corky" area is uniform in the degree of tissue breakdown. Several fruit with recent stink bug damage showed initial signs of tissue breakdown in a straight line into the fruit originating from a feeding site on the fruit skin, indicating the initial signs of tissue breakdown, or "corking", resulting from penetration by stink bug stylets.

Further studies are planned to develop improved exclusion cages to definitively show that what is being called stink bug damage can be eliminated with a physical barrier. Studies will also be done to examine the phenology of fruit damage by exposing fruit to stink bugs and observing the fruit for development of symptoms. Fruit flesh samples from just under the skin were taken and will be analyzed for calcium and boron content.

Not for Citation

EVALUATION OF PHEROMONE DISRUPTION IN COMBINATION WITH INSECTICIDE APPLICATIONS FOR CONTROL OF PEACHTREE BORERS IN PEACHES - 2001

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ABSTRACT

The effectiveness of three different treatments were compared in the control of infestations and damage by peachtree borer (PTB) and lesser peachtree borer (LPTB) in commercial peach orchards: (1) pheromone disruption dispensers combined with directed trunk insecticide applications; (2) pheromone disruption dispensers only; (3) directed trunk insecticide applications only. Pheromone dispensers were placed in blocks (2–3 acres) of peaches on two farms in Wayne Co., and insecticide treatments were applied to single-tree plots in each block. These insecticide sprays were also applied to comparable trees in another planting at each farm not containing the pheromone dispensers. The effectiveness of the different treatments was evaluated by comparing adult male trap catches in pheromone traps in each block, postharvest excavating around the trunks to search for borers and damage in the fall, and enclosing infested cankers with sleeve cages to assess adult emergence at the end of the season. Pheromone trap catches of both borer species were completely supressed by the pheromone dispensers in the disrupted plots. Fall 2000 trunk inspection revealed no damage attributable to PTB infestation in either the test trees or the untreated checks. In 2001, very low levels of damage were found in all plots, but there were no treatment differences. On unsprayed trees caged during 2001, higher numbers of LPTB exuviae were found in non-disrupted peach blocks than in blocks treated with pheromones. Damaged areas on sprayed vs. unsprayed trees will be caged in 2002. Results will be used to assess the advisability of using pheromone mating disruption as a borer management strategy in commercial peach orchards.

BACKGROUND

In New York, there are two species of sesiid (clearwing) moths that attack peaches — the peachtree borer, *Synanthedon exitiosa*, and the lesser peachtree borer, *Synanthedon pictipes*. The adult borers are striking clear-winged moths with yellow and steel-blue body markings. The adults of these insects have from one to four yellow-orange stripes across the abdomen, depending upon species and sex. The PTB enters the tree near soil level and does not require the presence of wounds or breaks in the bark for entry, but the LPTB nearly always enters the tree at a pruning scar, canker, mechanical injury, or winter-injured area. Both species pass the winter as borers inside the tree, and in the spring emerge as moths that lay eggs on or in the trunk during the summer. In New York, the LPTB moth emerges first, in late May, and the PTB doesn't show up until mid-June; both stay active (laying eggs) through August. When the borer stages hatch, the PTB tends to crawl down the tree to soil level and burrow in there, but the LPTB will move to the nearest injured area, which may be on the lower trunk or just as easily up in the scaffold limbs. LPTB completes its development in one year, but some PTB larvae take two years to develop, so any control measure a grower would elect will require repeating for at least 2–3 years.

Injury is caused by larval feeding on the cambium and inner bark of the trunk close to the soil level (PTB) or on the upper trunk and lower scaffold branches (LPTB). Occasionally, larger roots are also attacked by PTB. Areas attacked often have masses of gum, mixed with frass, exuding from the bark. All ages of trees are injured. Young trees are at times completely girdled and subsequently die. Older trees are often so severely injured that their vitality is lowered and they are rendered especially susceptible to attack by other insects or by diseases. Although both species may be found in infested trees, younger plantings and those not afflicted by extensive cankers or other bark splits are attacked primarily by PTB. Control is difficult, owing to the concealed habit of the larvae, and most growers must rely on one or more coarse insecticide sprays of the trunks and lower scaffold branches to deter egg laying and kill newly established larvae. Because this is a labor-intensive measure that often fails to completely control these pests, many growers choose not to elect treatment, or else do an incomplete job, with the intention of getting what they can out of a planting until infestations combine with other peach production factors to warrant tree removal. This approach has been common in the recent past, during which there has been little demand for New York stone fruits outside of local farmstand markets. However, with a recent increase in the planting of new peach varieties and short-range distribution to other markets, there is now more interest in examining currently available pheromone disruption tools for the control of these perennial pests.

This research involved trials testing the efficacy of pheromone disruption with and without directed trunk sprays, and here we report our findings after the second of a 2-year trial, in order to establish reliable guidelines for the use of mating disruption against these pests in commercial New York plantings.

OBJECTIVES:

1. To compare the effectiveness of different treatments (pheromone disruption, directed trunk insecticide sprays, and pheromone/insecticide in combination) in controlling infestations and reducing trunk damage to peach trees by two species of clearwing borers during successive growing seasons; also, to evaluate the relationship of trap catch in pheromone-disrupted peach orchards and the level of tree infestations by peachtree borers over a period of 2–3 years.

PROCEDURES:

1. This was multi-year trial in commercial orchards having serious annual problems with borers. Because we were targeting both lesser peachtree borer and peachtree borer, we selected orchards infected with cankers (necessary for LPTB). Trials were conducted at two locations in Wayne Co., Furber (Sodus, NY) and Herman (Williamson, NY). In each location, we compared mating disruption versus no pheromone treatment in two separate orchards, each approximately 2.5 acres in size. We further selected a group of 10 trees in each of these orchards for treatment with insecticide using directed trunk sprays, so the following treatments were evaluated:

1 - Pheromone disrupted+trunk spray
2 - Pheromone disrupted, no trunk spray
3 - Non-disrupted+trunk spray
4 - Non-disrupted, no trunk spray

On 31 May (2000) and 22-23 May (2001), Shin-Etsu Isomate-L ties containing a 30:70 blend of (Z,Z):(E,Z)-3,13-octadecadienyl acetate were placed in the test blocks at a rate of approximately 200/acre (1/tree). This blend is formulated to be appropriate for disruption of both borers in situations where LPTB is the predominant species, such as we believed to be the case at these sites. On these same dates, three wing-style (Pherocon) traps baited with pheromone lures (Scentry) for each species were hung in the interior of each disrupted and non-disrupted block; traps were checked twice per week from early June through August each year. On 22–28 May, 2001, screen cages made out of greenhouse netting (SolarGard, Griffin Premium Knitted 40% shadecloth, Tewksbury, MA) were used to enclose 2 canker/damage sites on the branches and 1 site on the trunk of each of 10 unsprayed trees in each plot.

Insecticide treatments consisted of directed trunk sprays of Asana (4.0 oz/100 gal) applied three times during the season. In 2000, 2 June, 6–7 July, and 20 Sept (postharvest); and in 2001, 13 June, 18 July, and 19 Sept (postharvest), using a Nifty Pul-Tank handgun sprayer operating at a pump pressure of 150 psi. Applications of approximately 1.25 gal per tree were made to single-tree plots, and replicated 10 times per block.

In the fall, from 13–27 Oct (2000) and 10–11 Oct (2001), trees were examined for PTB larvae and larval damage. The bases of the trunks on all the sprayed trees, plus an equal number of unsprayed trees in each block, were excavated around their entire circumference to a depth of 3–6 inches. The surface of the trunk circumference was inspected for exudations of gum containing frass, as well as for exuviae of any PTB larvae evident in the excavation. In 2001, the fabric sleeve cages on each tree were also examined for emerged adults or pupal exuviae of LPTB.

RESULTS:

The pheromone dispensers completely suppressed trap catches of both PTB and LPTB at both sites for both seasons, compared with relatively heavy flights noted in the non-disrupted comparison blocks (Figs. 1 and 2). Therefore, it may be concluded that this pheromone treatment was highly successful in disrupting the chemical communication of males and females in these two species. The PTB pheromone traps did regularly catch small numbers of a related species, determined to be lilac/ash borer, *Podosesia syringae*, which is not an economic pest of stone fruits.

The tree trunk inspections in 2000 turned up no evidence of any PTB larvae or gum exudations resulting from infestations, in both the treated and untreated trees. In 2001, very low levels of damage were detected that were consistent with PTB entry sites, although no empty pupal cases were found, and no significant differences were seen among any of the treatments (Table 1). These results were not entirely unanticipated, as the previous year's inspection implied that the incidence of this species was relatively low in these blocks, and any damage noted might have been caused by the small number of specimens that could have been in the trunk tissue from infestation during the year before this study began.

Inspection of the sleeve cages enclosing canker and damage sites on the trees revealed numerically higher numbers of LPTB pupal cases in the non-disrupted blocks than in those treated with the pheromones, although the difference was significant only at the Herman site. This is further argument for the effectiveness of the pheromone dispensers in disrupting the sexual behavior of this species to a noticeable degree. Although the Isomate-L label does not actually claim effectiveness against PTB, anecdotal evidence from a number of researchers corroborates that low-level populations of this species are generally also controlled by this formulation.

Table 1. Infestation[a] of peachtree and lesser peachtree borers as determined by fall trunk inspections, 2001.

	PTB trunk injury sites		LPTB pupal exuviae		
			Mean avg.	Proportion on	
Block/Treatment	Sprayed	Unsprayed	no./tree	trunk	scaffolds
Furber					
Pheromone	0.1 a	0.3 a	0.1 a	1.0	0.0
No pheromone	0.1 a	0.1 a	0.7 a	1.0	0.0
Herman					
Pheromone	0.0 a	0.2 a	0.2 a	0.5	0.5
No pheromone	0.2 a	0.1 a	2.1 b	0.5	0.5

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

In the spring of 2002, screen cages again will be used to enclose cankers found on scaffold branches prior to first emergence of LPTB and PTB adults, this time using the trees that have been previously treated with insecticide sprays (and compared with other unsprayed trees), to assess the relative effectiveness of this combined treatment on LPTB moth emergence.

After two seasons of these trials, there is already sufficient evidence to determine that pheromone disruption alone is able to provide quite adequate protection from infestation in commercial plantings, but this last component of the study could also provide information on whether a combined insecticide+pheromone approach would be any more effective in cases of severe infestation such as on these farms.

We wish to acknowledge the cooperation of Todd Furber, Cherry Lawn Farms; and Don Herman Fruit Farms, without whom this study could not have taken place. We also thank our Technical Field Assistants, Rick Cicciarelli, Honor Costello, Christie Cottingham, Laura Gillespie, and Scott Granish. We are also grateful for support and product received from Kinya Ogawa, Shin-Etsu Chemical Co., Ltd., and Bob Ienaga, Pacific Biocontrol/CBC America Corp. This work was supported by a grant from the N.Y.S. Dept. of Ag. & Mkts. IPM program.

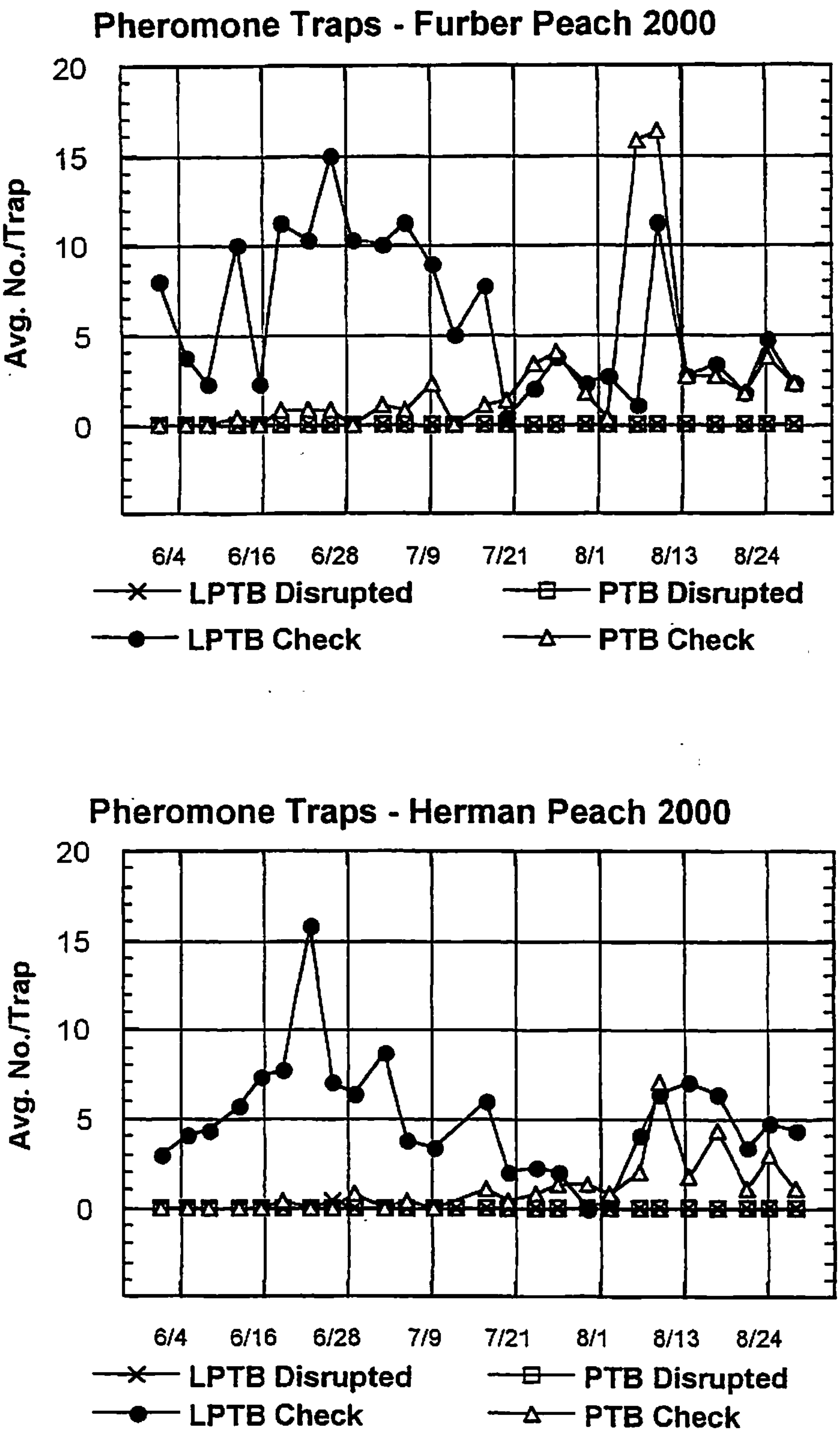
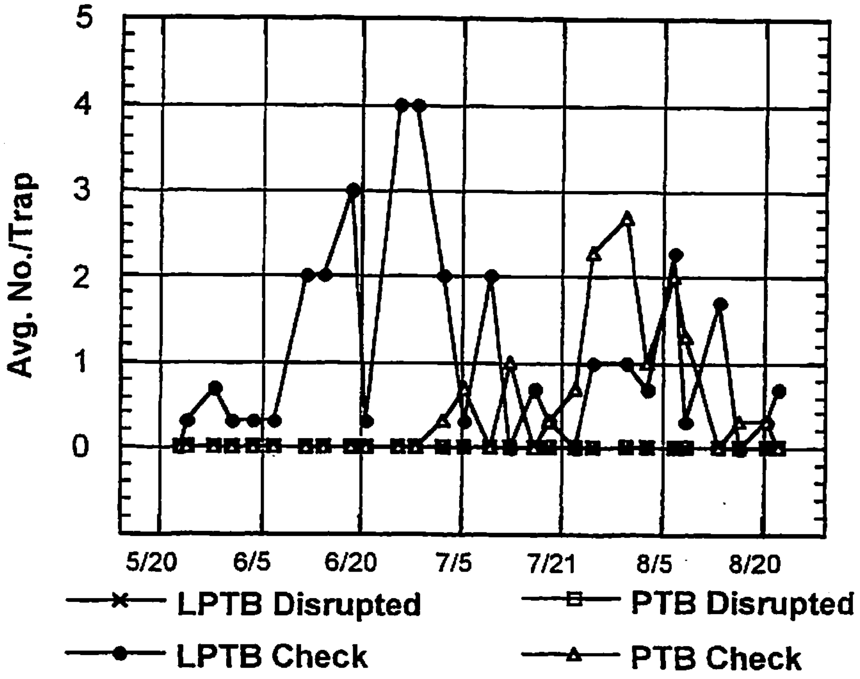
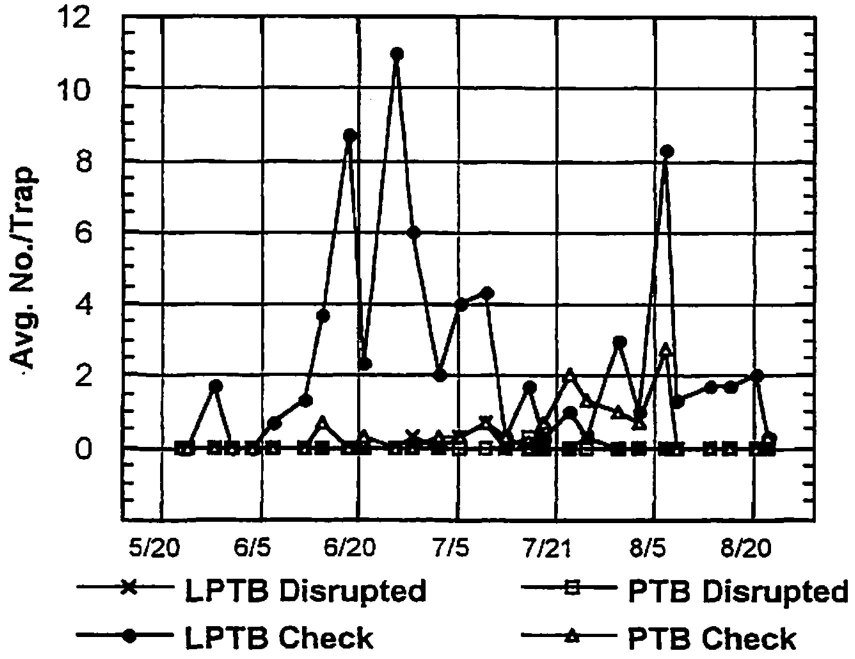


Fig. 1. Pheromone trap catches of lesser peachtree borer (LPTB) and peachtree borer (PTB) moths in pheromone-disrupted and non-disrupted peach plantings in Wayne Co., 2000.



Pheromone Traps - Furber Peach 2001



Pheromone Traps - Herman Peach 2001

Fig. 2. Pheromone trap catches of lesser peachtree borer (LPTB) and peachtree borer (PTB) moths in pheromone-disrupted and non-disrupted peach plantings in Wayne Co., 2001.

Not for Citation or Publication
Without Consent of the Author

DOGWOOD BORER FIELD STUDIES: PRELIMINARY DATA ON SEASONAL PHENOLOGY, MONITORING AND VOLTINISM IN VIRGINIA AND WEST VIRGINIA

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The dogwood borer (DWB) has increased in importance as a pest of apple in recent years. This is thought to be due primarily to increased plantings of apple cultivars on size-controlling rootstocks that promote the formation of burrknots near the graft union and, in some varieties, elsewhere on the scion. On apple and other host trees, female DWB oviposit near wounds on bark, which provide their larvae access to the wood. Burrknot tissue is also a preferred oviposition site, and it may be that the sensory perception of and behavioral response to burrknots by female moths is equivalent or similar to that evoked by wounded tissue.

Given that the most effective material for borer control, chlorpyrifos, is under FQPA review and that its future availability is uncertain, we have become interested in the potential for development of other, non-chemical strategies for DWB management. These could include tactics involving behavioral manipulation through use of sex pheromones for mating disruption and/or host-plant derived volatiles that elicit orientation and oviposition by female moths.

In our review of the DWB literature, it became apparent that there are many aspects of the life history, reproductive biology and field ecology of DWB that have not been examined systematically, and that this is particularly true in the apple ecosystem. Some of the unresolved issues directly influence our ability to proceed with research on the potential for development of semiochemical-based, alternative management strategies. For example, there are conflicting interpretations and conclusions among studies of the seasonal phenology of DWB in apple and other host plants, as measured using pheromone traps. Unimodal, bimodal and multimodal flight patterns have been reported from different regions within its range, although all authors suggest that DWB is a univoltine species. Geographical (latitudinal) differences among studies may account for some of the discrepancies, however the issue is confused further by numerous qualitative or quantitative accounts of differences in the effectiveness of commercially available pheromone lures for monitoring DWB. Studies from New York and Ontario have shown that pheromone trap captures of DWB correlate well with emergence patterns from apple trees in commercial orchards, as measured by pupal cases or adult emergence, although there are no similar data from more southern parts of its range. Unlike for the peach tree borers, there only anecdotal information on the response of DWB to sensory stimuli associated with its host plants.

At the outset of the 2001 field season, our primary objectives were: 1. to compare the response of DWB to young apple trees with and without burrknot tissue, 2. to examine the response of DWB to a combination of visual and olfactory stimuli, 3. to develop the relationship between the capture of males in pheromone traps and the abundance of pupal cases, and 4. to measure the sex ratio of DWB over the season, based on pupal case morphology. Unexpected negative results from our pheromone trapping during the early part of the 2001 flight season prompted us to include a preliminary comparison of the effectiveness of pheromone lures and to begin to examine the phenology and voltinism of DWB in apple, based on temporal changes in the frequency distribution of larval instars collected from apple burrknot tissue.

DB Response to Tree Condition. 'Ida Red', 'Red Chief', 'Gala' and 'Fuji' trees (AGE) showing the following conditions were included in this test; 1. No burrknots at the graft union 2. Burrknots at the graft union not infested by borer larvae and 3. Burrknots at the graft union with active borer infestation (based on presence of fresh frass). Burrknots on trees without active borer infestations were enclosed in screening to prevent oviposition and larval infestation during the experiment. The experiment was performed at two orchards in VA and two in WV, and each tree condition was replicated 5 times/orchard.

Clear Plexiglas panels (12" x 12") were mounted on wooden stakes (2 panels/stake), the stakes were positioned at the four cardinal compass points around each tree (12" from the trunk), and the panels on each stake were at ground level and at approximately 4' above the soil surface. Clear acetate sheets coated on one surface with Tangletrap were attached to each panel with the sticky surface facing away from the tree, and were intended to capture moths flying toward the tree. The interception traps were deployed continuously from mid June until late July, and the acetate sheets were inspected weekly for captured DWB moths.

During this experiment, the interception traps captured many insects representing many orders. However, despite the fact that the traps were deployed during a period when male DWB were captured in pheromone traps and fresh pupal cases were collected from burrknots in the same orchards (see Table 2 and Fig. 2), only one DWB moth was captured.

DB Response to Visual and Olfactory Stimuli. This experiment was performed at one orchard in VA and one in WV. The visual stimulus offered was a 4' section of black plastic ABS pipe (3" diameter), coated with Tangletrap. A putative olfactory stimulus was combined with half of the traps at each orchard and consisted of ground apple burrknot tissue on which DWB larvae were feeding. The tissue and three larvae were held in the upper chamber of plastic cages with screened areas, and were kept moist by water wicked from a lower chamber. The exterior of each larval/burrknot cage was also coated with Tangletrap. Two cages with burrknot tissue and larvae were attached to the base of five pipe traps at each orchard, and five pipe traps had no olfactory stimulus. The traps were deployed from late June until late July and checked weekly for DWB moths captured by the sticky surface.

Despite the fact that the traps were deployed during a period when male DWB were captured in pheromone traps and fresh pupal cases were collected from the same orchards, no DWB moths were captured. Based on the negative results of this and the previous experiment, we conclude that we do not sufficiently understand the behaviors and stimuli involved in DWB host plant and oviposition site location to use these approaches to measure the orientation of DWB to apple burrknots under field conditions.

Comparison of Commercially-Available Pheromone Lures. Based on published and unpublished reports that the Lilac borer (LB) lure manufactured by Trécé was the most attractive lure for capturing male DWB in VA and WV, we began our flight monitoring using that product. Two Pherocon 1C traps were deployed in each of four orchards (2 in VA, 2 in WV) beginning May 12-15. Traps were checked weekly and DWB males were counted. Although fresh pupal cases were being found in the orchards, no DWB males were captured during the first weeks of the test, prompting the inclusion of other lures in the study. In VA, two traps baited with the Scenturion DWB lure were deployed at each orchard beginning on June 4, while in WV orchards, two traps baited with the Trécé DWB lure were introduced beginning on June 25.

During the period when both lures were deployed in the orchards, traps baited with the Scenturion DWB lure captured significantly more DWB than those baited with the Trécé LB at both the Snapp and Swing orchards in VA (Table 1). In WV, the Trécé LB lure captured significantly more moths than the Trécé DWB lure at the WVU Research station orchard but not at the Darkesville orchard.

Table 1. Comparison of clearwing borer lures for capturing male dogwood borer moths in four apple orchards in Virginia and West Virginia, 2001.

	Mean (± SD) no. DWB males/week (2 traps/lure type/orchard)		
	Scenturion dogwood borer	Trécé lilac borer	Trécé dogwood borer
Snapp, VA	12.3 ± 8.2 a	2.0 ± 3.0 b	
Swing, VA	5.0 ± 2.2 a	0.0 b	
WVU Station, WVA		1.2 ± 1.3 a	0.3 ± 0.7 b
Darkesville, WVA		1.5 ± 2.2 a	1.1 ± 1.7 a

Although these data do show differences in the relative attractiveness of the three lures tested, we consider them preliminary and it is not our intention to recommend one lure type over another, especially since the three lures were not tested simultaneously in the same orchards. However, given that previous reports have also shown differences in the relative attractiveness of lures for trapping DWB, our data highlight the need for further work on attractants for this species. Ideally, this research should combine field and flight tunnel studies involving examination of the effects of isomeric blends and concentration of the sex attractant, using calling virgin females or extracts of female pheromone glands as a standard. Bergh and Leskey (unpublished data) captured 19 DB males in <24 h in a single virgin female baited trap, but only average of 7.5 males (range = 7-8) in two traps baited with the Scenturion DWB lure.

Seasonal phenology, pupal case/trap catch relationship, and sex ratio. The number of pupal cases found on 20 trees/orchard in Virginia and 12 trees/orchard in West Virginia was recorded weekly from the same orchards described above. Counts were made from the same trees each week, at the same time that males in traps were counted. All pupal cases were removed from the trees and brought to the laboratory for gender determination. Female DWB pupae have four rows of spines on their terminal, fused abdominal segments, whereas male pupae have three rows (Leskey, unpublished data). Simple linear regression was used to develop the relationship between the number of males captured per week and the number of fresh pupal cases found.

Both male and female pupal cases were collected from apple burr knot tissue from May through October, suggesting that mating and oviposition can occur in the orchards throughout most of that period (Fig. 1).

Contrary to the results of studies from VA, TN and KY, the capture of male DWB in pheromone traps did not show a consistent bimodal flight among the four orchards in 2001 (Fig. 2), although early in the season the trap catch was probably adversely affected by the pheromone lures deployed. Our data also conflict with previous conclusions that early and later flight peaks of DWB consist predominantly of moths emerging from dogwood and apple, respectively. We found fresh pupal cases on apple trees throughout the season (Table 2), and there was no indication that moths emerging from other host plants contributed disproportionately to the flight at any point in the season.

Table 2. Monthly percentages of the total number of DWB pupal cases collected in 2001 from apple trees in Virginia (N = 20 trees/orchard) and West Virginia (N = 12 trees/orchard), 2001.

	Snapp, VA (n = 43 cases)	Swing, VA (n = 61 cases)	WVU station, WV (n = 49 cases)	Darkesville, WV (n = 9 cases)
May	28	10	6	0
June	21	34	20	0
July	16	31	39	67
August	19	21	24	22
September	14	2	10	11
October	2	2	0	0

Contrary to the results of studies from New York and Ontario, the relationship between the abundance of pupal cases and the number of males trapped in the four orchards ranged from weak to nonexistent (Table 3). Given that the two previous studies occurred in more northern locations, where DWB shows a unimodal flight pattern with a distinct peak in July, the differences between those studies and ours might be explained by a more synchronous emergence of moths in New York and Ontario than in Virginia and West Virginia.

Table 3. Coefficients of determination for the relationship between pupal case or adult abundance and the capture of male DWB in pheromone traps.

Authors	Year and location of research	Relationship Adult emergence vs trap catch	Pupal cases vs trap catch
Warner and Hay	1983, Ontario	$r^2 = 0.781$	
Riedl et al.	1982, New York	$r^2 = 0.679$	
	1983, New York		$r^2 = 0.337$
	1984, New York		$r^2 = 0.679$
Bergh	2001, Snapp, Virginia		$r^2 = 0.029$
	2001, Swing, Virginia		$r^2 = 0.001$
Leskey and Wright	2001, WVU Research Stn, WVA		$r^2 = 0.148$
	2001, Darkesville, WVA		$r^2 = 0.319$

Larval instar distribution. DB larvae were excavated from burr knot tissue at the Snapp orchard in VA in December, 2000. Thereafter, larvae were collected at monthly intervals, beginning on July 23, 2001, from 10 trees/orchard in the Snapp and Swing orchards. Head capsule widths of all larvae were measured and instar determinations were based on published measurements.

In December 2000, all instars were present but instars 3 through 6 predominated (Fig. 3), in general agreement with the results of a survey conducted in New York in April. Monthly surveys from July through October showed a clear progression of larval development. Only late instars and a single pupa were found in samples collected in late July. By late August, first instar larvae were found and more pupae were collected than in July. In September, all larval instars were represented and no pupae were found. The October sample consisted of larval instars 3 through 6, with no pupae.

Our data raise questions about the voltinism of DB in this region and we suggest the following scenario as being a possibility. Given the range of instars of overwintering larvae, completion of that generation would presumably occur in May, June and July. Female moths were present and presumably mating and ovipositing in May and June, as indicated by the gender of pupal cases, and their progeny were represented as the later instars and pupae found in the July and August samples. Emergence of adults from eggs deposited in the spring occurred in late July, August and September and oviposition by females of that generation was reflected in the presence of early instars in the August and September samples. Although these data are preliminary, we suggest that DB completes two generations in this region in a 12-month period and therefore, by definition, is bivoltine in this area. However, before we can unequivocally conclude bivoltinism in Virginia and West Virginia, the developmental rate of DB on apple and other host plants must be quantified. Furthermore, examination of the distribution of larval instars at regular intervals over a 12-month period will further illuminate the number of generations that DB can complete in this area.

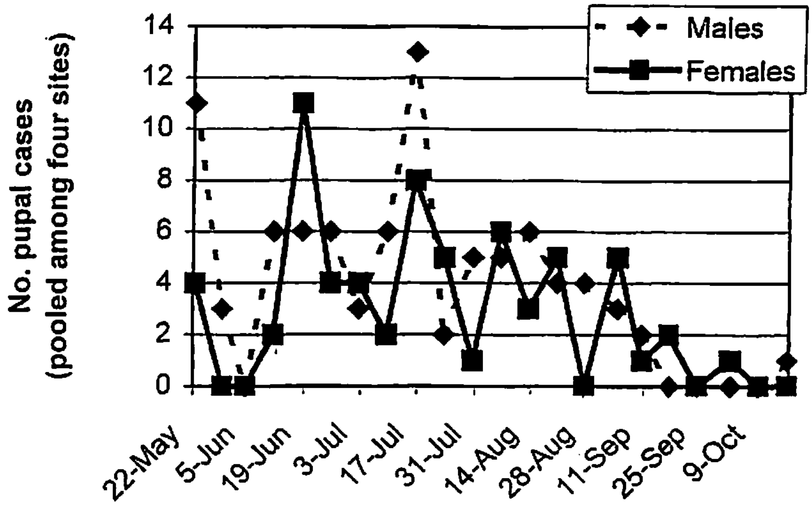

Fig. 1. Number of male and female DWB pupal cases collected at weekly intervals from apple burrknot tissue in orchards in Virginia and West Virginia, 2001.

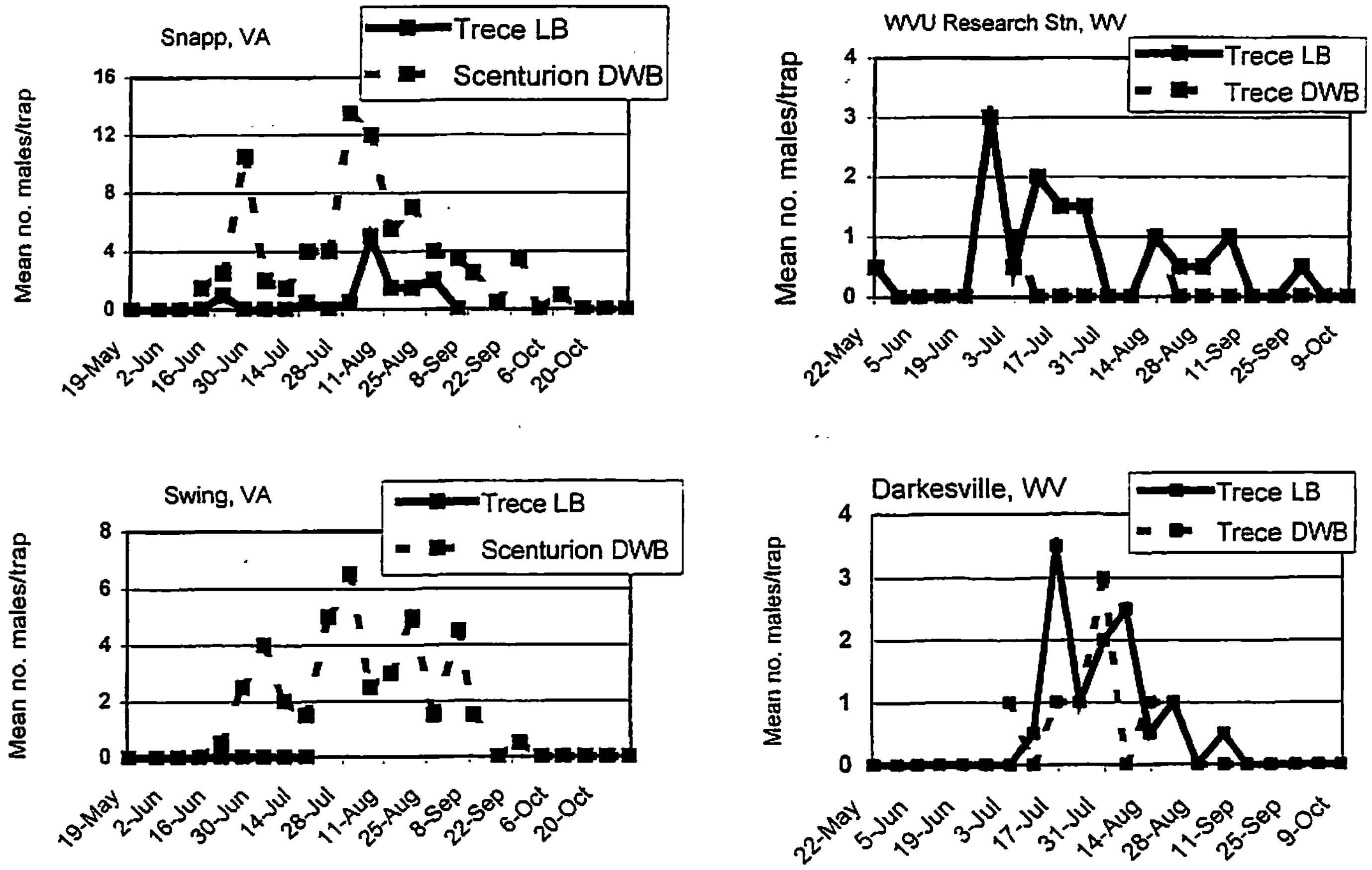

Fig. 2. The number of DWB males captured in traps baited with different pheromone lures in apple orchards in Virginia and West Virginia, 2001.

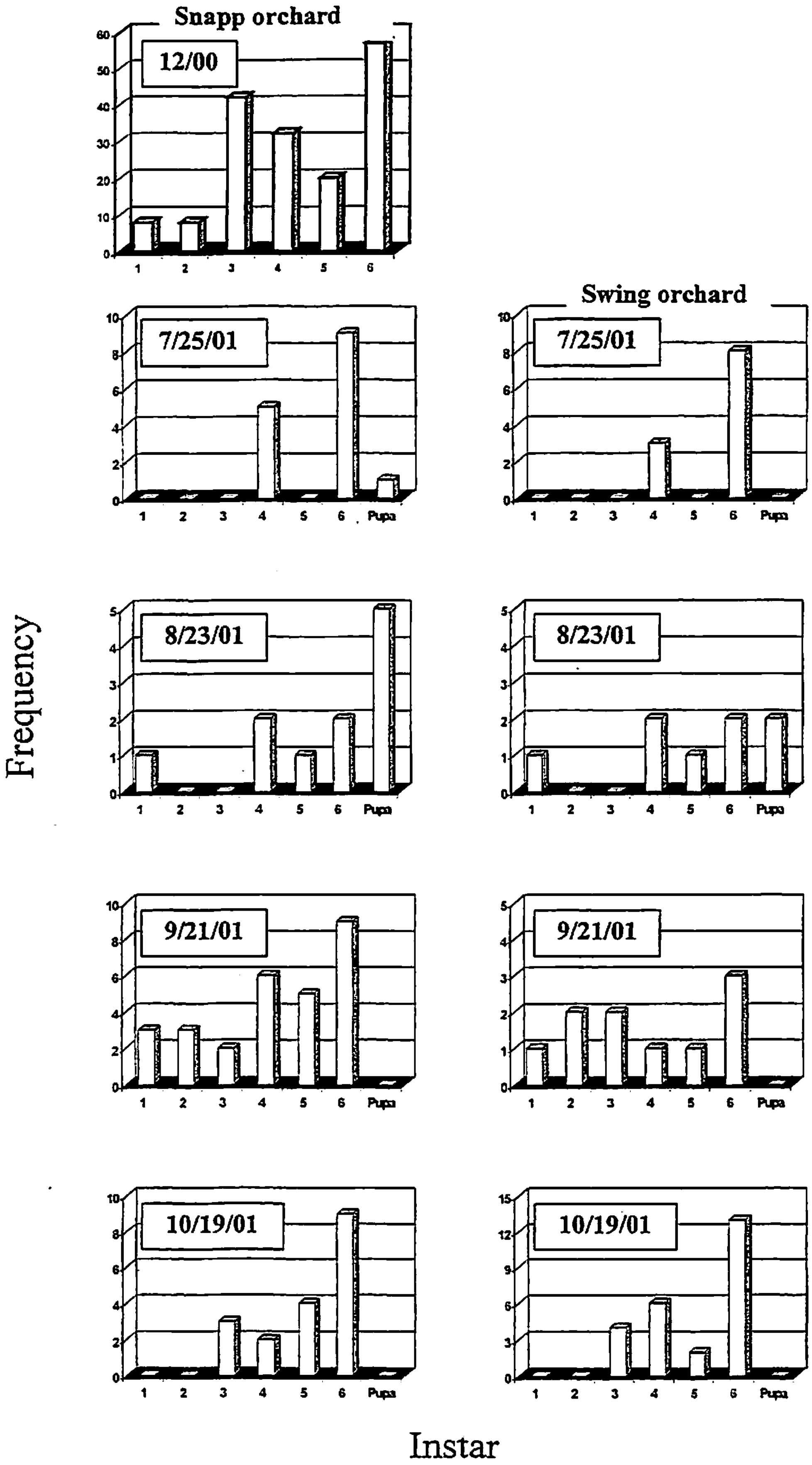

Fig. 3. Temporal changes in the frequency distribution of larval instars of DWB collected from burrknot tissue from apple trees in commercial nurseries in Virginia.

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Rearing Methods for the Dogwood Borer, *Synanthedon scitula* (Harris)

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The dogwood borer (DWB), *Synanthedon scitula* Harris, is becoming an increasingly important economic pest in commercial apple orchards due in large part to increased plantings of apple trees on size-controlling rootstocks that promote the formation of burr knots near the graft union and elsewhere on the scion. Burr knot tissue serves as an oviposition site for host-seeking female DWB and a feeding site for DWB larvae. Trees heavily infested with larvae exhibit reduced growth, yellowing of foliage, reduced yields, and even death if larvae girdle the tree. Furthermore, review of chemical tolerances as dictated by the Food Quality Protection Act (FQPA) has made continued availability of the most effective insecticide for controlling dogwood borer (chlorpyrifos) uncertain.

Our short-term projects focus on assessments of male DWB to various lures available for monitoring, studies of DWB mating behavior, DWB responses to plant-derived olfactory cues, and studies of the basic biology of DWB in apple. The unified goal of these projects is to gain a deeper understanding of mate- and host-finding behavior of DWB in order to improve upon existing monitoring strategies and explore the potential for semiochemically based management strategies based on female-produced sex pheromones, mating disruption, and "attract-and-kill" strategies. Given the short- and long-term project goals, in 2001 we began development of methodologies for rearing and maintenance of DWB in the laboratory.

Although laboratory rearing methods exist for related species peachtree borer, *S. exitiosa*, and lesser peachtree borer, *S. pictipes*, there are no published reports of success in rearing DWB. Several authors have reported anecdotal accounts of attempts to mate DWB in captivity, but copulation was never observed. In 2000-2001, we attempted to standardize rearing procedures at each stage of the following steps: field larval collections, larval development, pupation, mating, oviposition, egg hatch, and development of first instar larvae.

Field collection of DWB larvae is straightforward but time consuming—larvae are carefully extracted by hand from infested burrknots and returned to the laboratory. In a typically infested, untreated plot, a single person may expect to collect 60-80 viable larvae in a day. Using field-collected larvae, we tested four basic types of diet: bean-based Lepidoptera diet, ground burrknot tissue, combined Lepidoptera diet and burrknot tissue, and apple bark strips. In these trials, bean-based diets were most consistent in sustaining larval development through adult emergence. However, the high water content of commercially available diets is not ideal for rearing of burrowing larvae, especially younger instars. Introduction of ground, unsterilized burrknot tissue commonly led to fungal development, reducing larval survivorship as well.

Our first attempt toward controlled mating of lab-reared female DWB was a field-based, passive system requiring containment of a virgin DWB. Individual DWB females were held in a small container attached to a funnel-style trap, allowing release of natural pheromone and entry of mate-seeking male DWB. Although we did have limited success using this system, a tendency toward female escape rendered it unreliable. In lab-based mating trials, we observed no matings in small containment devices such as 500 ml paper cups and small screen or glass cages. However, in large devices, such as a 96 inch x 24 inch x 24 inch flight tunnel, mating reliably occurred within several hours after introduction of a single male and single female DWB (both aged 2-4 days). Mated pairs typically remained *in copula* for 2-4 hours, after which female DWB cease expression of calling behavior.

Using mated females, we tested five potential oviposition substrates: bean-based Lepidoptera diet; ground, compressed burrknot tissue; whole, uninfested burrknots, moistened cotton wick; and empty plastic diet cups. From 2-6 days after mating, female DWB regularly deposited eggs (20-60 per day, to a maximum observed of 221) on any of the substrates tested. After deposition, eggs were transferred (with a probe) from oviposition cups to clean diet. Unfortunately, we were unable to achieve hatch of any of the transferred eggs, due either to the characteristics of the final substrate (Lepidoptera diet) or damage from handling of eggs during transfer. In a separate trial, however, we did observe hatch of and successful larval development from eggs laid on sections of carrot by a field-mated female DWB, leading us to believe that eggs from lab-mated females were fertile, but improperly handled and/or contained.

Through these trials, we have achieved some success in each step of laboratory rearing of DWB (mating, oviposition, egg hatch, larval development, pupation, and adult emergence). However, we have yet to develop a complete, reliable, lab-based rearing methodology. In future studies, we will perform replicated studies to determine conditions and handling procedures that are favorable for maintaining a DWB colony, and integrate lab-reared DWB into lab- and field-based trials of alternative strategies for DWB monitoring and control.

BORER PROBLEMS AND THEIR CONTROL IN DWARF APPLE TREES
UPDATE 2001

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Plantings of apple trees on dwarfing rootstocks, that have a tendency to develop burrknots, have become more common in recent years. As a result, damage caused by dogwood borer and American plum borer (that we have identified as the prevalent borer pest of tart cherries in western New York, and that are now invading burrknots on apple trees) seems also to be becoming more common. (Table 1)

Table 1. Incidence of trunk borers in New York apple orchards, 1999-2001.

Location	Block	Proportion w/burrknots	Proportion infested	Average damage rating*	Larvae per 10 infested trees DWB	Larvae per 10 infested trees APB	Mouseguards	Stone fruit w/in 0.5 mile
Wayne Co.	1	0.66	0.58	0.61	7	0	No	No
Wayne Co.	2	0.68	0.76	1.26	12	0	No	No
Wayne Co.	3	0.94	0.94	2.64	12	12	No	Yes
Wayne Co.	4	0.82	0.46	0.63	0	15	Yes	Yes
Wayne Co.	5	0.98	0.94	2.18	9	7	Yes	Yes
Wayne Co.	6	0.78	0.56	1.56	15	2	Yes	Yes
Wayne Co.	7	0.30	0.00	0.00	0	0	Yes	Yes
Wayne Co.	8	0.52	0.27	0.50	6	0	Yes	No
Wayne Co.	9	0.78	0.62	1.44	17	0	No	Yes
Wayne Co.	10	0.88	0.16	0.43	8	1	No	Yes
Champlain	1	0.52	0.00	0.50	0	0	Yes	No
Champlain	2	0.50	0.15	0.15	1	0	Yes	No
Champlain	3	0.52	0.34	1.18	3	0	Yes	No
Champlain	4	0.28	0.00	0.69	0	0	No	No
Orleans	1	0.60	0.23	1.46	1	7	No	Yes
Orleans	2	0.90	0.05	0.27	2	1	No	No
HV	1	0.38	0.50	1.35	10	0	No	No
HV	2	0.40	0.23	0.61	8	0	Yes	No
HV	3	0.32	0.42	1.00	6	0	No	No
HV	4	0.40	0.16	0.30	9	0	No	No
HV	5	0.18	0.08	0.12	1	0	No	No
HV	6	0.48	0.18	0.48	9	0	No	No
HV	7	0.62	0.23	0.73	10	0	No	No
HV	8	0.44	0.20	0.45	11	0	No	No
Albany	1	0.80	0.58	1.13	12	0	No	Yes
Albany	2	0.38	0.11	0.26	4	0	Yes (on 1/2)	Yes
Albany	3	0.68	0.35	1.56	13	0	No	No
Albany	4	0.48	0.00	0.38	0	0	No	No

* Damage rating: 0 = none; 1 = burrknot feeding only, < 50% consumed; 2 = burrknot feeding only, > 50% consumed; 3 = feeding outside burrknot, < 25% trunk girdled; 4 = feeding outside burrknot, 25–50% trunk girdled; feeding outside burrknot, > 50% trunk girdled

Our survey results, which are from orchards on dwarfing rootstocks only, indicate that the proportion of trees in an orchard on dwarfing rootstock, and the proportion of those trees that are infested by borers, has remained about the same since a similar survey was conducted in New York in the early 1980's. (Riedl, et al 1985) The perception that borer problems have increased is probably because the acreage of apple trees on susceptible dwarfing rootstocks has increased. (by about 25% from 1985 to 1996) (Schooley 1990, 1996) Therefore, the proportion of trees on a farm or statewide that are infested has probably increased. This survey also indicates that: 1) Borers are more evident in trees with mousegaurds, especially the plastic spiral type. 2) While American plum borer can be prevalent in orchards that are near infested stone fruit trees, dogwood borer is more commonly found throughout the state.

Both insects overwinter inside bark as larvae. Dogwood borer begins flying in late-June. Cornell Pest Management Guidelines for Commercial Tree-Fruit Production for 2000 suggested one application of Lorsban 50WP sometime between July 15 and August 15, or two applications of Thiodan, one in early-July and one in early-August, for dogwood borer control. American plum borer has two generations per year. Eggs of the first are being laid from mid-May to mid-June. The second generation begins in mid-July. The 2000 dogwood borer control recommendation would have led to the first generation of American plum borer going uncontrolled if it was present. Lorsban is very effective against both pests if applied at the right time. To determine the best borer control strategy for both pests in apple, we conducted trials in 2000 to evaluate the efficacy of different timings of Lorsban 50 WP sprays. In 2001, because of the threat of losing postbloom use of Lorsban, we evaluated Lorsban 4EC applied prebloom, in addition to some other strategies.

Results in 2000 suggested that Lorsban applied at petal fall, which was much earlier than previously recommended, would control both borers season-long. In addition, it was apparent that the insecticide penetrated the burrknot and killed larvae concealed within, preventing early-season feeding by dogwood borer that would have gone unchecked using the conventional timing for this pest. During 2001 we evaluated prebloom application of Lorsban 4EC at half-inch green and at pink. We did not find enough American plum borer larvae to evaluate efficacy against them, so results given are from an orchard where only dogwood borers were present. Prebloom sprays appeared to be the superior treatments in early (late-June) evaluations because they controlled overwintered larvae before they began spring feeding, as evidenced by decreased production of frass. (Table 3)

Table 2. Efficacy of insecticides and white paint against borers infesting apple in upstate NY, 2001. Wafler, June evaluation.

Treatment	% trees infested	Mean No. DWB larvae/tree
Lorsban 4EC (3 qt/100) @ HIG	6.7 a	0.03 a
Lorsban 4EC (3 qt/100) + paint (1 part paint: 2 parts water) @ HIG	13.3 a	0.17 ab
Lorsban 4EC (3 qt/100) @ Pink	16.7 a	0.03 a
Lorsban 4EC (3 qt/100) @ PF	50.0 b	0.20 ab
Avaunt 30WG (6 oz/100) @ PF	50.0 b	0.40 bc
Avaunt 30WG (6 oz/100) @ PF + July	60.0 bc	0.70 cd
Endosulfan 3EC (1 qt/100) @ PF + July + August	63.3 bc	0.67 cd
Paint alone (1 part paint: 2 parts water) @ HIG	63.3 bc	0.67 cd
Untreated	76.7 c	0.90 d

Means followed by the same letter are not significantly different ($P < 0.001$). n=10

In the late September evaluation (Table 4), the petal fall Lorsban application was equal to, and maybe a little better than the earlier Lorsban applications, indicating that Lorsban applied prebloom may be beginning to lose some of its effectiveness by mid-July, when the dogwood borer flight peaks. However, the addition of paint to Lorsban at half-inch green appears to have extended the duration of Lorsban activity from that early application. All treatments were better than the check, in terms of both the proportion of trees infested and the number of larvae, but Lorsban treatments were superior to all others. Efficacy of Avaunt applied at petal fall and again in mid-July was intermediate.

Table 3. Efficacy of insecticides and white paint against borers infesting apple in upstate NY, 2001. Wafler, September 11 evaluation.

Treatment	% trees infested	Mean No. DWB larvae/tree
Lorsban 4EC (3 qt/100) @ HIG	6.7 ab	0.07 a
Lorsban 4EC (3 qt/100) + paint (1 part paint: 2 parts water) @ HIG	3.3 a	0.03 a
Lorsban 4EC (3 qt/100) @ Pink	13.3 ab	0.13 a
Lorsban 4EC (3 qt/100) @ PF	3.3 a	0.03 a
Avaunt 30WG (6 oz/100) @ PF	40.0 cd	0.50 bc
Avaunt 30WG (6 oz/100) @ PF + July	23.3 bc	0.23 ab
Endosulfan 3EC (1 qt/100) @ PF + July + August	33.3 cd	0.43 bc
Paint alone (1 part paint: 2 parts water) @ HIG	46.7 d	0.53 c
Untreated	76.7 e	0.90 d

Means followed by the same letter are not significantly different ($P < 0.001$). n=10

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COMPARISON OF INSECTICIDES FOR APPLE MAGGOT CONTROL

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A western New York apple orchard which has been in organic production for several years was selected for use in this trial because high levels of apple maggot and internal lepidoptera damage were observed in fruit harvested during the previous season. Dilute to runoff sprays were applied with a hand gun sprayer (450 psi) on either a weekly or bi-weekly basis depending on the material used. The Spinosad volatile bait was applied with a MeterJet™ spray gun (Model 2362, Spraying Systems Company, North Avenue, Wheaton Illinois 60188) connected to a CO^2 backpack sprayer at 40 psi. All applications were started several days after the first flies were captured on monitoring traps in the orchard on 6 Jul and continued on 12 Jul, 19 Jul, 26 Jul, 1 Aug, 9 Aug. 18 Aug and 21 Aug. Treatments were replicated four times and included an untreated check on single 'Cortland' trees and arranged in a RCB design. Treatments were separated with unsprayed buffer trees within each row. Red sphere traps with volatile bait were hung in each of the check treatments, as well as in one tree, two rows to the west of the test rows. Traps were checked on a weekly basis and cumulative counts were recorded throughout the season. Fruit was harvested on 29 Aug by randomly selecting 200 fruit per tree in each replication. Damage from AM as well as internal lepidoptera was taken upon fruit inspection and were subjected to an AOV with SuperAnova (Abacus concepts). Means were separated with Fisher's Protected LSD Test ($P<0.05$). Data was transformed Arcsin (Sqrt X) prior to analysis.

Guthion 50 (8.0 oz. form/100), Actara 25W (0.46 oz form/100), Calypso 4F (1.0 oz form/100) and Avaunt 30WG (1.9 oz form/100) were applied on a bi-weekly schedule. Surround WP (25 lbs. form/100), Aza-Direct EC (11.0 oz form/100), Spintor 2SC (2.5 oz form/100) and Spinosad Volatile Bait (32 ml form/tree) were applied each week throughout the season. The Spinosad Volatile Bait was applied with the metered sprayer in 8.0 ml aliquots. One aliquot was applied to each of the 4 directional quadrants of the outside of the tree canopy.

AM and internal lepidoptera pressure in the test orchard was extremely high as indicated by the damage levels found in the untreated check plots and by high trap catches of flies throughout the season. The grower standard material of Guthion gave excellent control of both pests with less than 0.5% AM and internal lepidoptera damage. The weekly application of Surround also provided excellent control of AM damage (0.0%). The exact mode of action of this material against AM is not known. However, the coverage of kaolin reduces visual stimuli, and may affect the ability of the flies to recognize and orient to apples. Also, the buildup of clay on the apple may act as a deterrent to females attempting to oviposit. Surround was also quite effective in controlling damage from internal lepidoptera. The other organically approved material in this test, Aza-Direct, was not effective in reducing AM damage, but did significantly reduce damage from internal lepidoptera. Avaunt, Actara ,Spintor, and the Spintor bait all were relatively ineffective in preventing apple maggot damage. However, Avaunt and Spintor were quite effective against internal lepidoptera. Actara also significantly reduced damage from internal lepidoptera, although it was not as effective as Avaunt and Spintor. Calypso was the only non-organophosphate material that controlled both AM and internal lepidoptera, although it was not as effective against lepidoptera as the Guthion standard.

APPLE: COMPARISON OF INSECTICIDES FOR APPLE MAGGOT CONTROL 2001

Table 1. Fruit Damage

Material	Rate form/100	Timing	Mean % Fruit damage Apple Maggot	 Internal Lep.	% Clean
Surround WP	25 lb.	Weekly	0.0 a	3.5 c	96.4 c
Avaunt 30WG	1.9 oz	Bi-weekly	40.1 c	2.9 c	57.9 ab
Calypso 4F	1.0 oz	Bi-weekly	2.5 a	2.0 bc	93.4 c
Aza-Direct EC	11.0 oz	Weekly	42.0 c	6.9 d	51.6 a
Actara 25W	0.46 oz	Bi-weekly	18.0 b	6.9 e	70.0 b
Spintor 2SC	2.5 oz	Weekly	28.1 bc	1.1 ab	71.5 b
Spinosad Bait	32.0 ml*	Weekly	34.3 bc	15.8 ef	51.6 a
Guthion 50	8.0 oz.	Bi-weekly	0.4 a	0.4 a	98.5 c
Untreated Check			35.1 bc	20.1 f	47.4 a

*-applied @ 32.0 ml/tree with CO^2 backpack sprayer
Means within a column followed by the same letter are not significantly different (Fisher's Protected LSD Test, P<0.05). Data transformed Arcsin (Sqrt X) prior to analysis.

Table 2. Trap Catch

Date	# of traps	# of flies
6 Jul	5	8
12 Jul	5	12
19 Jul	5	36
26 Jul	5	190
1 Aug	5	196
9 Aug	5	183
13 Aug	5	41
21 Aug	5	13

Traps placed in each check tree (4) and two rows to west (1) of test rows on 29 Jun.

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EVALUATION OF A SUSTAINABLE ORGANIC INSECTICIDE PROGRAM

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In an effort to evaluate current organically approved insecticides, a field trial was established to compare two programs on a season long basis in a commercial organic setting. Treatments were evaluated in a western New York apple orchard that has been certified for organic production. Sprays were applied by the grower with a FMC airblast sprayer (300 psi) using 100 GPA. Applications of insecticides started at petal fall (5 May) and continued until the final cover spray (14 Aug). The orchard was divided into two treatments: 1) Surround WP (50.0 lbs. form/A) applied weekly for all sprays between petal fall (5 May) and the last application on 14 August (13 applications); 2) Surround WP (50.0 lbs. form/A) applied weekly for five applications followed by Aza-Direct EC (32.0 oz form/A) applied on 18 June and continued weekly for the remainder of the cover sprays until 14 August (8 applications). Because this was a commercial operation, the entire orchard was sprayed and treatments were not replicated. In the treatment of Surround and Aza-Direct, Surround was used early in the season at petal fall and in early cover sprays to control the plum cucurlio and the first generation of internal lepidoptera species. Aza-Direct cover sprays were applied later in the season after the accumulation of 340DD (Base 50°) after petal fall, after which PC oviposition is predicted to be over. The late season Aza-Direct sprays were targeted against later generations of internal lepidoptera, the obliquebanded leafroller, and apple maggots. Harvest evaluations were conducted by randomly selecting 500 'Delicious' fruit (100 apples from each of 5 trees) on 10 September from each treatment and inspecting them for damage. Data was subjected to an AOV by SuperAnova (Abacus concepts, Fisher's Protected LSD Test P<0.05 and transformed Arcsin (Sqrt X) prior to analysis). Economic aspects, such as the cost of these materials, marketability of the fruit, and labor costs were also analyzed in this project. Also in this orchard, two rows of 'Cortland' apples were excluded from these treatments and put into another trial to test the efficacy of handgun applications of Surround and Aza-Direct against AM and the later season generations of the complex of internal lepidoptera (OFM, CM and LAW). These applications were made with a high-pressure handgun sprayer (450 psi).

The Surround only program was significantly more effective in controlling internal lepidoptera and had a higher percentage of clean fruit than the combination program of Surround and Aza-Direct (Table 1). Damage from other pests was not significantly different between the two treatments (Table 1). The higher percentage of clean fruit in the Surround only treatment was due to improved control of internal lepidoptera and plum curculio, since damage from other pests in the two treatments was similar. The late season handgun sprays of both Surround and Aza-direct were significantly more effective in controlling internal lepidoptera than the airblast treatments (Table 2). The handgun sprays of Surround were also significantly more effective in controlling apple maggot than the airblast sprays. The Aza-direct handgun sprays were not effective in controlling apple maggot in the sprayed 'Cortland' trees, but maggot damage in the 'Delicious' apples treated with airblast sprays was significantly lower than that in the handgun plots. It is unlikely that the lower damage level in the Aza-Direct airblast treatments was due to the effectiveness of the sprayer, since most studies conducted in the past have shown that handgun sprayers provide more complete coverage than airblast sprayers. Therefore, these differences between the apple maggot damage levels in the different application methods of Aza-Direct were probably largely due to differences in apple maggot infestation levels in the two apple cultivars. 'Cortland' apples, which had the highest apple maggot infestation levels in the handgun Aza-Direct sprays (42%) are generally considered to be more susceptible to apple maggot than 'Delicious' apples

In this study, less than half of the harvested fruit was free from insect damage in trees treated with a conventional airblast sprayer. Although there were no unsprayed check trees left in the orchard to estimate insect pest population levels, observed damage levels and evaluations of harvested fruit taken from the orchard in previous years indicate that indigenous pest pressure within this orchard is very high. Obviously, it is very difficult to protect fruit in heavily infested orchards with available materials certified for use in organic programs. These two materials evaluated in this study are probably some of the best insecticides currently available to growers opting to appeal to an organic market. Application technology for these particular products has not yet been perfected, but this study has shown that handgun spraying results in substantially better control of control of two key direct pests of apples, the apple maggot and plum curculio, particularly with Surround. Although handgun applications were not evaluated in this study against the plum curculio, previous studies conducted in a heavily infested research orchard at the New York State Agricultural Experiment Station have shown that handgun sprays of Surround were very effective against all direct fruit feeding insects, including the plum curculio. Therefore, applying sprays of Surround with a handgun may be a viable option for growers seeking to increase the amount of insect free fruit their organic orchards.

Identification of adequate markets for fresh organic apples in the Northeast is another challenge for organic producers. Most organic fruit is sold in this region for processing, and there are small niche markets that have limited amounts of fresh fruit. However, organic apples are usually sold at prices 2-3 times higher than conventionally grown apples. By increasing the percentage of clean fruit the grower also increases his profit margin, but this may still not be enough to make this system economically feasible.

These organically approved insecticides are about five to six times more expensive than conventional products (Table 3). Also, more frequent, weekly applications are required and labor costs for these treatments, especially if handguns are used, are very expensive. These high labor costs for organic production not only apply to pesticide applications, but also to hand thinning, hand weeding, and harvesting. Other inputs such as increased fuel, water, and wear on equipment should also be considered.

Organic production does have positive effects as well. If the quality of fruit is high enough, the price that it fetches may cover the input costs and still make a profit for the grower. Competition for the organic market is small and consumers concerned about the pesticides being used for conventional growing are probably willing to pay considerably more for certified organic products. This increased interest by both the grower and consumer then prompts not only the apple industry, but also researchers to develop better materials and techniques. Also, most of the organically certified materials tend to be "softer" and offer more of an opportunity for biological control, even further reducing the amount pesticides needed.

Because of the complexities associated with organic production systems, a grower must be completely prepared to make a substantial investment to enter into this market. The increasing interest of organic consumers has had an effect on the number of farmers attempting to grow organic produce. With the development of more efficient materials and techniques, producing a high quality certified organic product may be possible. However, consumers willing to pay premium prices for this type of produce will be the driving factor behind future organic markets.

APPLE, EVALUATION OF A SUSTAINABLE ORGANIC INSECTICIDE PROGRAM, 2001

Table 1. Fruit Damage

	Mean % Fruit Damage	
	Surround	Surround/Aza-Direct
Internal Lepidoptera	20.4 a	34.0 b
Spring OBLR	0.2 a	0.4 a
Summer OBLR	5.0 a	8.0 a
Apple maggot	9.0 a	3.6 a
Plum cucurlio	25.4 a	32.8 a
Tarnished plant bug	0.4 a	0.8 a
Clean	44.6 b	29.2 a

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

Table 2. Handgun vs. Airblast Treatments

	% Internal Lepidoptera	% Apple Maggot
Surround Handgun*	3.5 a	0.0 a
Aza-Direct Hangun*	6.9 a	42.0 c
Surround Airblst**	20.4 b	9.0 b
Aza-Direct Airblast**	34.0 c	3.6 ab

* - Data taken from 'Cortland' trees

** - Data taken from 'Delicious' trees

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

Table 3. Pesticide Cost Analysis

Material	Rate/A	Cost	Cost/A/Application	Cost/A/Season
Guthion 50	1.5 lbs./A	$8.13 lb.*	$12.20	$85.40 (7 applications)
Surround WP	50.0 lbs./A	$0.65/lb.*	$32.50	$422.50 (13 applications)
Aza-Direct EC	32.0 oz/A	$1.48/oz*	$47.36	$615.68 (13 applications)

*- Prices quoted from UAP Northeast 10/19/01

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Influence of Competition from Host Trees on Plum Curculio Responses to Baited Traps

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Introduction

The plum curculio (PC), *Conotrachelus nenuphar* is a major pest of both apples and peaches in the mid-Atlantic region. Currently, the organophosphate insecticides (OPs) azinphosmethyl and phosmet, and to a lesser degree the synthetic pyrethroids (SPs) permethrin and esfenvalerate, are the only labeled materials that provide a commercially acceptable level of PC control, although several new materials, notably thiamethoxam and indoxacarb (on apples) and kaolin clay (on apples and peaches) have recently been labeled for use against PC. In the mid-Atlantic region, plum curculio is generally managed by OP or SP sprays directed at the lepidopteran pest complex on apple or the lepidopteran/hemipteran complex on peach. However, limited-spectrum strategies and chemistries have begun to supplant seamless applications of OPs and SPs for control of key insect pests in both crops. As reliance on OPs and SPs is alleviated, it is likely that secondary pests (such as PC in the mid-Atlantic) will emerge as an increasing annual threat. In order to effectively manage PC in a narrow-spectrum, reduced-spray environment, it is imperative that treatments for PC be triggered by detection of increases in PC abundance or activity. Aside from inspecting fruit for evidence of fresh egglaying scars, which is particularly difficult on peaches, there exists no effective means for monitoring levels of PC activity in orchards.

Development of trapping systems for PC has been based on the behavioral understanding that most PCs overwinter as adults outside of commercial orchards and immigrate into orchards at or near petal fall. Given this, there are four basic trapping strategies as PC colonize commercial fruit trees: interception 1) before entering orchards; 2) after entering orchards, but before encountering host trees; 3) after encountering host trees, but before entering the canopy; and 4) after entering the canopy. For several years, researchers in New England, Michigan, and other regions have developed visual, olfactory, and combination visual/olfactory systems designed to capture PCs for monitoring purposes at these four transition points. In this study, our intent was to advance development of an effective trap-based monitoring system for mid-Atlantic PCs through assessment of trapping protocols used to date in other regions and identification of potential shortcomings of current trapping strategies.

Assessment of Current Trapping Protocols

Materials and Methods

In this trial, traps were deployed to capture immigrating PCs at each of the four transition points described above. Each plot consisted of at least 32 border-row apple trees (four plots of six trees and buffer trees between plots), replicated across three orchards. To intercept PCs before entering orchards, we placed six double-sided 24-inch sticky-coated Plexiglas squares, each mounted five feet above the ground on wooden posts. Two sets of panels were placed five meters deep in vegetation surrounding orchards, two sets were placed one meter from the terminus of surrounding vegetation, and two sets were placed between the first and second rows of orchard trees. Each panel trap set was baited with a 500 *u*g polyethylene vial of benzaldehyde and a 5 mg dispenser of synthetic male-produced PC aggregation pheromone (grandisoic acid). To intercept PCs after entering orchards but prior to encountering host trees, we placed eight 48-inch tall trunk-mimicking black pyramid traps immediately adjacent to border-row trees. To capture PCs after encountering host trees, but prior to entering the canopy, we affixed eight "Circle" traps consisting of folded aluminum screen and designed to capture PCs ascending trunks of host trees. To capture PCs after entering host trees, we deployed eight 12 inch by 2.5 inch black plastic branch-mimicking cylinder traps, designed to capture PCs foraging within tree canopies. For each of the latter three trap types (pyramid, Circle, and cylinder), four traps remained unbaited, while one of each trap type was baited with a polyethylene dispenser (10 *u*g odor release per day) of benzaldehyde, limonene, ethyl isovalerate (synthetic fruit volatiles), or a 5 mg dispenser of grandisoic acid. Beginning at bloom and twice weekly for eight weeks thereafter, we sampled each trap for captures of PCs and removed all detritus from traps. At each trap sampling date from petal fall through the close of the study (1½-inch fruit), we also sampled 20 fruit per trapped tree (a total of 480 fruit per orchard) for presence of PC egglaying scars.

Results and Discussion

Through the course of this study, we captured a total of 51 PCs across 90 traps. Pyramid traps captured the greatest number of PCs (1.04/trap), followed by Circle traps (0.46/trap), cylinder traps (0.38/trap), and panel traps (0.25/trap) (Table 1). In no case did traps baited with any of the four candidate olfactory attractants significantly outperform companion unbaited traps in terms of total captures. In terms of correlation between amount and timing of trap captures with amount and timing of fruit injury, no trap exceeded an r^2 value greater than 0.29; that is, none of the baited or unbaited traps tested here provided any clear correlation with the abundance or timing of PC activity in orchards. In fact, 82% of total PCs captured across all traps were captured at or before bloom (5/1), while injury to fruit was not detectable for an additional two weeks (Figure 1). In this study, we were able to detect an initial, major PC immigration through full pink, but traps lost nearly all ability to capture PCs after petal fall. Thus, we were unable to detect increases in PC abundance or activity at or near actual time of PC oviposition.

Influence of Competition from Host Trees

Materials and Methods

Given the phenology of PC trap captures in comparison with timing of fruit injury in the study described above, we hypothesized that natural odor sources present in orchards after petal fall were effectively able to outcompete visual and olfactory stimuli of synthetically baited traps. To determine the impact of competition from these natural sources of visual and olfactory stimuli on PC responses to baited traps, we conducted an experiment comparing relative recapture rates of marked/released PCs in traps placed within orchards with relative recapture rates in traps placed in an open field. For this trial, we established two 55 meter by 20 meter plots, one in an open field and one in a bearing apple orchard. Within each plot, we placed three circles of eight ground-mounted traps, alternating between pyramid traps (to capture crawling PCs) and panel traps (to capture flying PCs). Each plot contained one eight-trap circle at each of three diameters (20 meters, 10 meters, 5 meters) and a PC release device was placed at the center of each circle. One trap of each type within each circle was baited with one of the following candidate attractants: a) benzaldehyde alone; b) grandisoic acid alone; c) benzaldehyde plus grandisoic acid; and d) unbaited control. All odors were deployed in accordance with the field-use protocol described in the previous experiment, all dispensers were replaced, and traps were rotated clockwise to the next cardinal position at each PC release. For releases, PCs were collected from unsprayed host trees and marked with a small dot of enamel paint on their elytra as a color-code indicator of sex, site of release, and release replicate. We conducted four releases of 40 PC (20 male/20 female) per trap circle, and assessed trap captures and environmental conditions daily for four days following each release. In total, we marked and released 960 PCs.

Results and Discussion

In this trial, plots were designed to assess the influence of 3 factors on PC response to traps: 1) odor bait type, 2) distance from PC release point to traps, and 3) location of traps (orchard versus open field). We made no direct comparisons of pyramid traps versus panel traps, given that pyramid traps are principally effective when PCs are crawling while panel traps only capture flying PCs. For PCs, mode of movement is strongly influenced by environmental conditions which were recorded but not controlled in this experiment. Given that similarly baited pairs of traps were drawing from the same released PC population, coupled with the assumption that the impact of environmental conditions were equal across treatments, we pooled data across trap type (pyramid and panel) for each odor treatment within each subplot.

To assess the relative attractiveness of each odor bait within each subplot, we compared the percentage of released PCs recaptured per treatment, replicated by release interval. Although we found no significant differences between treatments for any subplot (Figure 2), the data suggest that at very close range (<2.5 m), the current formulations of benzaldehyde and grandisoic acid are attractive to released PCs. However, at mid (5.0 m) to long range (10.0 m), we found no trend toward greater recapture in baited versus unbaited traps.

Comparisons of effectiveness of similarly baited traps at close, mid, and long range (2.5 m, 5.0 m, and 10.0 m, respectively) partially confirm previous findings. Expectedly, traps at close range captured a greater proportion of released PCs (Figure 3). For traps placed in an open field and baited with either benzaldehyde alone or grandisoic acid alone, this difference was significant, indicating that traps baited with the current method of dispensing either benzaldehyde or grandisoic acid may only allow for attraction of PCs from very close range, even in the absence of competing olfactory stimuli.

In the presence of competing olfactory stimuli (as in a fruiting orchard), performance of every trap treatment was numerically (though not statistically) inferior to performance of identical traps placed in an open field. Figure 4A highlights these data; although no individual comparisons were statistically significant, there is a clear trend toward deterioration of effectiveness of baited traps in the presence of fruiting apple trees. Pooling data across statistically similar treatments (baits) clarifies the trend (Figure 4B): significantly more released PCs were recovered in the absence of natural olfactory stimuli at close to mid range (39.4% vs. 7.5% at 2.5 meters, 15.6% vs. 1.3% at 5.0 meters). At long range, recovery of PCs was statistically similar between field and orchard, though the numerical trend held (8.1% vs. 0.0% at 10.0 meters).

Figure 1. Phenology of captures of PCs in traps versus timing of fruit damage. At each sampling date, PC captures and fruit damage were pooled across replicate, bait, and trap type for ease of interpretation.

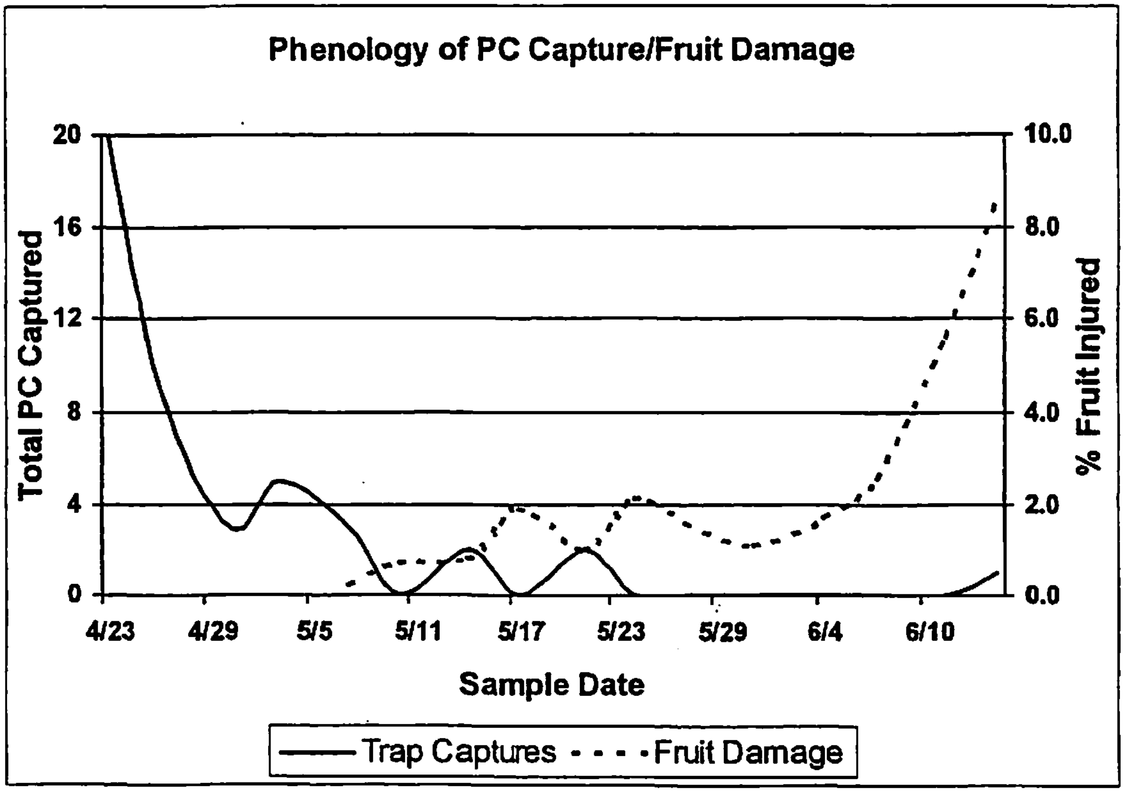
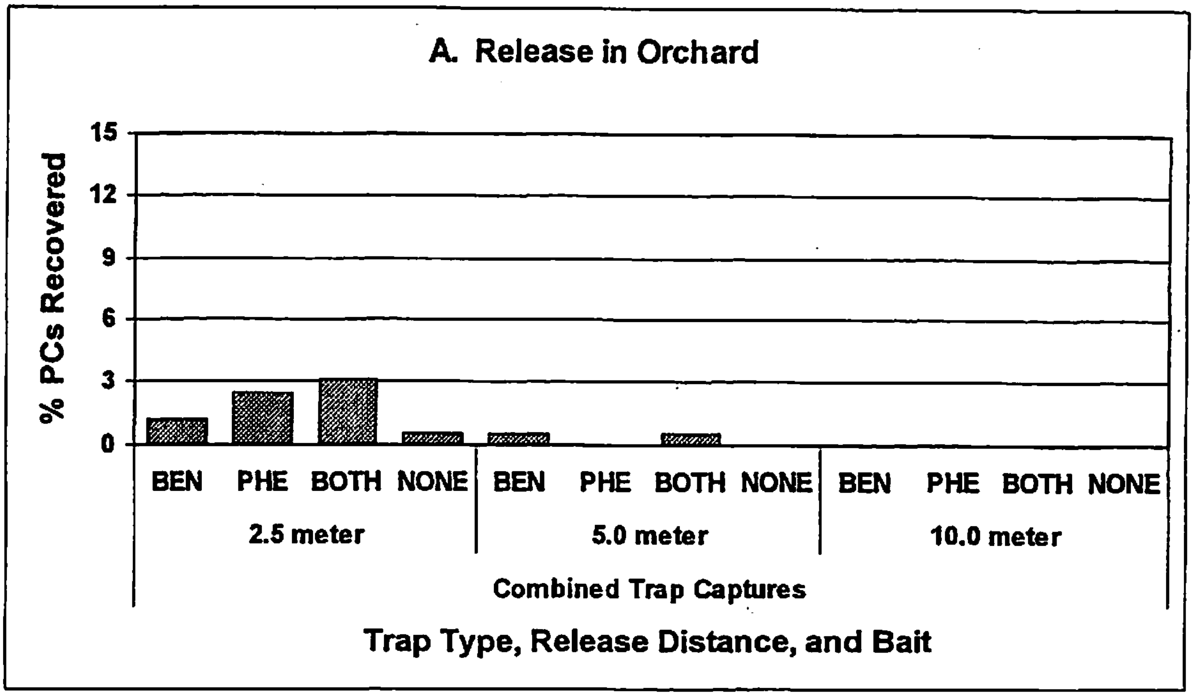


Figure 2. Relative recovery of marked-released PCs in traps placed (A) in a fruiting orchard or (B) open field. Data represent percentage of PCs recovered for each odor treatment across four releases; a total of 160 PCs were released at each distance at each location. Although numerical trends are apparent, no statistical differences were detected between baits for any release distance at any location, accordin to a comparison of means (LSD, p=0.05).

BEN=Benzaldehyde, PHE=Grandisoic Acid



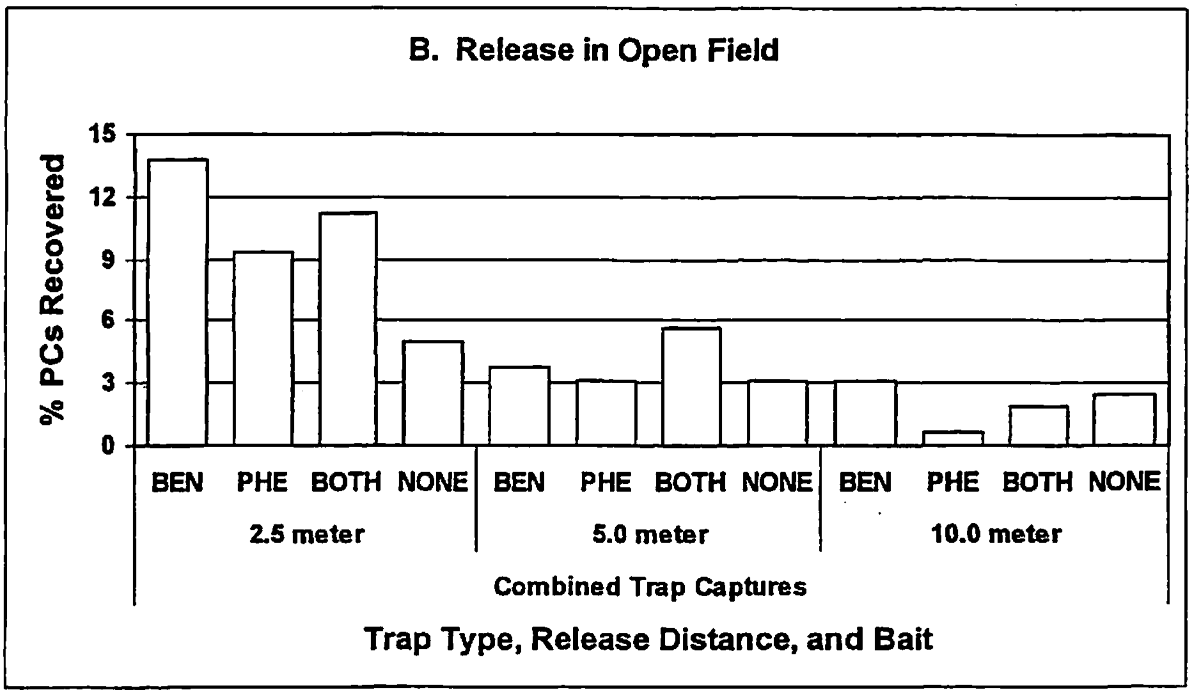
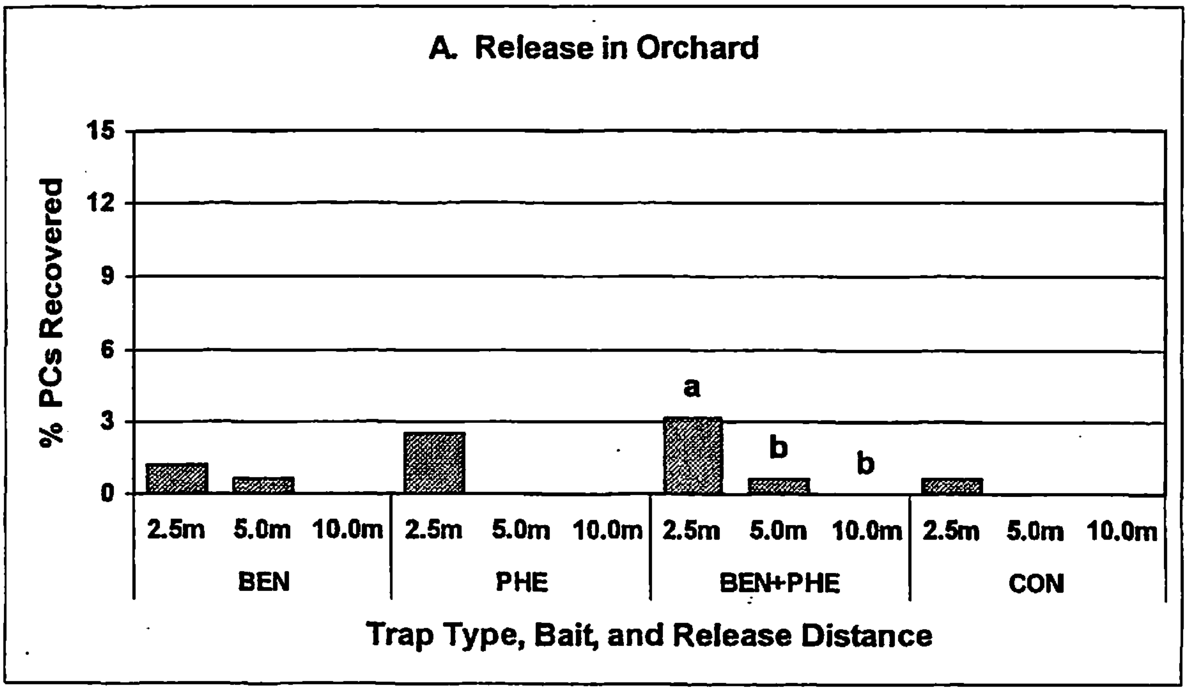


Figure 3. Relative recovery of marked-released PCs in traps placed (A) in a fruiting orchard or (B) open field. Data represent percentage of PCs recovered across four releases; a total of 160 PCs were released at each distance at each location. Data bars imposed with a different letter are significantly different according to a pairwise comparison of means (LSD, p=0.05). Statistical comparisons were not made if mean recovery <1.0%.
BEN=Benzaldehyde, PHE=Grandisoic Acid


A. Release in Orchard

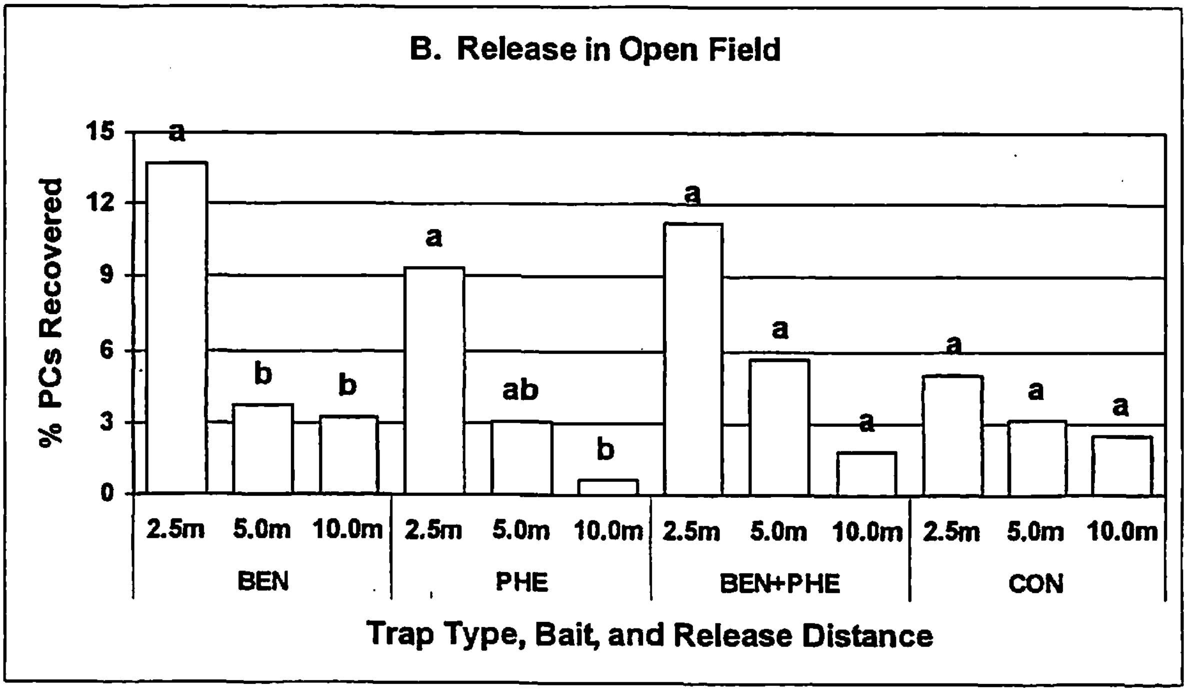

B. Release in Open Field

Figure 4. Comparison of recovery rates for PCs released in orchard versus open field. Relative recovery of marked-released PCs categorized (A) by odor bait and release distance and (B) pooled across statisitically similar treatments. Data represent percentage of PCs recovered across four releases; a total of 160 PCs were released at each distance at each location. No significant differences were recorded for (A), asterisks in (B) denote points of significance according to a paired t-test (p=0.05). BEN=Benzaldehyde, PHE=Grandisoic Acid

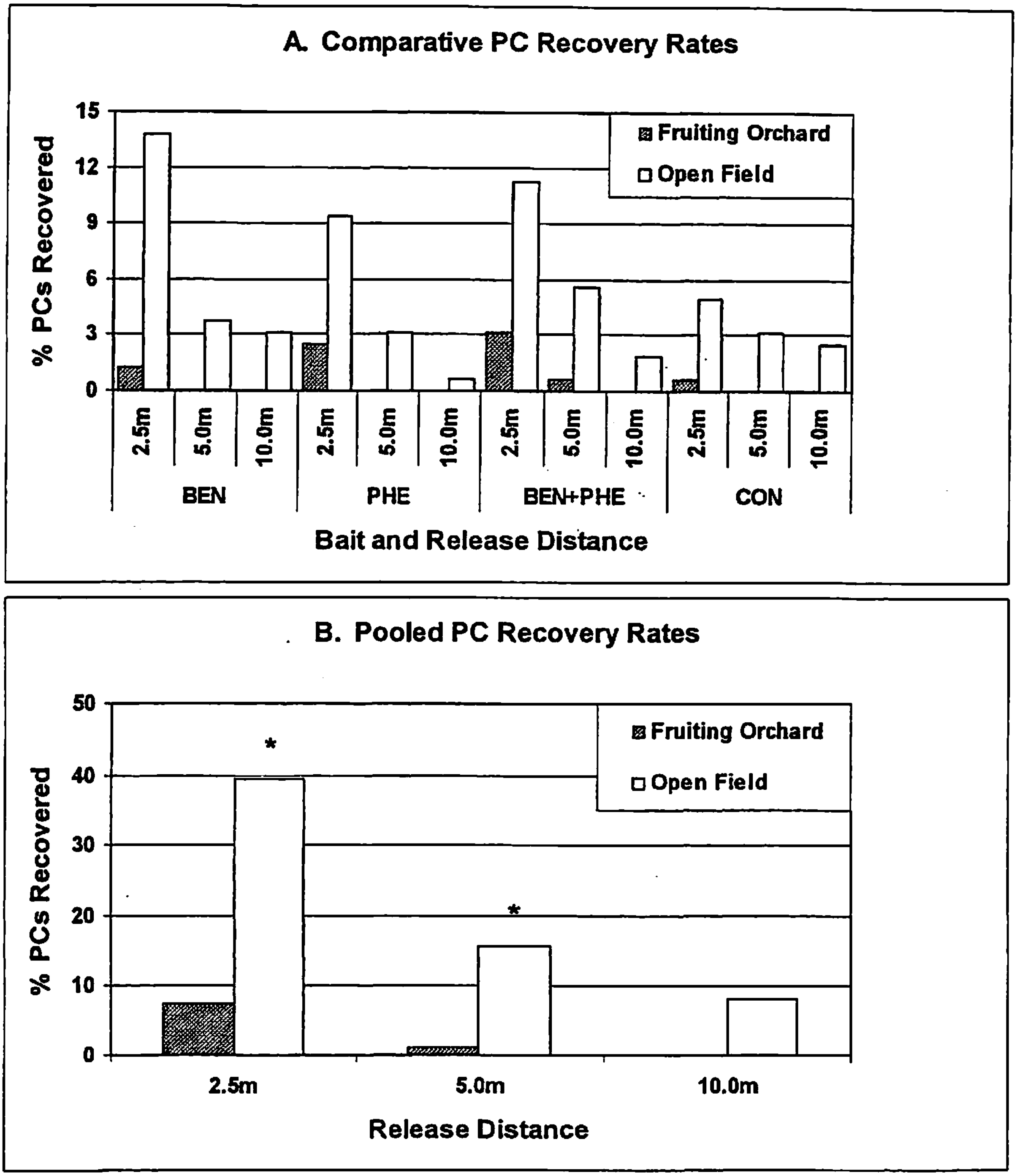


Table 1. Season-long captures of wild PCs across three apple orchards in four candidate trap types. Pyramid, circle, and cylinder traps were baited with one of three candidate synthetic plant volatiles or synthetic aggregation pheromone (grandisoic acid). All panel traps were baited with a combination of benzaldehyde and grandisoic acid.

Trap Type	Odor Bait	# Traps	Cumulative PCs per trap
Pyramid	Benzaldehyde	3	2.3
	Ethyl Isovalerate	3	0.0
	Limonene	3	1.0
	Grandisoic Acid	3	1.0
	Unbaited	12	1.0
Circle	Benzaldehyde	3	1.0
	Ethyl Isovalerate	3	2.0
	Limonene	3	0.0
	Grandisoic Acid	3	0.0
	Unbaited	12	0.2
Cylinder	Benzaldehyde	3	1.7
	Ethyl Isovalerate	3	0.3
	Limonene	3	0.3
	Grandisoic Acid	3	0.3
	Unbaited	12	0.1
Panel	Benzaldehyde + Grandisoic Acid	24	0.3

AREAWIDE MATING DISRUPTION OF THE ORIENTAL FRUIT MOTH, *GRAPHOLITA MOLESTA*, IN PENNSYLVANIA APPLES AND PEACHES – 2001

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Introduction

The Oriental fruit moth (OFM) has become a significant pest of peach and apple in Pennsylvania in recent years. Fruit processors in Adams County, PA rejected 113 loads of apples in 1998, 88 loads in 1999, and 464 loads in 2000 because of the presence of Oriental fruit moth larvae in fruit at harvest (Hull et al. 2000). To counter the growing threat to the processing apple industry in the eastern U.S., new pest management strategies such as pheromone mating disruption need to be tested. In this study we tested Isomate OFM M100 twist tie dispensers in two large blocks of apple and one large peach block. We also tested Isomate M Rosso twist ties, and Confuse OFM (paraffin emulsion) in peaches.

Materials and Methods

The trials were conducted in three commercial fruit orchards in Adams County, PA. At each site, the grower's standard insecticide program was compared to one or more mating disruption treatments for efficacy in preventing fruit injury by OFM. At Sites 1 and 2, which were apple orchards, the grower's standard insecticide practice was compared to Isomate M100. At Site 3, which was a peach orchard, the grower's standard insecticide was compared to treatments of Isomate M100, Isomate M Rosso, and Confuse OFM (paraffin emulsion). The sizes of the treatment blocks at each site are given in Table 1.

The Isomate M Rosso dispensers were applied on 23 April to disrupt mating during the first and subsequent OFM broods. The Isomate M Rosso dispensers were only applied at Site 3 only, at the rate of 200 dispensers (48 g a.i.) per acre in the upper part of the canopy. The other mating disruption treatments were applied at all sites to coincide with the second brood flight of OFM. M100 dispensers were placed at all three sites between 6 and 13 June, in the upper parts of the tree canopy, at 100 dispensers (24.4 g a.i.) per acre. Confuse OFM was applied with forestry paint guns on 8 June and again on 22 August at Site 3 only. The rate was 30 g a.i. per acre, which amounted to 428 squirts of formulated material per acre.

The treatments were evaluated using pheromone traps to monitor male moth response to a point source with each block, timed counts of injured shoots (i.e., flagging, peaches only), on-tree fruit samples, and harvest fruit samples (apples only). OFM shoot counts on peaches were taken by searching 2% of the trees in any block for 1 min. Fruit injury data was collected either by visually examining a number of fruit (withough picking them) on a given number of trees per treatment, or by picking samples of fruit from a given number of trees. The actual sample dates and numbers are given in Table 2.

Pheromone trap capture (Delta traps, Scenturion Inc, Clinton, WA) of OFM was monitored for all treatments. The traps were monitored weekly and the lures (0.11 mg/lure) and bottoms were changed monthly (bottoms more often if soiled). The number of traps per treatment was determined using the following formula: 3 traps for blocks under 12 acres, 4 traps for blocks up to 16 acres, 5 traps for blocks up to 20 acres, and 6 traps for blocks larger than 20 acres. Where possible, additional pheromone traps were placed at mating disruption treatment edges and outside of mating disruption blocks to measure any effect that the treatment border had on trap capture. Suppression of trap capture in the mating disruption blocks was considered to be evidence that the pheromone was altering male behavior.

Results

The average total seasonal pheromone trap capture of Oriental fruit moth males ranged from 6.6 to 147.8 moths per trap in the insecticide standard treatments, but trap capture was almost completely suppressed in all of the mating disruption blocks (Fig. 1). Notable exceptions were 1.4 (±1.3) moths in the OFM M-100 treatment at Site 2, 2.0 (±0.6) moths in the Confuse OFM treatment at Site 3, and 0.4 (±0.4) moths in the OFM M-100 treatment at Site 3. Trap catch at the edge of mating disruption treatments was also very low, but increased significantly at 50 and 100 m away from treated orchards (Table 3). The average number of injured peach shoots was very low for all counts in all treatments at Site 3, although the shoot count in the Isomate M Rosso treatment was considerably higher on 19 July and 7 Aug than in the other treatments (Fig. 2). Fruit injury due to OFM was extremely low for apples and peaches in all of the treatments, and leafroller damage ranged from 0.90 to 4.36% with no discernable effect by treatment (Table 2).

Although we encouraged the growers at Sites 1 and 3 to reduced insecticide usage in the mating disruption treatments (Site 2 had a history of high population pressure), they did not do so except for the removal of one application of Intrepid® (methoxyfenozide) at Site 1 (Table 4). At Site 3, very few insecticides were applied after the placemtne of the M-100 and the Confuse OFM mating disruption treatments in June.

Table 1. Treatment acreage, crop, and application dates.

Site	Treatment	Acres	Crop	Application Dates
Site 1	Standard insecticide	25.4	Apples	–
	Isomate M 100	22.8	Apples	6 June
Site 2	Standard insecticide	13.0	Apples	–
	Isomate M 100	33.5	Apples	11-13 June
Site 3	Standard insecticide	10.0	Peaches	–
	Isomate M 100	18.0	Peaches	8 June
	Isomate M Rosso	12.0	Peaches	17 April
	Confuse OFM	7.0	Peaches	8 June and 22 Aug

Table 1. Mean (±SEM) fruit injury in the mating disruption and standard insecticide treatments at the three study sites.

Site	Treatment	Sample date	Sample Type	# Trees sampled	# Fruit sampled per tree	%Entries	%Leafroller
1	OFM M-100	24-Sep-01	Apples	25	75	0.30 (0.17)	1.22 (0.30)
	Standard Insecticide	25-Sep-01	Apples	25	75	0.15 (0.08)	3.82 (0.48)
2	OFM M-100	07-Sep-01	Apples	38	100	0.49 (0.12)	1.12 (0.31)
	Standard Insecticide	07-Sep-01	Apples	15	100	0.25 (0.14)	0.90 (0.37)
2	OFM M-100	09-Oct-01	Apples	15	100	0.18 (0.10)	4.36 (0.56)
	Standard Insecticide	05-Oct-01	Apples	15	100	0.06 (0.06)	3.58 (0.67)
3	Confuse OFM	11-Jul-01	Peaches	14	100	0.00 (0.00)	–
	OFM M-100	11-Jul-01	Peaches	30	100	0.00 (0.00)	–
	Isomate M Rosso	11-Jul-01	Peaches	26	100	0.00 (0.00)	–
	Standard Insecticide	11-Jul-01	Peaches	18	100	0.06 (0.06)	–
3	Confuse OFM	27-Jul-01	Peaches	9	50	0.00 (0.06)	–
	OFM M-100	27-Jul-01	Peaches	19	50	0.00 (0.00)	–
	Isomate M Rosso	27-Jul-01	Peaches	19	50	0.00 (0.00)	–

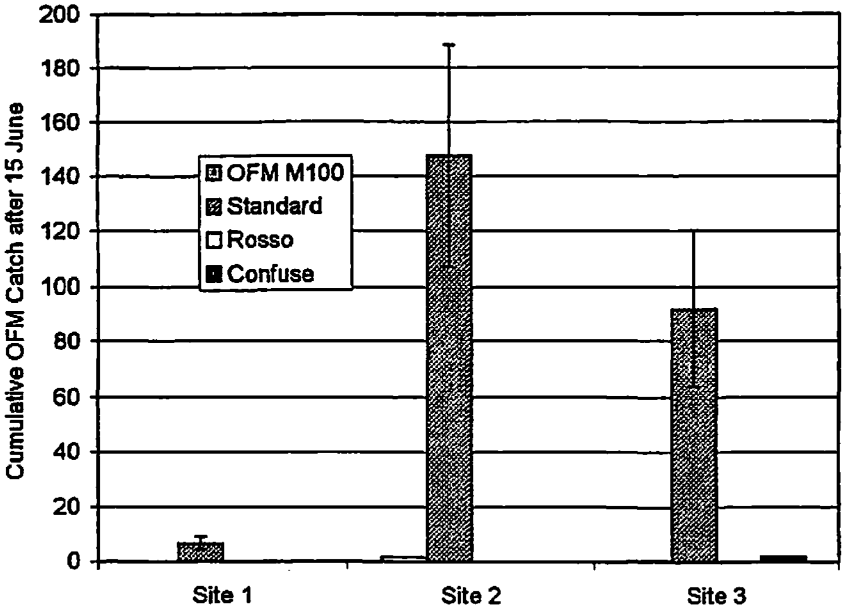

Fig. 1. Mean (±SEM) cumulative OFM trap capture per trap after 15 June at sites 1-3.

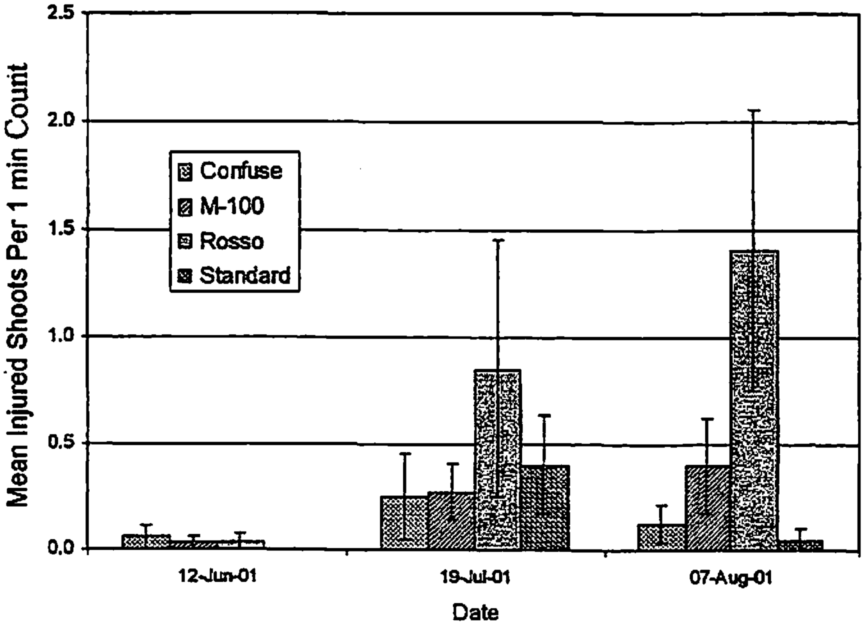

Fig. 2. Mean (±SEM) OFM injured peach tree shoots per 1 min count (Site 3 only).

Table 2. Mean (±SEM) cumulative seasonal trap capture of Oriental fruit moth males per trap by treatment and distance from the mating disruption treatment edge, beginning 15 June, 2001.

Site	Treatment	Number of pheromone traps	Avg. cumulative moths per trap (±SEM)
1	Insecticide Standard	5	6.6 (0.5)
	OFM-100	5	0.0 (0.0)
	Mating disruption edge	4	0.0 (0.0)
2	Insecticide Standard	4	147.8 (40.8)
	OFM-100	9	1.4 (1.3)
	Mating disruption edge	3	2.7 (1.3)
	50 m from edge	4	98.8 (78.1)
	100 m from edge	2	180.3 (108.0)
3	Insecticide Standard	3	92.0 (28.1)
	Confuse OFM	3	2.0 (0.6)
	OFM-100	5	0.4 (0.4)
	Isomate M Rosso	3	0.0 (0.0)
	Mating disruption edge	1	0.0 n/a
	50 m from edge	2	16.0 (12.0)

Table 3. Total insecticides applied at and after petal fall.

Site	Treatment	Trade Name	Common Name	Form. acre	Unit	lbs ai/acre	g ai/ha
1	Insecticide standard	Guthion 50 WP	Azinphosmethyl	3.6	lb	1.81	2031
		Provado 1.6 FL	Imidacloprid	5.5	fl oz	0.07	77
		Avaunt 30 WDG	Indoxacarb	6.0	oz	0.11	126
		Intrepid 2F	Methoxyfenozide	20.0	fl oz	0.31	350
		Imidan 70 W	Phosmet	3.0	lb	2.10	2353
		Pyramite 60 WSP	Pyridaben	2.2	oz	0.08	92
		Spintor 2 SC	Spinosad	7.5	fl oz	0.12	131
	M100	Guthion 50 WP	Azinphosmethyl	3.6	lb	1.81	2031
		Provado 1.6 FL	Imidacloprid	5.5	fl oz	0.07	77
		Avaunt 30 DG	Indoxacarb	6.0	oz	0.11	126
		Intrepid 2F	Methoxyfenozide	8.0	fl oz	0.13	140
		Imidan 70 WSB	Phosmet	3.0	lb	2.10	2353
		Pyramite 60 WSP	Pyridaben	2.2	oz	0.08	92
		Spintor 2 SC	Spinosad	7.5	fl oz	0.12	131
2	All treatments	Azinphos 50 WSB	Azinphosmethyl	4.0	lb	2.00	2801
		Diazinon 500-AG	Diazinon	2.0	lb	0.96	1076
		Provado 1.6 FL	Imidacloprid	5.0	fl oz	0.06	70
		Intrepid 80 2F	Methoxyfenozide	52.0	fl oz	0.81	910
		Pyramite 60 WSP	Pyridaben	4.4	oz	0.17	185
3	All treatments	Guthion 50 WP	Azinphosmethyl	3.0	lb	1.5	1681
		Asana 0.66 EC	Esfenvalerate	6.0	fl oz	0.03	35
		Sevin 4F	Carbaryl	1.5	qt	1.5	1681

Discussion

The mating disruption treatments completely suppressed trap capture of OFM, except for a few moths captured in the Confuse OFM treatment block at Site 3 in August before Confuse OFM was reapplied, and single incidents of moth capture in the other mating disruption blocks. Pheromone traps were evenly distributed throughout the orchard, so the trap capture results suggest that the pheromone was present throughout the mating disruption treatments and persisted through the growing period. Of pheromone traps placed at the border between mating disruption and neighboring orchards (not represented in Fig. 1), only traps at Site 2 caught any moths with a mean of 4 (±2) for the entire season. The pheromone effect did not reach far beyond the borders of the treatment, however, as indicated by traps placed outside of mating disruption treatments (Table 3).

Fruit injury was extremely low in all treatments at all of the sites (Table 2), despite the fact that insecticide use was generally low at Sites 1 and 3 (Table 4). Insecticide use was not very different between the mating disruption and standard insecticide blocks, which made it somewhat difficult to determine the level to which mating disruption limited fruit injury. Because the unique mode of action and recent commercial availability of mating disruption, growers are understandably reluctant to limit insecticide treatments in mating disruption blocks. As evidence increases that mating disruption is taking place, i.e., trap shutdown and low fruit injury in mating disruption blocks, growers will be encouraged to rely more heavily on mating disruption alone in treatment blocks. In this way we will be able to find the limits and strengths of mating disruption to protect fruit from OFM while reducing other insecticide inputs.

Acknowledgements

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Not for Citation

PHEROMONE DISRUPTION AND EGG HATCH OF ORIENTAL FRUIT MOTH IN PEACHES - 2001

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Pheromone Mating Disruption

Mating disruption was evaluated as a control tactic against oriental fruit moth (OFM) in peaches using twist-ties, paraffin-based liquid and sprayable pheromone formulations in commercial orchards. The treatments were:

1 – Isomate M-100 ties, applied 6-11 June at a rate of 150/acre
2 – 3M Sprayable Pheromone, applied by the growers beginning mid-June, at 2-week intervals at a rate of 1.7 oz/acre
3 – Confuse-OFM paraffin, applied 2-3 times in each site (6-11 June; 9 July (Kappus only); 2 August (Topp & Murray only); and 13 August (Kappus only), at a rate of 30 g a.i./acre (1-2 squirts/tree from a plastic squirt bottle).

Pheromone trap catches of OFM adult males in the disrupted plots were very low throughout the entire season, essentially remaining at or near zero in most cases despite considerable population pressure, as reflected in the check (Transit and Storage) plots. In one case, at the Kappus site, there was breakthrough in the Confuse plot traps, which occurred at two times, in each case approximately 3 weeks after the treatment's application date. Following re-application, moth numbers returned to zero in both instances. This level of breakthrough was not seen any of the other plots, and it is assumed that the problem was caused by the fact that the Confuse plot at Kappus was directly adjacent to an apple planting, which likely had its own population of OFM that was being attracted into the traps of the pheromone plot. In general, the growers did a good job of applying the sprayable formulations at the appropriate schedule timings, which is a particularly important aspect of using these products at their highest level of effectiveness.

Results of the pre-harvest fruit inspection showed fruit damage from OFM feeding and infestation to be quite low in most of the treatments, with the exception of the Kappus site, where internal larval infestation surpassed 10% in the Confuse plot. This corresponds with the pheromone trap results, and corroborates the assumption of mated female immigration from the apples, as the injury level was 3.3% in the Isomate plot (next in line after the Confuse plot) and only 1% in the 3M Sprayable (the plot farthest from the apples).

The occurrence of "stings" was generally in the range of 1.5-3.5% in all plots; this category represents skin puncturing or nominal pitting progressing less than a few millimeters into the fruit, attributable to either OFM or some other undetermined cause. An "internal" injury category was reserved for actual tunnelling in the fruit flesh, with either the larva or its trail or frass evident when the fruit was cut. Except for the Kappus site, few major differences among treatments were seen. The highest incidence of internal injury in the other plots was 1.3%. In summary, all treatments appear to have the potential for acceptable control within plot interiors, but border sprays may need to be incorporated to forestall infestations by moths immigrating from non-disrupted areas when these products are used in typical commercial production areas in western N.Y.

Predictive OFM Egg Hatch Model

A second study was conducted to develop an egg hatch model for OFM on peaches based on degree days. This information could be used to determine the optimum application times for different insecticides in orchards, thereby increasing the efficacy of these compounds and reducing resistance of OFM to these compounds.

A plot of 19 unsprayed peach trees located in Appleton (Niagara Co.), New York, was selected for this study. Inspection of these trees for newly laid eggs began in early May, shortly after the April 28 biofix (first male moth catch in a pheromone trap) and was continued through the second flight (July), as well as into the third flight in mid-August. Terminal shoots on each tree in the block were checked for OFM eggs for five minutes, and checks were made twice a week. Unhatched eggs were collected and recorded before they were brought to the lab in Geneva. They were then placed in a petri dish with a source of humidity and stored in an insectary under ambient temperature. Eggs were checked daily and hatches were recorded along with the daily degree day (base 45°F) accumulation. This information was then combined with moth biofix, moth trap capture, and degree day caculations to develop an egg hatch model. Information for this study relies on the data from the first flight in Niagara Co., which occurred from late April until June 25.

A total of 300 OFM eggs were collected and held until hatch during the first generation flight in 2001. The data from of this cohort of eggs was used to construct a curve showing the relationship between cumulative percent hatch and total degree days accumulated since the biofix (Fig. 3). From this graph, it was possible to derive a table of estimated hatch progression in increments of 5% (Table 1), which can be used to help time insecticide applications for most efficient management of this pest.

Attempts to construct a similar degree-day model for the 2nd brood hatch were not successful, as egg deposition on the terminal leaves fell off to nearly zero during the second flight. It was assumed that the eggs were instead being laid on the fruit surfaces, which would have been impractical to sample. However, researchers in NJ and PA determined that oviposition had shifted instead to fruit cluster leaves. Sampling procedures will be modified next season to take this fact into account in developing a hatch model for the 2nd brood hatch.

Table 1. Predicted 1st brood OFM hatch using data from 2001.

% Cumulative Egg Hatch	Degree Days (Base 45°F) from Biofix
0	0
5	232
10	244
15	261
20	273
25	283
30	293
35	305
40	307
45	310
50	313
55	318
60	320
65	327
70	332
75	341
80	344
85	362
90	392
95	427
100	509

Fig. 1. Oriental fruit moth pheromone trap catches in plots treated with different pheromone disrupt ion techniques, Niagara Co. 2001

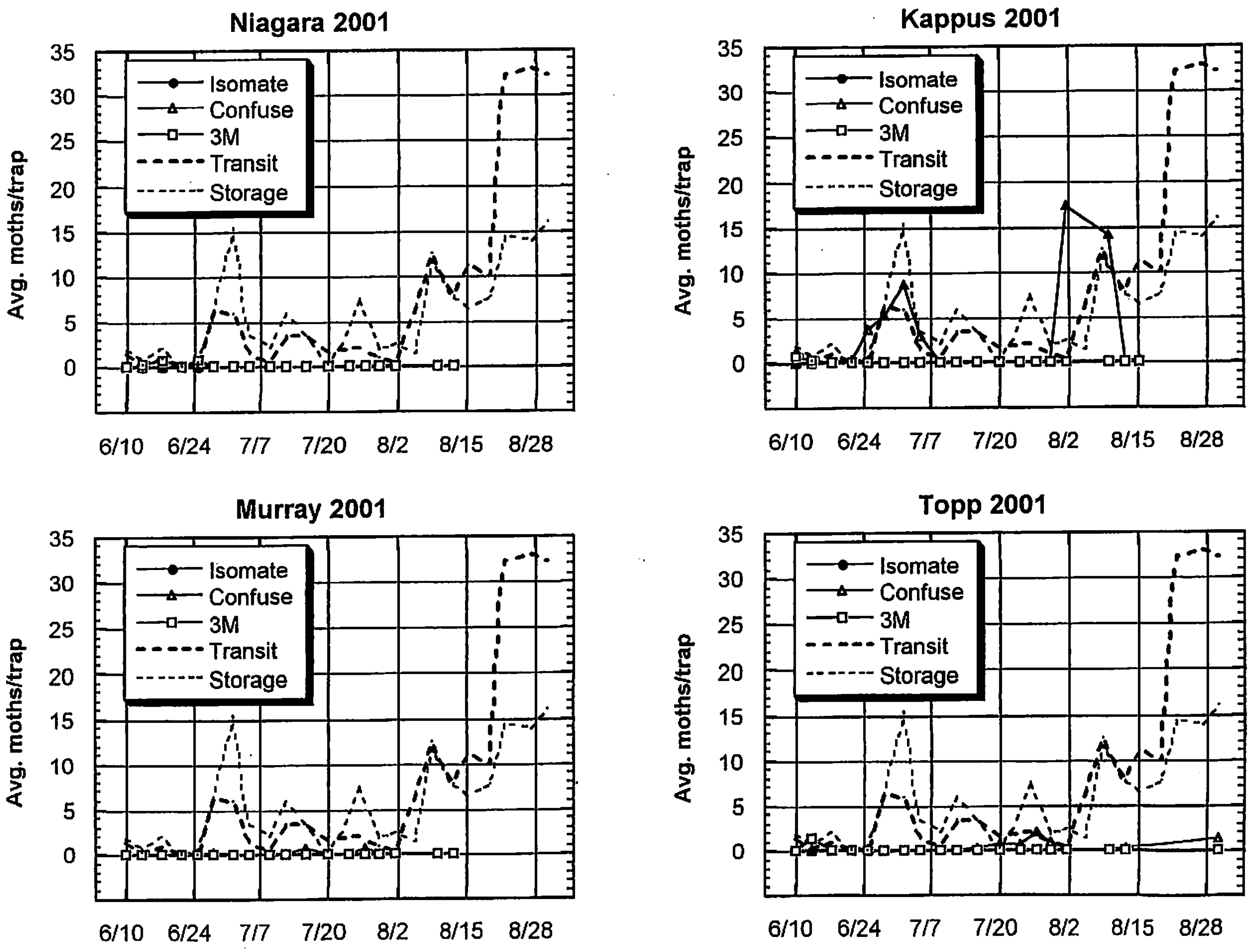


Fig. 2. Fruit injury in peach plots treated with different oriental fruit moth pheromone disrupt ion techniques, Niagara Co. 2001

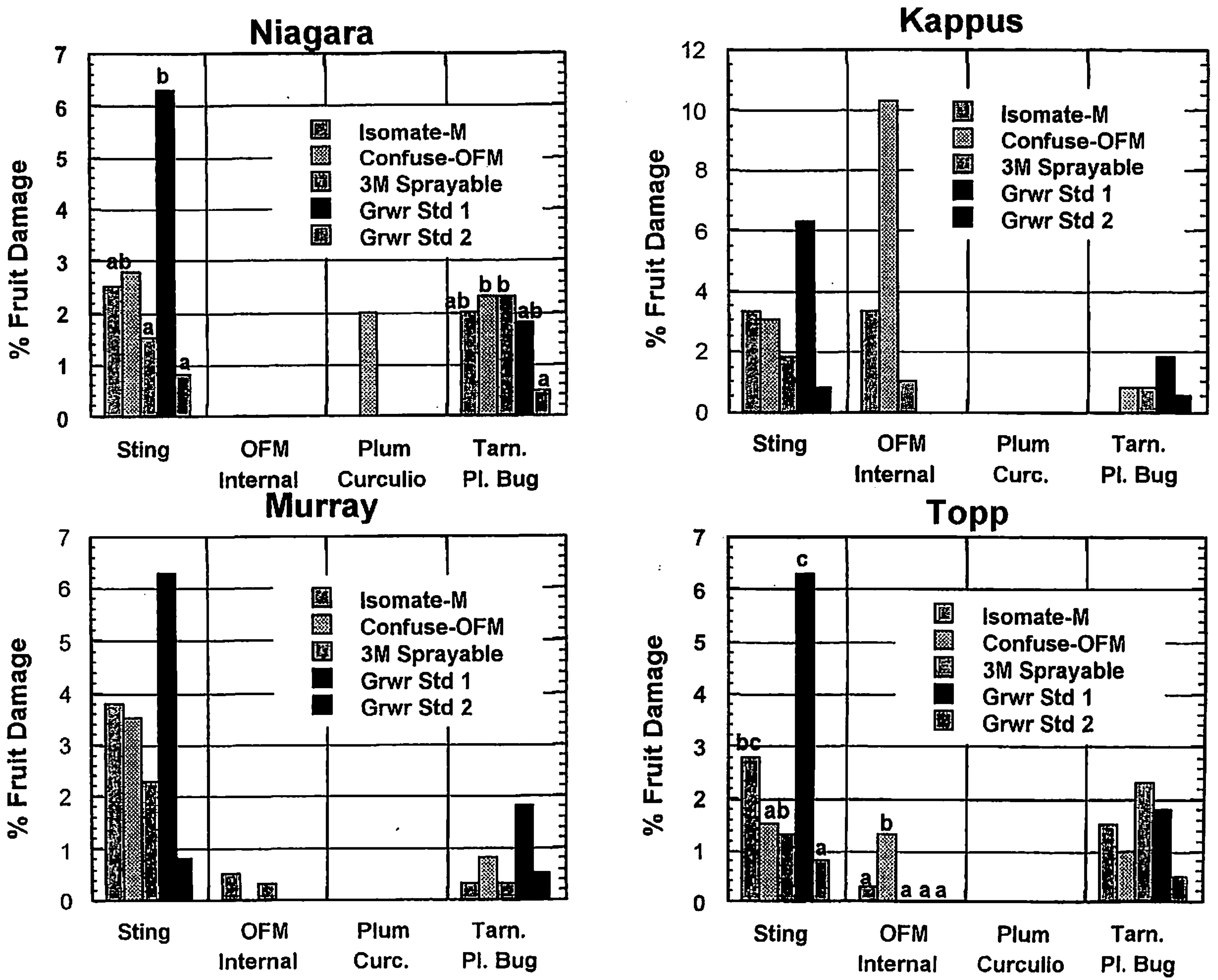
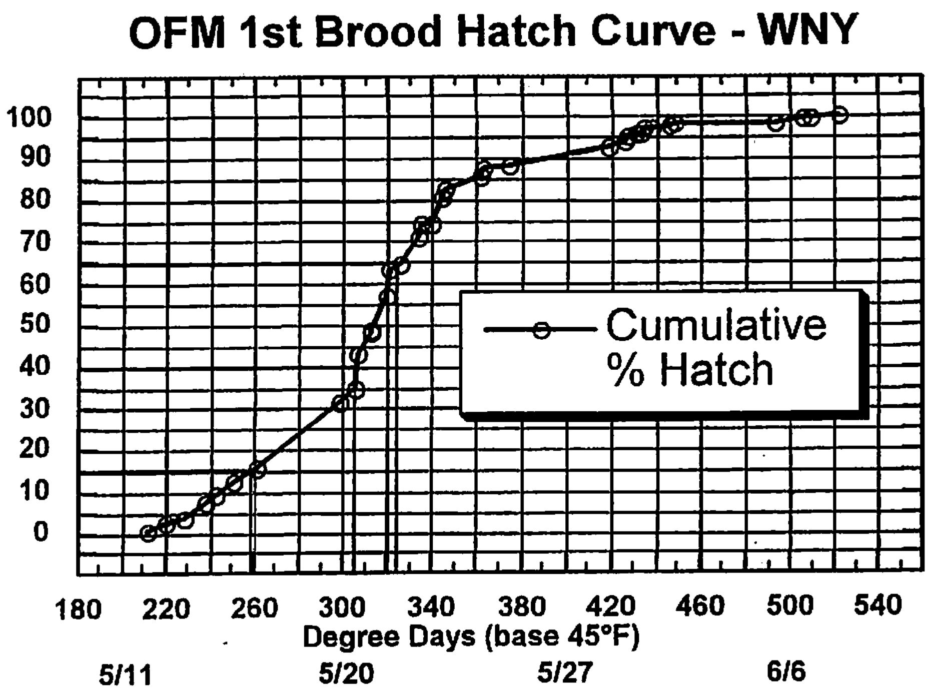


Fig. 3. Relationship between cumulative % of first generation OFM egg hatch and degree days (base 45°F) since first adult catch in a pheromone trap.



NOT FOR CITATION

THE POTENTIAL OF PARAFFIN-BASED PHEROMONE DISPENSING SYSTEMS FOR THE MATING DISRUPTION OF ORIENTAL FRUIT MOTHS, *GRAPHOLITA MOLESTA* (BUSCK)

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INTRODUCTION

A pheromone dispenser should meet several criteria to compete with pesticide spray programs. It should provide effective pest control, be cheap to produce, quick and easy to apply, long-lasting, and withstand stresses such as rain and pruning while in the orchard environment. Hand-applied dispensers and microencapsulated formulations are the most commonly used commercial products for OFM mating disruption. While those technologies provide adequate OFM control in many cases, hand-applied dispensers are labor intensive and microencapsulated OFM pheromone is still being fine-tuned to last for sufficient time in the orchard. Paraffin wax has recently been demonstrated to be a good pheromone carrier. Confuse-OFM paraffin emulsion provides effective pest control, is cheap to produce, and can withstand orchard stresses. It also has the potential to meet requirements of longevity and ease of application and to compete with pheromone dispensers currently on the market.

During the 2001 growing season, we compared the efficacy of Confuse-OFM to other pheromone dispensers and worked to refine the protocol for Confuse-OFM application; we sought to determine the best application height and number of point sources of application for Confuse-OFM. We also investigated the disruption efficacy of solid paraffin disk dispensers.

MATERIALS, METHODS, AND RESULTS

Statistical analyses

For all experiments, data were analyzed using a two-way analysis of variance (ANOVA, PROC GLM, SAS Institute 1999). Means were separated using least significant differences (LSD, $P<0.05$).

Comparative efficacy of Confuse-OFM

Confuse-OFM paraffin emulsion (30 g AI/acre) (Gowan Co.) was compared to Checkmate OFM-F microencapsulated pheromone (30g AI/acre) (Consep, Inc.), Isomate-M100 hand-applied dispenser (100 ropes/acre) (Shin-Etsu Chemical Co., Ltd.), and grower spray programs (comparison) for providing OFM control in commercial orchards. Confuse-OFM was squirted onto branches, preferably one inch or more in diameter using a hand pump, according to manufacturer specifications. The experimental design was a randomized complete block design. It was replicated in four peach blocks on commercial farms in southwest Michigan during the first and second generations of three total generations of OFM in Michigan. The treatments were applied to two to nine acre peach plots. Isomate-M100 was applied once at the beginning of the first generation; Confuse-OFM and Checkmate OFM-F were applied twice, at the beginning of each generation.

Moth captures in lure-baited traps, shoot injury counts, and fruit injury counts were used to assess the treatments. Three to five traps were placed in each plot. Traps were checked on a biweekly basis. Shoot injury counts were conducted during generations one and two. Ten shoots in the upper half of the canopy and 10 shoots in the bottom half of the canopy were examined on 18-20 trees per plot for OFM larval feeding or the presence of OFM larvae. Harvest fruit injury was assessed at the end of generation two. Fifteen fruits in the top half of the canopy and 15 fruits in the bottom half of the canopy were examined on 18-20 trees per plot for signs of internal fruit injury. Perimeter trees were not included in the injury counts. Peaches began to be harvested one week following the end of generation two, thus all Confuse-OFM plots and most Checkmate OFM-F plots were not retreated for the third generation. Transformations were used to normalize the data prior to analysis: Moth-catch data were log transformed (log (x+1)) and injury data were arcsine transformed (arcsine (x)).

There were significant differences in numbers of moths caught in the four treatments during both generations (Figure 1) (generation one: F=13.19, df=6, P=0.0005, generation two: F=21.27, df=6, P<0.0001). During generation one, numbers of moths caught in the Confuse-OFM treatment were not significantly different than numbers of moths caught in the M100 treatment, but were less than numbers of moths caught in the Checkmate OFM-F and Comparison plots. During generation two, numbers of moths caught in the pheromone treatments were not significantly different, but were all less than the numbers of moths caught in the comparison treatment. There were no significant differences in percent shoot injury during generations one and two (Figure 2) (generation one: F=4.30, df=6, P=0.0253, generation two: F=0.65, df=6, P=0.6928) or percent fruit injury at harvest (figure 2) (F=0.82, df=6, P=0.5863). Thus, Confuse-OFM performed as well as the other treatments in achieving OFM control in commercial peach orchards.

Confuse-OFM application height

The experiment was conducted in a 2.6 acre abandoned peach block (Douglas, MI). Small (0.17 acre) plots were arranged in a completely randomized design with four replicates. Trees were approximately 12 feet tall. Three treatments were evaluated: Confuse-OFM applied at a five-foot height (lower 1/3 of the canopy), Confuse-OFM applied at a nine-foot height (upper 1/3 of the canopy), and untreated. Confuse-OFM was applied at a rate of 30 g AI/acre for both Confuse-OFM treatments. Confuse-OFM was applied three times, once at the beginning of each OFM generation. Two traps were placed in the center of each plot on non-adjacent trees, a low trap (hung at five feet) and a high trap (hung at nine feet). The traps were alternated from the low and high positions at each sampling date. The experiment was carried out during the first, second, and third generations of OFM. Data were normalized using a log transformation (log (x+1)) prior to statistical analysis.

During each of the three generations, there were no significant differences in moth catch in low and high traps (Figure 3) (generation one: F=2.86, df=1, P=0.1083, generation two: F=0.13, df=1, P=0.7209, generation three: F=0.56, df=1, P=0.4644). In all three generations, there were significant differences in numbers of moths caught across treatments (generation one:

F=11.36, df=2, P=0.0006, generation two: F=10.5, df=2, P=0.0009, generation three: F=11.56, df=2, P=0.0006). There were no significant interactions between trap height and treatment in all three generations (generation one: F=0.35, df=2, P=0.7108, generation two: F=1.30, df=2, P=0.2960, generation three: F=0.49, df=2, P=0.6191). In all generations, significantly more moths were caught in the untreated plots than in the five-foot and nine-foot Confuse-OFM treatment plots. There were no significant differences between the numbers of moths caught in the five-foot and nine-foot Confuse-OFM treated plots. We conclude that Confuse-OFM treatment height did not influence the efficacy of the product in reducing moth catch.

Number of Confuse-OFM point sources

Small (0.21-0.25 acre) apple plots at the MSU Trevor Nichols Research Complex (Fennville, MI) were used to identify a minimum number of pheromone point sources necessary to achieve trap shutdown with Confuse-OFM. The treatments were: All trees treated, 1/3 of the trees treated, 1/9 of the trees treated, and untreated for generation one and all trees treated, 1/2 of the trees treated, 1/3 of the trees treated, and untreated for generations two and three. In all pheromone treatments, Confuse-OFM was applied at a rate of 30g AI/acre. Confuse-OFM was applied three times, once at the beginning of each generation. The experimental design was a randomized complete block design with three replicates during generations one and two and four replicates during generation three. Two traps were placed in each plot on non-adjacent trees and sampled biweekly during all three generations of OFM. In addition, during one week of peak flight during generation two and two weeks of peak flight during generation three, traps baited with one to three day old virgin OFM females were placed in the plots three to four times in succession, at a rate of three to five traps per plot each time. Traps were placed in the plots in the early evening and sampled each morning for the three following days. Data from both lure-baited and virgin female-baited traps were log transformed (log (x+1)) to normalize the data prior to statistical analysis.

In all generations, there were significant differences numbers of moths caught in lure-baited traps among treatments (Figure 4) (generation one: F=5.40, df=5, P=0.0317, generation two: F=7.92, df=5, P=0.0128, generation three: F=6.15, df=6, P=0.0083). In all cases, significantly more OFM were caught in the untreated plots than in the Confuse-OFM treated plots. A dose-response relationship is apparent among the treatments in all generations: As the disruption increased slightly with increasing numbers of point sources, we tentatively conclude that the best OFM control was achieved with the highest number of point sources. The same conclusion can be drawn from the virgin female-baited trap data (Figure 5) (generation two: F=4.79, df=5, P=0.0414, generation three: F=6.43, df=6, P=0.0071).

Number of paraffin disk point sources

Two abandoned apple blocks (Douglas, MI) and one apple block at the MSU Trevor Nichols Research Complex (Fennville, MI) were used to identify the minimum number of point sources necessary to achieve OFM control using paraffin disks. We made paraffin disks five centimeters in diameter and one half of a centimeter thick. Each disk contained four percent OFM pheromone (Shin-Etsu Chemical Co., Ltd., Tokyo, Japan), nine percent (±)-α-tocopherol (Sigma Chemical Co., St. Louis, MO), and 87 percent paraffin wax (Conros Co., Detroit, MI) by weight . The experimental setup and sampling were conducted as in the Confuse point source experiment. The disks were applied at a rate of 100 disks/acre. New disks were applied and old disks removed at the beginning of each OFM generation. The experiment ran during the second and third generations of OFM. Lure-baited traps were sampled during both flights, virgin female-baited traps were sampled during the third generation of OFM. Data for both lure-baited and virgin female-baited traps was square root transformed (square root (x+0.5)).

There were significant differences in numbers of OFM caught in lure-baited traps among treatments for both generations (Figure 6) (generation two: F=7.52, df=5, P=0.0145, generation three: F=4.65, df=5, P=0.0442). In both generations, significantly more moths were caught in the untreated plots than in the disk-treated plots. As in the Confuse-OFM point source study, a dose-response relationship is apparent. However, the slope of increasing numbers of point sources *versus* OFM caught seems to plateau at 1/3 trees treated and all trees treated. This indicates that similar OFM control may be achieved when one third of the trees are treated with disks as when all trees are treated with disks. The virgin female-baited trap data supports this conclusion as well (Figure 7) (F=4.37, df=5, P=0.0505).

CONCLUSIONS

Lure-baited trap data as well as shoot and fruit injury data demonstrate that Confuse-OFM, applied at the beginning of each OFM generation, was as effective as other pheromone dispensers and grower spray programs in controlling OFM in commercial peach orchards. These data give us confidence that Confuse-OFM can compete with other mating disruption technologies in a commercial setting.

New information was gathered about how Confuse-OFM should be applied. First, application height did not influence the efficacy of Confuse-OFM. Not needing to apply confuse-OFM high in the canopy will save time during application. Second, the Confuse-OFM formulation used during the 2001 growing season should be applied at high numbers of point sources. In addition, paraffin disks (not commercially available) could be applied on as few as every third tree in an orchard and achieve adequate OFM control. As Confuse-OFM emulsion becomes thicker, it begins to behave more like solid paraffin. Thus, there is a chance that thicker Confuse-OFM may not need to be applied at as high a number of point sources as the formulation used in these studies.

These experiments convince us that Confuse-OFM has the potential to compete with other pheromone dispensers. In future studies, we will assist with the development of a thicker wax emulsion. This should improve release rates and increase the longevity of Confuse-OFM in orchards, so that Confuse-OFM will need to be reapplied less frequently. We anticipate further reducing the application time for Confuse-OFM with the development of a better applicator. The dispensing of pheromone in a paraffin medium provides a promising alternative to sprayable pheromone and ropes currently used for OFM mating disruption.

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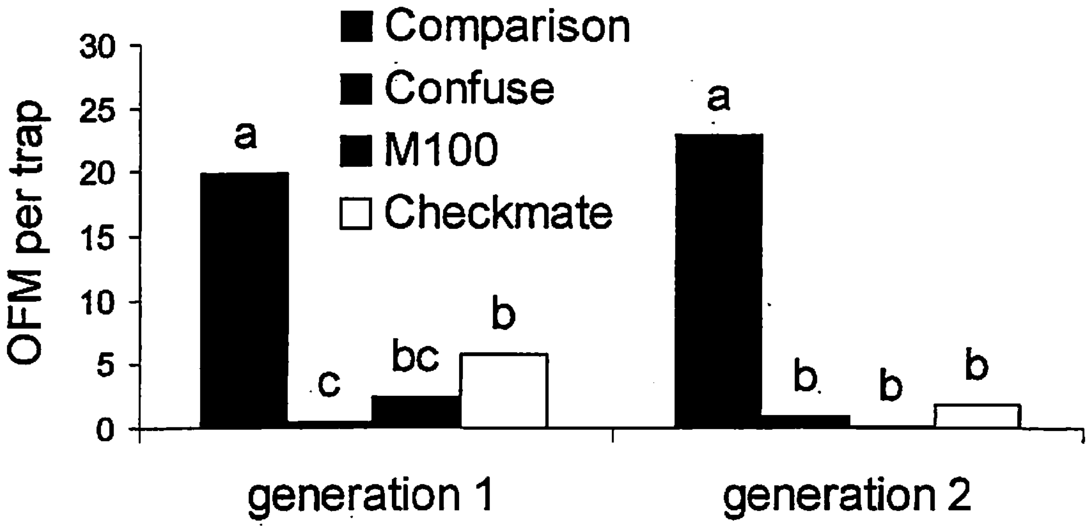

Figure 1: OFM caught in lure-baited traps. Bars with same letters in one generation are not significantly different (LSD, P<0.05).

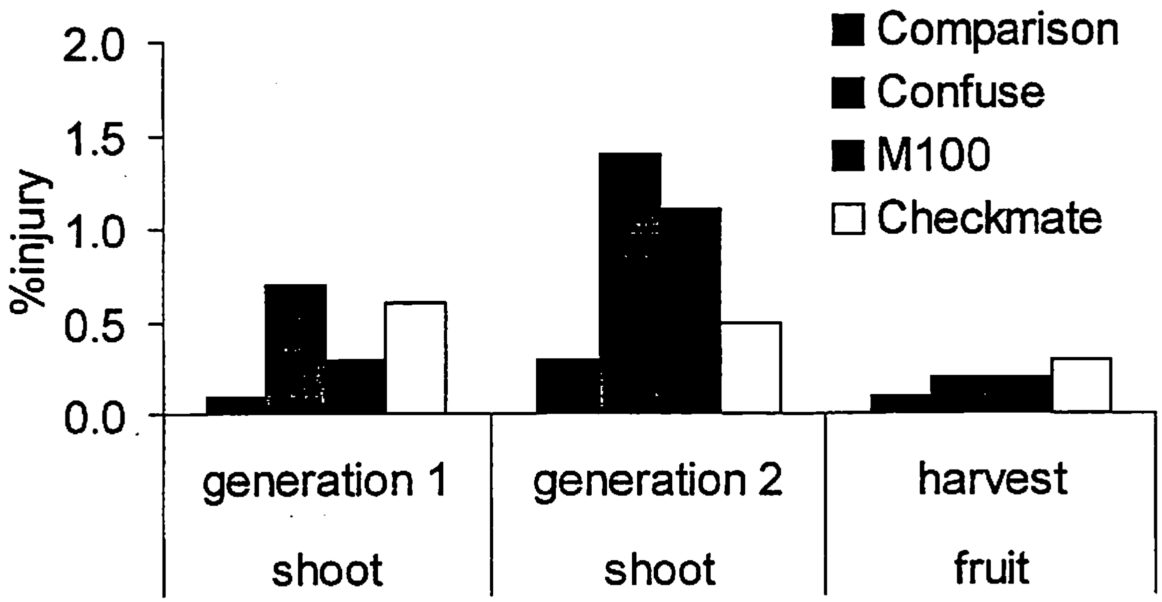

Figure 2: Percent fruit and shoot injury. There are no significant differences among treatments for each assessment (LSD, P<0.05).

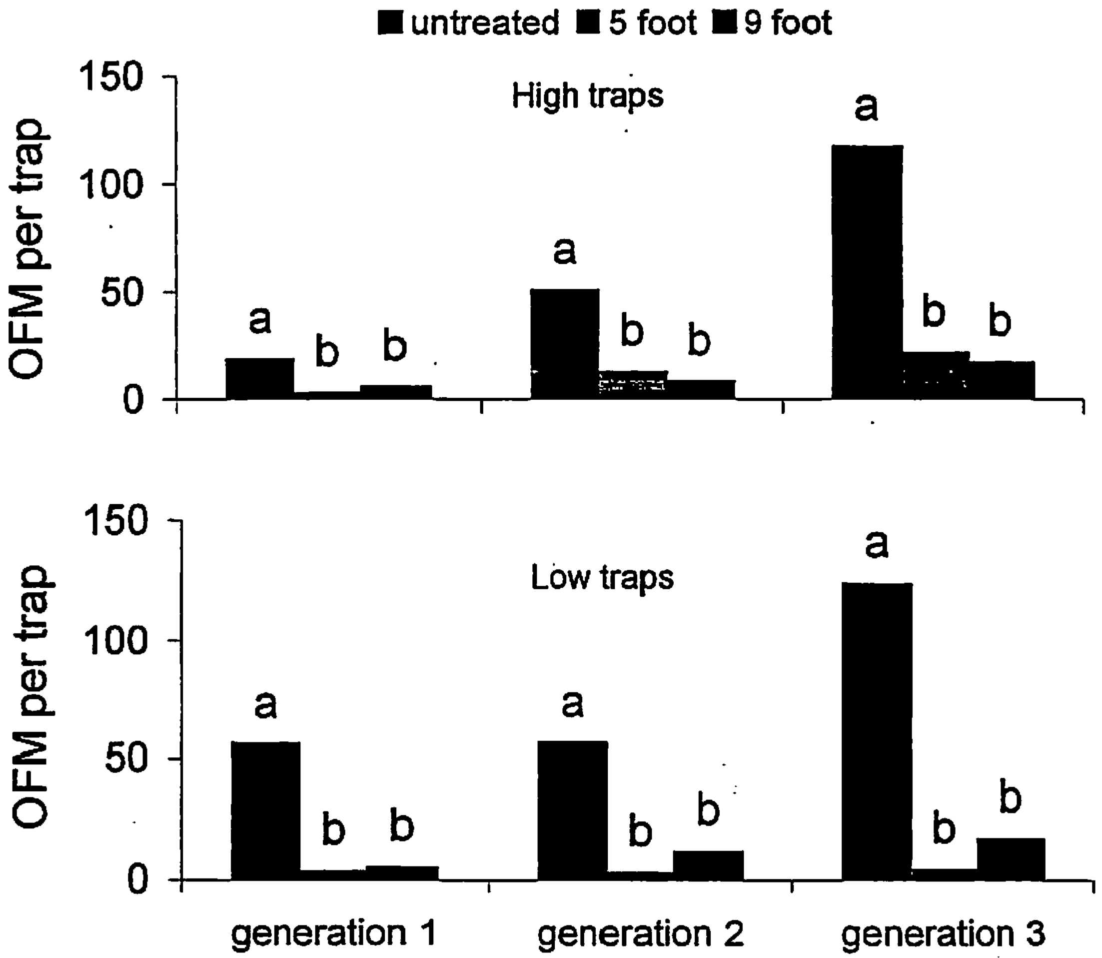

Figure 3: OFM caught in lure-baited traps placed at high and low heights. There is no significant difference between numbers of OFM caught in low and high traps for all treatments in all generations. Bars with same letters are not significantly different within a generation (LSD, P<0.05).

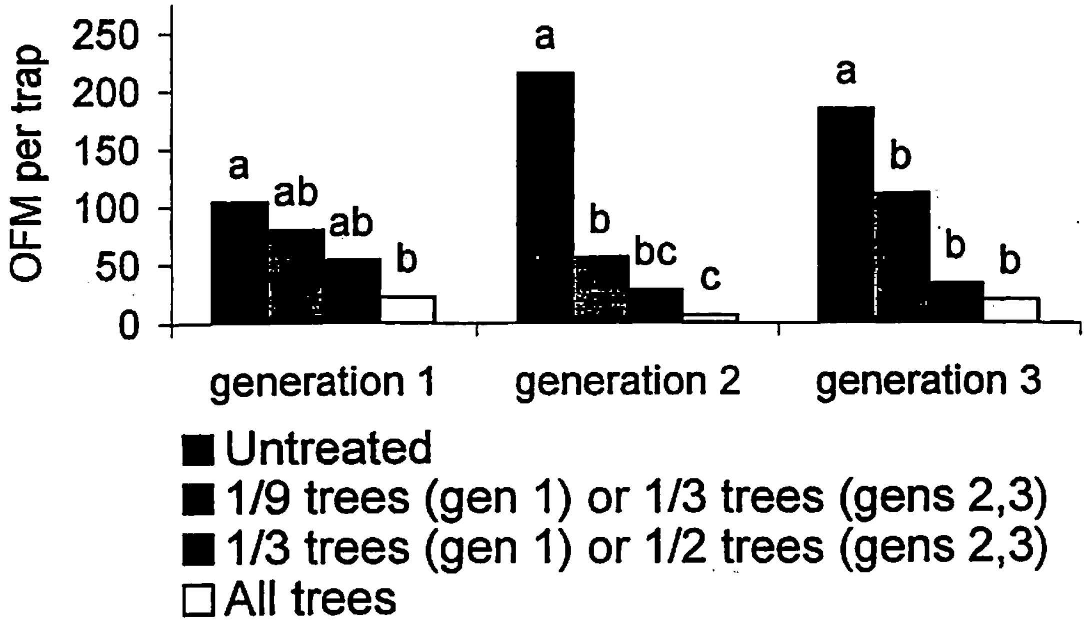

Figure 4: OFM caught in lure-baited traps. Bars with same letters within a generation are not significantly different (LSD, P<0.05).

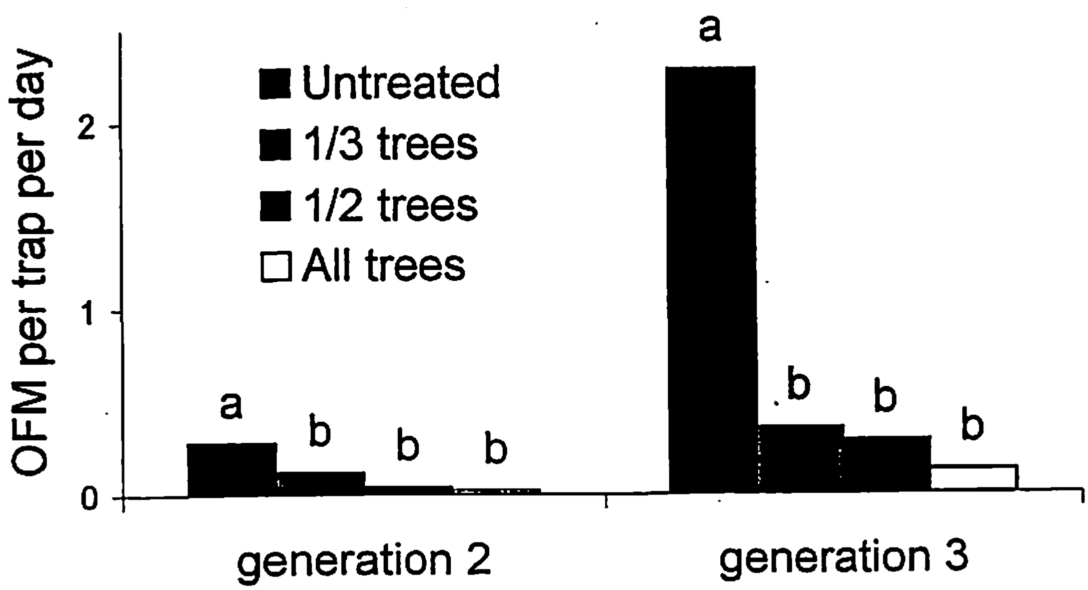

Figure 5: OFM caught in virgin female-baited traps. Bars with same letters within a generation are not significantly different (LSD, P<0.05).

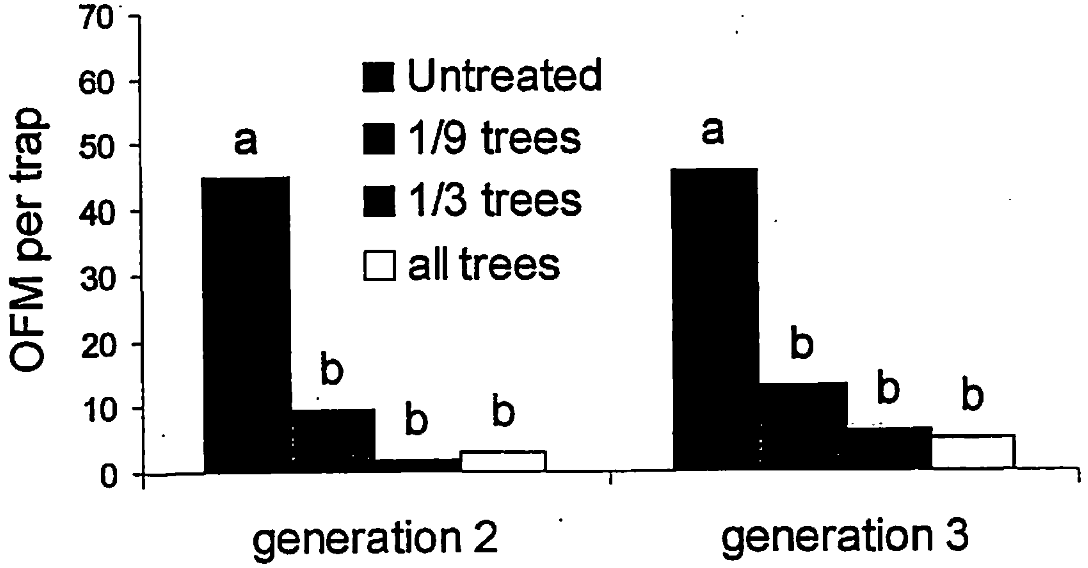

Figure 6: OFM caught in lure-baited traps. Bars with same letters within a generation are not significantly different (LSD, P<0.05).

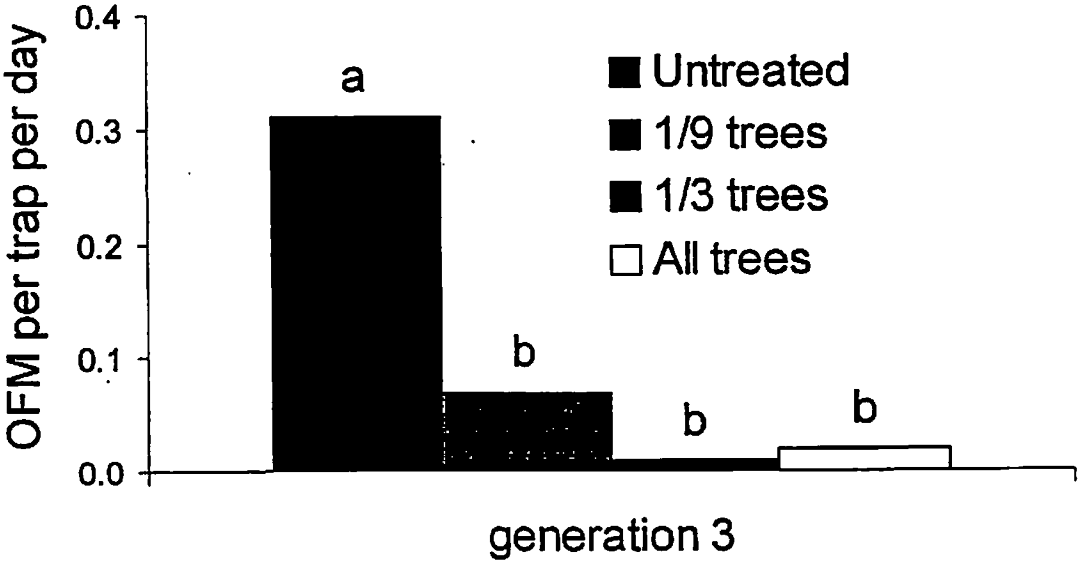

Figure 7: OFM caught in virgin female-baited traps. Bars with same letters within a generation are not significantly different (LSD, P<0.05).

N. H. Ellis and L. A. Hull
Penn State University
November, 2001

EFFICACY STUDIES WITH 3M SPRAYABLE OFM PHEROMONES AND PUFFERS--SUMMER, 2001

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Introduction

In 2001, trials were conducted to replicate our studies in 2000 to evaluate the efficacy of sprayable pheromones against oriental fruit moth. Phase I and Phase III sprayable pheromones were used. Treatments of broad-spectrum insecticides, and Phase III pheromones were continued in a block (Grower 1) with severe OFM infestation in 2000; one objective was to observe the impact of the 2000 season treatments in the current year. Additionally, data regarding performance of puffers at a density of 1 unit per acre as opposed to the 2000 density of 1 unit per 2 acres), at the same sites as those used in 2000, were complied and evaluated.

Methods and Materials

- *Large-plot commercial mating disruption studies: MEC Phase I*

Two sites in northern Adams County, PA were used. Each site was grower-owned and operated. At both sites, blocks that had been treated with MEC Phase I in 2000 were similarly treated in 2001. An additional block at the first grower's site (hereafter "Grower 1") was treated with MEC Phase III. Pertinent information regarding MEC rates, blocks, and spray specifications are given below (Table 1). All pheromone sprays were mixed with the adjuvant Nu-Film 17® at the label rate of 1 pint per acre.

Table 1. Application dates and specifications, large-plot studies–2001

Grower (site)/target	Dates applied	Rate	Method/GPA
1			
Phase I			
1st application	11 Jun, 19 Jun, 26 Jun	7.5 g a.i./acre per side	Alternate row middle 42 gal water per acre per side
2nd application	12 Jul, 18 Jul		
3rd application	9 Aug, 21 Aug		
Phase III			
1st application	11 Jun, 19 Jun,		
2nd application	26 Jun, 19 Jul	7.5 g a.i./acre per side	Alternate row middle 42 gal. Water per acre per side
3rd application	28 July, 21 Aug		

Due to a failure to maintain proper communication with the technician in charge of spraying for Grower 1, an additional application of pheromones was made in both sprayable pheromone test blocks on 26 June. Puffer protocols followed in 2001 are outlined in Table 2. In both seasons, puffers were deployed in early June, prior to the onset of second brood OFM flight. Aerosol cans for the puffers were provided in two fill-weights (216 g and 288 g), the former designed to last 150 days, the latter 200 days (R. Gerber, personal comm.). Respective amounts of active ingredient are shown in Table 2. Conventional spray programs at both sites incorporated azinphosmethyl, phosmet, and methomyl for broad-spectrum insect management. Total amount of pheromone per acre over the course of the season is listed for each site in Table 2 (in column "programming").

Table 2. Puffer usage information–2001

Grower (site)	Date deployed	Density	Programming
1	5 Jun	1 unit per acre	1500-0259 hours 1 puff every 15 minutes 17.9 g or 23.9 g AI per can* 2.5 mg pheromone per puff **19.6 g AI/ acre/ season**
2	1 Jun	1 unit per acre	1500-0259 hours 1 puff every 15 minutes 17.9 or 23.9 g AI per can 2.5 mg pheromone per puff **19.1 g AI/ acre/ season**

* Puffer aerosol cans were provided in two sizes by Paramount Farming, Inc. (Bakersfield, CA).

In both years, leafroller mitigation was effected with spinosad, tebufenozide, or methoxyfenozide at the test sites. In 2000, Grower 1 made remedial applications of esfenvalerate to the puffer block in early August; in 2001, Grower 1 targeted a codling moth threat in the MEC Phase I and puffer blocks with azinphosmethyl and methoxyfenozide.

Six delta-style pheromone traps, baited with OFM lures (0.11 mg pheromone per lure, Scenturion, Inc.) were deployed in each orchard. Weekly checks of the traps were made throughout the season, and lures were changed approximately every four weeks. Bottoms were also changed at four-week intervals, unless accumulation of debris and insects necessitated more frequent replacement.

Shoot injury counts on 5% of trees in each block (3 minute search per tree) were made in Grower 2's orchards on 12, 13, and 20 June. Mid-season (mid- to late-July) *in situ* fruit injury surveys were conducted on 1% of the trees in Grower 1's test blocks (50 whole fruit examined on each tree), and on 4-5% of the trees in each of Grower 2's test blocks (100 half-apples observed on each tree). In September, harvest-time injury evaluations were made at both sites. Test blocks in Grower 1's orchards were sampled according to the following protocol: conventional, 100 fruit from each of 25 trees ('Red Delicious'); MEC Phase I, (100 fruit from each of 25 trees ('York'); MEC Phase III, 100 fruit from each of 25 trees ('Crispin' [also known as 'Mutsu']); and puffer, 100 fruit from each of 25 trees ('York'). In each of Grower 2's blocks, 24 trees of cultivar 'Greening' and 16 trees of cultivar 'Golden Delicious' were sampled, taking 100 fruit from each tree. In the conventional block of this orchard, 39 total samples only, were collected.

RESULTS AND DISCUSSION

- *Pheromone trap capture—large-plot Phase I commercial sites:*

Data from the 2000 season is shown here to better illustrate some phenomena seen in 2001. Generally, Grower 1 had fewer OFM in his conventional insecticide block, and this is most likely a function of better insecticide spraying during the season (Fig. 1A). Both Phase I and Phase III MEC caused "trap shutdown" (*i.e.*, an absence of moths in traps, due to the effect of the pheromones on the males' ability to locate the artificial pheromones released from the lure in a trap) during the 2001 season (Fig. 1B and 1C). As Fig. 1D clearly shows, however, in 2000, the puffer dispensers did not prevent trap capture after the middle of July. But this failure occurred after the puffers demonstrated consistent potential for trap-catch reduction after deployment in early June. This failure was likely due to an insufficient amount of aerosol in the cans inside the puffers. A cumulative trap capture graph (Fig. 2), clearly showing that in the absence of pheromone treatments, trap captures increased in Grower 1's conventional block.

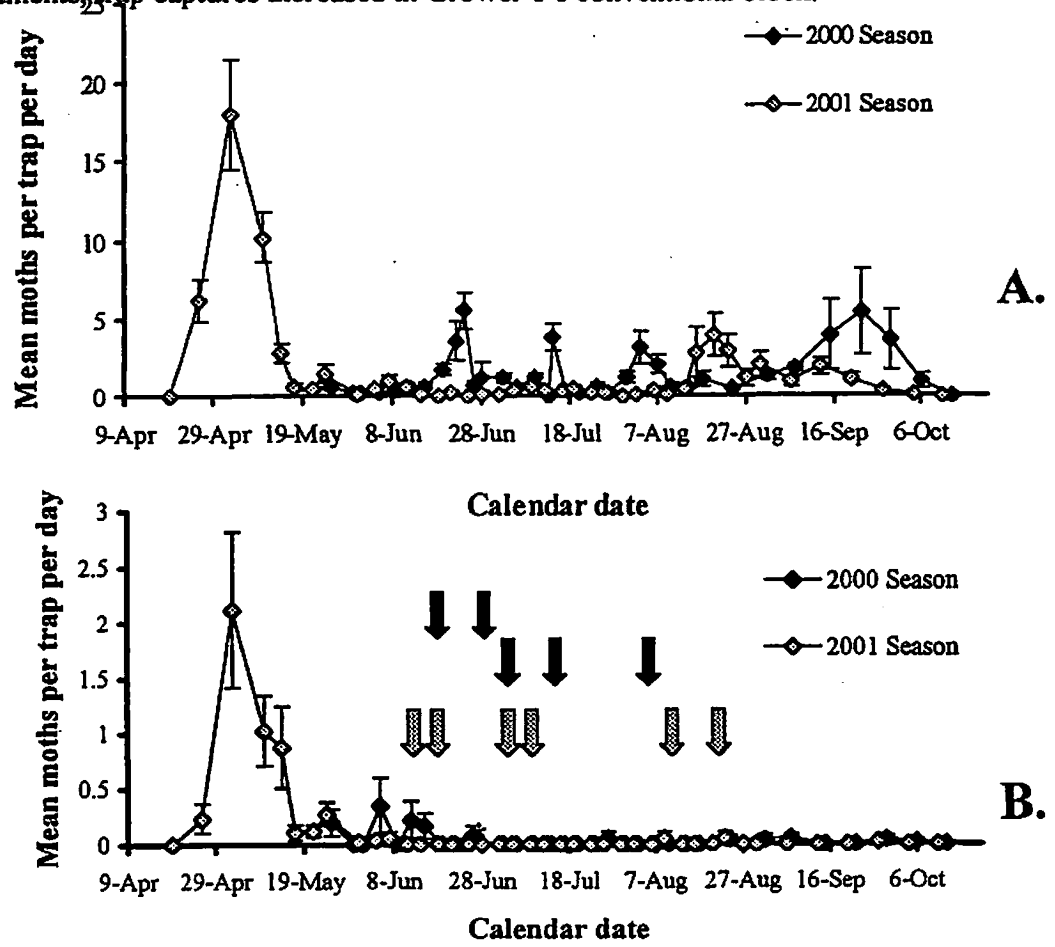

Fig. 1. Daily trap capture of OFM, conventional insecticide block (A), and sprayable pheromone Phase I block (B), Grower 1. The blocks were 6.1 ha (15 acres) and 6.9 ha (17 acres), respectively. Each was monitored with six pheromone traps. Arrows denote approximate ARM MEC application dates; the asterisk denotes extra application. Values reported are means ± SEM.

In 2000, both growers were instructed to apply sprayables in rough conjunction with male OFM flight phenology. This strategy was altered in 2001, by having applications made according to timings based on formulation longevity, regardless of the time of the OFM flight or brood. As Figs. 1B, 1C and 3B all show, the timings to which we adhered in 2001 nearly corresponded with those used in 2000.

Of particular interest is Fig. 1C, which clearly illustrates a dramatic reduction in early-season OFM flight in that block.

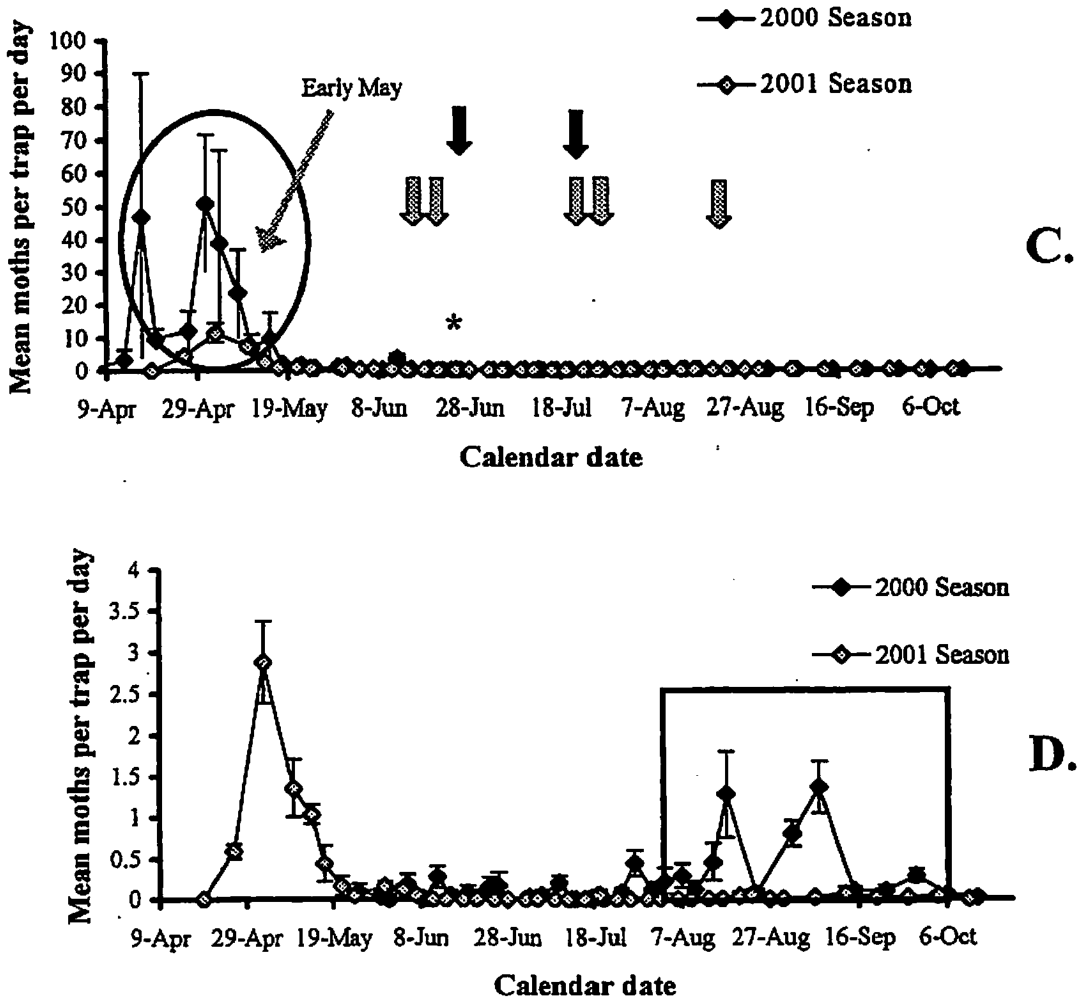

Fig. 1 (con't.). Daily trap capture of OFM, sprayable pheromone Phase III block (C), and aerosol puffer block (D), Grower 1. The blocks were 3.6 ha (9 acres) and 4.0 ha (10 acres), respectively. Each was monitored with six pheromone traps. Arrows denote approximate ARM MEC application dates; the asterisk denotes erroneous extra application. Values reported are means ± SEM.

The oval and arrow in Fig. 1C highlight a sharp contrast between trap capture at this time of the season in 2000, and 2001. The highest peak, on the line representing the 2000 season, is 486.5 moths--captured in a one-week period (observed on 4 May 2000). At the same time of the season in 2001 (3 May 2001), only 80.8 moths were captured in the same block, in weekly counts. No pheromones were applied early in the season, so the lower number seen in 2001 cannot be attributed to reduction of trap-finding by semiochemicals. The grower in question did re-calibrate his spray equipment over the winter, enabling more precise spray delivery in 2001 than in 2000; the resulting precision of application of both insecticides and pheromones undoubtedly contributed to this precipitous decline in OFM captures in the latter year. It is unclear from these data if the pheromones are solely responsible, however.

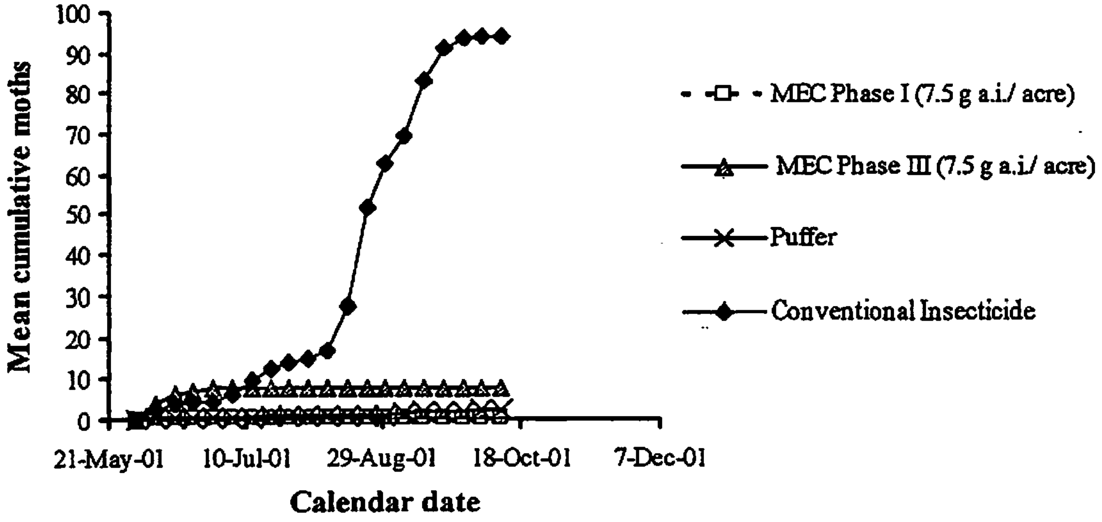

Fig. 2. Cumulative OFM trap capture, Grower 1, 2001. Means are reported.

In Fig. 2, the lines show that as trap capture increased steadily in the conventional block after initial MEC applications (11 Jun), trap catch was virtually eliminated in the pheromone blocks, regardless of application technique. Pheromone treatments were initiated in early June, and despite the high beginning moth pressure in the Phase III block, trap shutdown was achieved. Overall, Figs. 1 and 2 strongly suggest that the pheromones affected moth behavior to the extent the insects did not locate the traps by way of the chemical signal released by the lures.

The OFM flight phenologies were very similar in the conventional block at Grower 2's farm (Fig. 3); and, in both seasons, trap shutdown in the MEC Phase I block was excellent (Fig. 4A). Similarly to the results found at the first grower site, the puffers apparently performed better in 2001 than in 2000, the 2001 data not reflecting a failure to cause shutdown in the latter part of the season (Fig. 4B, boxed-in region).

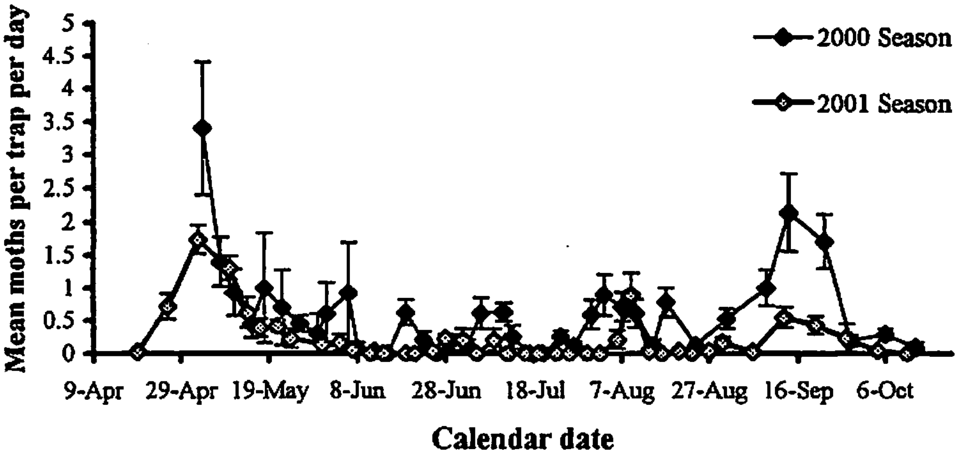

Fig. 3. Daily trap capture of OFM, conventional block, Grower 2. The block was 4.7 ha (11.6 acres). It was monitored with six pheromone traps. Values reported are means ± SEM.

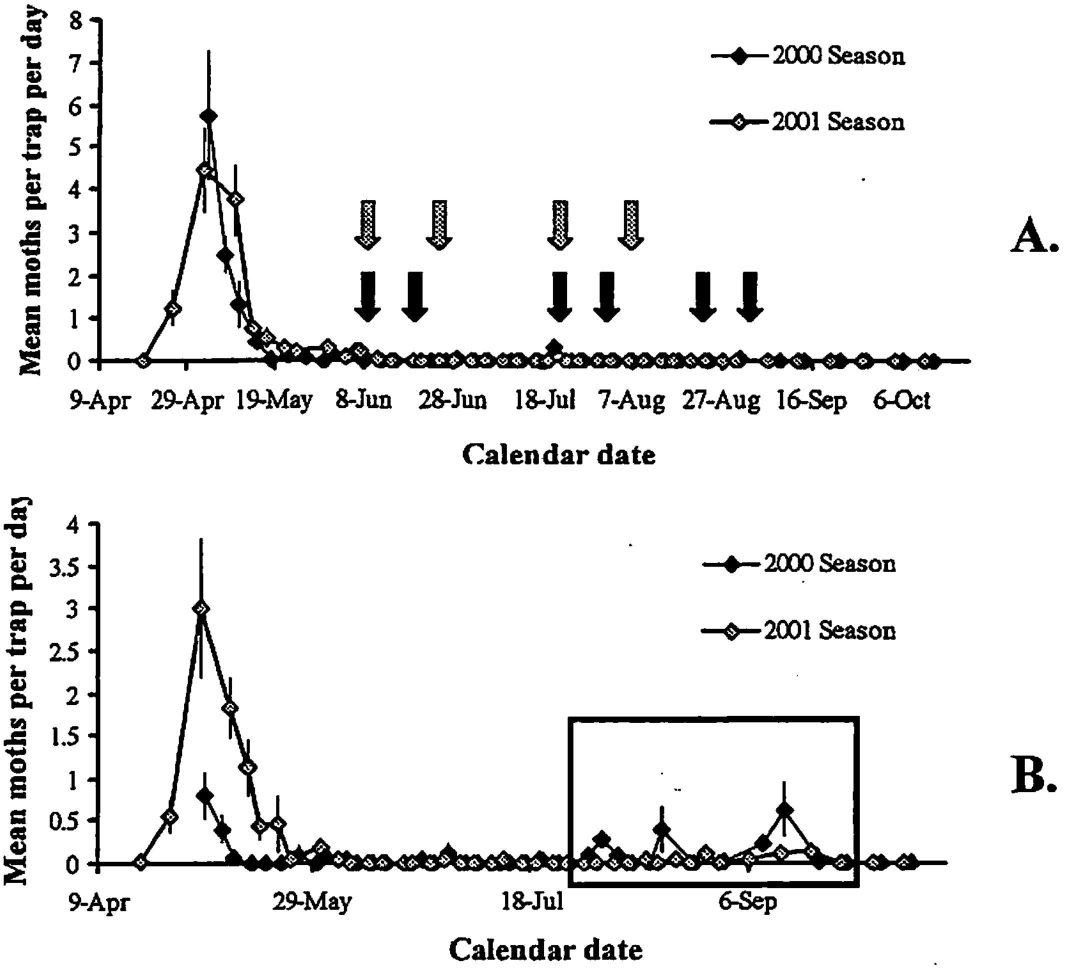

Fig. 4. Daily trap capture of OFM, sprayable pheromone Phase I block (A), and aerosol puffer block (B), Grower 2. The blocks were 4.4 ha (10.8 acres) and 4.7 ha (11.6 acres), respectively. Each was monitored with six pheromone traps. Arrows indicate approximate MEC application times. Values reported are means ± SEM.

After the beginning of June—a period between broods, and in which the first MEC's were applied—the cumulative trap capture reached a plateau (Fig. 5). The MEC and puffer technologies were therefore successful in inhibiting males' trap-finding, until late in September--especially for sprayable MEC pheromones.

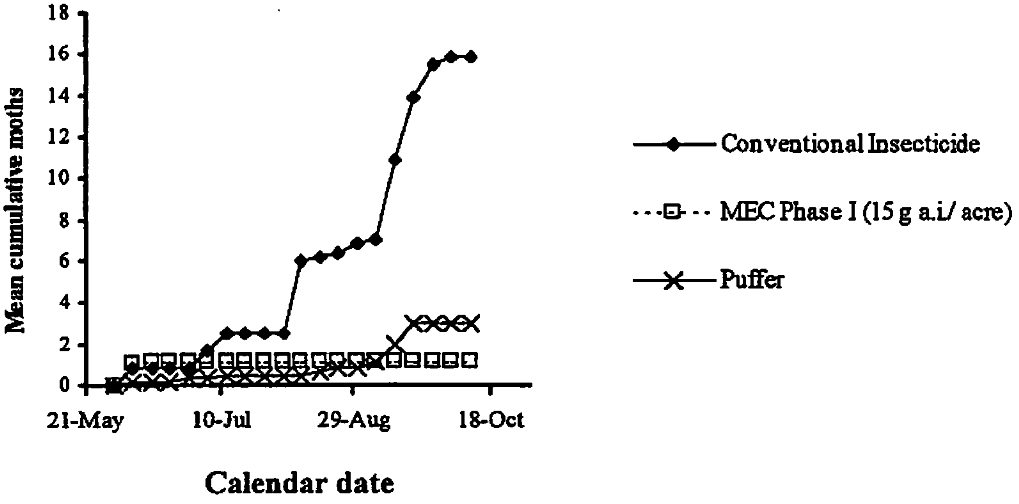

Fig. 5. Cumulative OFM trap capture, Grower 2, 2001. Means are reported.

- *Shoot and fruit injury—large commercial Phase I sites*

After initial shoot injury searches were made, it was determined that *in situ* fruit injury counts in apples, rather than shoot estimates, would better represent the presence and activity of OFM in the test blocks. As a result, shoot injury counts were not conducted in Grower 1's orchards. No shoot injury was measured in either of the rate studies previously described. Surveys of immature fruit, as described in the preceding sections of this report, revealed no injury or larvae. These surveys were made in the large commercial blocks only, and not in the smaller blocks dedicated to the rate studies.

Harvest time injury evaluations for 2001 are given in Table 4. As this table shows, injury in all categories was low in all test blocks (except the conventional insecticide block) at the Grower 1 site in 2001. There were no entries found in the MEC Phase I and puffer blocks. The MEC Phase I block was characterized by low OFM pressure in both 2000 (not shown here) and 2001 [the low population in the latter year may have been a function of pheromones applied the previous season]. A curative application of methoxyfenozide was made in the Phase I block due to concern that codling moth may have pervaded the block (data not shown). No codling moth larvae were found in this block at the end of the season.

Especially impressive is the reduction of entries in the Phase III block. A 100-fold decrease in this category occurred in 2001 (a comparison based on data from 2000, which is not displayed here). A single OFM larva was recovered from an injured fruit in the conventional insecticide block, but no live larvae were recovered in the Phase III block.

Although we maintain that the pheromones were integral in reducing trap capture in blocks where they were employed, some of the reduction must also be accredited to the calibration changes made by the grower. Prior to the 2001 season, his spray equipment was re-calibrated, and this technical improvement to his program and the accompanying precision of spray applications very likely contributed towards achieving these satisfactory results. This assumption can be applied to all blocks used in this study as they were sprayed with the same sprayer, and by the same operator.

Table 4. Harvest sample injury record, Growers 1 and 2—2001.

				Mean no. injured apples per 100 apples			
Grower Site	Treatment	Sample Date	Total Fruit Sampled	Entries mean (SEM)	Stings mean (SEM)	Leafrollers mean (SEM)	% Clean mean (SEM)
1	Conventional Insecticide	28 Sept 01	2673	0.16 (0.09)	0.04 (0.04)	1.46 (0.35)	98.3 (0.35)
1	MEC Phase I	5 Oct 01	2745	0	0	0.33 (0.10)	99.7 (0.10)
1	MEC Phase III	21 Sept 01	2641	0.04 (0.04)	0	0.15 (0.07)	99.8 (0.08)
1	Puffer	4 Oct 01	2749	0	0.07 (0.05)	0.25 (0.10)	99.7 (0.12)
2	Conventional Insecticide	4 Sept 01 17 Sept 01	4166	0.06 (0.05)	0.48 (0.12)	7.4 (0.70)	92.0 (0.72)
2	MEC Phase I	4 Sept 01 17 Sept 01	4299	0.21 (0.07)	0.67 (0.16)	11.4 (0.99)	87.8 (1.0)
2	Puffer	4 Sept 01 17 Sept 01	4244	0.094(0.04)	0.25 (0.1)	3.32 (0.46)	96.3 (0.52)

No less than 98% of the fruit in any block was clean; from a practical commercial standpoint, this increase in the percentage of clean fruit from 2000 to 2001 is very significant. The reduction of mean entries from 4.2% to 0.04% in the Grower 1 Phase III block is particularly impressive. Of the 46 live larvae found in fruit in the Phase III block in 2000, 23 were OFM, 14 were lesser apple worms, 3 were codling moths, and 6 were unknown. The Phase III block was infested with a complex of internal feeders dominated by OFM. The combination of insecticides and pheromones in 2001 reduced the injury in this block to a very low and acceptable level. Grower 1 did make late-season applications of azinphosmethyl (Appendix A), due to mistaken communications between the researchers and the grower. Although these applications undoubtedly had an impact on the OFM activity in the orchards, there was still a period of time, between 19 June and 2 August, in which no broad-spectrum insecticides were applied in the Phase I and puffer blocks, and a period between 12 June and 8 August in which no broad-spectrum insecticides were applied in the MEC Phase III block.

At Grower 2's farm, the mean number of entries in the MEC Phase I block in 2001 was equal to that in 2000 (data not shown) [Table 4]. We can safely say that mean entries were not higher in 2001, indicating that some stability and control was present in this block from the year 2000 to 2001. Both mating disruption technologies resulted in similar amounts of larval entries, and was not different than control afforded by conventional insecticides. In Table 4, it is also evident that much of the injury found in Grower 2's orchards in 2001 was due to feeding by the leafroller complex (*i.e.*, obliquebanded leafroller and tufted apple bud moth), leading us to conclude that better control of these pests would reduce overall injury.

Although it is impossible to account for every biotic and abiotic factor influencing the OFM biology in the puffer block-- including grower management and ecological phenomena such as natural enemy activity—it is logical to infer from these data that the puffers, at a density of 1 unit per 1 acre, were effective in mitigating larval entries. One larva was recovered from an injured fruit in the Grower 2 puffer block, but its recognizable characters were too diminutive for positive species identification.

The use of pheromones itself resulted in reduced need for input of broad-spectrum insecticides. In appendices A and B, the total amounts of broad-spectrum insecticides (in pounds) applied per acre for Growers 1 and 2, respectively, are given at the bottom of the column listing amounts of active ingredient applied per acre. In the MEC Phase I and puffer blocks at Grower 1's site, a 57.9% reduction in broad-spectrum insecticide was achieved after 1 June. In the Phase III block, a reduction of 30.7% was achieved. The experiment was initiated in 2000 with continuous insecticide input into this block until the end of the season. But by the end of the 2001 season, the performance of the pheromones permitted insecticide reduction—an important consideration, given the heavy infestation in this block in 2000. At Grower 2's farm, after 1 June, 90.4% reductions of insecticide input were achieved in both blocks using pheromone technology. These reductions represent the feasibility of sprayable pheromones and puffers as options for growers in their efforts to suppress OFM injury to fruit. In essence, they make a strong case for using pheromone technologies to augment growers' chemical arsenals.

The aerosol cans, in which the puffer pheromones were contained before discharge, were provided in two sizes—216g and 288g. Each can, regardless of mass, had 8.3% active ingredient. This discrepancy in can masses explains the different amount of active ingredient listed in Table 2. The puffers were deployed for 132 days at the Grower 1 site, and 136 days at the Grower 2 site. Even though cans of both masses were used at both sites, puffers were removed before the expiration of the lower-weight cans, precluding control failure due to depletion of aerosol. Despite the different can masses, the puffers discharged aerosol at mean rates slightly above 19 g AI/ acre over the whole season and were as effective as the MEC's at 7.5 g AI/ acre (ARM) and 15 g AI/ acre (complete). This amount of AI per acre represents a much lower amount than that applied when MEC's are sprayed over the course of the season for three broods, regardless of method (*i.e.*, ARM or complete) [Table 1]. The use of MEC's at the rates specified in this research required 45 g AI/ acre of material over the whole season, for three broods' worth. Essentially, the puffers used less than half that amount, and the injury that could be attributed to OFM was nonetheless lower in puffer blocks (Table 4). One additional advantage of the puffers is the constant replenishment of pheromone into the orchard over the course of their programmed discharge period. Whereas the MEC efficacy after application may be reduced by ultraviolet light and precipitation, puffer aerosol continually restores the pheromone barrier to the orchard atmosphere for the 12-hour puff activity period. Any pheromone lost to abiotic factors may be replaced by the puffers' operation (S. P. Robertson, personal communication).

Overall, these results show that the MEC and puffer technologies, at their respective amounts of active ingredient per acre, affected OFM male behavior enough to prevent their locating pheromone-baited lures, regardless of trap location in the orchards. This effect was apparent in blocks of any size, as shown by its appearance in both large- and small-plot studies. In large plots, however, a regularly applied rate of 15 g a.i./acre of MEC suppressed trap capture consistently throughout the season. In a large block with low OFM pressure (*i.e.*, Grower 1's MEC Phase I block), these pheromone technologies may contribute significantly to the presence of clean fruit at harvest time. A 3-fold decrease in trap catch in a block known to have a heavy OFM population indicates that a combination of properly timed Phase III pheromones with insecticides applied from a properly calibrated sprayer, may act together to reduce both moth populations and injury. From a practical commercial standpoint, sprayable pheromones and puffers both appeared to successfully reduce internal feeder entries in blocks where broad-spectrum insecticide applications were reduced.

ACKNOWLEDGEMENTS

We wish to thank the proprietors and staffs of the following commercial orchards for their voluntary use of property, manpower, and equipment for the execution of these studies: Bear Mountain Orchards, Aspers, PA; James R. Oyler Orchards, Biglerville, PA; and Westbrook Orchards, Biglerville, PA. Our gratitude is also extended to the Department of Plant Pathology at the Penn State Fruit Research and Extension Center, for their voluntary use of manpower and equipment. Funding and pheromones were provided by 3M Canada (London, Ontario, Canada) and puffer units were provided by Paramount Farming Co. (Bakersfield, CA, USA): to these corporations we offer our thanks for their invaluable support. We also thank the State Horticultural Society of Pennsylvania (SHAP), who also contributed financial support to complete this research.

Mating Disruption of Grape Berry Moth - 2001

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

II. Materials and Methods: In a vineyard in Nelson County, Shin Etsu dispensers were placed at 27 April (before the first flight) and on 25 May (just before the second flight). Each treated block was about 1.6 ha. The control block was treated with phosmet about every 2 weeks. The pheromone-treated blocks were treated once with phosmet on 17 Aug. Several times during the season (19 Jun, 13 Jul, 1 Aug, 23 Aug), injury in the pheromone-treated blocks was evaluated by examining 200 clusters per treatment were examined on the vine, quantifying percent injured clusters. Harvest injury was estimated by harvesting 4 clusters from each of 5 vines per section (edge and middle of each treatment block). Clusters were returned to Blacksburg, where berries were removed from the rachis and injured berries counted.

A vineyard block in Albemarle County was treated with 3M sprayable grape berry moth pheromone at about 2-week interval during the season. A nearby conventionally managed vineyard was used as the control treatment. Percent infested clusters were evaluated periodically during the season. At harvest time, 4 clusters per vine were collected from each of 5 vines per section (three distances from the vineyard edge in the disruption block, and from the edge and middle of the control block. Clusters were brought to Blacksburg for dissection.

III. Results and Discussion: Harvest fruit injury data from the placement timing trial are presented in Table 1. The two placement timings of rope dispensers provided equivalent control. The control block showed substantial injury in the edge.

The sprayable formulation of GBM pheromone appeared to give effective control, though there was some injury in the edge of the block. In the control, substantial injury was present in the beginning of the trial, but the grower switched to tebufenozide with the approval of a Section 18 registration; injury decreased thereafter.

IV. References Cited:

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

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

Table 1. **Grape berry moth injury data from a vineyard in Nelson County, Va, with two placement dates of pheromone dispenser, compared with conventional treatment (4 clusters/vine, 5 vines/section)**

Trt	Section	# Berr	%. Inj.	% w/Live larv
27 Apr	Edge	90.4	0.2	0
	Center	86.9	0	0
25 May	Edge	94.4	0.2	0
	Center	99.0	0.1	0
Cont	Edge	69.4	7.2	0.4
	Center	65.4	0.2	0

Table 2. **Grape berry moth injury data comparing a sprayable grape berry moth pheromone with conventional treatment (4 clusters/vine, 5 vines/section; each mean represents 20 clusters)**

Vineyard	Row	Avg. Berries/ Cluster	% injured	% w/ Live larvae
King (3M)	Row 2	54.6	5.2	0.5
	Row 12	59.4	0.6	0.2
	Row 32	72.0	0.6	0.1
Gorman (Control)	Edge	68.4	2.4	0
	Center	77.8	0.8	0

Mating Disruption of Internal Feeders in Apple - 2001

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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. Oriental fruit moth, *Grapholita molesta* (Busck) (OFM) was the first target of mating disruption in Virginia orchards (Pfeiffer and Killian 1988). In recent years OFM has been causing increased infestation in apple orchards. This tortricid complex was the subject of this mating disruption trial.

II. Materials and Methods: Albemarle County: Sections of an apple orchard composed primarily of 'Delicious' trees at Miller School, Albemarle County, were treated with several types of pheromone dispensers for CM and OFM. Trees were 2.4-3.0 m tall (8-10 ft). In section A, a rope-style dispenser combining pheromone of CM and OFM was used (1000/ha (400/A) on 18 April) (ca 10 A (4 ha)). In section B, Hercon Disrupt CM-Extra laminate pheromone dispensers (Hercon Environmental Company; 525/ha at petal fall) were used for CM and 3M Sprayable (30 g ai/ha (12 g ai/A)) for OFM. In section C, Hercon dispensers were applied for both species. In section D, Hercon CM dispensers were used with Gowan Confuse, a paraffin-based material for OFM (75 g ai/ha (30 g ai/A)). Section E was a conventionally treated control. In pheromone-treated blocks, a conventional insecticide program was followed through first cover. Three pheromone traps each for CM, OFM, VLR, TBM, and RBL were placed in each block and monitored weekly. Fruit were examined on the tree periodically during the season (29 May, 26 June, 1 August and 26 August); 10 fruit were examined on each of 20 trees. Harvest injury was assessed on 31 August. At that time, 300 fruit from the edge and center of each block were picked and returned to Blacksburg for examination.

Winchester: Three mating disruption programs for CM and OFM were compared with a standard pesticide program in a 10.5 ha (26 acre), commercial orchard near Winchester, VA. The orchard was divided into four rectangular, contiguous plots. Mating disruption plots ranged in size from 2.09-2.12 ha (5.17-5.25 A), while the conventional plot was 4.0 ha (9.87 A). Most trees in each plot were 'York', with rows of 'Greening', 'Rome' and 'Golden Delicious' in different plots. Trees were 23-yr-old, 5.2 m tall x 5.2 m wide (17 ft tall x 17 ft wide) and planted at a spacing of 4.9 x 7.3 m (16 x 24 ft). All plots received ARM sprays of Lorsban, Asana, and Azinphos-methyl through 1C (14 May) for management of first generation CM. Thereafter, the conventional plot received ARM sprays of Intrepid 2F (8.0 fl oz) and/or Guthion 50W (1.5 lb) through 23 August. The mating disruption plots received no pesticide after 14 May. A fungicide maintenance schedule in all plots included ARM applications of copper, Nova, Dithane, Ziram and Captan. Isomate C/OFM and Hercon Disrupt CM-Xtra dispensers were placed on branches in the outer canopy, in the middle or top third of trees. The distribution of dispensers among trees in rows is shown in Table 3. Trees with three dispensers had them deployed around the periphery of the tree. Trees with two dispensers had them deployed on opposite sides of the tree. An FMC Model 252S airblast sprayer calibrated to deliver 100 gpa at 3.0 mph was used to apply complete sprays of 3M OFM Sprayable pheromone. Duz-All hand pump sprayers were used to apply Confuse OFM to the upper third of trunks of trees. Treatment effect on disrupting the orientation of male moths to pheromone traps was measured as the number of male CM and OFM captured in three pheromone-baited traps per species in the center of each plot. Fruit damage from OFM and CM was evaluated by counting the number of fruit with frass during a 5-min examination of 10 or 20 'York' trees/plot. The leafroller complex was assessed by counting the number of shelters with and without larvae during a 5-min examination of 10 or 20 'York' trees/plot. An evaluation of internal feeder and leafroller damage at harvest was made from 100 apples/tree from each of 10 'York' trees in the center rows of each plot.

III. Results and Discussion:

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

Winchester: Very low trap catch of CM in the standard plot indicated that CM pressure in the orchard was probably light (Table 2). Orientation of male CM to pheromone traps was completely disrupted by Isomate C/OFM. Two male CM were captured in plots treated with Hercon Disrupt CM-Xtra (Table 2). Trap catch of OFM on 4 and 11 May indicated that OFM pressure in the orchard was moderate to high (Table 2). Since the Isomate C/OFM dispensers were deployed earlier than the other OFM pheromone formulations, OFM trap catch was eliminated in that plot for the duration of the season. Following the first application of the 3M Sprayable pheromone, OFM trap was eliminated for the rest of the season. OFM trap catch in the Confuse plot was eliminated until through 27 July, after which 1 or 2 moths were captured for 7 of the 9 following weeks. No fruit infested by CM or OFM were recorded from the first visual evaluation on 20 July, although TABM shelters were evident in each mating disruption plot (Table 3). On 8 August, some damage by internal feeders was recorded in the Confuse and the standard plots, and the number of leafroller shelters had increased since the previous evaluation (Table 4). All live larvae recovered were TABM. Some internal feeder damage was found in the 3M Sprayable plot on 28 August (Table 5). The Isomate C/OFM dispenser was the only formulation that eliminated trap catch of CM and OFM and damage to fruit by internal feeders. Between 99.8 and 100 percent of fruit were clean of damage by internal feeders at the harvest evaluation on 27 September (Table 6). Leafroller damage in the mating disruption plots, which had not been treated with pesticide since 14 May, ranged from 32.4 to 42.4 percent, and was substantially higher than in the conventionally managed plot (Table 6).

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Table 1. Number injured fruit per 300 sampled fruit per section in a mating disruption trial in Albemarle Country, Virginia (2001).

Treatment	Section	CM	OFM	Internal	*Platynota*	RBLR	TPB
A (Shin-Etsu CM/OFM combo rope)	Edge	0	0	0.3	0	0	2.3
	Center	0	0	0	0	0	3.7
B (Hercon CM, 3M Sprayable OFM)	Edge	0	0	0	1.3	0	2.7
	Center	0	0	0.3	0.3	0	5.7
C (Hercon CM, Hercon OFM)	Edge	0	0	0	1.3	0.7	2.3
	Center	0	0	0	1.7	0	4.3
D (Hercon CM, Gowan OFM)	Edge	0	0	0	0.3	0.3	2.0
	Center	0	0	0	1.3	0	2.0
E (control)	Edge	0	0	0.3	0	0	0.0
	Center	0	0	0	0	0	0.7

Table 2.

No. moths/trap (3 traps/species)

	CM						OF
Date	Confuse OFM/ Hercon Disrupt CM-Xtra	Isomate C/OFM	3M OFM Sprayable/ Hercon Disrupt CM-Xtra	Standard	Confuse OFM/ Hercon Disrupt CM-Xtra	Isomate C/OFM	3
May 4	0	0	0	0	71	0	
11	0	0	0	0.33	21.7	0	
18	0	0	0	0	0.67	0	
25	0	0	0	0	0.67	0	
June 1	0	0	0	0	0	0	
8	0	0	0	0	0	0	
15	0	0	0	0.67	0	0	
22	0	0	0	0	0	0	
29	0	0	0	0	0	0	
July 6	0	0	0.33	0	0	0	
13	0	0	0	0	0	0	
20	0	0	0	0	0	0	
27	0	0	0	0	0	0	
August 3	0	0	0	0	0.67	0	
10	0	0	0	0	0.33	0	
17	0.33	0	0	0	0.33	0	
24	0	0	0	0	0	0	
31	0	0	0	0	0.33	0	
Sept 7	0	0	0	0	0.33	0	
14	0	0	0	0	0	0	
21	0	0	0	0	0.33	0	
28	0	0	0	0	0.33	0	

Table 3.

Treatment/ formulation	Rate (no./acre or amt/acre)	Dispenser distribution (no./tree)	Time of application	CM and OFM damaged apples/5-min (July 20) (20-tree sample)			No. shelters/5-min
				Percent infested	No. live larvae CM	OFM	
Confuse-OFM	3791 - 4443 g		5/23, 6/27, 8/14	0.0	NA	NA	2.2
Hercon Disrupt CM-Xtra	204 clips	2-1-2-1-2	4/26				
3M OFM Sprayable +	2.0 fl oz	NA	5/23, 6/6, 6/25, 7/12, 7/30, 8/14, 8/29	0.0	NA	NA	1.3
Nu-Film 17	16.0 fl oz						
Hercon Disrupt CM-Xtra	266 clips	3-2-2-3-2-2	4/26				
Isomate C/OFM	362 ropes	3-3-3-3-3	4/25	0.0	NA	NA	2.3
Standard		NA		0.0	NA	NA	0.5

Table 4.

Treatment/ formulation	Rate (no./acre or amt/acre	Dispenser distribution (no./tree)	Time of application	CM and OFM damaged apples/5-min (August 8) (10-tree sample)			No. shelters/5-min
				Percent infested	No. live larvae		
					CM	OFM	
Confuse-OFM	3791 - 4443 g	NA	5/23, 6/27, 8/14	0.25	0	0	3.2
Hercon Disrupt CM-Xtra	204 clips	2-1-2-1-2	4/26				
3M OFM Sprayable +	2.0 fl oz	NA	5/23, 6/6, 6/25, 7/12, 7/30, 8/14, 8/29	0.0	NA	NA	7.3
Nu-Film 17	16.0 fl oz						
Hercon Disrupt CM-Xtra	266 clips	3-2-2-3-2-2	4/26				
Isomate C/OFM	362 ropes	3-3-3-3-3	4/25	0.0	NA	NA	5.2
Standard		NA		0.03	0.0	0.0	0.8

Table 5.

Treatment/ formulation	Rate (no./acre or amt/acre	Dispenser distribution (no./tree)	Time of application	CM and OFM damaged apples/5-min (August 28) (10-tree sample)			
				Percent infested	No. live larvae		No. shelters/5-mi
					CM	OFM	
Confuse-OFM	3791 - 4443 g	NA	5/23, 6/27, 8/14	0.0	NA	NA	
Hercon Disrupt CM-Xtra	204 clips	2-1-2-1-2	4/26.				
3M OFM Sprayable +	2.0 fl oz	NA	5/23, 6/6, 6/25, 7/12, 7/30, 8/14, 8/29	0.36	0	0	
Nu-Film 17	16.0 fl oz						
Hercon Disrupt CM-Xtra	266 clips	3-2-2-3-2-2	4/26				
Isomate C/OFM	362 ropes	3-3-3-3-3	4/25	0.0	NA	NA	
Standard		NA		0.0	NA	NA	

Table 6.

Treatment/ formulation	Rate (no./acre or amt/acre)	Mean percent fruit with:			Mean perc clean frui
		CM	OFM	Stings	
Confuse-OFM	3791 - 4443 g	0.0	0.0	0.0	100
Hercon Disrupt CM-Xtra	204 clips				
3M OFM Sprayable +	2.0 fl oz				
Nu-Film 17		0.0	0.10	0.10	99.8
Hercon Disrupt	16.0 fl oz				
CM-Xtra					
	266 clips				
Isomate C/OFM	362 ropes	0.0	0.0	0.10	99.9
Standard		0.0	0.0	0.10	99.9

RAPD-PCR and *Wolbachia* in Plum Curculio, *Conotrachelus nenuphar* (Herbst) (Coleoptera: Curculionidae), Strains.

Michelle E. M^c^Clanan[1], Shirley Luckhart[2], and Douglas G. Pfeiffer[1]

Abstract

Two morphologically identical strains of plum curculio, *Conotrachelus nenuphar*, exist: a univoltine (northern) strain and a bivoltine (southern) strain. Here we give the preliminary results for our molecular work. The RAPD-PCR primers were tested to differentiate the strains. Gene targeted PCR revealed the presence of *Wolbachia* in both the univoltine and bivoltine strains. Analysis of the *wsp* gene sequence shows the *Wolbachia* of the univoltine curculios is in a different supergroup than the *Wolbachia* strain carried by the bivoltine curculios. The use of RAPDs and gene targeted PCR will allow us to test plum curculios in Virginia and quickly determine if they are univoltine or bivoltine.

Introduction

The plum curculio, *Conotrachelus nenuphar* (Herbst), is endemic to eastern North America and is a pest of stone and pome crops. Chapman (1938), Bobb (1952), and Racette (1992) reviewed the life history of the plum curculio. The plum curculio attacks many fruit crops including apple, apricot, blueberry, cherry, nectarine, peach, pear, plum, and quince. Adults overwinter in woodlots, hedgerows, and abandoned trees (Butkewich and Prokopy 1993, Prokopy et al. 1999), and enter the orchard at bloom, with males entering a day or two before females.

In 1938, Chapman delineated the ranges of the northern and southern strain of plum curculio. This line runs through the fruit producing regions of Virginia, suggesting that southern strain larvae may be present in Virginia fruit at harvest. Because of this possibility, trade barriers have been placed against Virginia fruit in California and countries such as Brazil.

RAPD-PCR has been used to differentiate populations of numerous extant (Gawell and Bartlett 1993, Erney et al. 1996, Lu and Rank. 1996, Taberner et al. 1997) and ancient insect species (DeSalle et al. 1992, Cano et al. 1993, Farrell 1998). RAPD-PCR is based on the analysis of diagnostic DNA fragments, evaluated as observable banding patterns in agarose or polyacrylamide gels. DNA fragments are amplified using small PCR primers (10-mers in most studies) of random but defined sequence. These small primers bind to homologous sites within the genome during PCR amplification. Sequence variation within the binding sites among individuals or strains of a species may prevent primer annealing and amplification of some DNA fragments, resulting in different banding patterns (Loxdale and Lushai. 1998). Differences in amplification among individuals may be diagnostic for known or suspected patterns of population distributions.

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Stevenson and Smith (1961) reported that crossing a northern (univoltine) plum curculio female with a southern (bivoltine) strain male resulted in significantly fewer eggs laid and fewer larvae eclosing from the eggs. Padula and Smith (1971) reported reproductive incompatibility when testing crosses of a southern female and a northern male. This type of reproductive incompatibility is typical of several strains of *Wolbachia pipientis* Hertig (Werren 1998, Stouthamer et al. 1999, Bandi et al. 2001), a rickettsia-like bacterium that affects the reproduction of its host. Our preliminary data suggest that plum curculio is infected with *Wolbachia*. Infections with *Wolbachia* have been shown to result in the death of male embryos, feminization of males, parthenogenesis, and cytoplasmic incompatibility (Rousset et al. 1999, Bandi et al. 2001). Cytoplasmic incompatibility between infected males and uninfected females has been shown to result in restricted directional mating and may be the cause of directional mating patterns observed for plum curculio strains.

The *wsp* (*Wolbachia* surface protein) gene is used to determine *Wolbachia* strain classification (Zhou et al. 1998). The *wsp* gene mutates at a higher rate than the 16S ribosomal protein and the *fts Z* gene previously used to classify *Wolbachia*. This allows for a finer degree of strain separation phylogenetically. The *wsp* gene is divided into two supergroups (A and B) (Zhou et al. 1998) which correlate to the supergroups A and B defined by Werren et al. (1995) by the *fts Z* gene and to the supergroups I and II as defined by Stouthamer et al. (1993) by the 16S sequences.

Methods and Materials

Insects

Plum curculio northern strain adults were obtained from Dr. Ron Prokopy (U. Mass, Amherst); southern strain adults were provided by Dr. Dan Horton (U. GA, Athens).

PCR

Plum curculio DNA extraction was carried out as described in Ashburner (1989).

RAPD-PCR primers (Haymer 1994, Hsiao 1996, Taberner et al. 1997) were used to amplify 6.25 ng aliquots (n=10) of weevil DNA using PCR cycling conditions as described (Black IV and DuTeau 1997). Ethidium bromide-stained amplification products were electrophoresed through 2.0% agarose gels and photographed using a Kodak EDAS 290 digital analysis system (Figure 1).

Wolbachia 16S rDNA primers and PCR amplification protocol were adopted from Hsiao (1996) and Heddi et al. (1999). Amplified DNA fragments were cloned into TOPO-TA™ plasmid vector (Invitrogen) and sequenced (Davis Sequencing, U C Davis).

The *Wolbachia wsp* gene protocol was taken from Zhou et al (1998). DNA fragments amplified from the univoltine strain of plum curculio and the bivoltine strain of plum curculio were also cloned using the TOPO-TA™ kit from Invitrogen and sequenced at Davis Sequencing.

Results and Discussion

RAPD-PCR

Fifteen RAPD primers were tested to differentiate the univoltine and bivoltine populations. Of these, five were picked based on their ability to differentiate between the two strains and consistent amplification from replication to replication. Banding patterns for one primer, OPE-01, tested on two samples of DNA from each population (M= Massachusetts, B= Bryon, Georgia) is shown in Figure 1.

Wolbachia

The bivoltine strain gave consistent results each time it was tested. Fragments of the 16S r DNA gene were amplified for each individual tested (n=10) and showed putative homology with *Wolbachia* sequences previously deposited in GenBank (Table 1). The 16S rDNA primers yielded inconsistent results when tested with the univoltine population (n=10) and the sequence of one of the amplified fragments from the univoltine strain showed homology with a gene encoding for a 60S ribosomal protein. However, when tested with the *wsp* gene primers, strong amplification was achieved from all individuals (n=20).

The *wsp* gene fragments amplified from the univoltine plum curculios and the bivoltine plum curculios showed homology with *Wolbachia* strains that are in different subgroups (Figure 2). The bivoltine plum curculios carry a strain of *Wolbachia* which is in the A supergroup and shows strong homology to *Aus*. :The univoltine plum curculios carry a strain of *Wolbachia* that is in the B supergroup, but does not show strong homology to any of the strains in Figure 2.

Our goal is to use these procedures to test plum curculios in Virginia and determine if the bivoltine strain is indeed present in the fruit growing regions. If the bivoltine strain is not present then trade barriers can be lifted. If the bivoltine strain is present these methods can be used to determine the increase, decrease or spread of the bivoltine population.

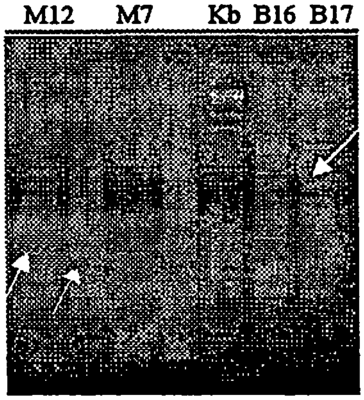

Figure 1. Banding differences between populations. Arrows mark the differentiating bands.

Table 1 Putative *Wolbachia* sp. 16S rDNA fragment (447bp) BLAST analysis results

Plum curculio derived sequence compared to…	Sequence Identity
W. pipientis 16S rDNA (host: *Aedes albopictus*)	446/447 (99%)
Wolbachia sp. 16S rDNA (host: *Phlebotomus papatasi*)	443/445 (99%)
W. pipientis 16S rDNA (host: *Hypera postica*)	442/447 (98%)
Wolbachia sp. 16S rDNA (host: *Nasonia vitripennis*)	442/447 (98%)

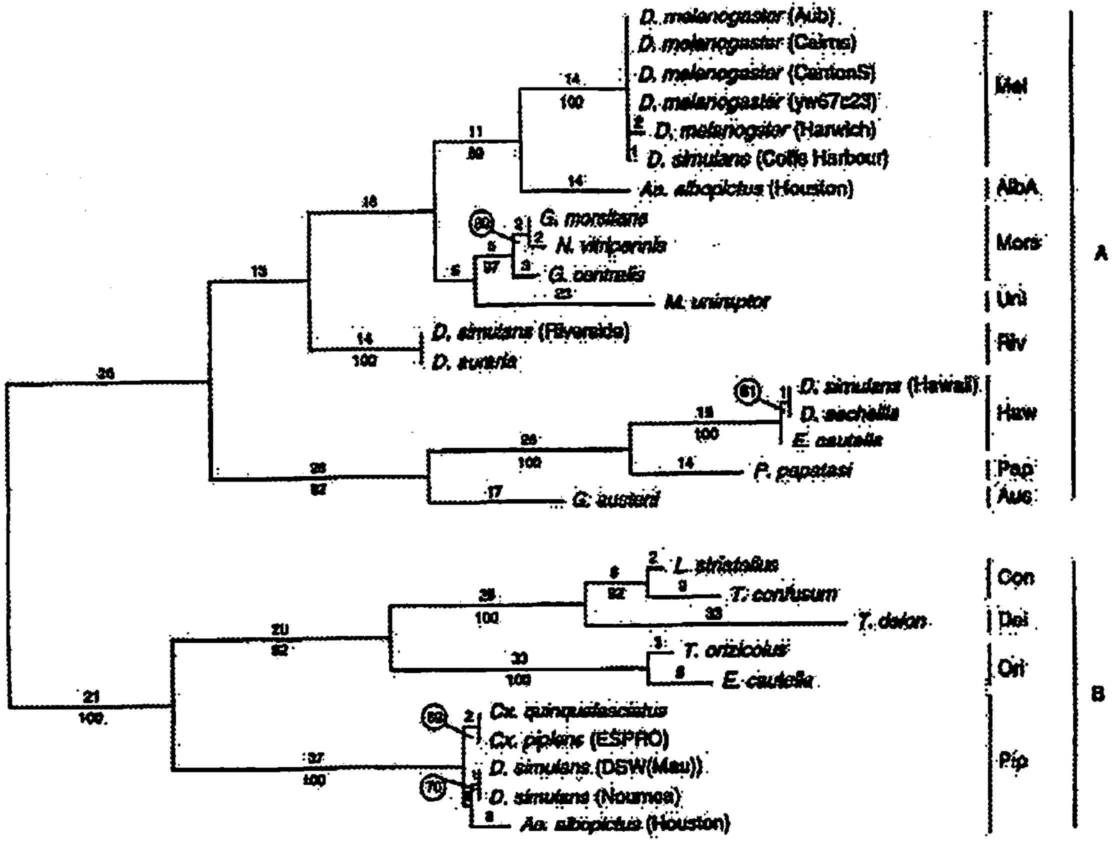

Figure 2. Phylogenetic tree from Zhou et al. (1998) showing the supergroups and strains of *Wolbachia* and their hosts. The strain of *Wolbachia* carried by the univoltine plum curculios is in the A supergroup and shows strong homology to the strain *Aus*. The strain of *Wolbachia* infecting the bivoltine plum curculios is in the B supergroup, but does not show strong homology to any of the strains in this tree.

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Three Summers of Trapping Plum Curculio, *Conotrachelus nenuphar* (Herbst), (Coleoptera: Curculionidae) in Virginia Orchards.

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Abstract

We tested three different traps designs baited with grandisoic acid, plant volatiles, and a combination of pheromone and plant volatiles. The host plant volatiles tested were limonene, ethyl isovalerate, benzadlehyde, 2-hexanol, plum essence and sour cherry essence. The three trap types tested were: the Tedders trap, the Circle trap with a wire boll weevil cone on top, and a branch mimic with a wire boll weevil cone on top. Results from 1999 with Tedders traps showed significantly more plum curculios being captured in the control or the grandisoic baited trap than the traps baited with either limonene, or plum essence. 2000 did not yield enough data to analyze with Circle traps baited with plum essence, sour cherry essence and grandisoic acid. Total trap capture was 2. 2001 yielded similar results with a branch mimic trap. The interaction between the pheromone and the host plant volatiles was significant and showed a quadratic trend toward the high release rate. Overall, all three of the traps are ineffective and trap captures were fairly low.

Introduction

Plum curculio, *Conotrachelus nenuphar* (Herbst), is a pest of pome and stone fruits in the eastern and central United States (Racette et al. 1992). There are two strains; a univoltine strain, found in the north, and a bivoltine strain, found in the south (Chapman 1938, Bobb 1952, Racette et al. 1992). The adults overwinter in hedgerows, woodlots, and unmanaged orchards(Butkewich and Prokopy 1993, Prokopy et al. 1999). In the spring the adults invade orchards with the males entering shortly before the females. The adults feed on twigs, leaves, and branches until fruit is formed. Both males and females feed on the immature fruit and the females oviposit in it. Feeding and oviposition damage worsen early abscission (June drop) and cause corky scars on the fruit remaining in the tree (Chapman 1938, Bobb 1952, Racette et al. 1992), making it unmarketable. These two factors may cause the loss of most of the crop. In addition, the fruit remaining on the tree may contain live larvae at harvest (in areas where a bivoltine strain occurs), resulting in exportation of this pest to other states or countries where plum curculio is not present. This prospect has caused trade barriers to be raised against states, like Virginia, that are suspected or known to have a bivoltine strain of plum curculio in the fruit growing regions.

Because of plum curculio's cryptic coloring and scotophasic habits, scouting for plum curculio is often unsuccessful and its presence in the orchard is not noticed until the fruit has been damaged. Currently there is no reliable monitoring system for detection of plum curculio populations in an orchard.

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Much work has been done in Massachusetts with host-plant volatiles that are attractive to the northern strain of plum curculio (Butkewich and Prokopy 1993, Prokopy et al. 1995, Butkewich and Prokopy 1997, Leskey and Prokopy 2000, Prokopy et al. 2000, Leskey and Prokopy 2001, Leskey et al. 2001). Landolt (1997) noted that host plant volatiles are often synergistic with pheromones produced by males. Eller and Bartelt (1996) isolated a male-produced aggregation pheromone, (+)-(1*R*, 2*S*)-1-methyl-2-(1-methylethenyl)cyclobutaneacetic acid . Due to its similarity to the aggregation pheromone of the boll weevil, *Anthonomus grandis grandis* (Boheman), (+)-grandisol, the compound was given the trivial name, grandisoic acid. Eller and Bartelt isolated this compound from both northern strain and the southern strain plum curculio adults. Therefore this pheromone may be tested in all areas, regardless of the strain of curculio present. This pheromone, in both a racemic blend (1999 and 2000 field trials) and a single isomer (2001 field trials), has been tested with host plant volatiles described by Butkewich (1997) and Leskey and Prokopy (2001) as being attractive to the plum curculio.

Three traps were tested. The Tedders trap, designed originally to be used for *Conotrachelus schoofi* Papp by Tedders and Wood (1994). A branch mimic designed by Prokopy et al (1998a, 1998b) and the Circle trap (Prokopy et al. 2000).

Methods and Materials

1999- Plum curculios were collected in Tedders Traps (pyramid traps, a dark (black) pyramid (mimicking a tree trunk) that stands on the ground with an inverted wire cone trap, adapted from the boll weevil trap, on top). Traps were placed under trees in apple and peach orchards in Augusta and Orange Counties during the summer of 1999 (all trees were of fruit bearing age). These traps were set out in May and removed in October. Each trap was placed at the base of an edge row tree. In Augusta County two replications of each treatment were conducted in each of two 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 an unbaited control: grandisoic acid (racemic blend) (IPM Technologies, Scenturion), ethyl isovalerate (IPM Technologies), limonene (IPM Technologies) and plum essence (proprietary blend IPM Technologies). The traps were checked weekly and the plum curculios in each trap were counted and recorded. In Augusta County grandisoic acid from IPM Technologies was compared to the other baits. In Orange County grandisoic acid from both sources was compared to the other baits. Data were analyzed using a generalized random block design to account for block treatment interactions as well as differences in the treatments. Tukey's HSD was used to separate statistically significant means. Due to low capture rates at the end of the summer, only the first eight weeks of captures were analyzed.

2000- Plum curculios were collected in Circle traps, the inverted wire cone trap with a "skirt" of aluminum insect netting attached to the bottom. The traps were attached to a branch with a length of bailing twine in edge row trees in apple blocks in Augusta County and apple and peach blocks in Orange County. The traps were set out in May and removed in September. In Augusta County two replications of each treatment were conducted in two blocks of apples. In Orange County one replication of each treatment was conducted in the apple block and two replications were conducted in the peach block.

The following treatments were compared to the unbaited control: plum essence (proprietary blend, IPM Technologies), sour cherry essence(proprietary blend, IPM Technologies), plum essence with grandisoic acid (racemic blend, IPM Technologies), and sour cherry essence with grandisoic acid (racemic blend, IPM Technologies). The traps were checked weekly and plum curculios in each trap were counted and recorded. Due to the lack of captures from this set up, there were no data to analyze. Total trap capture was 2 adult plum curculios.

2001- Plum curculios were collected in branch mimic traps. These traps are pieces of PVC pipe 25.5 cm long and 6.5 cm diameter, painted flat black with inverted wire cone traps at the top. The traps were attached to the branches using zip ties, in four abandoned apples trees and one abandoned plum tree in Craig County. The treatments were replicated once per tree, with each tree constituting a block. The treatments (obtained from Dr. T. Leskey, USDA-ARS Kearneysville, WV) were blends of limonene, 2-hexanol, ethyl isovalerate and benzaldehyde at low, medium, and high concentrations, with or without grandisoic acid (Great Lakes IPM). These six treatments were compared to a control. The traps were checked weekly and the plum curculios in each trap were counted and recorded. The data were analyzed as a completely randomized 3x2 factorial block design.

Results and Discussion

1999- 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, not being significantly different from either group. The fact that significantly more plum curculios were caught in the control than in traps baited with limonene or plum essence could be explained if these two substances function as a deterrent at the rates of release employed in this study. This possibility has not been tested though. In Orange County, there were no significant differences among the treatments.

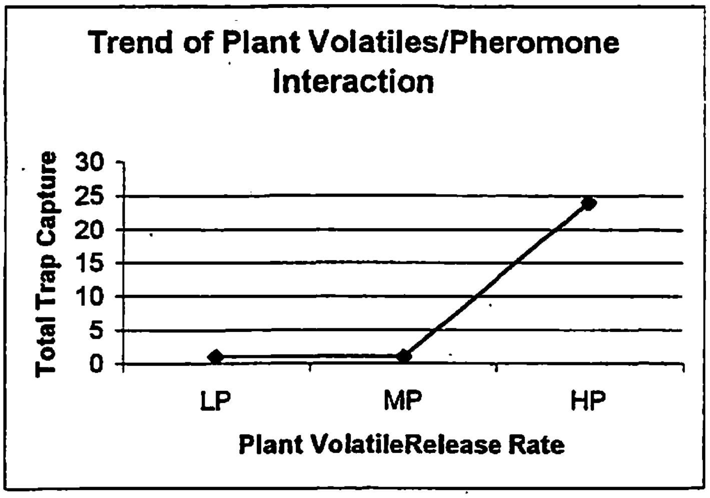
Table 1 Results from 1999 field study

Treatment	Augusta	Orange
grandisoic acid (IPM Technologies)	5.0b	4.0a
grandisoic acid (Scenturion)	—	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)

2001- Trap captures were low for the summer with 43 individuals being caught during the 12 weeks the traps were in the field. However, analysis of the data shows the interaction between the plant essences and the pheromone was significant ($p = 0.0161$ $\alpha = 0.05$) Trend analysis shows a quadratic trend (Figure 2) toward the high release rate. This may be due to a threshold within the tree, which must be reached before the direction of the plant volatile/pheromone combination can be distinguished from the volatiles given off by the plant itself.

Figure 2 Interaction Between Plant Volatiles and Pheromone



Overall, all three of the traps were ineffective. None of the traps were effective enough to be used in a commercial orchard to monitor adult populations of plum curculio nor to determine the timing of control measures needed.

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FINAL YEAR OF AN IPM DEMONSTRATION PROGRAM USING "SOFT INSECTICIDES" TO MANAGE INSECTICIDE RESISTANCE AND DAMAGE FROM THE OBLIQUEBANDED LEAFROLLER IN NY APPLE ORCHARDS.

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The objectives of this 3-year study conducted during the growing seasons of 1999, 2000, and 2001 were: (1) To determine if populations of OBLR will decline in orchards treated for several consecutive seasons with soft pesticides and (2) To determine if resistance levels of OBLR to organophosphates will decline in orchards not treated with organophosphate insecticides. These studies were conducted in 5 plots ranging from 30-4 acres in size set up in commercial apple orchards in western NY. At each site, a grower's comparison block was chosen that had horticultural characteristics (cultivars, tree size and spacing, training systems age of planting) that were as similar as possible to those of the research plots. The growers applied standard insecticide sprays to these comparison blocks at each site. Pest populations were sampled throughout the season in these standard blocks and insect fruit injury was sampled at harvest in these standard blocks so that population levels and damage could be compared at each site in the research and standard block. In the "soft" pesticide blocks, Dipel was applied at petal fall and first cover to control the obliquebanded leafroller, and internal lepidoptera. Provado was applied when needed to control aphids and tentiform leafminers. Spintor was applied at the first estimated egg hatch of the obliquebanded leafroller (early July), followed by two more sprays at 14 day intervals to control subsequently hatching obliquebanded leafroller larvae, internal lepidoptera, and apple maggots.

During each year of the study, overwintering OBLR larvae were collected from the soft pesticide blocks prior to bloom and colonized in the laboratory in order to monitor levels of resistance of larvae to organophosphate insecticides. Neonate larvae from the F 1 generation of each colony were tested for susceptibility to azinphosmethyl and chlorpyrifos in laboratory bioassays using treated petri dishes to monitor contact activity of the insecticides. The responses of these larvae were compared to those of a "susceptible" colony of OBLR from a population that had never been exposed to insecticides.

At the beginning of this study during the 1999 growing season, larvae from the 5 orchards in the blocks selected for the "soft" pesticide treatments were about 30-15X more resistant to azinphosmethyl and 3-4X more resistant to chlorpyrifos than larvae from the susceptible colony. OBLR larval populations declined substantially in all of the "soft" pesticide blocks during the second and third year of the study and it was difficult to obtain sufficient larvae to establish a colony from several of the research blocks. However, in those blocks from which larvae were bioassayed, levels of resistance to both materials remained fairly constant during the three years of the study, despite the absence of selection pressure from organophosphate applications in the "soft" pesticide blocks. For example, overwintering OBLR larvae that were bioassayed from 2 of the "soft" pesticide blocks during the beginning of 2001 growing season were about 20X more resistant to azinphosmethyl and 2-4X more resistant to chlorpyrifos than susceptible larvae.

During the initial year of the study in 1999, control of OBLR was slightly better in the "soft" pesticide plots than in the grower's standard blocks, but more than 5% of the fruit was damaged in most of the blocks. However, during the two remaining years of the trial, OBLR damage substantially declined and remained at fairly constant low levels of 1-3% average fruit damage. OBLR damage also declined in the grower's standard blocks during the 2000 and 2001 seasons, but control in these blocks was generally not as good as in the "soft" plots (Fig. 1 & 2).

Fig. 1. Total OBLR damage in soft pesticide plots, 1999-2001

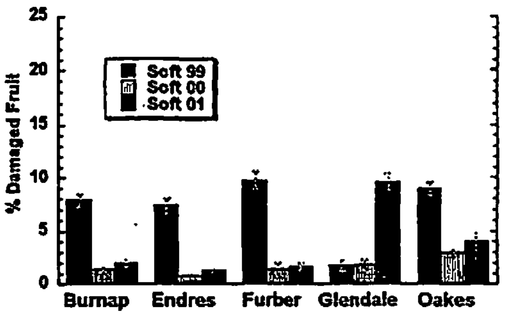
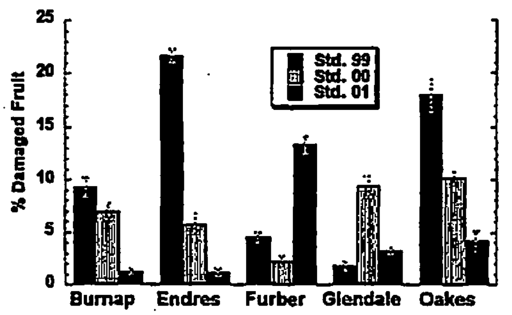


Fig. 2. Total OBLR damage in standard pesticide plots, 1999-2001



Secondary foliar pests such as mites, aphids, leafminers, and leafhoppers were generally not serious problems in the "soft" pesticide blocks during all three years of the study. However, some of the primary pests that cause fruit injury were not adequately controlled by the "soft" program. Plum curculio was one of the most serious pests in the "soft" blocks. Fruit injury from this pest steadily increased in the "soft" blocks during the second and third year of the study and damaged 10-15% of the fruit in 2 of the plots during the 2001 growing season. By the end of the third season of this study, curculio damage was found even in the "soft" blocks in which no damage had been detected during the initial season. Also, control of internal lepidoptera failed in one of the "soft" blocks, resulting in almost 30% fruit injury from this pest. Several of the other "soft" plots had traces of internal lepidoptera during the 2000 and 2001 growing seasons, although these low levels would probably not have been detected in normal fruit inspections. Apple maggots were not a serious problem in the "soft" plots, and only one damaged apple was observed in any of these plots during 3 years of harvest sampling. Levels of tarnished plant bugs in both the standard and soft plots were fairly similar during the study and usually an average of 1-3% of the apples in both treatments were damaged by this pest. Rosy apple aphids and scales were sporadic problems in the soft pesticide blocks, but damage in general was similar to that observed in the standard blocks. Although an economic analysis of data has not been completed, the costs of pesticides in the "soft" blocks and grower's standard plots appeared to be fairly similar.

WITHIN CANOPY VARIATION IN EFFICACY OF METHOXYFENOZIDE APPLIED TO APPLE WITH AN AIR-BLAST SPRAYER

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Codling moth and oriental fruit moth (OFM) have become important pests of North Carolina apples in recent years. Methoxyfenozide is an insect growth regulator that is highly effective at preventing egg hatch of both codling moth and OFM, and this is an important mode of action in controlling these pests in the field. The long residual activity of this insecticide makes it an ideal candidate for controlling the key lepidopterous pest complex occurring during May and June in NC; including first generation codling moth and tufted apple bud moth, and second generation OFM. To be cost effective, however, precautions must be taken to ensure proper timing of application(s) and that it is used in such a manner to take advantage of its long residual activity.

We have previously shown in laboratory bioassays that spray coverage is an important factor in determining the efficacy of methoxyfenozide as a codling moth ovicide. The volume of water applied to trees is a key factor in determining spray coverage, particularly on mature trees. The objective of this study was to examine the residual activity and efficacy in the field of one versus two applications of methoxyfenozide applied at different spray volumes.

Materials and Methods

The study was conducted in a commercial apple orchard in Lincoln County, NC, with a history of high codling moth and oriental fruit moth populations. The experimental block consisted of 20-year old mixed block of 'Delicious' and 'Golden Delicious' trees with an estimated tree-row-volume of 273 gpa. Plots consisted of a 0.21 block of trees (3 rows x 9 trees), and each treatment was replicated three times and arranged in a randomized complete block design. For methoxyfenozide treatments consisted of one and two applications made at 73 and 220 gallons per acre; all methoxyfenozide applications were made at 0.22 lb[ai]/A (14 oz of Intrepid 2F). In addition, a standard treatment consisting of two applications of azinphosmethyl (Guthion 50W at 1.0 lb/acre) and an untreated control were also included. Treatments were timed for the first generation of codling moth, with the first application made on May 9(about 281 DD after codling moth biofix and 649 DD after OFM biofix). For those treatments receiving two applications, the second application was made on May 23(about 530 DD after codling moth biofix and 965 DD after OFM biofix). All methoxyfenozide treatments received two applications of indoxacarb (5 oz per acre), directed at the second generation of codling moth, on June 20 (1143 CM DD and 1731 OFM DD) and July 2 (1346 CM DD and 1990 OFM DD) at the same gpa as previously applied. The azinphosmethyl treatment was treated with azinphosmethyl (1 lb per acre) on the same dates.

Fruit were collected from the center five trees of each plot on 9 and 23 May and 6 and 19 June to monitor residue levels and to and to monitor biological activity of methoxyfenozide. Residue samples and laboratory bioassay samples were collected from four positions within the tree canopy: low outside (LO), low inside (LI), high outside (HO) and high inside (HI). High samples were from the upper half of the tree, and inside samples were in close proximity to the center of the tree. Eight fruit from each position were collected for residue samples, and two fruit were collected from each position for lab bioassays for both codling moth and oriental fruit moth. Residue samples were processed and sent to Rohm and Haas Co. for analysis. Bioassay samples were placed into oviposition chambers that contained codling moth (10 females/10 males) or oriental fruit moth (15 females/15 males) adults for ~12-h oviposition period. Apples were then removed, eggs counted, and apples placed into separate containers held at ~27°C for 7 days, after which fruit were examined to determine percentage egg hatch and number of larval entries into fruit. Field fruit damage assessments were conducted once per week throughout the season, with 100 fruit per replicate examined (25 fruit per position). At the end of each generation, 200 fruit per replicate were examined (50 fruit per position) for damage and the presence of larvae.

Results and Discussion

Residue analysis. On the treatments that received one application of methoxyfenozide on 9 May, residue was detected through 19 June, although the residue levels were <0.1 ug/cm^2 at this time. Residue levels were generally higher on the outside versus inside of the tree, but these differences were not apparent after 23 May. Relatively high levels of methoxyfenozide (>0.1 ug/cm^2) were detected on those treatments receiving two applications (on 9 and 23 May) through 19 June, or 27 days after the last application. In addition, the differences between residue levels on the inside versus outside of the tree were much more dramatic for the two versus one application treatments. Spray volume had very little effect on residue levels regardless of the number of applications.

Laboratory bioassays. Percent codling moth egg hatch and number of larval entries into fruit are presented for each sample date in Table 1. All treatments were significantly different from the control for both percent egg hatch and number of larval entries per egg through 6 June. On 19 June, treatments that received two applications of methoxyfenozide continued to significantly suppress egg hatch and larval entries into fruit compared to the control, while the single methoxyfenozide application treatments were not significantly different from the control. There were significant differences in percent egg hatch for all dates between positions, with the outside versus inside contrast having the greatest effect. Position was not significant for number of entries per egg on 23 May and 6 June, but it was significant on 9 May and 19 June. Although fruit positioned high inside generally had higher percent egg hatch at 73gpa than at 220 gpa, there were no significant treatment by position interactions, which allowed positions to be combined within treatments. Two applications of methoxyfenozide did reduce egg hatch and larval entries more than one application, but there were no differences between 220 and 73gpa.

Percent oriental fruit moth egg hatch and numbers of larval entries per egg are presented for each sample date in Table 2. Oriental fruit moth data was not as consistent as that of the codling moth data. Based on the low OFM egg hatch rates in the control, it was assumed that fruit were introduced into the oviposition chambers before sufficient mating took place, which resulted in infertile eggs being laid. All treatments significantly reduced OFM egg hatch below that of the control from 9 May through 6 June, and, except for the single application of methoxyfenozide at 73 gpa, all treatments significantly reduced egg hatch compared with the control on 19 June. The main interactions of interest, application number and spray volume, were not as apparent with oriental fruit moth as codling moth, as data from one versus two applications were similar, as was egg hatch and entries in 73 versus 220 gpa.

Field damage assessments. All treatments significantly reduced damage below that of the control throughout the season. Furthermore, harvest damage assessment on 22 August showed that all treatments significantly reduced damage below that of the control, and there were no differences among insecticide treatments (Table 3). The control had more damage in the upper areas of the tree, but this trend was not observed in the insecticide treatments. A total of 48 live larvae were collected from control fruit at harvest, of which 60% were codling moth and 40% oriental fruit moth. In contrast, of the 17 larvae collected from insecticide treatment plots, 29% were codling moth and 79% oriental fruit moth. This discrepancy suggests that methoxyfenozide treatments were more effective against codling moth compared with oriental fruit moth. Fifty three percent of larvae found in the treated plots were from the single application methoxyfenozide treatment (3 CM and 6 OFM).

Conclusions

Based on residue and bioassay data, these results suggest that spray volume was not an important factor affecting the efficacy of methoxyfenozide against codling moth or oriental fruit moth. Rather, the number of applications was the more important factor. When two applications of methoxyfenozide were applied at 14-d intervals, significant levels of residue were detected for approximately 30 days after the second application, and this resulted in significant levels of protection from codling moth and oriental fruit moth throughout this time. Although no differences in fruit damage were observed between one and two methoxyfenozide applications, these data by themselves do not support the use of one application for control of both species throughout May and June, particularly under high population conditions. This study only examined treatment effects eggs and larvae, and possible sublethal effects of one or more treatments on adults may have affected all treatments. Because of the relatively small plots that were adjacent to one another, we cannot assume adults were not affected.

Acknowledgements

We thank Alan Davis for allowing us to use his farm and for applying all treatments, Marilyn Sawyer for colony rearing and laboratory bioassays, Jim Quinn for processing the residue samples, and Rohm and Haas for support of this project.

Table 1. Percent codling moth egg hatch and larval entries per egg in laboratory bioassays.

			% Codling Moth Egg Hatch			
Insecticide	GPA	Appl. Date	5/9	5/23/01	6/6/01	6/19/01
Intrepid	220	5/9/01	22.9 B	30.5 B	53.6 B	47.4 AB
Intrepid	73	5/9/01	25.6 B	29.9 B	48.5 B	45.3 AB
Intrepid	220	5/9,5/23		13.3 C	23.0 D	37.0 B
Intrepid	73	5/9,5/23		18.4 BC	30.9 CD	33.9 B
Guthion	220	5/9,5/23	18.6 B	16.1 C	43.1 CB	39.5 B
Control			84 A	87.1 A	85.0 A	65.1 A
	Treatment	*P*	<0.01	<0.01	<0.01	<0.01
	Position	*P*	<0.01	0.028	<0.01	<0.01
	Trt*Pos	*P*	0.44	0.32	0.41	0.56
Contrast	Out vs. In	*P*	<0.01	<0.01	<0.01	<0.01
	Hi vs. Low	*P*	<0.01	0.95	0.12	0.66
			Number of Codling Moth Larval Entries per egg			
Intrepid	220	5/9	0.06 B	0.12 BC	0.25 B	0.16 AB
Intrepid	73	5/9	0.11 B	0.16 B	0.20 BC	0.17 AB
Intrepid	220	5/9,5/23		0.06 BC	0.08 D	0.16 B
Intrepid	73	5/9,5/23		0.07 BC	0.13 CD	0.11 B
Guthion	220	5/9,5/23	0.06 B	0.05 C	0.14 CD	0.2 AB
Control			0.36 A	0.38 A	0.40 A	0.3 A
	Treatment	*P*	<0.01	<0.01	<0.01	<0.01
	Position	*P*	<0.01	0.13	0.43	<0.01
	Trt*Pos	*P*	0.22	0.16	0.81	0.09
Contrast	Out vs. In	*P*	0.018	0.022	0.133	<0.01
	Hi vs. Low	*P*	<0.01	0.80	0.772	0.2

Treatments with different letters within the same column are significantly different at $P = 0.05$.

Table 2. Percent oriental fruit moth egg hatch and larval entries per egg in laboratory bioassays.

			% Oriental Fruit Moth Egg Hatch			
Insecticide	GPA	Appl. Date	5/9	5/23/01	6/6/01	6/19/01
Intrepid	220	5/9/01	7.8 B	31.1 AB	24.6 B	27.0 D
Intrepid	73	5/9/01	13.0 B	17.1 B	30.3 B	43.5 AB
Intrepid	220	5/9,5/23		22.5 AB	33.7 B	24.8 D
Intrepid	73	5/9,5/23		29.5 AB	31.9 B	30.4 CD
Guthion	220	5/9,5/23	9.0 B	25.5 AB	20.8 B	37.8 BC
Control			78.3 A	52.7 A	70.9 A	47.2 A
	Treatment	*P*	<0.01	0.12	<0.01	<0.01
	Position	*P*	0.21	0.30	0.62	0.17
	Trt*Pos	*P*	0.03	0.87	0.94	0.50
Contrast	Out vs. In	*P*	0.08	0.12	0.32	0.38
	Hi vs. Low	*P*	0.30	0.34	0.49	0.97
			Number of Oriental Fruit Moth Larval Entries per egg			
Intrepid	220	5/9	0.05 B	0.19 AB	0.07 AB	0.09 B
Intrepid	73	5/9	0.06 B	0.03 B	0.08 AB	0.13 AB
Intrepid	220	5/9,5/23		0.14 AB	0.09 AB	0.08 B
Intrepid	73	5/9,5/23		0.13 AB	0.06 B	0.08 B
Guthion	220	5/9,5/23	0.05 B	0.04 B	0.05 B	0.14 AB
Control			0.33 A	0.26 A	0.16 A	0.22 A
	Treatment	*P*	<0.01	0.15	0.10	0.01
	Position	*P*	0.13	0.11	0.69	0.86
	Trt*Pos	*P*	0.19	0.62	0.77	0.86
Contrast	Out vs. In	*P*	0.17	0.05	0.51	0.64
	Hi vs. Low	*P*	0.85	0.12	0.69	0.84

Table 3. Mean (± SEM) percentage fruit damage of apples treated with different volumes of water. Lincoln County, NC. 2001

Insecticide	GPA	Application date	5/16	5/23	5/30	6/6	6/13	6/19	8/22
Intrepid	220	5/9	2.3±1.9	3.9±1.8	2.3±1.2	2.7±1.4	3.3±0.9	3.3±0.9	5.5±2.0
Intrepid	73	5/9	0.0±0.0	5.3±2.8	1.3±0.9	0.3±0.3	2.0±0.0	3.7±1.2	4.0±1.5
Intrepid	220	5/9,5/23	0.0±0.0	4.0±3.0	1.0±1.0	3.0±1.0	3.0±1.0	1.0±0.1	3.0±2.1
Intrepid	73	5/9,5/23	1.0±0.6	3.0±0.1	2.0±0.0	1.0±1.0	2.0±1.0	1.0±0.3	3.0±1.5
Guthion	220	5/9,5/23	1.0±0.6	3.0±0.9	4.0±1.0	3.0±1.0	4.0±1.0	4.0±2.0	6.5±2.5
Control			2.0±1.0	8.0±2.0	7.0±3.0	14.0±3.0	16.0±7.0	20.0±3.0	26.0±15.4

Alternative Codling Moth Control Trials

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In trials with a reduced insecticide application program, codling moth has been one pest that causes unacceptable levels of fruit damage. In this study I used two ecologically non-disruptive, pheromone-based control methods for codling moth: attract and kill, and mass trapping. Four, five-year-old orchards with 'Empire' and 'Granny Smith' were used to test these control methods in an unreplicated trial. The insecticide control was a 0.25 ha orchard of apples treated with an organo-phosphate (phosmet and methomyl) based program of insect control. The biological control orchard, 0.5 ha of mixed peach and apple, had no controls directed at codling moth but did have flowering plants to attract parasitoids. The attract and kill block was 0.25 ha of apple and had three applications of 2700, 50 microliter drops of Last Call™ (IPM Technologies, Portland, OR) applied on 1 May, 19 June, and 1 August. The mass trapping orchard was 0.5 ha of mixed peach and apple and had 11 Multipher III traps with 500 ml of Quick Sand™ (Powder Trap Inc., Nanaimo, BC) as the collecting medium and a sex pheromone lure from Trécé. The Quick Sand™ and lures were replaced on the same dates as the Last Call™ applications.

Data were collected with weekly monitoring of one pheromone trap in each block using the same Trécé lure as in the Multipher traps, three visual examinations of 15 trees in each block, and examination of 600 fruit per block at harvest. The pheromone trap in the mass trapping block had significantly fewer moths (0.32 per week) than traps in the other blocks (1.23 in the attract and kill block, 3.00 in the chemical control block, and 6.26 in the biological control block). There was no difference in the number of codling moth infested fruit per tree at 25 June or 3 August, but at 9 September the insecticide control block had significantly fewer infested fruit per tree (0.00) than the other three blocks (0.47 to 1.00 infested fruit per tree). At harvest both 'Empire' and 'Granny Smith' apples from the attract and kill and mass trapping blocks had significantly more codling moth damage than the insecticide control. For the two treatments combined, 'Empire' had 4% and 'Granny Smith' had 5% damage from codling moth compared with 0% and 1% in the insecticide control and 3% and 15% in the biological control check. Every apple was cut open, and all Lepidoptera larvae were identified as codling moth based on the absence of the anal comb.

Neither the attract and kill nor mass trapping provided adequate control of codling moth in this test. The plot size, however, was smaller than recommended for pheromone-based population manipulation due to the immigration of mated codling moths from outside the orchard. Further work with the mass trapping is planned with a revised trap design and the addition of the newly discovered female attractant.

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2001 SURVEY OF INTERNAL FEEDERS CAUSING REJECTION OF APPLES BY VIRGINIA PROCESSORS

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Historically, the codling moth (CM) has been the most damaging and abundant internal feeder of apple in mid-Atlantic orchards, whereas the Oriental fruit moth (OFM) has been the most serious pest of peach and nectarine in this region. Recently, OFM has been found in increasing numbers in mid-Atlantic apples, and surveys of the species of internal feeders causing the rejection of loads of apples by Pennsylvania fruit processors have revealed that it has become the predominant problem. These two species differ in their seasonal phenologies, and optimal control of them using pesticides requires the application of sprays at different times (ideally based on biofix dates and degree-day accumulations). Consequently, documentation of the relative abundance of each species is important to understanding how management programs should be modified or focussed. As well, the developmental stage of larvae of each species found in apples from rejected loads can provide information about when the infestation (and hence weaknesses in the program) may have occurred. Since there are no data like those generated in Pennsylvania for apples being taken to Virginia processors, we initiated a survey of the species responsible for the rejection of loads of apples in Virginia.

Methods:

The project was conducted in cooperation with National Fruit Products Company, Bowman Apple Products Company and the USDA Inspection Service. On June 26, 2001, introductory letters were mailed to 162 growers identified from the client lists provided by both companies. This mailing was followed on July 24 by a letter of authorization that enabled those wishing to participate to authorize the release of samples of infested fruit to JCB.

Samples were received daily on most weekdays from September 5 through October 29, 2001. All fruit received were inspected for live or dead larvae and larvae found were categorized as follows:

1. Live or dead internal larvae with no anal comb were assumed to be CM
2. Live internal larvae with anal comb were placed on diet. Both OFM and lesser apple worm (LAW) larvae possess an anal comb and are difficult to separate. Morphological characteristics of adult moths facilitate species identification.
3. Very young live larvae were placed on diet.
4. Dead larvae with no abdomen were discarded
5. Dead larvae with anal comb were assumed to be OFM

The width of the head capsule of all live and dead larvae was measured for determination of the developmental stage of each. All larvae placed on diet were held at 25°C and 14:8 L:D until the larva pupated and emerged as an adult or died.

Results

Forty-seven signed authorization letters were returned, and the number of rejected loads included in this data set (248 loads) are from companies owned by those growers only. The majority of companies represented in the survey (29) had a single load rejected, eleven companies had between 2 and 4 loads rejected, while a few had much more severe problems.

The majority of loads were rejected during the first month of the survey (Fig. 1). Although we did not keep records of the varieties from which data were taken, there were many samples of 'Golden Delicious' in the September loads. The number of samples received showed a pronounced reduction during the first week of October, coinciding with the end of harvest of earlier maturing varieties and preparation for harvest of the later varieties. The number of loads rejected per week increased during the second week of October and showed a steady reduction thereafter.

A total of 175 live larvae were placed on diet (Fig. 2). Of the 86 adult insects recovered, there were 74 OFM, 1 TABM, and 11 parasitic wasps. OFM was responsible for the rejection of the great majority of loads (77%) (Fig. 3), while CM was responsible for 17%, and 6% were rejected due to the presence of both OFM and CM. TABM was not a significant problem. CM and OFM were about equal in importance during the first week of the survey (Fig. 4), but through the rest of September and October the proportion of loads rejected due to CM decreased greatly. The greatest number of loads rejected due to the presence of both CM and OFM was in September; this was quite rare in October (Fig. 5).

The larval developmental data show a progression of development through the harvest period. During the first two weeks of the survey, most of the CM instars were represented in the samples, although the majority of larvae recovered were late instars (Fig. 6). From the last half of September through the end of the harvest, early instar CM larvae were not found and only the last two instars were recovered during the last two weeks of October (Fig. 6). There were many more early instars of OFM than CM recovered during the first two weeks of the survey (Fig. 7), and all but first instar larvae were represented in samples throughout September. Through October, late instar OFM larvae were most abundant, although some 3rd instars were present during the last two weeks of harvest (Fig. 7).

Conclusions

1. OFM was the primary problem in all varieties
2. Both CM and OFM broke through some programs
3. There were more rejections of early than late varieties
4. CM was more important in early than late varieties
5. No lesser apple worm was found

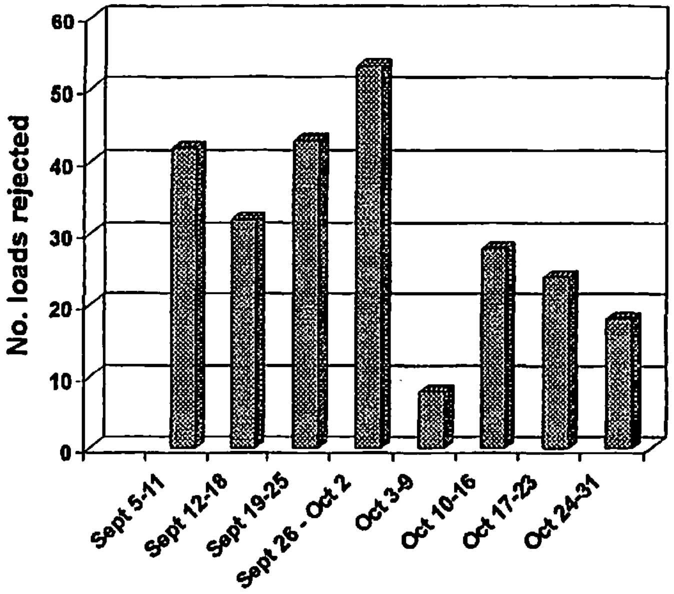

Fig. 1. The number of loads of apples rejected per week.

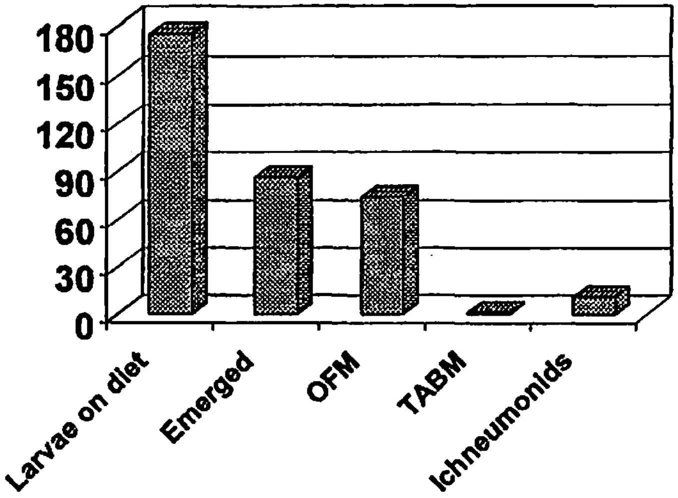

Fig. 2. The survival and species composition of larvae collected from infested apples and reared on diet.

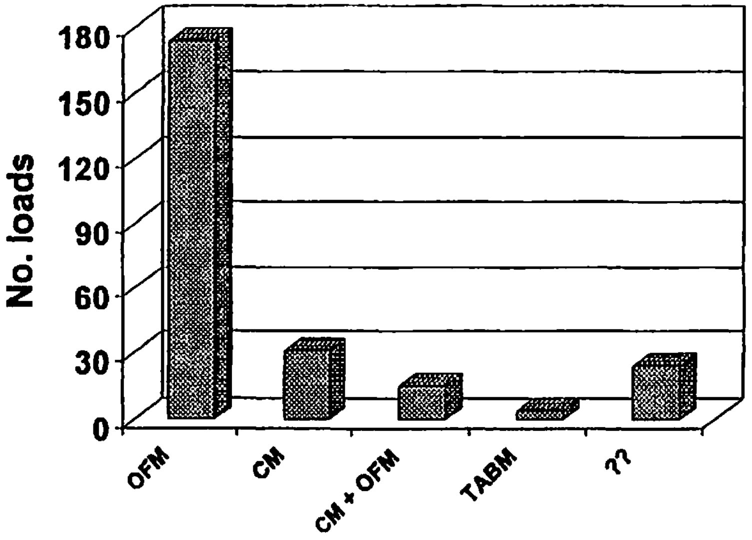

Fig. 3. Load rejections based on the species of insect recovered.

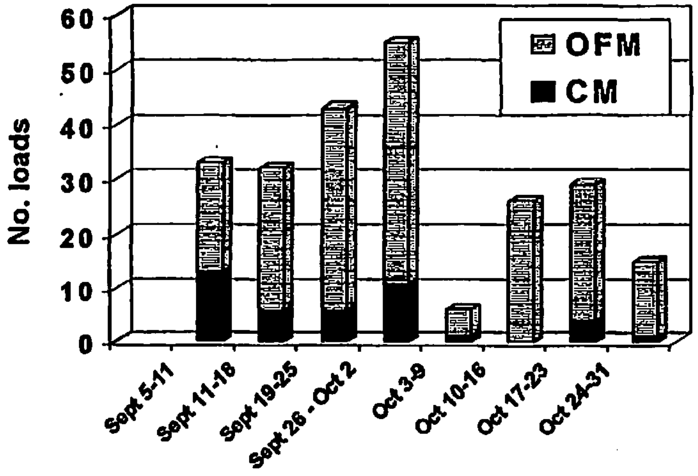

Fig. 4. The number of loads rejected per week due to the presence of codling moth or oriental fruit moth.

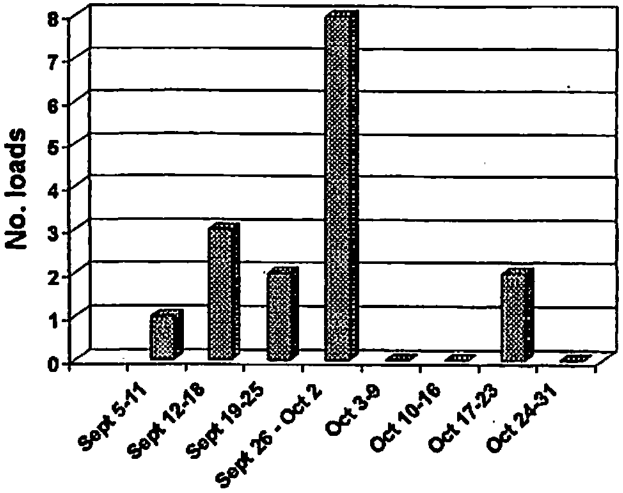

Fig. 5. The number of loads rejected per week due to the presence of both CM and OFM in fruit.

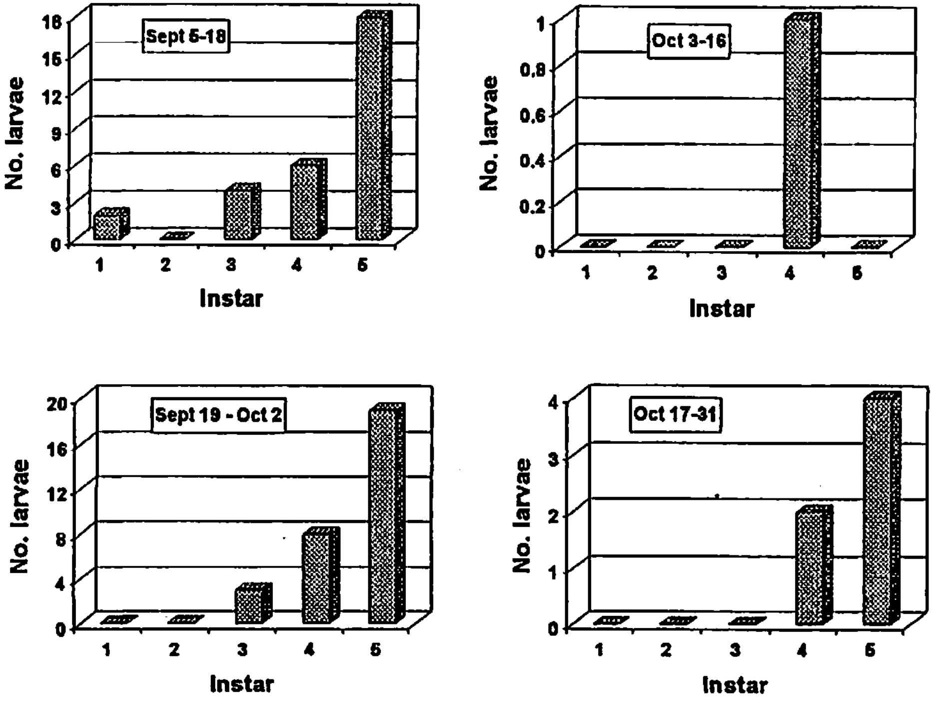

Fig. 6. The frequency distribution of CM larval instars at bi-weekly intervals.

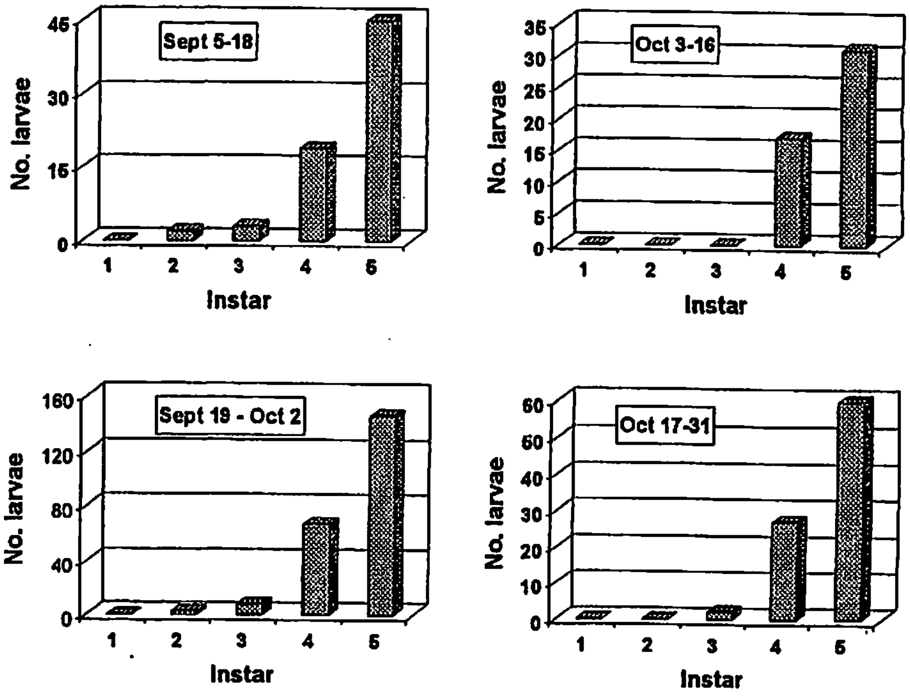

Fig. 7. The frequency distribution of larval instars of OFM at bi-weekly intervals.

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ARTHROPOD PEST SUSCEPTIBILITY OF NEW APPLE CULTIVARS

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Differences in cultivar susceptibility to injury from arthropod pests can have a significant impact on the effectiveness and cost of pest management programs. Higher populations of European red mites typically occur on Delicious compared to other cultivars, resulting in higher acaricide costs. The tendency for fruit to grow in clusters on cultivars such as York and Rome usually leads to higher levels of injury from leafroller species, compared to cultivars with fewer clustered fruit. In order to determine the pest susceptibility of some newer apple cultivars, pest evaluation plantings were established at nine sites in seven states in 1995 as part of a regional NE-183 project (Multidisciplinary Evaluation of New Apple Cultivars). This paper presents pest susceptibility data for the second year (2001) of a two-year study.

Methods and Materials

This study was conducted in a 0.14 hectare planting of 26 cultivar/rootstock combinations (23 cultivars on M.9 337 rootstock and 3 cultivars on MARK rootstock) established in 1995 at the USDA-ARS Appalachian Fruit Research Station. Five replications of each cultivar/ rootstock combination were planted in a randomized block design at a spacing of 2.5 m x 4.3 m. Insecticide/acaricide sprays were limited to applications of oil on 3 Mar, Sevin on 10 May (for thinning), and Pyramite on 22 Jun.

Incidence of rosy apple aphid (RAA) was determined on 5 Jun by counting the number of colonies on each tree. Spirea aphid (SA) populations were evaluated on 5 Jun by counting the number on the most infested leaf on each of 10 terminals per tree. Abundance of European red mite (ERM) was determined on 20 Jun by sampling 20 leaves per tree, removing mites with a mite-brushing machine, and counting motile stages with a binocular microscope. Injury from Japanese beele (JB) was assessed on 31 Jul by determining the number of injured leaves per tree. Injury from spotted tentiform leafminer (STLM) was evaluated on 5 Sep by counting all tissue-feeder mines during a 5 minute period per tree. Incidence of white apple leafhopper (WALH) was determined on 7 Sep by counting nymphs on the underside of 25 leaves per tree. Injury from fruit-feeding insects was determined by sampling up to 100 picked apples and up to 100 drop apples per tree at optimum harvest for each cultivar. Cultivars were numerically ranked from the least to the most susceptible to incidence or injury from each pest, and these numbers were summed to develop a pest susceptibility rating.

Results and Discussion

Of the 23 cultivars on M.9 337 rootstock, the pest susceptibility was as follows. For RAA, the least susceptible were Braeburn, Ginger Gold, Goldrush, Honeycrisp, NY75414-1, Orin, Sansa, Senshu, Suncrisp and Pioneer Mac, and the most susceptible were Enterprise and Cameo (Table 1). For SA, the least susceptible were Goldrush and Honeycrisp, and the most susceptible were Shizuka, Cameo, Enterprise and Arlet (Table 1). For ERM, the least susceptible were Enterprise and Pioneer Mac, and the most susceptible were Yataka, Pristine, Arlet and Shizuka (Table 1). For JB, the least susceptible were Golden Supreme, Goldrush, Sunrise, Pioneer Mac and Sansa, and the most susceptible were Enterprise, Gala Supreme, Yataka and Senshu (Table 2). For STLM, the least susceptible were Sansa and Golden Delicious, and the most susceptible were Fortune and Cameo (Table 2). For WALH, the least susceptible were Braeburn and Golden Delicious, and the most susceptible were Enterprise, Shizuka, Creston and Suncrisp (Table 2). For tarnished plant bug (TPB), the least susceptible were Yataka and Creston, and the most susceptible was Cameo (Table 3). For plum curculio (PC), the least susceptible were Fuji Red Sport #2 and Braeburn, and the most susceptible were Ginger Gold, Yataka and NY75414-1 (Table 3). For codling moth (CM) and oriental fruit moth (OFM), the least susceptible were Sunrise, Pristine and Sansa, and the most susceptible were Golden Delicious, Cameo, Shizuka, Goldrush and Gala Supreme (Table 3). The amount of injury was related to date of cultivar maturity, averaging 8, 26 and 29 percent for cultivars harvested in July to Aug, Sep and Oct, respectively. A total of 51 internal larvae were collected from fruit examined at harvest, consisting of 78% CM and 22% OFM. For tufted apple bud moth (TABM) and redbanded leafroller (RBLR), the least susceptible were Pristine and Sunrise, and the most susceptible were Gala Supreme, Fortune, Cameo and Enterprise (Table 3). Injury increased with date of cultivar maturity, averaging 4, 11 and 19 percent for cultivars harvested in July to Aug, Sep and Oct, respectively. For AM, no injury was found on 16 of the cultivars, and of the remaining 7 the most susceptible were Shizuka and Braeburn (Table 3). The highest percentage of clean fruit occurred with Sansa, Pristine and Sunrise, while Shizuka and Cameo had the lowest (Table 3).

Pest susceptibility to all foliage pests combined was lowest for Goldrush and highest for Shizuka, Cameo, Yataka and Pristine (Table 4). Susceptibility to all fruit pests combined was lowest for Pristine and highest for Shizuka, Cameo and Orin (Table 4). When both foliage and fruit pests were combined, susceptibility was lowest for Sansa and Pioneer Mac and highest for Shizuka and Cameo (Table 4).

Of the three cultivars on both M.9 337 and MARK rootstocks (Braeburn, Golden Delicious and Yataka), susceptibility to all foliage pests combined was higher on M.9 337 for all three cultivars (Table 4). Susceptibility to all fruit pests combined was also higher on M.9 337 for Golden Delicious and Yataka, but slightly higher on MARK for Braeburn due only to a significantly higher level of injury from TPB (Table 4). When all pests and both rootstocks were considered, the susceptibility of these three cultivars on MARK was in the lowest category, comparable to Sansa and Pioneer Mac on M.9 337 (Table 4). Trees on MARK rootstock generally exhibited lower vigor than those on M.9 337, especially Braeburn which was very runt-like in appearance.

Hogmire and Miller

Table 1. Incidence of rosy apple aphid, spirea aphid and european red mite on new apple cultivars.

No.	Cultivar/Rootstock	RAA colonies/tree	SA/most infested leaf/terminal[1]	ERM/leaf
		5 Jun	5 Jun	20 Jun
1.	Braeburn/M.9	0 b	0.88 ghi	140.2 abc
2.	Braeburn/MARK	0 b	0.50 ij	94.5 bc
3.	Golden Delicious/M.9	4.2 ab	1.50 b-h	172.9 abc
4.	Golden Delicious/MARK	0.4 b	0.60 ij	135.6 abc
5.	Yataka/M.9	2.2 ab	1.84 a-d	200.2 a
6.	Yataka/MARK	0 b	0.93 ghi	170.4 abc
7.	Arlet/M.9	3.4 ab	2.02 abc	195.7 ab
8.	Creston/M.9	4.2 ab	1.80 a-e	167.5 abc
9.	Cameo/M.9	7.6 ab	2.20 ab	154.6 abc
10.	Enterprise/M.9	8.8 a	2.08 abc	76.1 c
11.	Fuji Red Sport #2/M.9	2.8 ab	1.76 a-f	136.1 abc
12.	Gala Supreme/M.9	4.6 ab	1.36 c-h	143.5 abc
13.	Ginger Gold/M.9	0 b	0.92 ghi	126.5 abc
14.	Golden Supreme/M.9	3.8 ab	1.18 d-i	174.6 abc
15.	Goldrush/M.9	0 b	0.12 j	106.6 abc
16.	Honeycrisp/M.9	0 b	0.10 j	163.8 abc
17.	Fortune/M.9	1.3 ab	1.63 b-g	108.6 abc
18.	NY75414-1/M.9	0 b	0.82 hij	155.9 abc
19.	Orin/M.9	0 b	0.92 ghi	168.1 abc
20.	Pristine/M.9	4.3 ab	1.05 f-i	200.4 a
21.	Sansa/M.9	0 b	1.42 c-h	115.4 abc
22.	Senshu/M.9	0 b	1.36 c-h	128.3 abc
23.	Shizuka/M.9	2.2 ab	2.48 a	195.7 ab
24.	Suncrisp/M.9	0 b	1.18 d-i	111.1 abc
25.	Sunrise/M.9	1.3 ab	1.95 abc	130.9 abc
26.	Pioneer Mac/M.9	0 b	1.08 e-i	77.8 c

[1] Rating for aphids/most infested leaf/terminal: 0 = none, 1 = 1-20, 2 = 21-100, 3 = 101-200, and 4 = > 200. Means in a given column followed by the same letter are not significantly different (Waller-Duncan K-ratio, *P* ✂ 0.05).

Table 2. Injury from Japanese beetle and spotted tentiform leafminer, and incidence of white apple leafhopper on new apple cultivars.

No.	Cultivar/Rootstock	JB injured leaves/tree[1]	STLM mines/5 min	WALH nymphs /25 leaves
		31 Jul	5 Sep	7 Sep
1.	Braeburn/M.9	1.6 gh	37.6 c-g	0 a
2.	Braeburn/MARK	1.0 h	27.8 efg	0 a
3.	Golden Delicious/M.9	3.0 cde	27.4 efg	0 a
4.	Golden Delicious/MARK	1.0 h	16.6 g	0.2 a
5.	Yataka/M.9	3.8 ab	50.8 a-f	0.2 a
6.	Yataka/MARK	2.5 def	39.8 c-g	0 a
7.	Arlet/M.9	2.4 ef	38.0 c-g	0.2 a
8.	Creston/M.9	2.6 def	32.6 d-g	1.0 a
9.	Cameo/M.9	3.2 bcd	69.8 ab	0.8 a
10.	Enterprise/M.9	4.0 a	40.0 c-g	1.3 a
11.	Fuji Red Sport #2/M.9	3.4 abc	35.4 c-g	0.6 a
12.	Gala Supreme/M.9	4.0 a	37.8 c-g	0.8 a
13.	Ginger Gold/M.9	3.6 abc	42.4 b-g	0.4 a
14.	Golden Supreme/M.9	1.2 h	61.6 a-d	0.4 a
15.	Goldrush/M.9	1.2 h	40.8 b-g	0.2 a
16.	Honeycrisp/M.9	3.0 cde	37.6 c-g	0.6 a
17.	Fortune/M.9	2.5 def	80.3 a	0.3 a
18.	NY75414-1/M.9	3.2 bcd	62.2 abc	0.2 a
19.	Orin/M.9	3.2 bcd	40.8 b-g	0.2 a
20.	Pristine/M.9	3.5 abc	55.3 a-f	0.3 a
21.	Sansa/M.9	1.4 gh	25.8 fg	0.4 a
22.	Senshu/M.9	3.8 ab	47.6 b-f	0.6 a
23.	Shizuka/M.9	2.6 def	57.6 a-d	1.2 a
24.	Suncrisp/M.9	2.0 fg	40.0 c-g	1.0 a
25.	Sunrise/M.9	1.3 h	56.3 a-e	0.3 a
26.	Pioneer Mac/M.9	1.4 gh	46.2 b-f	0.6 a

[1] Rating for JB injured leaves/tree: 0 = none, 1 = 1-50, 2 = 51-100, 3 = 101-200, 4 = >200. Means in a given column followed by the same letter are not significantly different (Waller-Duncan K-ratio, *P* ✂ 0.05).

Table 3. Fruit injury at harvest from tarnished plant bug, plum curculio, codling moth, oriental fruit moth, tufted apple bud moth, redbanded leafroller and apple maggot on new apple cultivars.

		Percent fruit injury by:					Percent
No.	Cultivar/Rootstock	TPB	PC	CM & OFM	TABM & RBLR	AM	clean fruit
1.	Braeburn/M.9	0.4 hi	2.6 hi	27.7 bcd	19.5 bc	6.7 b	43.2 klm
2.	Braeburn/MARK	13.5 a	2.6 hi	28.1 bcd	10.6 efg	1.7 cd	58.4 f-i
3.	Golden Delicious/M.9	2.3 cde	5.2 ghi	38.8 a	4.6 hij	1.7 cd	50.3 ijk
4.	Golden Delicious/MARK	1.2 e-i	1.7 i	33.6 ab	5.1 hij	0 d	60.3 e-h
5.	Yataka/M.9	0.2 i	18.8 b	18.2 efg	6.3 ghi	0 d	60.7 e-h
6.	Yataka/MARK	0.5 hi	4.2 ghi	16.5 fg	4.6 hij	0 d	74.1 bcd
7.	Ariet/M.9	1.5 d-h	12.5 cde	5.8 h	9.0 fgh	0 d	71.4 bcd
8.	Creston/M.9	0.2 i	8.1 e-h	22.9 c-f	8.6 fgh	3.9 c	55.9 g-j
9.	Cameo/M.9	5.8 b	6.4 f-i	38.0 a	21.2 b	0 d	38.6 lm
10.	Enterprise/M.9	1.9 c-g	8.1 e-h	21.7 d-g	20.2 bc	0.5 d	53.5 g-j
11.	Fuji Red Sport #2/M.9	1.5 d-h	2.6 hi	24.1 cde	16.2 cd	1.1 d	51.4 h-k
12.	Gala Supreme/M.9	0.3 hi	5.4 ghi	33.1 ab	28.4 a	0 d	40.0 lm
13.	Ginger Gold/M.9	1.5 d-h	25.7 a	3.8 h	3.4 ij	0 d	66.0 def
14.	Golden Supreme/M.9	1.1 e-i	8.5 efg	16.0 fg	3.2 ij	0 d	76.0 abc
15.	Goldrush/M.9	2.6 cd	4.9 ghi	34.6 ab	11.5 ef	0 d	53.3 g-j
16.	Honeycrisp/M.9	1.1 e-i	16.7 bcd	14.7 g	6.7 ghi	0 d	61.3 efg
17.	Fortune/M.9	1.1 e-i	7.7 e-h	21.5 d-g	21.6 b	0 d	52.7 g-k
18.	NY75414-1/M.9	0.4 hi	18.4 b	16.7 efg	6.7 ghi	0 d	60.4 e-h
19.	Orin/M.9	2.0 c-g	17.2 bc	29.3 bc	14.3 de	0.4 d	46.9 jkl
20.	Pristine/M.9	1.0 f-i	15.6 bcd	2.0 h	1.4 j	0 d	80.5 ab
21.	Sansa/M.9	2.1 c-f	8.6 efg	2.0 h	2.6 ij	0 d	85.0 a
22.	Senshu/M.9	0.5 hi	11.5 def	16.2 fg	3.6 ij	0 d	69.9 cde
23.	Shizuka/M.9	1.9 c-g	11.2 def	35.0 ab	14.6 de	11.0 a	36.3 m
24.	Suncrisp/M.9	2.1 c-f	3.4 ghi	23.1 c-f	16.4 cd	0 d	57.9 f-i
25.	Sunrise/M.9	2.9 c	16.6 bcd	0.3 h	1.5 j	0 d	80.1 ab
26.	Pioneer Mac/M.9	0.8 ghi	15.9 bcd	7.1 h	5.7 hij	0 d	73.5 bcd

Means in a given column followed by the same letter are not significantly different (Waller-Duncan K-ratio, *P* ✂ 0.05).

Table 4. Susceptibility rating of new apple cultivars to pests of foliage, fruit and all pests combined.

		Pest Susceptibility Rating		
No.	Cultivar/Rootstock	Foliage Pests	Fruit Pests	All Pests
1.	Braeburn/M.9	33	49	82
2.	Braeburn/MARK	13	56	69
3.	Golden Delicious/M.9	57	56	113
4.	Golden Delicious/MARK	21	39	60
5.	Yataka/M.9	79	45	124
6.	Yataka/MARK	48	25	73
7.	Arlet/M.9	67	42	109
8.	Creston/M.9	64	43	107
9.	Cameo/M.9	85	71	156
10.	Enterprise/M.9	68	57	125
11.	Fuji Red Sport #2/M.9	56	49	105
12.	Gala Supreme/M.9	66	54	120
13.	Ginger Gold/M.9	47	41	88
14.	Golden Supreme/M.9	66	30	96
15.	Goldrush/M.9	23	57	80
16.	Honeycrisp/M.9	41	44	85
17.	Fortune/M.9	57	52	109
18.	NY75414-1/M.9	56	46	102
19.	Orin/M.9	52	68	120
20.	Pristine/M.9	76	26	102
21.	Sansa/M.9	31	30	61
22.	Senshu/M.9	57	33	90
23.	Shizuka/M.9	86	71	157
24.	Suncrisp/M.9	42	50	92
25.	Sunrise/M.9	56	37	93
26.	Pioneer Mac/M.9	36	37	73

MEASURING THE IMPACT OF APPLE ARTHROPOD FOLIAGE FEEDERS USING WHOLE PLANT AND SINGLE LEAF PHOTOSYNTHESIS

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Introduction

Apple trees grown in the eastern United States are subject to attack by several insects and mites that feed on foliage. While injury caused by foliage feeding pests may vary due to the time and type of feeding, the principal mechanism of damage appears to be the reduction of photosynthesis by leaves. If individual pests affect the apple tree via reductions in leaf photosynthesis, it is reasonable to hypothesize that the influence of multiple pests is an additive reduction in leaf photosynthesis. Affirming the additive affect of multiple sources of pest injury would bolster current pest management practices. Spotted Tentiform Leafminer (STLM) (Phyllonorychter blancardella) is an important apple insect pest. Larvae burrow beneath the layers of apple leaves and consume the mesophyll creating mines where most of the green tissue has been removed. Unfortunately, little is known about the influence of damage by this insect on apple tree photosynthesis. Here, we present results from experiments designed to answer three questions:

1. What is the relationship between STLM damage on a leaf and photosynthesis by the leaf?
2. What is the relationship between STLM damage and photosynthesis by the entire tree canopy?
3. Can STLM damage be simulated?

Materials and Methods

STLM damage and leaf photosynthesis We measured photosynthesis by leaves with naturally occurring mines on field-grown 'Red Delicious' trees. Measurements were taken once during the first generation of STLM and twice during the second generation (July 11, Aug. 4 and Aug. 24). On all three occasions, > 95 % of the larvae had completed development to the pupal stage. Measurements were obtained under sunny conditions with a portable infrared gas analyzer with a clamp-on leaf enclosure (PP-Systems, Hitchin, Herts, UK) held perpendicular to the sun. Photosynthesis (μ moles/m2/sec) was expressed on a leaf-area basis for both the entire leaf area measured (with mines) and for the leaf area without mines. The latter allowed us to determine whether there were compensatory or systemic effects of the leafminer damage. The data were analyzed using regression. In the analysis we allowed for nonlinear relationships as well as a differential affect of first and second generation mines.

STLM damage and whole tree photosynthesis To measure whole tree photosynthesis we used small, potted trees that were 2 years old and 1.5m tall as experimental units. To infest the trees with STLM larvae, trees were placed in large screen cages at the time of STLM adult flight (6/26/00) and for a period of 21 days. Nine trees were placed into each of four cages along with 1500, 1000, 500 or no STLM pupae. Adult STLM were allowed to emerge and oviposit on the caged trees. Densities of leafminers were estimated in early August by counting the mines on each of 10 leaves per tree. Photosynthesis by the entire tree canopy was measured by enclosing the tree canopies in flow-through clear Mylar® plastic "balloon" chambers, and measuring the reduction in air CO2 concentration from inlet to outlet. Photosynthesis by leaves with varying levels of STLM injury was also measured at the same time as previously described. Data were analyzed using regression.

Simulation of STLM injury STLM damage was simulated using either oil paint, latex paint, or by punched holes. Paint was applied to both sides of the leaf. Photosynthesis by 2.5 cm^2 healthy leaf tissue and the same area encompassing a simulated STLM mine or a natural STLM mine, was measured using the same apparatus described above, but with a smaller enclosure about the leaf. We also simulated damage by applying nail polish to the top surface of leaves. With this simulation a range of simulated mine densities was used (1-10 mines per leaf) and photosynthesis by entire leaves was measured. Data were analyzed using ANOVA and regression.

Results

STLM damage and leaf photosynthesis The relationship between photosynthesis by the entire leaf surface and the percent of leaf area damaged by STLM mines was approximately linear for both first and second generation STLM; however, the impact of first generation mines on photosynthesis was greater (Fig. 1). For both generations, the loss of photosynthesis was more than proportional to the area mined. This is reflected in the reduced photosynthesis by the non-damaged leaf area as the proportion of leaf area damaged by STLM increased (Fig. 2).

STLM damage and whole tree photosynthesis There was no relationship between STLM injury (mines per leaf) and whole-tree photosynthesis (Fig. 3). Photosynthesis by leaves on the potted trees was lower than that measured for the field-grown trees. As for the field grown trees, STLM mines reduced photosynthesis in a linear manner (Fig. 4). The relative influence of STLM damage was greater on the potted trees compared with the field grown trees.

Simulation of STLM injury There were no significant differences among the photosynthesis measurements for natural damage and damage simulated using latex paint, oil paint or a hole punch (Table 1). Reductions in photosynthesis due to natural damage and simulated damage using oil paint or a hole punch were similar (Table 1). However, simulated damage using latex paint did not result in a significant decline in photosynthesis compared to a healthy leaf (Table 1). Damage simulated using nail polish resulted in a similar pattern of response, but a steeper reduction in photosynthesis compared to natural mines (Fig. 5).

Table 1. Photosynthesis (μmoles/m^2/sec) (Pn) by apple leaves with natural or simulated STLM mine damage of similar area (numbers in parentheses are standard errors).

Damage type	Pn control[1]	Pn damaged[2]	Pn control - Pn damaged
Natural	13.81[a] (2.03)	11.01[a] (2.03)	2.81[b]
Oil paint	14.61[a] (2.10)	12.27[a] (2.06)	2.34[b]
Latex paint	12.71[a] (2.37)	12.45[a] (1.93)	0.26
Hole punch	14.05[a] (3.25)	11.81[a] (1.97)	2.24[b]

[1] Photosynthesis measured from 2.5 cm^2 of undamaged leaf area,
[2] Photosynthesis measured from 2.5 cm^2 of leaf area that included a natural or simulated mine
[a] Numbers in a column followed by the same letter are not significantly different
[b] Significantly different from 0 at a 0.01 level.

Discussion

Photosynthesis by apple leaves declined as a linear function of the leaf area removed by STLM larvae. There was also an effect by the mines on the photosynthetic capacity of the surrounding, healthy leaf tissue, and this effect was nonlinear. Therefore, as the foliage area removed by STLM larvae exceeds the maximum in our study (ca. 25%), reductions in photosynthesis may become nonlinear. It should be noted that on average, STLM mines of 0.5 cm^2 represent only about 1.5 to 2% leaf area reduction in typical apple leaves of 20-25 cm^2.

For the level of leaf miner injury we obtained in the caged-tree experiment (up to 3 mines per leaf), we observed no effect of this damage on whole-canopy photosynthesis. STLM damage on photosynthesis of individual leaves on the same trees showed similar responses to other leaf studies. There are several possible explanations for the lack of effect on the whole tree. First, variations due to variability in tree size and structure, a low number of replicates, and spatial variation in pest injury may have obscured any effect. The trees used were not as vigorous or uniform as desired. Second, 3 mines/leaf was a relatively low level of injury (representing about 8-10% leaf area damage with those leaves) that had no significant effect on the whole tree. Alternatively, dilution of damage by the undamaged leaves or compensation by the undamaged leaves may have lessened the overall impact to an undetectable level or eliminated it entirely.

It might be possible to simulate leaf miner damage. The nail polish data was promising in that it showed a general response similar to STLM mines. However, our results suggest that artificial damage of the same area had a greater impact on photosynthesis than natural mines, possibly due to lateral movement of toxic solvents. Logically, using nail polish on smaller treatment areas with may compensate for the stronger effect per unit area, but this will need to be confirmed.

Comparison of results from the single leaf photosynthesis measurements with comparable measurements taken for leaves damaged by European red mite (Lakso et al. 1996) indicates that each STLM mine causes about a 2.5% reduction in photosynthesis that is equivalent to approximately 125 mite days. Current recommendations are that no than about 500 mite days (or about a 10% reduction in leaf photosynthesis) be allowed on apples trees with a moderate crop load in order to prevent yield or quality reductions in the fruit (Francesconi et al. 1996). This suggests that apple trees can tolerate at least 4 STLM mines per leaf before adverse affects accrue to the fruit. This threshold may be even greater given the results from our whole tree photosynthesis measurements. A threshold of 4 mines per leaf is considerably higher than the current recommended threshold of 2 mines per leaf. Further work is required to verify and extend the results we obtained in this study. Fortunately, this project will continue for three additional years at the conclusion of which we should have a good understanding of the individual and combined effects of STLM and European red mite on apple tree performance.

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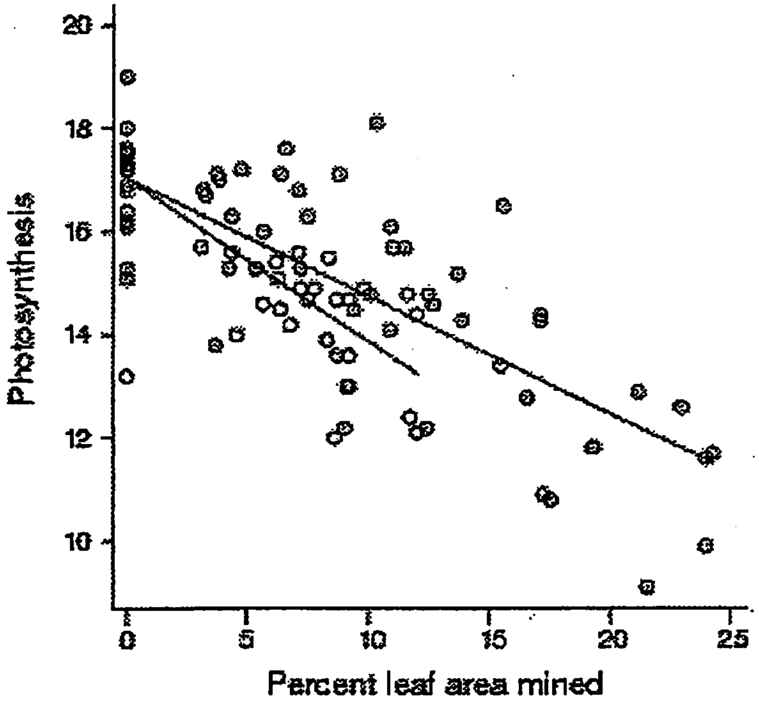

Figure 1. Photosynthesis (µmoles/m^2/sec) (Pn) by leaves with varying levels of first and second generation STLM mine injury. First generation data are indicated by open circles and corresponding predicted values from a linear model by the lower line. Average mine sizes were 0.64 cm^2 and 0.48 cm^2 for the first and second generation mines respectively. Leaf areas for which photosynthesis measurements were taken averaged 24.2 cm^2 and 26.4 cm^2 for the first and second generations. The fitted model was Pn = 17.03 - b*(% leaf area mined) where b = 0.316 for the first generation and 0.227 for the second generation. R^2 for the model was 0.57 and all parameters were significant at a 0.05 level.

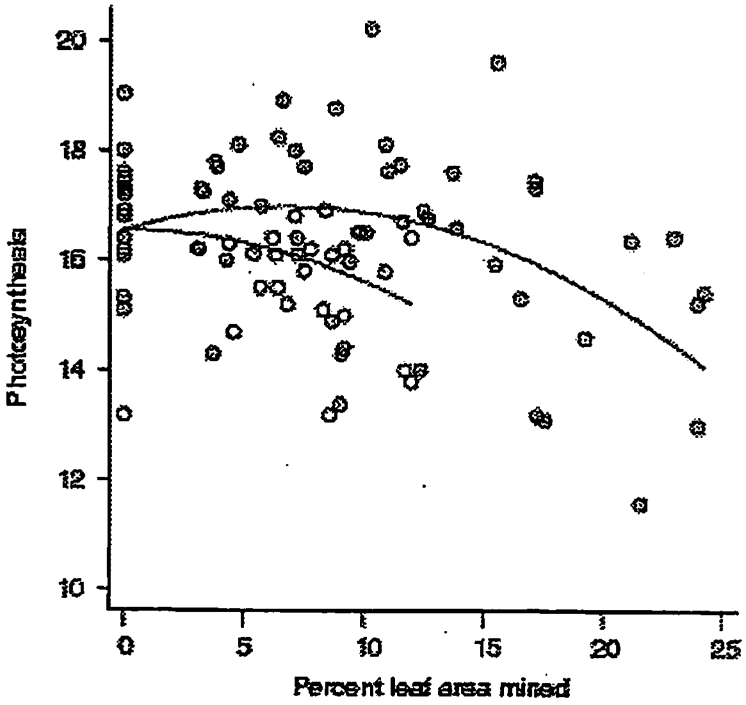

Figure 2. Photosynthesis (μmoles/m^2/sec) (Pn) by the non-damaged area of leaves with varying levels of first and second generation STLM mine injury. First generation data are indicated by open circles and corresponding predicted values by the lower line. The fitted model was Pn = 16.55- -.0094(% leaf area mined)^2 + 0.126*(% leaf area mined)*gen2 where gen2 = 1 for the second generation data and 0 otherwise. R^2 for the model was 0.16 and all parameters were significant at a 0.01 level.

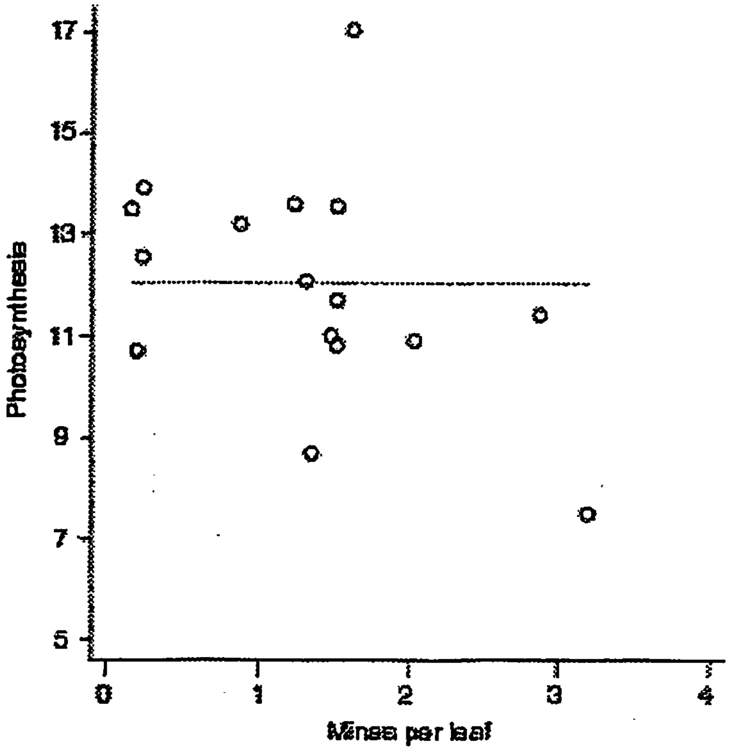

Figure 3. Whole-canopy average photosynthesis (μmoles/m^2/sec) by trees with varying levels of second generation STLM damage. The line is the overall mean response.

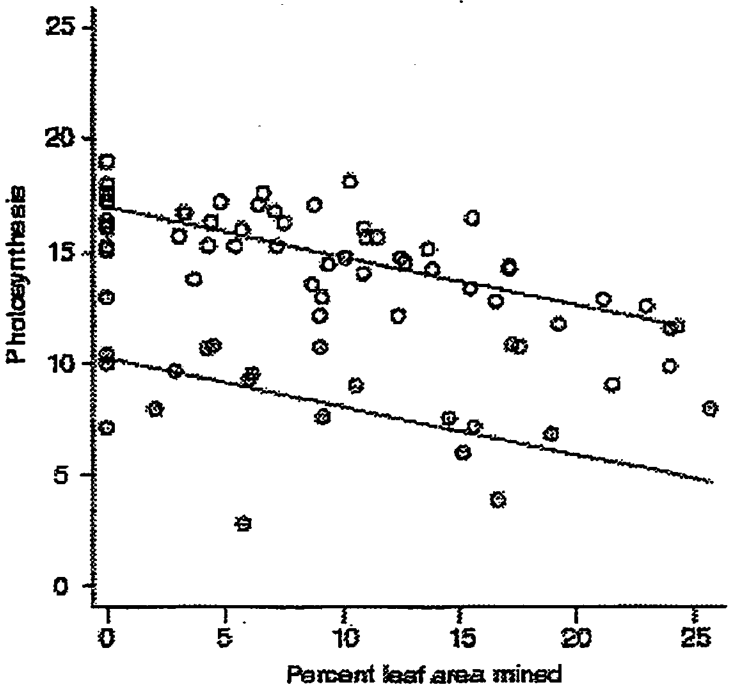

Figure 4. Photosynthesis (μmoles/m^2/sec) (Pn) by leaves from two sets of trees with varying levels of second generation STLM mine injury. The first set of trees were field grown

(open circles) and the second set were the potted trees used in the whole-canopy photosynthesis measurements (highlighted circles). The slopes of the two fitted lines were the same (-0.215); however, the intercepts were significantly different (16.96 vs 10.23).

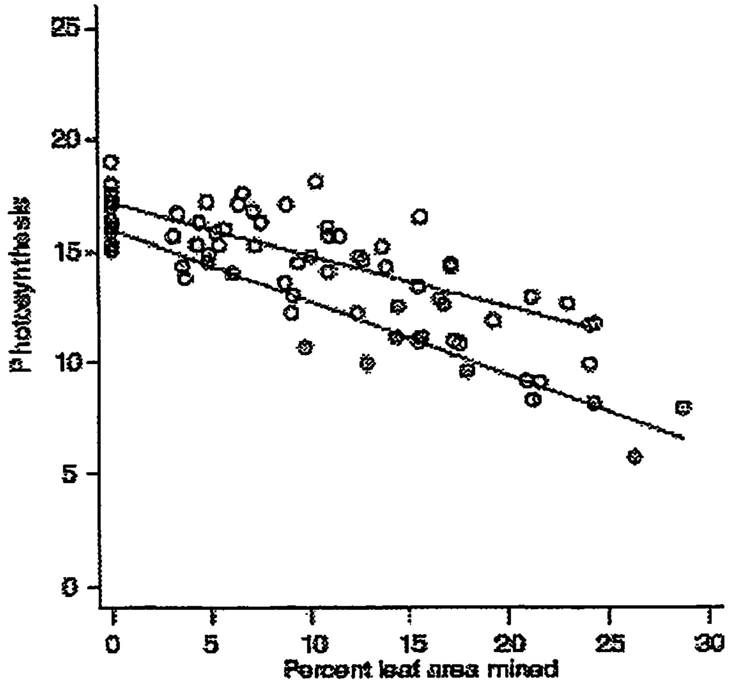

Figure 5. Photosynthesis (µmoles/m^2/sec) (Pn) by leaves with varying levels of second generation STLM mine injury (open circles) and injury simulated using nail polish (highlighted circles). The intercepts (17.15 and 15.98) and slopes (-0.235 and -0.329) differed significantly for the natural and simulated damage, respectively.

IMPACT OF PEACH EXTRAFLORAL NECTAR ON KEY BIOLOGICAL CHARACTERISTICS OF *TRICHOGRAMMA MINUTUM* (HYMENOPTERA: TRICHOGRAMMATIDAE)

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ABSTRACT: This study was conducted in 2001 and used both wild and commercially reared strains of *Trichogramma minutum* Riley. *T. minutum* provided peach extrafloral nectar and water lived significantly longer and parasitized significantly more *Grapholita molesta* (Busck) eggs when compared to *T. minutum* provided only water. When provided with nectar and water, no differences in longevity between wild and commercially strains were found. Wild females lived longer than commercially produced females when provided only with water. When provided with nectar and water, wild females produced significantly more offspring than commercially reared females. At the same time, no differences were found in parasitization levels between strains when provided only with water. When fed nectar wild females lived 11.6 days and produced 105.2 offspring and commercially reared females lived 9.9 days and produced 61.0 offspring. When provided only water, wild females lived 3.3 days and produced 52.8 offspring while commercially reared females lived 2.0 days and produced 24.4 offspring. In addition, nectar feeding significantly increased the number of *G. molesta* eggs destroyed by host feeding by both wild and laboratory strains. More *G. molesta* eggs (13.7) were destroyed by host feeding when wild females were provided with nectar and water. The fewest number of host fed eggs (1.5) were recorded when commercially produced females were provided only with water.

INTRODUCTION

Our Reduced Risk (RR) peach arthropod management program combines managed sod to reduce tarnished plant bug damage with mating disruption *Grapholita molesta* (Busck). Mating disruption of this program has reduced organophosphorus and carbamate insecticide use by up to 78% when compared with conventional pest management program with weedy orchard floor. We were concerned that by eliminating weeds in RR orchards may negatively impact levels of beneficial insects by reducing nectar sources. However, we constantly observe natural enemies in higher levels in our RR orchards. We attributed these higher levels to reduced insecticide use. In addition, we have observed natural enemies feed on extrafloral nectar from glands found at the base of peach leaves. These observations led us to explore the idea if peach extrafloral nectar serves as additional food source to *Trichogramma minutum* Riley (Hymenoptera: Trichogrammatidae) that might be one of the explanations for high levels of beneficial fauna in Reduced Risk orchards.

The objective of this study was to evaluate if peach leaf nectar serves as food to *T. minutum* and, if it does, what is its impact on parasitoid survivorship, fecundity, and host feeding.

MATERIALS AND METHODS

Indigenous *T. minutum* population

Individuals from an indigenous *T. minutum* population were used for this study. They were collected from an insecticide untreated plot of a peach orchard in Southern New Jersey in 2001, using laboratory reared *G. molesta* sentinel eggs (age < 24 h) that were laid on wax paper. Wax paper pieces (≈ 3 x 5 cm) containing random numbers of host eggs (> 50 per wax piece) were glued onto the bottom of peach leaves on the tip part of shoots using non-toxic glue (Elmer's products, Inc., Columbus, OH). A total of 18 wax pieces (one per tree per sample date) were placed on peach trees at ≈ 150 cm height from the ground, 12 days prior to each of the four replications experiment started. Sentinel *G. molesta* eggs were placed in the orchard on 25 May, 10 and 28 June, 13 July. After a two-day exposure, wax paper pieces were brought back into the laboratory where they were checked. All wax pieces with eggs destroyed by predators were removed. Then, the remaining wax paper pieces were kept together in a clear plastic container (0.946 liters) at 23 - 25° C and a photoperiod of 16:8 (L:D) for 2 –3 days until parasitized eggs turned black. Then, *G. molesta* parasitized eggs with a single developed parasitoid pupa were selected, cut with a small wax piece of paper, and placed individually into clear plastic Petri dishes (50 x 9 mm, Falcon®, Becton Dickinson Labware, Franklin Lakes, NJ) for further incubation at 23 - 25° C and a photoperiod of 16:8 (L: D) until parasitoids emerged. The first 10 emerged females (age < 1 h) of each sample date were used for the experiment. Species authenticity was confirmed by laboratory identification of specimens collected on each sample date. Specimens have been keeping in vials with Hood's solution (95 ml of 75% Ethyl alcohol + 5 ml Glycerin) at the RAREC collection.

Commercially-produced *T. minutum* population

Individuals from commercially produced *T. minutum* population, reared on *Ephestia kuehniella* Zeller (Lepidoptera: Pyralidae) eggs, supplied by IPM Laboratories, Inc. Locke, NY were also used for this experiment. Four shipments with *T. minutun* parasitized *E. kuehniella* eggs glued on cardboard were received on 18 May, 15 June, 10 and 20 July 2001 respectively. After receiving, cardboard were cut in small pieces (≈ 0.3 x 0.3 cm), placed singly in clear plastic Petri dishes (50 x 9 mm, Falcon®, Becton Dickinson Labware, Franklin Lakes, NJ), and kept at 23 - 25° C and a photoperiod of 16:8 (L:D) until adults emerged. The first 10 emerged females (age <1 h) of each shipment were used for the experiment.

Source of nectar

Nectar from reniform-shaped leaf gland of two-year potted peach rootstock seedlings growing in a greenhouse was used for parasitoid feeding. Nectar drops were transferred from peach leaves on to the bottom of dishes using a pinhead of a teasing needle. Seedlings were fertilized every other week and pruned when needed.

Impact of peach leaf nectar on *T. minutum* longevity, fecundity, and host feeding

Newly emerged virgin females (age < 1 h) were put individually in clear plastic Petri dishes (50 x 9 mm, Falcon®, Becton Dickinson Labware, Franklin Lakes, NJ) containing a piece of wax paper with 60 *G. molesta* eggs (age < 24 h). Nectar fed parasitoids were provided with a drop of peach extrafloral nectar (0.43 ± 0.04 mg) and a small drop of distilled drinking water placed on the bottom of Petri dishes. Control parasitoids were provided with only a small drop of distilled water placed on the bottom of Petri dishes. Water drops were provided using a Pasteur pipette. Dishes were kept in a lab at 23-25° C and a photoperiod of 16:8 (L: D) h. Parasitoids were checked every morning and if alive transferred to new Petri dishes and provided with 40 new *G. molesta* eggs (< 24 h old), water, and nectar if in the nectar-fed treatment. Longevity in days of each parasitoid was determined. Fecundity of each female was estimated daily by numbers of parasitized host eggs that were recognized as either single or double *T. minutum* pupae in each *G. molesta* egg. This study was replicated 4 times. A total of 5 *T. minutum* per replication were used. To synchronize the time of adult emergence of the both *T. minutum* strains before each replication started, parasitoid development of either commercial or indigenous population was delayed by keeping parasitized host eggs in a cooler at 12° C and 24 h darkness for 1 - 3 days. Each replication of the both populations and treatments, except the first replication, started simultaneously at the same time (within 1-2 day range) to avoid any unforeseen biotic or ambient condition effect.

Statistical procedures

All data were transformed (log (Y+1)) before analysis. We used analysis of variance and Turkey's mean separation tests to determine differences in longevity, fecundity, and host feeding between treatments (SAS Institute 1991). Untransformed means and standard errors are presented.

RESULTS

Trichogramma minutum lived longer when provided with peach extrafloral nectar and water when compared with *T. minutum* provided only with water ($F = 49.55$, df = 3, 73; $P < 0.001$) (Table 1; Fig. 1). The lab strain plus water only lived the shortest length of time.

Wild *T. minutum* provided with peach extrafloral nectar parasititized the greatest number of *G. molesta* eggs while the lab strain provided with only water parasitized the fewest number of eggs ($F = 18.92$, df = 3, 73; $P < 0.001$) (Table 1; Fig. 2). There was no statistical difference in the number of *G. molesta* eggs parasitized by the lab strain provided with extrafloral nectar and the wild strain provided with only water.

Trichogramma minutum provided with peach extrafloral nectar host fed on more *G. molesta* eggs than *T. minutum* provided only with water ($F = 20.94$, df = 3, 73; $P < 0.001$) (Table 1; Fig. 3). The lab strain with only a water source consumed the fewest number of *G. molesta* eggs.

More *G. molesta* eggs were destroyed through parasitism and host feeding by the wild *T. minutum* strain provides with peach extrafloral nectar and water than by the other *T. minutum* strain x water and extrafloral nectar combinations ($F = 19.85$, df = 3, 73; $P < 0.001$) (Table 1; Fig. 4). The lab strain with only a water source destroyed the fewest number of *G. molesta* eggs.

CONCLUSION

Peach extrafloral nectar enhances *T. minutum* survival and fecundity.

Indigenous *T. minutum* provided with nectar and water parasitized more *G. molesta* eggs than did a commercial strain.

It is possible that peach extrafloral nectar may augment *T. minutum* in the absence of other nectar sources (weeds).

ACKNOWLEDGEMENTS

We thank Joe Goffreda (Rutgers University) for providing peach trees for this study and Jeremey Wurtzel for technical assistance.

Table 1. Mean ± SEM of various biological characteristics of *T. minutum* when provided daily with freshly laid *G. molesta* eggs and either peach leaf nectar and water or water only

TRTM	Longevity (days) ± SEM[a]	Avg. no. parasitized eggs ± SEM	Avg. no. host fed eggs ± SEM	Avg. no. destroyed eggs ± SEM
Lab strain: with nectar	9.9 ± 0.2a	61.0 ± 21.7b	6.5 ± 1.5ab	67.5 ± 22.8b
Lab strain: no nectar	2.0 ± 2.1c	24.4 ± 23.7c	1.5 ± 1.7c	25.9 ± 25.1c
Wild strain: with nectar	11.6 ± 2.5a	105.2 ± 15.1a	13.7 ± 2.2a	118.8 ± 17.1a
Wild strain: no nectar	3.3 ± 2.0b	52.8 ± 7.4bc	4.5 ± 0.7b	57.2 ± 7.2b

[a] Means in a column followed by the same letter are not significantly different (Tukey's mean separation, P > 0.05).

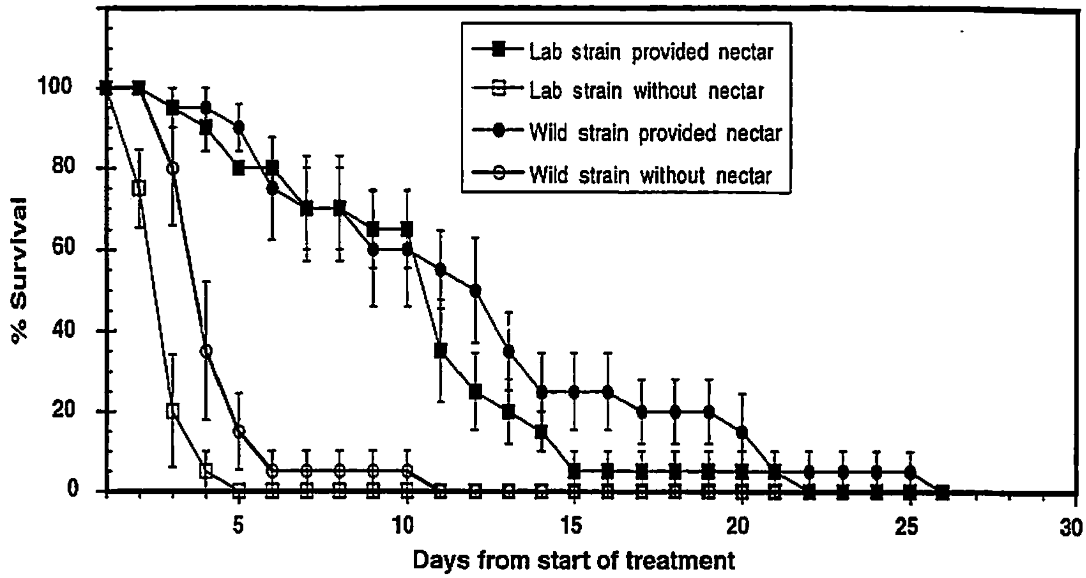

Fig. 1. Survivorship in days of *T. minutum*.

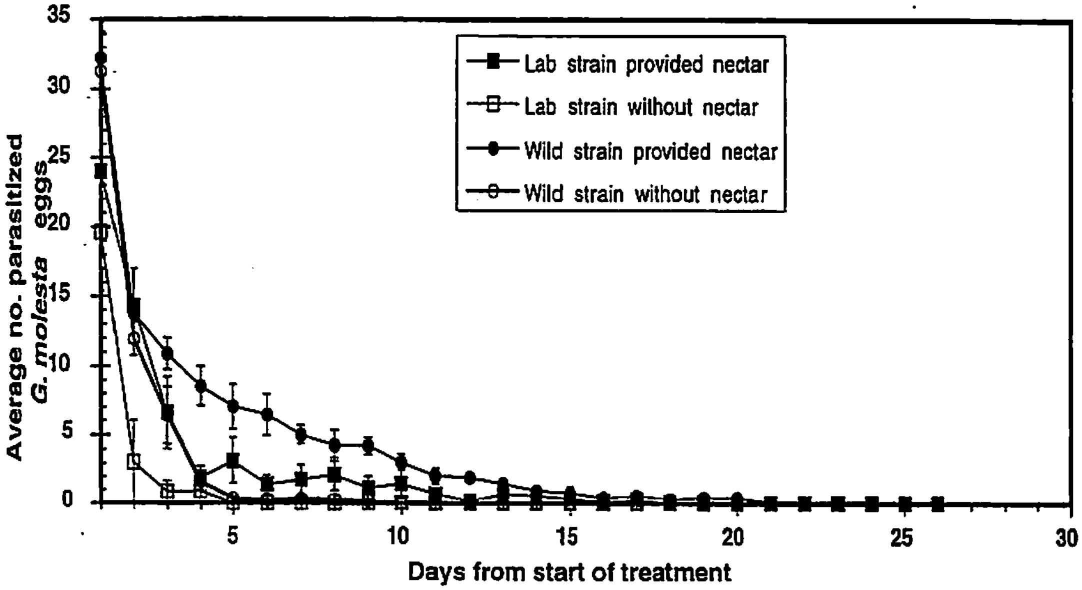

Fig. 2. Average number of *G. molesta* parasitized eggs by *T. minutum*.

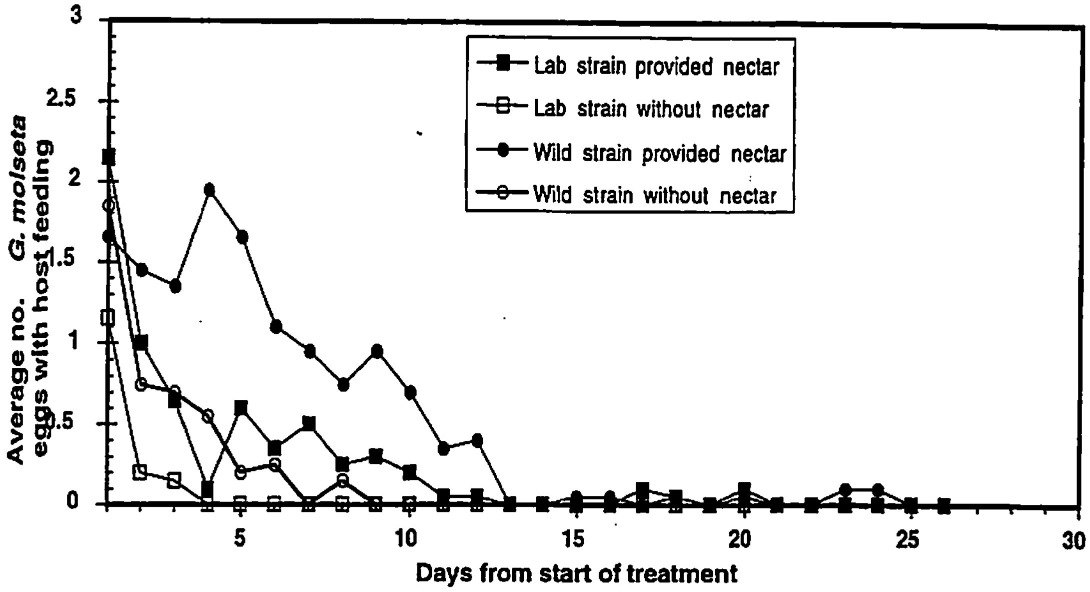

Fig. 3. Average number of *T. minutum* host feeding.

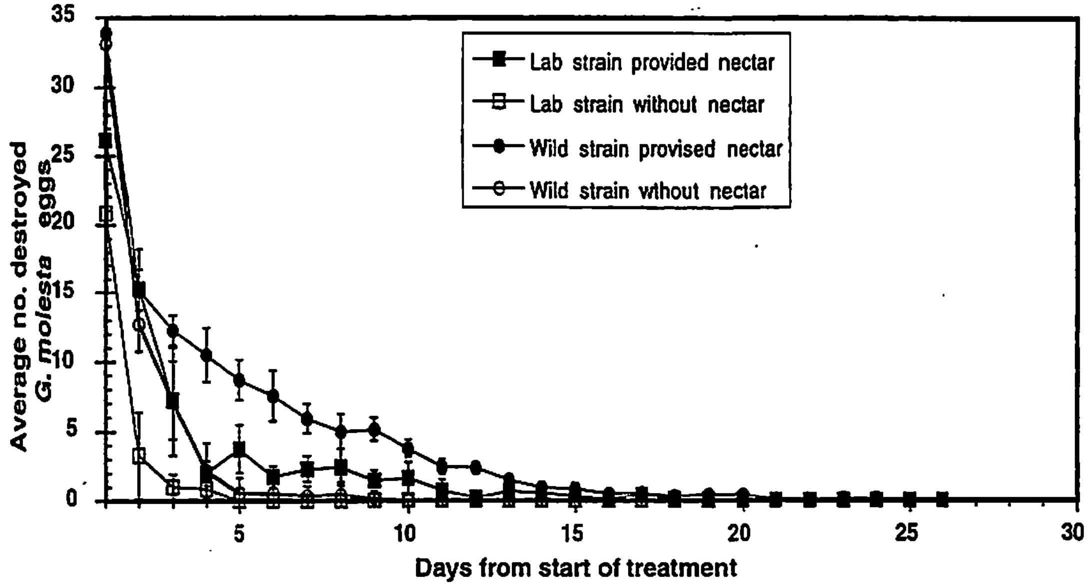

Fig. 4. Average number of *G. molesta* destroyed eggs by *T. minutum*.

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

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Results from various mating disruption and ground cover projects have been previously reported at earlier CSFW conferences. The use of a 'Reduced Risk (RR)' approach that combines the use of turf ground cover to manage catfacing insects and mating disruption for oriental fruit moth has also been discussed. These practices have previously not been used together on a commercial scale, or been evaluated for their economic impact. During the fall of 2000 we started a 2 year project which combined these practices.

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

Methods

We selected 4 varieties that represented early, mid, and late season picking dates. These were Redhaven (averages July 27-August 3), John Boy (August 4-10), Bounty (August 11-18), and Encore (September 3-10). Nine growers provided plantings such that a RR block could be compared to a separate block under conventional (conv.) insecticide use, or a large planting that was split between RR and conv. practices. RR block size ranged from 3 to 15 acres (avg. 6.7 acres), with similar acreage in conventional practices. Data was collected from 24 blocks, with RR practices on just over 81 acres. Hard fescue ground cover was established in RR blocks during the fall of 2000 on 4 farms, and had already been established on 2 other farms. The 3 other growers used K-31 tall fescue, 2 of whom had fescue established in both RR and conv. blocks. Herbicides were used to maintain pure fescue stands in all established RR plantings.

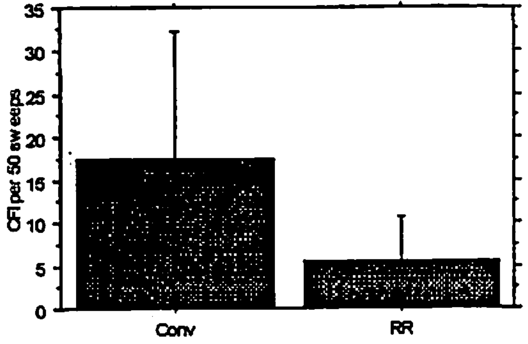
Our objective in controlling OFM with mating disruption dispensers was to disrupt generations 2 through 4, while allowing for normal pruning activities between March and late May. This also permitted insecticide treatments to be applied for early season management of tarnished plant bugs and stink bugs, as well as coverage for 1st generation OFM. Pheromone dispensers were placed in RR plantings between May 12 to May 18, or just after the first flight peak, but prior to any 2nd flight emergence. Isomate-M 100 (Shin Etsu) (243.8 mg a.i. per dispenser) were placed at the rate of 100 ties per acre in Redhaven and John Boy plantings. Isomate-M Rosso (264.3 mg a.i. per dispenser) were placed at the rate of 200 ties per acre in Bounty and Encore plantings. All Encore RR plots had been under mating disruption for the previous 3 years. All other plots had not previously been under mating disruption programs.

All plantings were scouted every 7 days for arthropods and disease incidence. OFM pheromone traps were placed to monitor male emergence (conv.) and trap shut down (RR). OFM larval populations were monitored by examining the number of flags present per tree, as well as any damage present (from all insects and disease) on developing fruit. Tarnished plant bug and stink bugs were monitored with sweep net sampling, as well as beating trays. Random at-harvest fruit samples were taken in all plantings for the presence of all insect and disease damage. At harvest samples consisted of 3 - 100 fruit samples taken from each plot for a total of 7,200 fruit sampled. Grower pesticide use records were collected at the end of the season and analyzed for comparative pesticide use. Actual use was analyzed and compared to suggested retail prices for various insecticides. Growers were also asked to maintain records for all labor time and other production expenses associated with establishing and maintaining turf ground cover and dispenser placement (data pending).

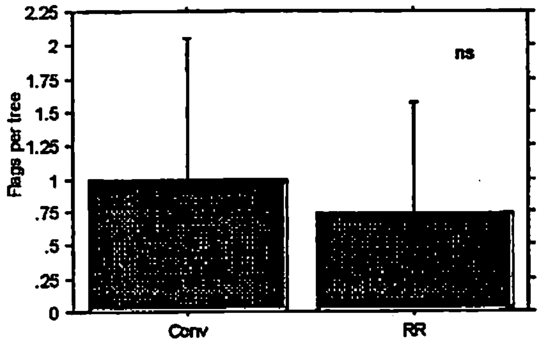
Results

Of the more noteworthy results from in-season monitoring, pressure from tarnished plant bugs and stink bugs was problematic on several farms. Greater levels were often found in conventional (non MD) plots. This is expected, since pure stands of turf discouraged plant bug activity. On average, no significant differences were found in OFM activity when measured by larval flagging on young shoots. Thus indicating that

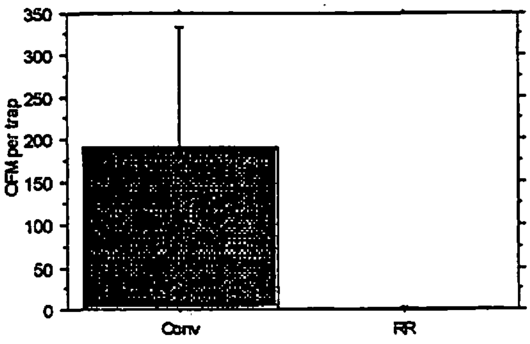
Total mean seasonal catfacing insects per 50 sweeps - all varieties.



Mean maximum OFM flags per tree - all varieties.

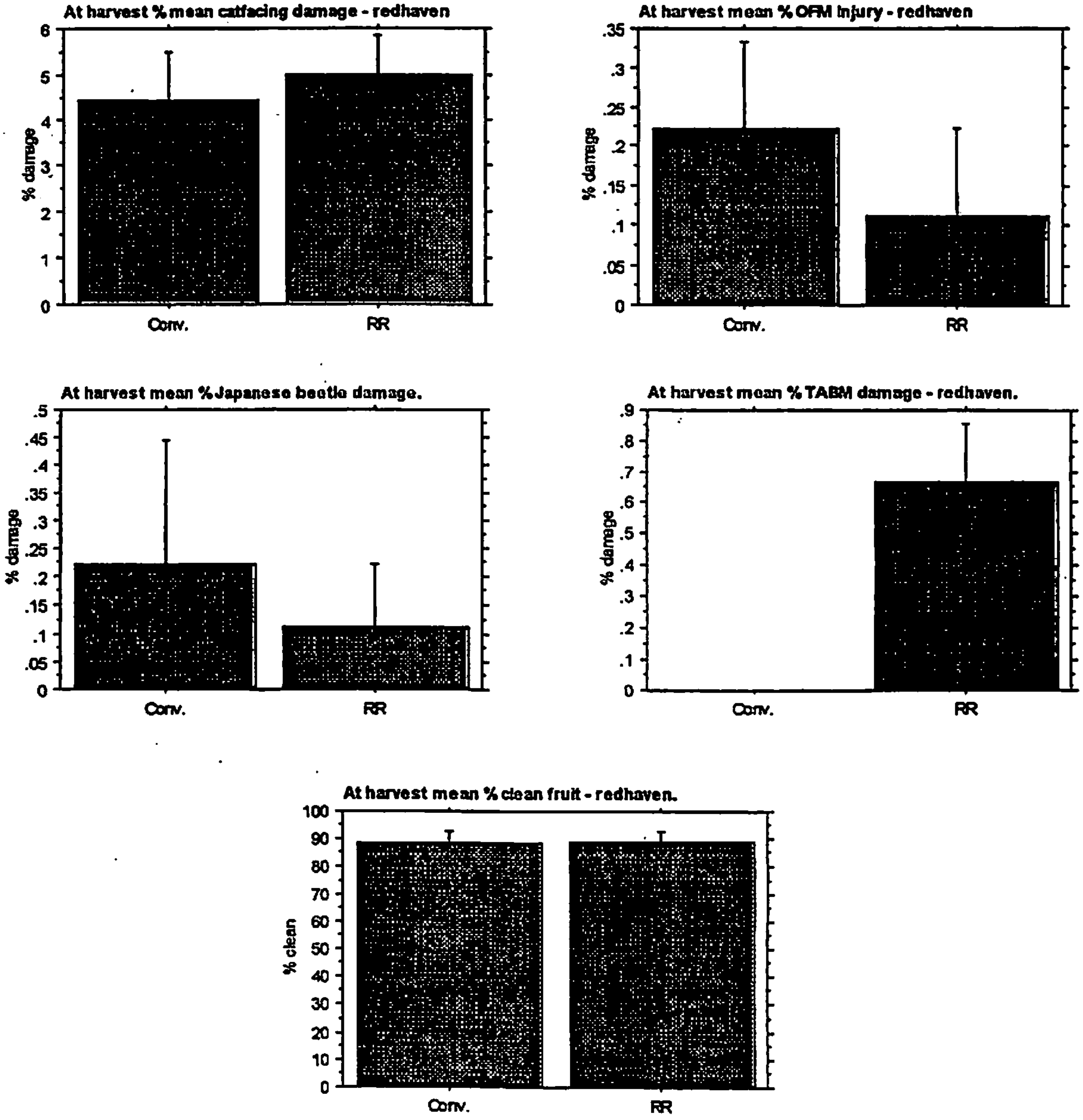


Mean total OFM trap captures - all varieties.

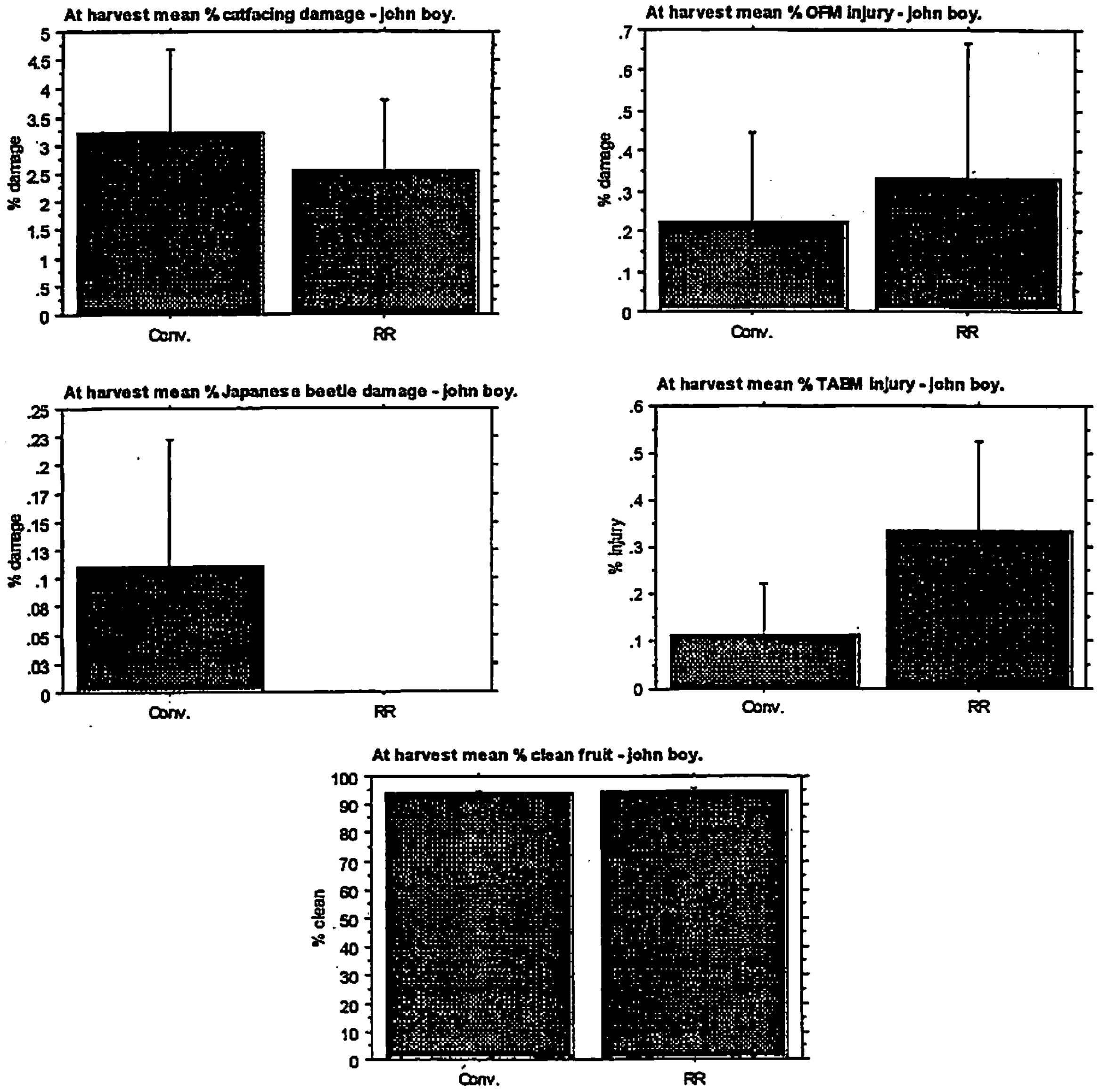


when mating disruption was substituted for insecticides, equivalent control was obtained. Significant amounts of flagging did develop in on one farm with John Boy, and was sprayed for the remainder of the season. Another farm with Bounty also had problems with catfacing insects moving into the orchards from hedgerows and wooded areas. Pheromone trap captures in RR plots were virtually shut down after dispenser placement. Some captures in RR plots were observed near peak flights, and near the end of the season in M-100 plots.

At Harvest Damage - Redhaven (ns except TABM)



At Harvest Damage - John Boy (ns)



At harvest mean % catfacing damage - john boy.

At harvest mean % OFM injury - john boy.

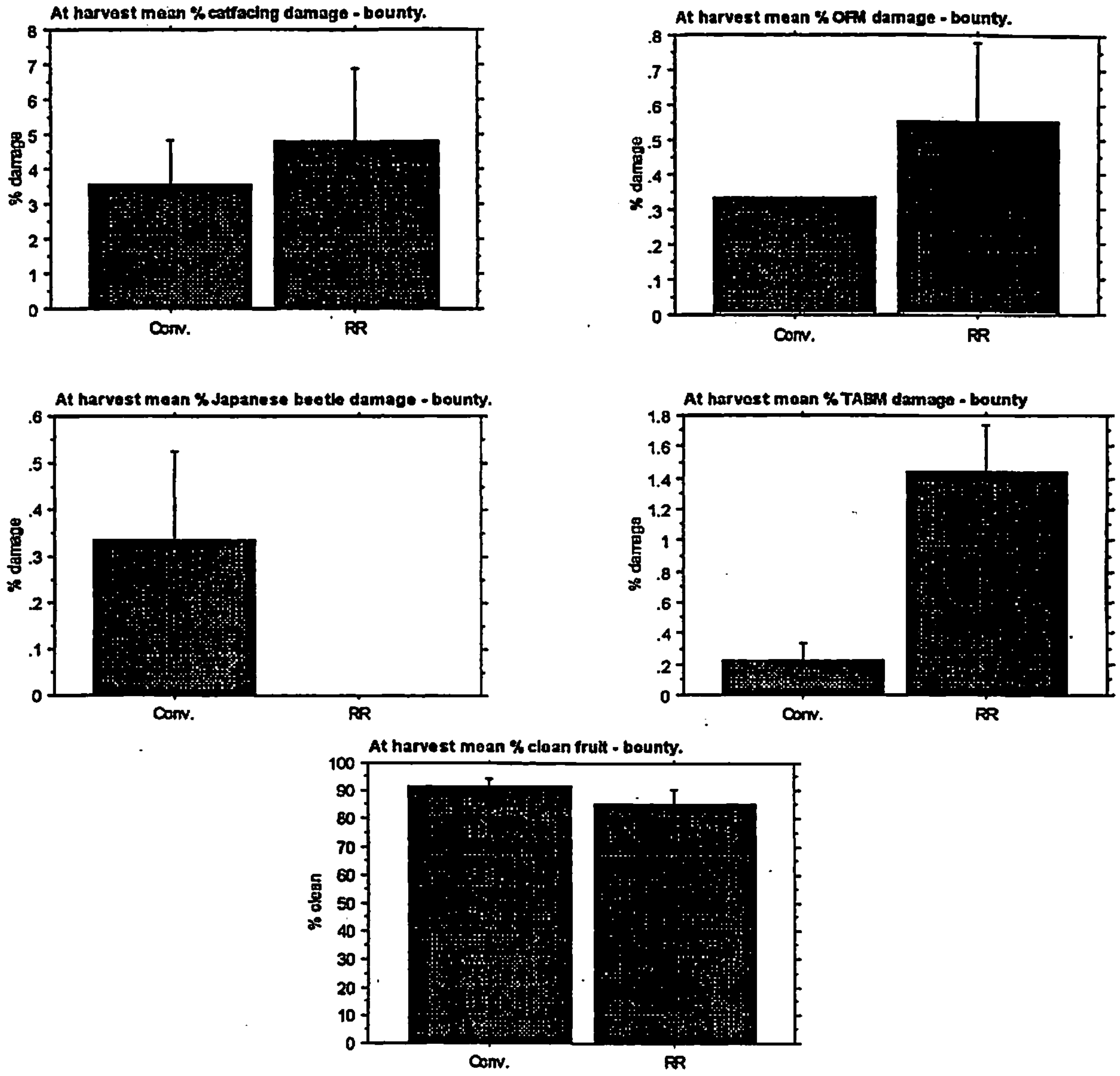
At harvest mean % Japanese beetle damage - john boy.

At harvest mean % TABM injury - john boy.

At harvest mean % clean fruit - john boy.

At harvest data showed that Bounty and Redhaven RR plots experienced higher levels of TABM damage. However damage still averaged less than 1%, although some individual growers did experience higher levels. There were no significant differences in overall damage from OFM, although some farms experienced trends towards higher damage in RR plots with Bounty and Encore varieties. One RR Encore planting did experience problematic 4th brood larval injury, possibly due to larger tree size, low placement of dispensers, and high population pressure. Across all varieties, there were no significant differences in other pest damage including damage from catfacing insects and Japanese beetle. The percent clean fruit was similar between RR and Conv. Plots in all varieties.

At Harvest Damage - Bounty (ns except TABM)


At harvest mean % catfacing damage - bounty.

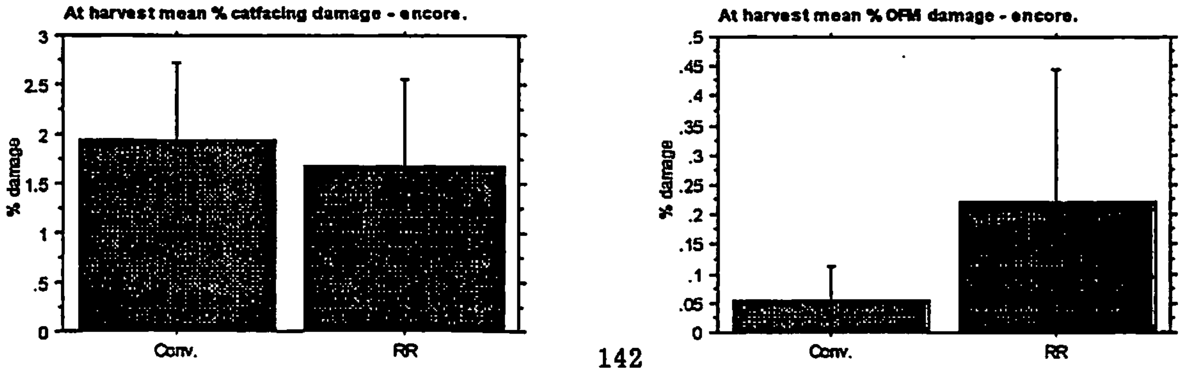
At harvest mean % OFM damage - bounty.

At harvest mean % Japanese beetle damage - bounty.

At harvest mean % TABM damage - bounty

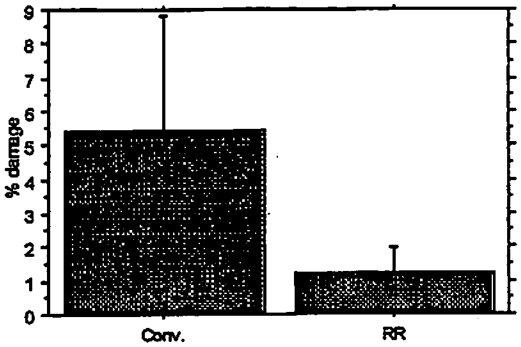
At harvest mean % clean fruit - bounty.

At Harvest Damage - Encore (ns, and no Japanese beetle damage)

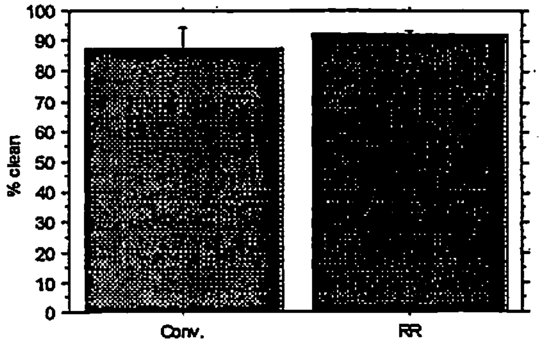

At harvest mean % catfacing damage - encore.

At harvest mean % OFM damage - encore.

At harvest mean % TABM damage - encore.

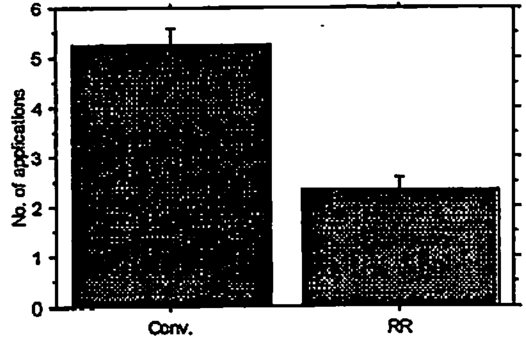


At harvest mean % clean fruit - encore.

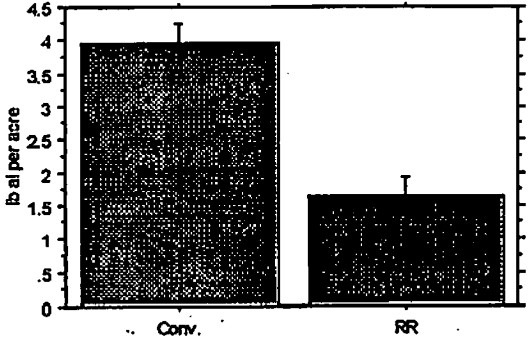


Insecticide Use

Effect of RR treatments on the number of insecticide applications across all varieties - full cover eq. (P<.0001).



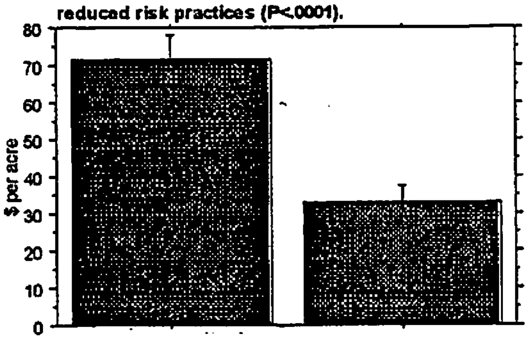
Comparison across all varieties of insecticide use in lb. a.i. per acre (P<.0001).



Insecticide use compared between treatments and varieties.

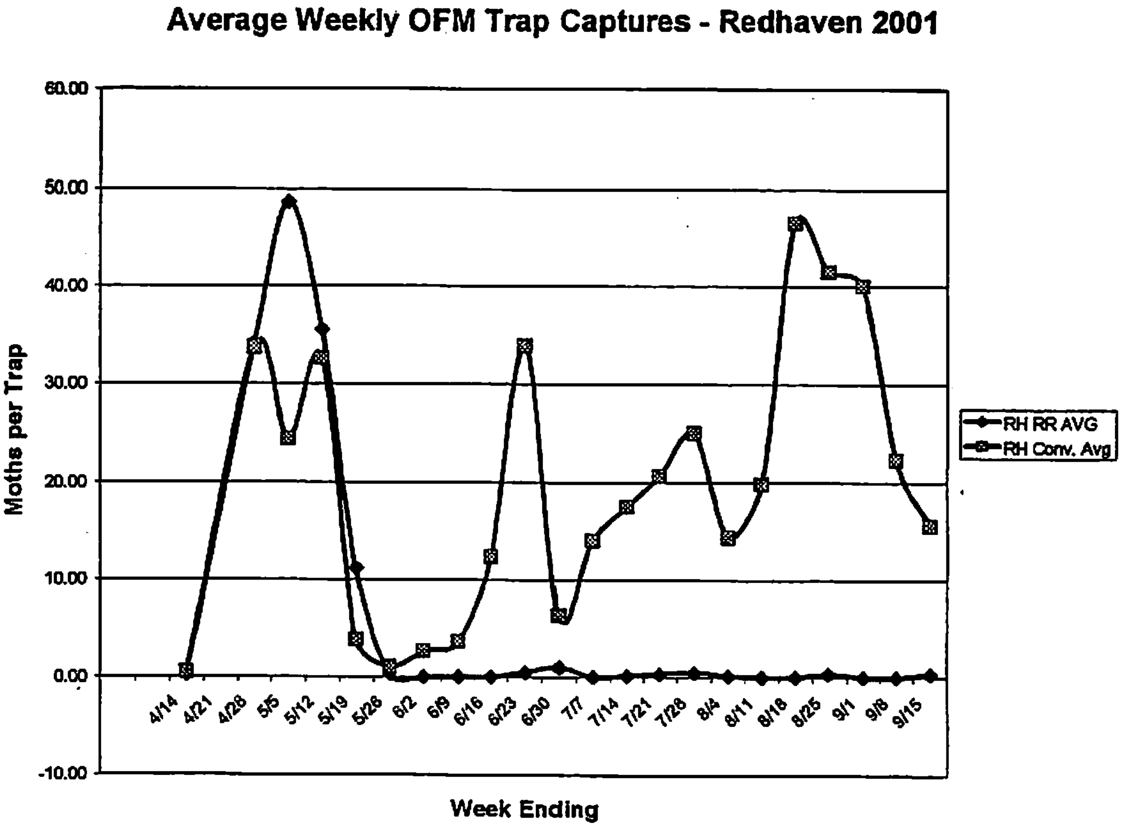
Variety	Trt	No. Appl. Full Cov. Eq.	Form. Amt / Acre (lb, pt)	AI / Acre (lb. pt)	Total Cost/Ac	Cost Difference
Redhaven	Conv.	4.17	6.42	3.24	$50.28	
Redhaven	RR	2.17	3.29	1.54	$25.83	$24.45
John Boy	Conv.	4.67	7.23	4.35	$78.78	
John Boy	RR	2.67	3.60	2.17	$43.96	$34.82
Bounty	Conv.	5.33	7.90	3.42	$65.65	
Bounty	RR	2.67	4.33	1.97	$37.38	$28.27
Encore	Conv.	6.83	9.27	4.81	$91.93	
Encore	RR	1.83	1.97	0.86	$23.69	$68.24

Insecticide cost savings across all varieties due to reduced risk practices (P<.0001).



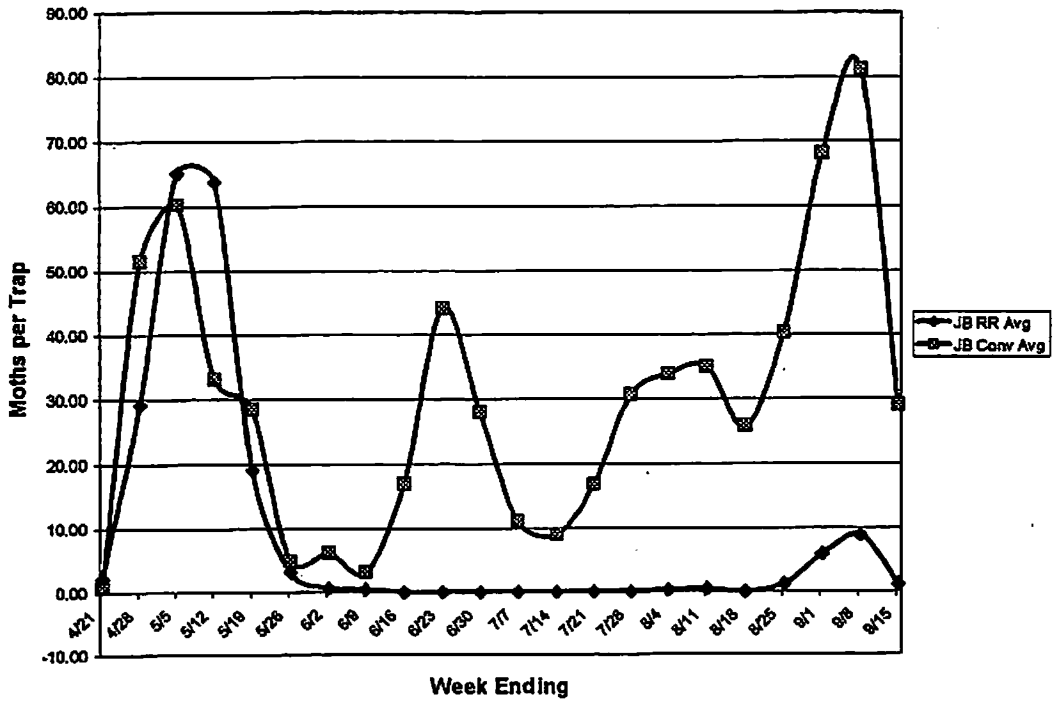
Overall a.i. insecticide use in RR plots was about 41% of that used in conventional plots across all varieties. Some growers showed more significant savings than others, partially due to recommended applications for catfacing insect and OFM pressure. Savings by variety ranged from just over $24.00/acre to about $68.00 per acre, and averaged $39.00 per acre. When compared to the suggested retail price of $35.00 per acre for M-100, and about $70.00 per acre for M Rosso, this seems to be within a competitive range for some growers, depending on the type of dispensers used and individual pest pressure.

OFM Trap Captures

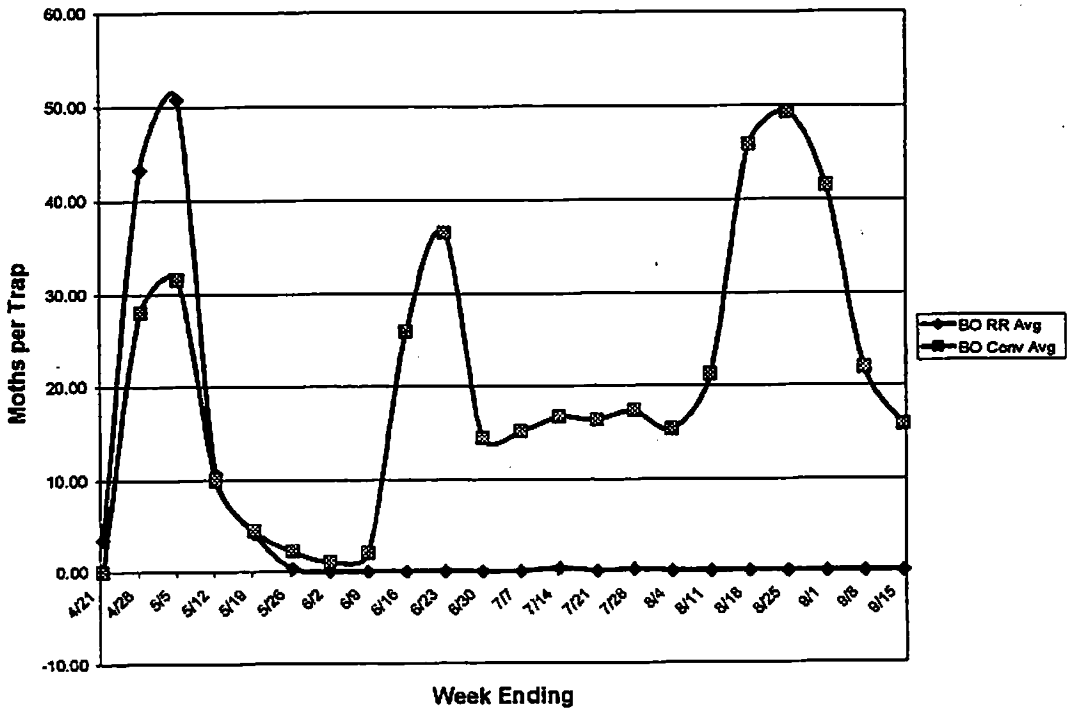


Polk

Average Weekly OFM Trap Captures - John Boy 2001

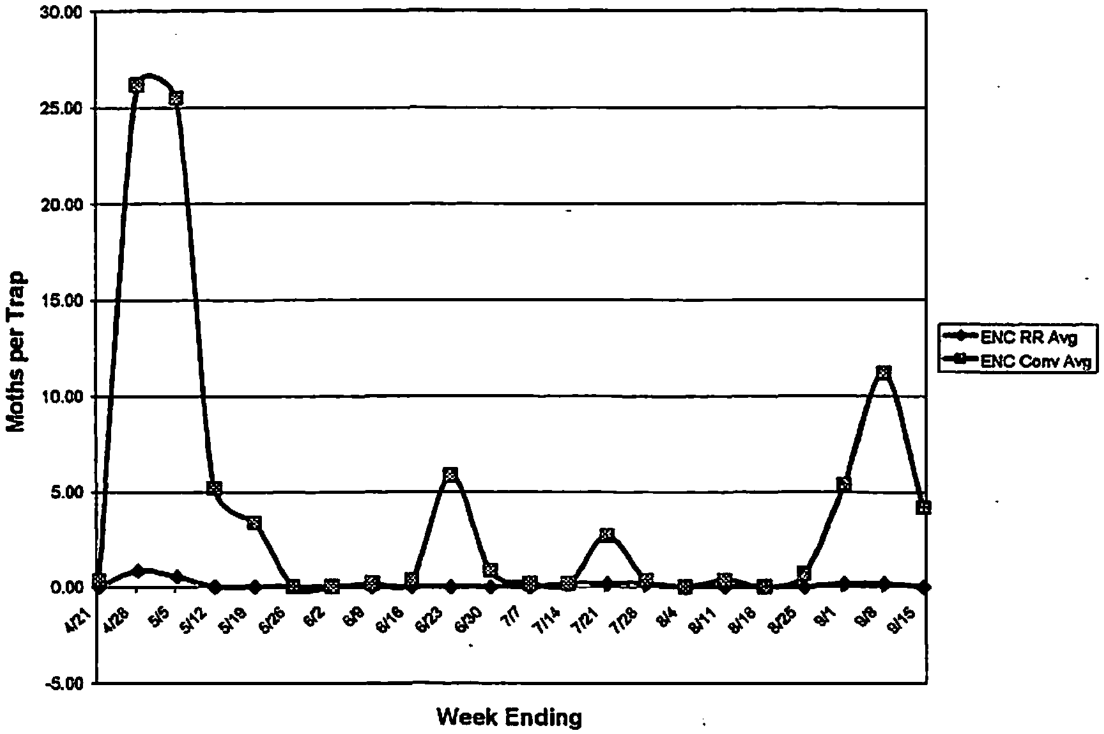


Average Weekly OFM Trap Captures - Bounty 2001



Polk

Average Weekly OFM Trap Captures - Encore 2001



Not for Citation or Publication without the Consent of the Authors

THE IMPACT OF TWO PEST MANAGEMENT PRACTICES ON PEACH PESTICIDE RESIDUES

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Protecting peach fruit from the several pests that attack them each year is the primary objective to orchard pest management programs. Traditionally, this objective has been accomplished through the use of sprays applied to peach foliage and fruit throughout the growing season (Rutgers Cooperative Extension, 2001). The materials applied have primarily been organophosphate insecticides, principally phosmet and azinphos methyl. Today, this class of insecticides has come under increasing scrutiny due to their acute and chronic toxicity profiles and the risk they may pose in the diets of infants and children (FQPA, 1996). In fact, their continued use in agriculture is in jeopardy due to new label restrictions and reductions in labeled sites (EPA 1999, 2001).

In response to this situation, a Reduced Risk (RR) Peach Arthropod Management Program (Atanassov et al., 2000) was developed. This program combines mating disruption of the Oriental fruit moth (Rice and Yirsch, 1990) with good ground cover practices (Shearer et al., 1998, Polk et al., 1999) for tarnished plant bug management and has reduced organophosphate and carbamate insecticide use by over 50%. When the RR program was compared to conventional practices, RR orchards were shown to have 42% fewer tarnished plant bugs and 50% less tarnished plant bug damaged peaches. In addition, Oriental fruit moth mating disruption gave approximately 4 months of non-insecticidal control of this major pest while providing control that was equivalent to 5+ additional organophosphate 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.

Fewer insecticides also reduce the risks to growers, applicators, field laborers and consumers, and the environment because of reduced exposure to these materials. In theory, this should be the case for the RR orchards because of the reduction in the number of applications. In practice, however, this impact of the program has not yet been documented. This report discusses preliminary results from a study conducted during 2001 to evaluate the peach pesticide residues found in RR orchards at harvest and after being run through a commercial packing line and to compare these residues with those found in orchards using conventional practices.

Methods and Materials:

This study was carried out on 6 commercial New Jersey peach orchards. At each site, a block of peaches (minimum size is 8 acres) was divided in half; each half was designated as either conventional or reduced risk. The blocks at the various farms were selected to provide use with RR demonstrations for early-, mid- and late-season peach varieties. During the fall of 2000, the RR blocks were also planted with sod in the drive rows to eliminate broadleaf weeds as part of the ground cover management program. In the spring of 2001, mating disruption dispensers were placed in trees in the RR blocks before emergence of second generation Oriental fruit moth adults. Both RR blocks and conventional blocks were monitored weekly throughout the growing season using methods outlined in the 2001 New Jersey Commercial Tree Fruit Production Guide (Rutgers Cooperative Extension, 2001) and the Mid-Atlantic Orchard Monitoring Guide (Hogmire, 1995). Levels of pest insects and mites and beneficial biological control agents were determined. Decisions for applying insecticides were based upon existing thresholds (Rutgers Cooperative Extension, 2001, Hogmire, 1995). In all orchards, standard disease control practices were used.

At harvest, fruit samples (minimum 10 lbs per site) were taken from each orchard and divided into two groups: pre- and post-packing line fruit. Post-packing line fruit were first hydrocooled and then run through a commercial packing line located at a commercial fruit farm (Sunnyslope Farms). The fruit from each group was then sent to the New Jersey Department of Environmental Protection Laboratory to determine the level of insecticide residues present on fruit. Once received, individual whole peach samples were homogenized and extracted. The laboratory used modifications of standard FDA residue protocols for evaluating food pesticide residues. These modifications give the analysis the ability to detect a variety of insecticide and fungicide residues.

A composite of each sample consisting of fifty grams was extracted by blending with acetonitrile and then collecting the filtrate. Target analytes were removed from the filtrate by using a solid phase extraction technique (Supelco Bulletin 900B, 1997). The final extracts were split for analysis between the Gas Chromatograph/Mass Spectrometer (GC/MS) operating in the EI mode and the High Performance Liquid Chromatograph (HPLC) which used a UV detector. The GC/MS and the HPLC were both necessary since two of the targeted analytes (phosmet and azinphos-methyl) are best analyzed using gas chromatography while the other two targeted analytes (methomyl and carbaryl) are best analyzed using liquid chromatography. The GC/MS employed for this project has the capacity to detect a wide range of pesticide residues beyond those identified in the management project. The GC/MS system routinely detects over 300 additional pesticide residues and/or degradates as part of the scanning capability.

Results:

Overall, residues for only four materials were recovered from both the RR and conventional orchards: two fungicides and two insecticides (Table 1). In all cases the levels detected were below the tolerance levels established by the United States Environmental Protection Agency. In terms of the number of detections found, residues of these materials were detected in 22 times in conventional orchards as compared to 15 times in RR orchards. There were also differences in the number of detections between conventional and RR orchards based on whether the samples were taken before or after being run through the packing line. Residues were detected 13 times from pre-packing line samples in conventional orchards versus 9 detections from RR orchards. This pattern was also seen for the post-packing line samples (Conventional – 9, RR – 6).

For the fungicides detected captan residues were found in both the conventional and RR orchards but were not quantified due to the analysis used. A second fungicide, propriconazole was detected in both the conventional and RR orchard pre-packing line samples but not the post-packing line samples. Mean residue levels for the insecticide phosmet were highest overall in conventional (pre – 0.557 ppb, post – 0.155 ppb) orchards and were substantially lower in RR orchards (pre – 0.1, post – 0.026 ppb). As with propriconazole, residue levels in each management system were highest prior to being run through the commercial packing line. Residues for the insecticide carbaryl were slightly lower in the pre- versus post samples (conventional: pre – 0.103 ppb, post – 0.109 ppb; RR: pre – 0.096 ppb, post – 0.101 ppb).

Conclusions:

The preliminary data presented here shows that very few residues are present in peach orchards despite the type of management system used. Those residues that were found were all well below established tolerance levels and tended to be lower in post-packing line samples than pre-packing line fruit. This suggests that the process of running harvested fruit through a commercial packing line can impact the residue levels present. This impact is most likely due to the process of hydrocooling and washing the fruit prior to sorting and packaging.

Acknowledgements:

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Table 1. Peach pesticide residue levels from orchards using Reduced Risk (RR) and conventional pest management practices.

Program	Chemical Detected	Type of Material[a]	Pre/Post Packing Line	Number of Detects	Mean Level Detected (ppb)	EPA Tolerance (ppm)
RR	captan	F	Pre	3	Detected[b]	50.0
			Post	3	Detected[b]	
	carbaryl	I	Pre	1	0.096	10.0
			Post	1	0.101	
	phosmet	I	Pre	2	0.100	10.0
			Post	2	0.026	
	propriconazole	F	Pre	2	0.005	1.0
			Post	0	ND[c]	
Conventional	captan	F	Pre	3	Detected[b]	50.0
			Post	3	Detected[b]	
	carbaryl	I	Pre	1	0.103	10.0
			Post	2	0.109	
	phosmet	I	Pre	5	0.557	10.0
			Post	4	0.155	
	propriconazole	F	Pre	3	0.017	1.0
			Post	0	ND[c]	

[a] F = fungicide, I = insecticide.

[b] Material was detected but not quantified.

[c] ND = Not Detected.

Effect of Gibberellin Synthesis Inhibition on Feeding Injury by Potato Leafhopper (Homoptera:Cicadellidae) on Apple

By Kathleen Leahy, Duane Greene, and Wesley Autio
University of Massachusetts, Amherst

Overview

Although the gibberellin synthesis inhibitor Apogee (prohexadione-calcium) was introduced in apple primarily as a horticultural tool, used to reduce shoot length and thereby decrease the amount of necessary pruning and associated costs, the inhibition of gibberellin has also shown beneficial effects in controlling some important pests of apple. The most dramatic effect has been seen on the shoot blight phase of the bacterial disease fire blight, but some effects have also been seen on flush-growth-feeding insects such as green apple aphid and obliquebanded leafroller. To date, however, no studies have been published on the effect of Apogee on potato leafhoppers *Empoasca fabae* (Harris).(Byers et al, 1997; Paulson and Hull, 1999; Yoder et al. 1999)

Potato leafhoppers are occasional orchard pests in the mid-Atlantic and Northeast. These insects are not able to winter in the north; they overwinter in the southern United States and migrate northward on storm systems over the course of the spring and early summer. In apple, they feed in vascular tissue in rapidly-developing shoot tissue; in mature trees, this injury is not generally considered serious, although in young trees it may be necessary to apply control measures for a moderate to severe infestation. There is, however, some evidence that potato leafhoppers may play a role in facilitating the shoot blight phase of fire blight, by introducing feeding wounds in susceptible tissue on which *Erwinia amylovora,* the bacterium which causes fire blight, is growing epiphytically, allowing the bacteria to invade the leaf and cause infection. (Koehler 2000; Pfeiffer et al. 1999)

Since potato leafhoppers feed directly on the tissue most likely to be affected by gibberellin synthesis inhibition, we thought that the possibility of suppressing or even completely controlling these leafhoppers with Apogee or a similar gibberellin synthesis inhibitor was strong enough to warrant further study. This work was done as part of a larger study looking at the interactions of gibberellin synthesis and potato leafhoppers with fire blight.

Materials and Methods

A 200-tree section of a block of 15-year-old McIntosh/M.7 in a commercial orchard in Dummerston, Vermont was used for the study. A randomized complete block design was used, with ten replications and two trees per treatment x rep. Buffer trees were employed within the row, and a buffer row was employed between treated rows. Apogee was applied at the rate and timings recommended for commercial growers in this area, 12 oz per 100 gallons tree row volume at early petal fall (May 12) and a second application at the same rate when growth would have been expected to resume, June 1.

There were two levels of two treatments used in this experiment: Apogee treated and non-treated, and potato leafhoppers excluded or permitted. The insecticide Provado (imidacloprid) was used for exclusion, at the highly reduced rate of 0.5 oz per 100 gallons tree row volume recommended by researchers at the Cornell Hudson Valley Laboratory (Scaffolds newsletter, June 2001). Provado was applied when potato leafhoppers began to appear in the orchard, June 22, and was re-applied when numbers appeared to be resurging, July 20.

Shoot length was measured using a measuring tape on 5 shoots per tree (10 shoots per tree for the first two sample sessions) at 10-day intervals beginning at petal fall to assess the effectiveness of the Apogee treatment. Potato leafhopper injury was evaluated with a spectrophotometer early in the season, but this method became cumbersome and was eventually supplemented with a visual rating scale of injury, with 0 being no visible injury and 5 being severe injury. Because of the high mobility of potato leafhopper adults, which were the predominant life stage, we did not succeed in getting a reliable count of leafhopper numbers per shoot. In future studies a field-adapted vacuum cleaner device may be used for this purpose.

Results and Discussion

Shoot length measurements showed that Apogee had a highly significant effect on shoot growth, both in the presence and absence of potato leafhoppers. Using the visual rating scale assessment of leafhopper injury, the control provided by Apogee and Provado individually on leafhopper injury were highly significant, and the interaction of the two was also significant. The effect of Apogee within Provado treatments was highly significant and within non-Provado treatments was significant. On the last assessment date, August 15, 2001, the average level of feeding injury where Apogee was used alone was 0.83, where Provado was used alone was 0.78, and where both were used together was 0.31. Untreated control trees showed an injury level of 2.13 for this date. Thus, there does appear to be a substantial benefit to potato leafhopper control using Apogee either alone or in combination with insecticide. Potato leafhoppers arrived later than usual in New England and did not reach high numbers in any location, leading to a relatively low damage level in the control.

The mechanism by which gibberellin inhibition affects leafhopper feeding is not known and will be further investigated. It is possible that visual or chemical cues used by the insects are muted by the treatment, or it could be that the leafhoppers do begin feeding but find the treated plant unpalatable or possibly even toxic. Behavioral studies of potato leafhoppers exposed to Apogee-treated and -nontreated foliage separately and in choice situations will be conducted to try to elucidate the nature of the response.

Regardless of the reason, however, the fact that injury appears to be reduced by the inhibition of gibberellin is of significance for growers needing to control this insect. Specifically, where Apogee has been used and leafhopper numbers are not exceptionally high, there may be no need for an insecticide directed at the leafhoppers. In cases where a severe fire blight outbreak is in progress and leafhopper numbers are high, an insecticide may still be warranted, and should hopefully have greater efficacy in combination with the Apogee.

More work needs to be done in understanding the nature of the effect of gibberellin inhibition on leafhoppers and on the relationship between potato leafhoppers and fire blight. In addition, it would be enlightening to repeat the experiment under higher populations of potato leafhopper and see whether the effect continues to hold true, or is muted or enhanced under such conditions.

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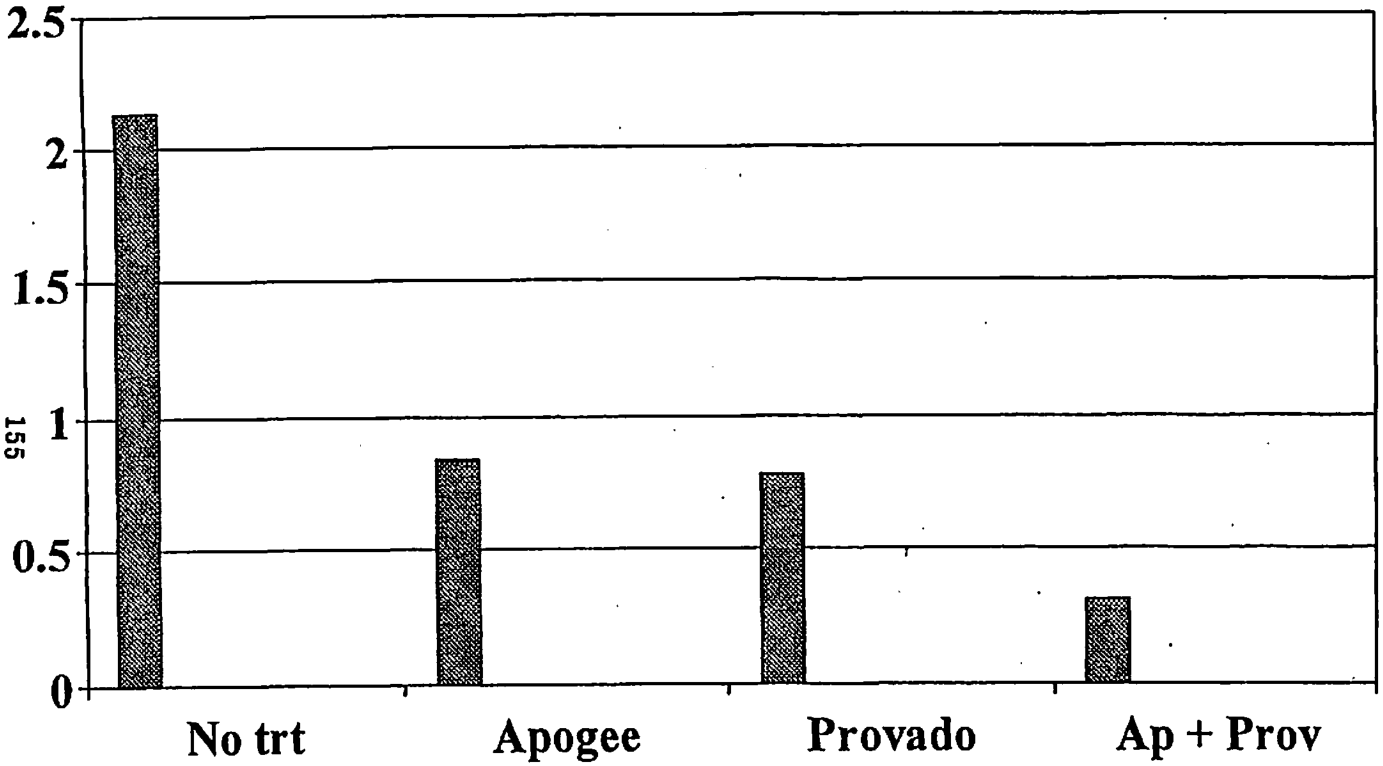
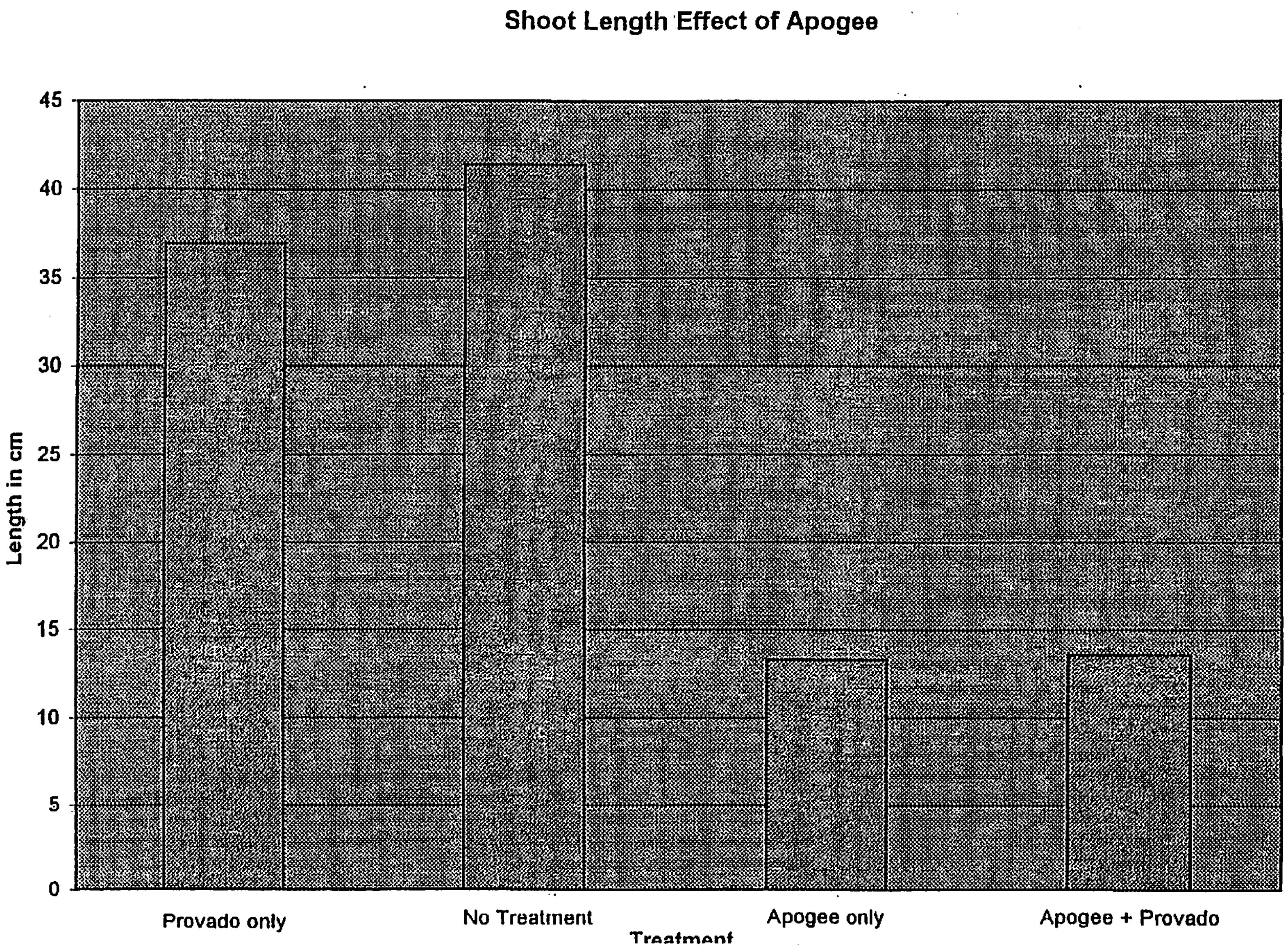
Average PLH Damage per Shoot (Scale 0-5) for each Treatment




Shoot Length Effect of Apogee
45
40
35
30
25
20
15
10
5
0
Length in cm
Provado only
No Treatment
Apogee only
Apogee + Provado
Treatment

Resistance of 'Geneva' Apple Rootstocks to *Erwinia amylovora* When Grown as Potted Plants and Orchard Trees

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Keywords: *Malus* X *domestica*, fire blight, disease resistance, disease susceptibility

Abstract

The objective of the USDA / Cornell apple rootstock breeding project is to develop pomologically superior rootstocks with resistance to biotic and abiotic stresses. Progeny of controlled crosses were selected for fire blight resistance following direct inoculation of seedling shoots with *E. amylovora*. Recently 3 rootstocks, 'Geneva (G.) 11', 'G.30', and 'G.16' were released for commercial sales and several other selections are in the final stages of evaluation. To compare their resistance with that of other apple rootstocks, liners of 48 different rootstocks were grown in the greenhouse, inoculated with differentially virulent strain E4001a and other highly aggressive *E. amylovora* strains, and the percent of the current season's shoot length blighted (SLB) calculated. The rootstocks most susceptible to direct inoculation were 'Budagovsky (Bud.) 9' (88% SLB), 'Ottawa 3' (87%), 'M.9' (86%), 'M.26' (80%), and 'Supporter 4' (69%), while 'M.7' (28%), 'G.30' (22%), 'G.16' (18%), 'G.11' (7%), and 13 other Geneva selections (CG.) (8-30%) were the most resistant. To evaluate the resistance of the rootstocks under orchard conditions, 3-yr-old 'Royal Gala' trees on 18 Geneva rootstocks and 6 control rootstocks were spray inoculated with strain E4001a twice during bloom in May 1999. All trees developed severe infections in the scion. Presence of ooze on rootstocks was first observed on 16 June. Greatest incidence of tree death by 15 Oct 1999 occurred on 'M.26' (92% and 60% on two clones), and 'M.9' (83%). No trees on 'MM.111', 'Marubakaido', or 'Bud.9' died. Of the commercialized 'Geneva' rootstocks, 'G.16' and 'G.30' had no tree death, and 'G.11' had 25%. Nine other advanced rootstock selections from Geneva had no tree death. In 2000, a natural blossom blight epidemic occurred in a duplicate planting of the 'Geneva' rootstocks at another location. The resistance observed agreed closely with that previously observed in the inoculated block.

INTRODUCTION

Fire blight infection of susceptible apple rootstocks, such as 'Malling (M.) 9' and 'M.26', frequently results in necrosis of the rootstock crown and tree death. Fire blight infection of the rootstock can occur by several different avenues including infection of rootstock suckers, basipetal internal movement of bacteria through healthy scion tissue, and direct infection of the rootstock crown through breaks or wounds in the bark. Rootstock infection has been one of the most economically devastating phases of fire blight for apple growers in the eastern U.S. A survey conducted in New York during the 1996/1997 growing season identified several commercial orchard blocks with a 10% incidence of rootstock infection (Momol, et al., 1997). For trees in their 4th leaf, total economic loss from a 10% tree loss was estimated to range from $1,600 to $3,500 per acre, depending upon tree density. These high economic losses result from the cost of tree replacement, lost investment in tree maintenance, and reduced productivity of the block for several years until replacement trees mature.

The objective of the USDA / Cornell apple rootstock breeding project is to develop pomologically superior rootstocks with resistance to biotic and abiotic stresses. Resistance to *Erwinia amylovora* has been a major objective in the selection of these rootstocks. Although resistant rootstocks do not prevent fire blight infection of susceptible scion cultivars, they do prevent tree loss due to rootstock infection. Progeny of controlled crosses were selected for fire blight resistance following direct inoculation of seedling shoots with *E. amylovora*. The rootstocks 'Geneva (G.) 11', 'G.30', and 'G.16' have been released for commercial use. All three rootstocks produce trees that are early bearing and highly productive (equal to 'M.9' in most tests). 'G.16' produces a tree in the 'M.9' size class that is very early bearing. 'G.16' is resistant to both fire blight and *Phytophthora*. Its negative attributes include sensitivity to common latent viruses, difficult propagation, and susceptibility to woolly apple aphid. 'G.11' produces a tree in the 'M.26' size class. It is moderately resistant to fire blight and *Phytophthora*, and moderately susceptible to woolly apple aphid. 'G.30' produces a tree in the 'M.7' size class. It is resistant to both fire blight and *Phytophthora*. Its negative attributes include sensitivity to common latent viruses, presence of many spines and feathers in the nursery making it costly to propagate, and susceptibility to woolly apple aphid.

Although the 'Geneva' rootstocks are known to be resistant to direct shoot inoculation with *E. amylovora* strains Ea273 or E4001a, it was not known if these apple rootstocks are resistant to infection by *E. amylovora* through other avenues under orchard conditions or if they would be resistant to other highly aggressive strains of *E. amylovora*. The purpose of this study was to evaluate the resistance of the 'Geneva' rootstocks and advanced selections of the breeding program as rootstocks of grafted trees grown under orchard conditions, and to compare their resistance with that of other apple rootstocks when inoculated with the differentially virulent strain E4001a and other highly aggressive *E. amylovora* strains.

MATERIALS AND METHODS

Potted Plants

Rootstocks were evaluated in the greenhouse for their resistance to fire blight by direct inoculation of vigorous shoots with one to 4 strains of *E. amylovora*: Ea273, a standard NY strain previously used for evaluation of cultivar resistance (Aldwinckle and Preczewski, 1976); E2002a, a highly aggressive strain (Norelli, et al., 1984; Paulin, et al., 1993); E4001a, differentially virulent to *M.* X *robusta* 'Robusta 5' (Norelli, et al., 1986), and E2017p, reported to be virulent to 'G.11' (pers. commun. J.A. Cline, 1999). Stoolbed propagated liners (rooted, hardwood shoot cuttings) obtained from various suppliers were potted in cylindrical pots containing a peat and vermiculite soil mix, and trained to a single shoot. Shoots at least 15 cm in length and in a stage of vigorous growth were selected for inoculation on 16 Jun 2000. Due to a limited supply of many of the rootstocks, not all rootstocks were inoculated with all 4 strains. If less than 20 shoots were available for inoculation a minimum of 5 shoots were inoculated with each specific strain. The priority of strain selection for shoot inoculation was first Ea273, then E2002a, then E4001a, and finally E2017p.

Inoculum consisted of 18-h-old shake cultures grown in Kado 523 broth (Kado and Heskett, 1970) at 28° C. The concentration of inoculum was estimated by absorbance at 620 nm using a standard curve and adjusted to the desired concentration by dilution with sterile 0.05M potassium phosphate buffer, pH 6.5. Inoculum was maintained on ice and was used for plant inoculation within 2 h of dilution. Shoots were inoculated by transversally bisecting the two youngest actively growing leaves with scissors dipped in a suspension of *E. amylovora* (1×10^{9} CFU ml^{-1}). Current season's shoot length and length of necrotic lesion were measured on 5 July 2000. The necrotic lesion length was divided by the current season's shoot length to calculate the proportion and percentage shoot length necrotic, and used as the measure of plant resistance. Individual plants were the unit of replication. GLM (SAS Institute Inc.) of the proportion of the shoot length necrotic was used to analyze treatment effects. Because the analysis indicated a significant rootstock by strain interaction, differences is rootstock resistance were analyzed for each strain using a Waller-Duncan K-ratio T test.

Orchard Trials

Rootstocks of grafted fruiting trees were evaluated for their resistance to *E. amylovora* when grown in orchards subjected to a blossom blight epiphytotic incited either by controlled blossom inoculation or natural blossom infection. To establish the orchard, rootstock liners were planted in a nursery, bud chip grafted with the 'Royal Gala' scion (Summer 1995), grown in the nursery for one season, dug (Fall 1996), graded and stored. Orchards were established at the Research North Farm of the NYS Agricultural Experiment Station, Geneva (inoculated block) and the Ray Smith Farm, Geneva, NY (natural infection) in a randomized block design (Spring 1997) that was blocked based upon trunk diameter. Trees were grown under recommended commercial orchard practices, trained to a central leader, and provided with post support.

Trees at the Research North Farm all bloomed heavily in 1999 and open blossoms were spray inoculated with *E. amylovora* strain E4001a using a backpack sprayer. To compensate for rootstock effects on the time of bloom and rootstock effects on the number of blossoms on 1-year-old wood, which tend to bloom later, trees were inoculated twice, 12 May 1999 and 17 May 1999, with 1.0×10^{7} and 1.4×10^{6} CFU / ml, respectively. The inoculum concentration was reduced for the second inoculation date due to the forecast of warmer weather conditions more favorable for blossom blight development.

During the 2000 growing season an epidemic of rootstock blight resulting from natural blossom infection occurred in the Ray Smith Farm block. Blocks of 'Jonagold', 'Spartan', and 'Cortland' trees on 'M.9' rootstock adjacent to the trial block sustained 60-80% incidence of rootstock blight.

RESULTS AND DISCUSSION

Potted Plants

'M.9' and 'M.26' were highly susceptible to direct inoculation by all four strains of *E. amylovora* and 'M.7' was significantly more resistant than 'M.9' and 'M.26'. The resistance of 'G.30', 'G.16', and 'G.11' to direct inoculation was statistically indistinguishable from 'M.7'. 'Bud.9' was evaluated as the most susceptible rootstock when vegetative shoots of rootstock liners were inoculated in the greenhouse, but surprisingly it did not develop any rootstock blight in either orchard trial. 'Vineland 2' and 'Vineland 7' were significantly more resistant than 'M.26' but were significantly more susceptible than 'M.7', whereas 'Vineland 1' and 'Vineland 4' were not significantly different than 'M.7'. The resistance of 'Supporter 4' was statistically indistinguishable from that of 'M.26'.

When shoots of rootstock cultivars were inoculated with different strains of *E. amylovora*, significant strain by rootstock interactions were observed in the amount of fire blight that resulted from inoculation. Those interactions were clearly differential and could not be explained by the greater aggressiveness of strain E2002a since some rootstocks, such as 'MM.106' and 'Support 4', were evaluated as significantly more susceptible when inoculated with the less aggressive strain Ea273 than when inoculated with the highly aggressive strain E2002a. Conversely, when 'Robusta 5' progeny 'CG.3007' was inoculated with strains E4001a and E2002a it was ranked significantly more susceptible in comparison to other rootstocks than when they were inoculated with strains Ea273.

'G.11', 'G.30', and 'G.16' were resistant to all four strains used for inoculation in a non-differential manner, even though 'G.11' and 'G.30' are progeny of 'Robusta 5', which is known to be differentially susceptible to strain E4001a. These rootstocks were selected and/or evaluated using a pooled mixture of different strains, and their resistance to individual strains indicates that pooled strains of *E. amylovora* can be used successfully to select for resistance to several strains of differing virulence (Norelli, et al., 1987). Resistance effective against strains of different virulence patterns (or races) should be more durable than that selected against a single strain.

Orchard Trials

When grown as rootstocks of fruiting trees in the orchard, 'M.9' and 'M.26' were highly susceptible to rootstock blight with 40% to over 90% of the trees dying within the first year following a fire blight epidemic initiated either by blossom inoculation or natural blossom infection. 'MM.111', 'Bud.9', 'G.16', and 'G.30' were resistant to rootstock infection under orchard conditions. Considering the high level of resistance of 'G.11' against all strains of *E. amylovora* in the greenhouse trial, it developed more disease than expected in both orchard trials (approximately 25% of the trees diseased). However, in comparison to disease development in 'M.9' and 'M.26' clones (70 to 100%

tree death in the blossom inoculated trial) the level of resistance in 'G.11' should be commercially useful under conditions of lower disease pressure.

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EVIDENCE ON THE ETIOLOGY OF PEACH RUSTY SPOT

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Rusty spot is an important powdery mildew disease of peach in New Jersey. Many commonly planted cultivars experience high levels of fruit infection. For example, if left uncontrolled, disease incidence can approach 100% on Jerseyqueen. Estimates of yield loss in New Jersey have ranged from $11/A in 1996 to as much as $206/A in 1997 (13).

Given the importance of rusty spot in New Jersey, much research over the last few years has focused on epidemiology and management aspects (6,7,8,9). In the process of performing these studies, information has been obtained that provides additional evidence on the unproven etiology of the disease. The purpose of this paper is to review past studies on causality, present new evidence, and propose a hypothesis on the etiology of peach rusty spot.

HISTORICAL PERSPECTIVE

Discovery. Rusty spot was first observed in an Idaho 'Elberta' peach orchard in 1941 (1,2). Rusty-colored spots were observed to first appear during spring on fruit when they were about "walnut-size". The discolored hairs in the lesions easily rubbed off, creating a bald, finely russetted, smooth and somewhat shiny appearance. No evidence of the disease was observed on twigs or leaves. During the summer, attempts to find either spores or mycelium in the spots failed.

Early Histology. In 1956 a histological study, which utilized paraffin sections, was performed comparing rusty spot, powdery mildew (as caused by *Sphaerotheca pannosa*), and healthy peach skin (15). Microscopic symptoms consisted of much corky tissue beneath rusty spot and powdery mildew lesions. An increased lignification was particularly noticeable in rusty spot lesions, as well as a greater number of plastids in the parenchyma cells beneath the infected areas. The powdery mildew lesions had abundant spores and mycelium, but these pathogen signs were lacking for rusty spot. Unfortunately, lesion age, fruit age, or name of the cultivar was not provided.

Apple Mildew. Results from three subsequent studies provided evidence that the causal agent may be the apple powdery mildew pathogen, *Podosphaera leucotricha*. In New Jersey in 1960, very high levels of rusty spot were observed on the peach cultivars 'Summerqueen', 'Rio Oso Gem', and 'Goldeneast'; as much as 100% fruit infection occurred on these latter two cultivars (3,4). Disease incidence on these cultivars was observed to decrease as distance from a neighboring powdery mildew infected apple orchard increased. Furthermore, in histological studies on young lesions, some mycelial strands and occasional mildew-like spores were observed. These signs, however, were absent from older rusty spot lesions.

In California in 1972, rusty spot was reported on Rio Oso Gem peaches interplanted with powdery mildew infected Jonathan apple trees (12). Peaches adjacent to apples had the highest rusty spot incidence. Application of benomyl and sulfur provided disease control, indicating that the pathogen may be a powdery mildew fungus. In another Rio Oso Gem orchard, isolated from apple trees, weekly fruit inoculations beginning at shuck-split were conducted using *P. leucotricha* and *S. pannosa* conidia. Typical peach mildew occurred in 19% (23/123) of the *S. pannosa* fruit, while similar but not identical rusty spot symptoms occurred in 25% (43/174) *P. leucotricha* inoculations.

A subsequent study, also involving a Rio Oso Gem orchard adjacent to a Jonathan apple orchard, was performed in Illinois in 1978 (14). In this experiment, the spatial relationship or rusty spot disease gradient was quantified using a linear log-log model. Maximum disease incidence of 43-50% fruit infection occurred at 10 m (closest peach row to apples), while a minimum of 3-10% incidence was observed at 90m. The researchers also made repeated attempts to produce rusty spot lesions by inoculation with *P. leucotricha* conidia, but were unsuccessful. They attributed this outcome to either sub-optimal environmental conditions, the incorrect stage of fruit development, or that *P. leucotricha* was not the causal agent.

Current Status. Evidence supporting the belief that the pathogen is a powdery mildew fungus and *P. leucotricha* was summarized as follows (10): (1) Koch's postulates demonstrated in California (although not substantiated elsewhere); (2) disease appearance on peaches near powdery mildew infected apple trees; (3) hyaline hyphae and conidia, typical of powdery mildews, sometimes observed; (4) similarity of symptoms to old powdery mildew lesions; and (5) control of disease with sulfur.

NEW JERSEY EVIDENCE

Early information from New Jersey, as in other states, focused on proximity of rusty spot to apple orchards (3,4). In those years, apple orchards were commonly found interspersed among peach orchards. Today, many apple orchards have been replaced by peach or nectarine orchards. Thus, large plantings of peach exist that are not adjacent to or near apples. Nevertheless, rusty spot is still a common occurrence in many of these plantings.

New evidence further substantiates that the pathogen is a powdery mildew fungus, but that it may be *Sphaerotheca pannosa* from rose. During the mid-1900's, multiflora rose bushes were planted by many farmers in New Jersey for conservation purposes. This practice was widely promoted throughout the eastern United States (5). This plant has since become naturalized by spread of its own seed. Consequently, stands of "wild" rose can be found scattered throughout the southern peach growing region of NJ.

Signs and Symptoms. A range of signs and symptoms are found in New Jersey orchards, and appear to be dependent on the cultivar examined. Some susceptible peach cultivars exhibit typical rusty spot lesions that lack discernable signs of a pathogen. These spots resemble lesions believed to be caused by *P. leucotricha*, except that apple orchards are not located nearby.

Other cultivars, such as 'Jerseyqueen' and 'Autumnglo', have white fungal colonies that initially look like older peach powdery mildew lesions. Upon microscopic examination, a very small amount of mycelium and mildew-like conidia is observable on colonies during these early stages of disease development. However, this appearance is soon lost as trichomes detach and the epidermis becomes russetted and smooth. This change in symptoms occurs from the center of the colony outwards.

The above signs and symptoms represent two extremes; some cultivars exhibit intermediate infection characteristics. Regardless of the degree of signs and symptoms expressed, the timing of infection (discussed in more detail below) is identical. Also, in all cases, infection of leaves or stems of the affected peach trees or on neighboring mildew susceptible nectarines has never been observed.

Vegetation Survey. An survey of.disease on vegetation surrounding Jerseyqueen (JQ) and Jerseyglo (JG) orchards was conducted in 2000 and 2001. The JQ orchard had a history of high rusty spot incidence, while disease levels in the JG orchard were usually moderate. All natural, commercial, and residential vegetation were included in the survey, which was conducted within a 2 km radius of each site. Emphasis was placed on searching for powdery mildews on all plant species, with particular attention given to finding *Malus* (apple) and *Prunus* (stone fruit) plantings.

The JQ orchard is surrounded by wooded, natural vegetation to the north and south, a Loring peach orchard to the east, and an ornamental nursery to the west. Wild black cherry trees, *Prunus serotina*, were found in the natural vegetation, but were never observed to be infected by a powdery mildew fungus. Other native woodland trees, shrubs, and vines, as well as ornamentals in the nursery, were also not found to be infected with powdery mildew fungi. However, at the edge of the wooded areas and immediately adjacent to the JQ peach block were large numbers of multiflora rose bushes (*Rosa multiflora*) that did contain powdery mildew infections.

The JG orchard, located at the experiment station, is surrounded by a nectarine block to the north, peach blocks to the east and west, and a field containing agronomic field crops (corn or soybean) to the south. A wooded area, adjacent to the peach block east of the JG orchard, was surveyed but not found to have any powdery mildew on its native vegetation. Also, rose bushes were not growing along the edge of these woods. However, wild roses containing powdery mildew were found in hedgerows approximately 0.4 km west of the JG block and at various other hedgerows scattered throughout the station.

Disease Control. During the 2000 growing season, Microthiol Special 80DF (12 lb/A) and Nova 40W (5 oz/A) treatments were applied to four replicate trees in an 'Autumnglo' block experiencing high levels of rusty spot. Applications were made from petal fall through third cover (5 sprays) using an airblast sprayer at 100 gpa.

Results showed that sulfur (Microthiol Special), a fungicide commonly used to control powdery mildews, significantly reduced both the incidence and severity of rusty spot (Fig. 1). Nova (myclobutanil), also commonly used for managing powdery mildews, showed excellent activity against the pathogen.

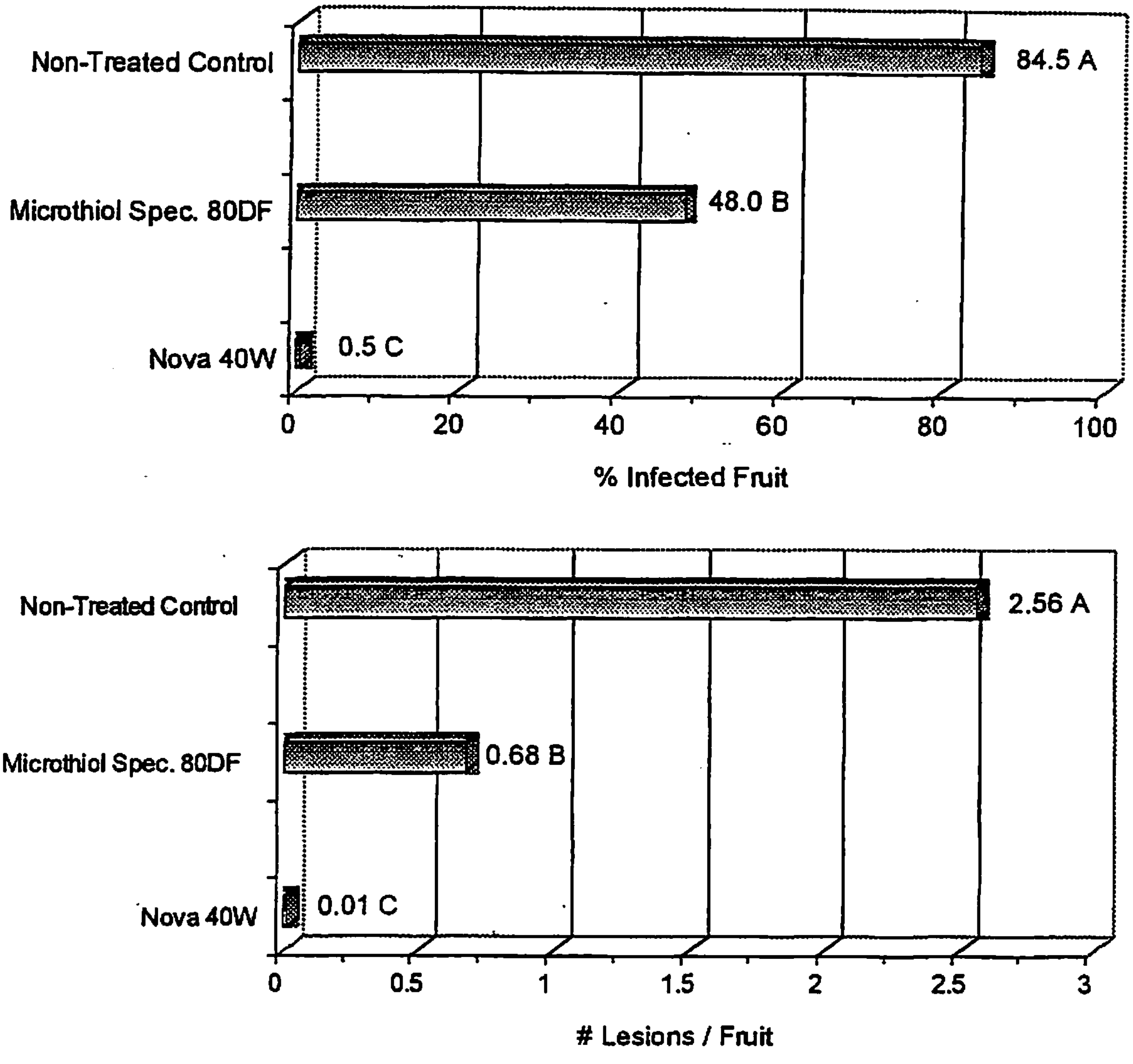

Fig. 1. Effect of sulfur (Microthiol Special) and myclobutanil (Nova) on incidence and severity of peach rusty spot on 'Autumnglo' peach in 2000. Data calculated from observations made on 9Jun on 50 fruit / replicate tree (four replicate trees / treatment). Means with the same letter do not differ significantly according to the Waller-Duncan K-ratio T-test (P=0.05; k=100).

Spatial Analysis. From 1998 through 2001, various rusty spot efficacy and disease management studies were conducted in a Jerseyqueen orchard bordered on the south side by powdery-mildew infected multiflora roses. In each of these years, the experimental design used in each study consisted of a RCBD with the arrangement of replicate blocks perpendicular to the roses; block one was closest to the roses, while block five was furthest. In each year, 40-50 fruit / replicate tree were examined in June for rusty spot lesions.

When replicate disease incidence and severity means were calculated, a disease gradient was evident in four of the five years examined (1998-2000). The highest level of disease was observed in block one, while block five had the least amount of disease.

To quantitatively examine this gradient, disease means for each replicate block were calculated across all four years and plotted against distance from the edge of the multiflora roses. Since fungicide treatments were randomly scattered throughout each block in each year, the distance to the middle of each block was used as the independent variable. Regression analysis was used to fit the negative exponential (Kiyosawa and Shiyomi model) and power (Gregory model) mathematical functions. Results show an excellent fit of the models to the data (Figs. 2 and 3), indicating a significant disease gradient.

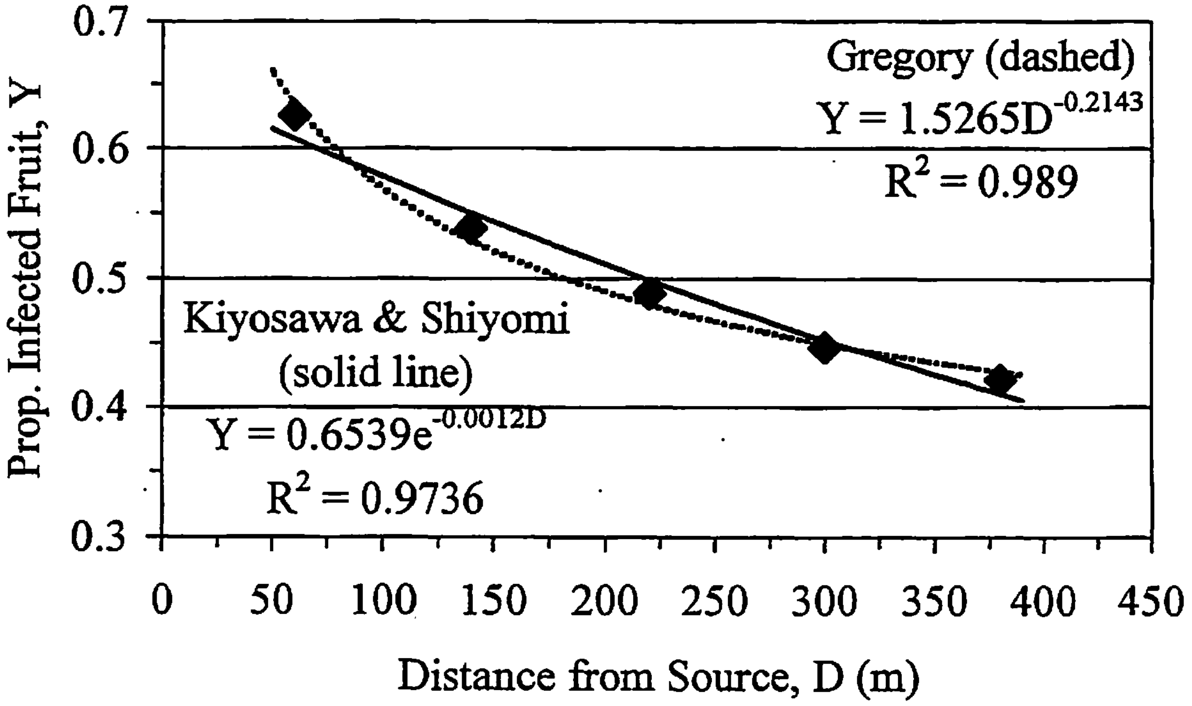

Fig. 2. Relationship between distance from powdery-mildew infected multiflora roses and disease incidence of peach rusty spot in a Jerseyqueen peach orchard. Data values (diamonds) are averages of replicate means calculated over three years (1998-2000). Models were fit by using linear regression analysis on transformed data.

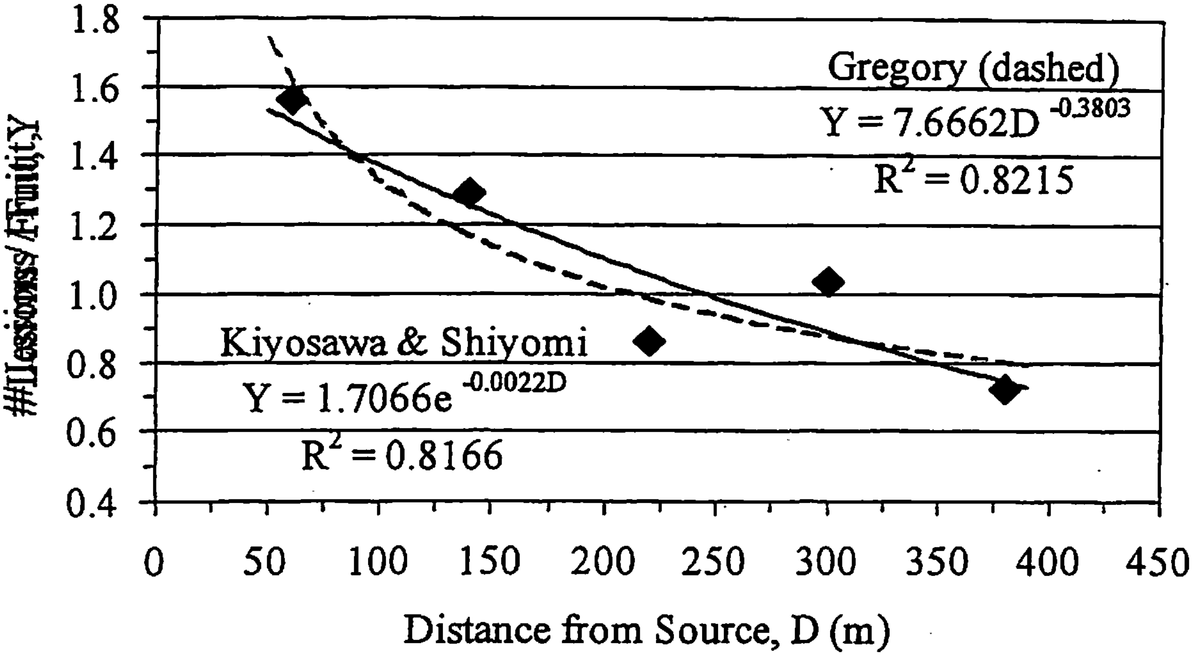

Fig. 3. Relationship between distance from powdery-mildew infected multiflora roses and disease severity of peach rusty spot in a Jerseyqueen peach orchard. Data values (diamonds) are averages of replicate means calculated over three years (1998-2000). Models were fit by using linear regression analysis on transformed data.

Temporal Analysis. An epidemiological experiment was conducted from 1999-2001 to quantitatively characterize the temporal aspects of peach rusty spot epidemics (7,9). One objective of this study was to determine the period during which fruit are susceptible to infection by the rusty spot pathogen.

Results showed that new lesions were no longer observed at 50-60 days after full bloom (Fig. 4). This observation was consistent across all three years of the study, even though disease progression was considerably delayed during the 2001 growing season. These results agree favorably with the period of susceptibility first reported in 1960 for peach powdery mildew caused by *S. pannosa* (16). In this study, the author states "The fruits were susceptible only during the early stages of their development. Two months after blossoming the fruits were completely resistant to mildew infection."

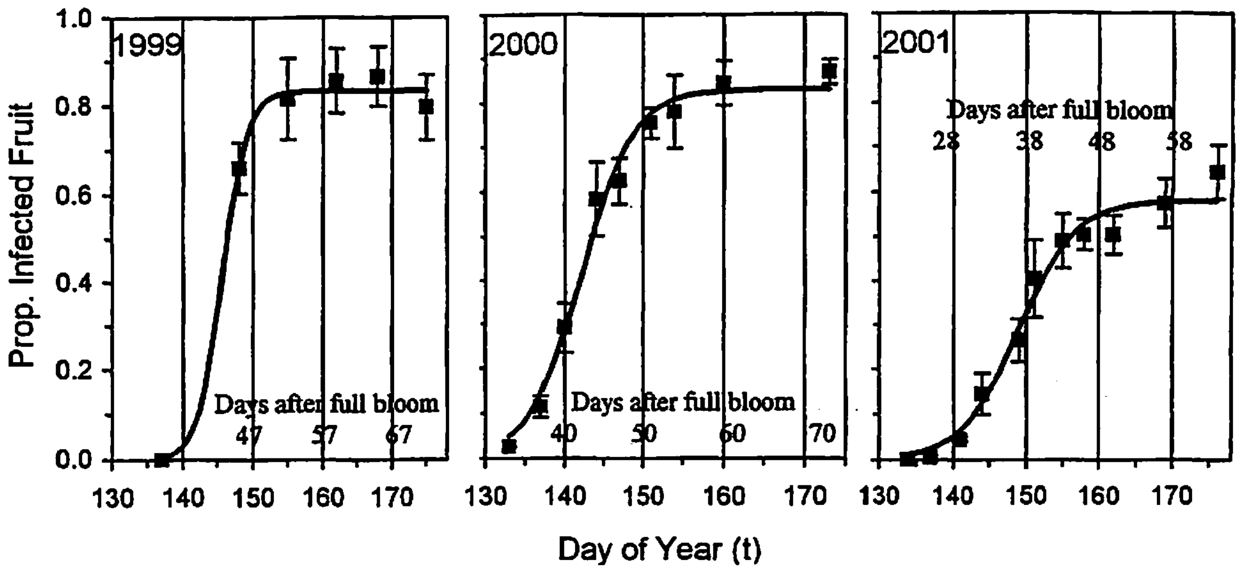

Fig. 4. Disease progress curves for peach rusty spot epidemics on non-treated Jerseyqueen trees in 1999, 2000, and 2001. Each data point (square) is a mean of five replicate trees on which 40 fruit/tree were assessed for disease; vertical bars represent standard error of the means. Solid lines represent the logistic model fit to the data using non-linear regression analysis.

HYPOTHESIS ON RUSTY SPOT ETIOLOGY

The species *S. pannosa* can be divided into two varieties or forms: *S. pannosa* f. sp. *persicae*, which infects peach and *S. pannosa* f. sp. *rosae*, which infects rose (18). Given this taxonomic classification, the *persicae* formae specialis is the causal agent for typical peach powdery mildew, capable of growing, reproducing, and overwintering on its stone fruit host. The *rosae* form does likewise on rose.

Based on the etiological, albeit circumstantial, evidence presented in this paper, we propose that the current rusty spot observed in New Jersey is caused by *S. pannosa* f. sp. *rosae*. Since this fungus is primarily a rose pathogen, the development of hypersensitive rusty spots on peach is a logical outcome for an "attempted" infection. As with *P. leucotricha, S. pannosa* f. sp. *rosae* would not be expected to grow, reproduce, or overwinter readily on peach.

A similar interaction between a mildew on rose and peach infection was reported in 1980 in Australia (11). Only peach fruit were observed to be infected, and disease levels decreased sharply as distance from the roses increased. Fruit infection declined from 70% incidence at 20 meters to < 10% at 60 meters. Some mycelium and conidia were observed in the peach lesions, but all inoculum for infection came from the roses. When the roses were removed, the disease no longer appeared on peach.

In New Jersey, evidence that supports the hypothesis of *S. pannosa* f. sp. *rosae* as the causal agent consists of: (i) visual signs and symptoms, which resemble old peach powdery mildew lesions; (ii) presence of mildewed roses (and lack of mildewed apples); (iii) temporal aspects of fruit susceptibility similar to peach powdery mildew; and (iv) occurrence of a disease gradient relative to mildewed roses. This disease gradient, however, was not as steep as observed in Australia (11) and incidence did not approach zero even at relatively far distances of 350-400 meters. We propose that this phenomenon may be due to "background" levels of airborne conidia, as wild roses are scattered throughout the region.

The evidence presented in this paper is circumstantial. Thus, more definitive research is needed to conclusively prove that *S. pannosa* f. sp. *rosae* is a causal agent of peach rusty spot. Such work could include peach inoculations, as performed with *P. leucotricha*, or molecular identification techniques utilizing PCR. Once proven, a more generalized etiology of peach rusty spot may be required, including all those pathogens that can incite a similar disease syndrome (Table 1). Indeed, other powdery mildew pathogens may be capable of causing the rusty spot condition. *P. oxycanthae* has also been suggested as a possible causal agent (17).

Table 1. Comparison of peach powdery mildew and peach rusty spot characteristics

	Powdery Mildew	Rusty Spot	
Characteristic	*S. pannosa* f.sp. *persicae*	*P. leucotricha*	New Jersey
Fruit Infection	▲	▲	▲
Leaf Infection	▲		
Twig Infection	▲		
Colonization	▲	None-sparse	None-sparse
Sporulation	▲	None-sparse	None-sparse
Overwinters on Host	▲		
PM Fungicides	▲	▲	▲
Associated with Apple		▲	
Associated with Rose			▲

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Effect of Apogee Dose Level on Fire Blight Shoot Infection in Young 'Gala' and 'York' Apple Trees

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Abstract: The objective of this research was to determine if the use of a reduced Apogee dose on young trees could provide significant fire blight protection without sacrificing tree growth. Three-yr-old 'Gala' and 'York' trees were either not treated, treated with a full rate of Apogee (an application of 250 mg /l prohexadione calcium followed by an application 125 mg /l prohexadione calcium), treated with a reduced dose of Apogee (5 applications of 63 mg /l prohexadione calcium), or treated with streptomycin. On 'Gala', the reduced dose of Apogee provided excellent control of shoot infection by *Erwinia amylovora* (92%) but also resulted in growth reduction equivalent to the full rate. On 'York' where the reduce dose of Apogee allowed for significantly more growth than the full rate, fire blight control was only 25%.

Introduction

Prohexadione calcium (Apogee^{TM}) is a plant growth regulator that reduces shoot growth by inhibiting gibberellin biosynthesis. On apple, controlling vegetative growth with Apogee also reduces the incidence and severity of fire blight shoot infection (Yoder et al., 1999). Apogee does not have direct antibacterial activity against *E. amylovora* but increases host resistance by reducing plant vigor. In addition, treatment of apple with Apogee results in alteration of phenylpropanoid biosynthesis pathways that may also enhance resistance (Evans et al., 1999).

Fire blight in newly planted orchards (1-5 years old) can be particularly devastating because infections of young trees often result in complete tree death. Early productivity and economic success of high-density apple plantings is dependent upon rapid growth of young trees so that they fill their within-row space in the first few years after planting. Although Apogee may limit fire blight damage in newly planted orchards, it may also limit tree canopy development. The goal of this research was to determine if the use of a reduced Apogee dose on young trees could provide significant fire blight protection without sacrificing tree growth.

Materials and Methods

Experiments were conducted on 'Gala' and 'York' trees in their fourth leaf (3-yr-old) on M.26 rootstock. Trees were planted at a 2.44 m by 6.1 m spacing, grown under recommended commercial orchard practices and trained to a central leader. In the summer of 2001 trees were treated with one of four spray treatments: 1) non-treated check, 2) full rate of Apogee (250 mg /l prohexadione calcium applied at 5 to 8 cm of shoot growth and 125 mg /l prohexadione calcium applied 2 to 3 wk after the first application), 3) reduced dose of Apogee (63 mg /l prohexadione calcium applied at 5 to 8 cm of shoot growth and repeated 4 times at approximately 2 wk intervals), and 4) AgriStrep (50 mg streptomycin /l plus 0.125% Regulaid) (Table 1). Sprays were applied using a hand gun. Apogee applications were applied to wet (equivalent to a rate of 100 gallons / acre). Streptomycin sprays were applied dilute to run off. Trees of each spray treatment were either inoculated with *E. amylovora* (see below) or left non-inoculated, resulting in a total of eight treatments. Treatments were arranged in a randomized complete block design with one tree / block and eight replicate blocks.

E. amylovora inoculum consisted of 18-h-old shake cultures grown in Kado 523 broth (Kado and Heskett, 1970) at 28° C. The concentration of inoculum was estimated by absorbance at 620 nm using a standard curve and adjusted to the desired concentration by dilution with sterile 0.05M potassium phosphate buffer, pH 6.5. Inoculum was maintained on ice until used for inoculation. To insure that shoots of similar growth potential before treatment were inoculated, terminal shoots of major scaffold branches were selected for inoculation based upon similar positions in all trees rather than vigor. Shoots were labeled with a paper tag and inoculated by transversally bisecting the two youngest leaves with scissors dipped in a suspension of *E. amylovora* (1×10^9 CFU ml^{-1}).

Current season's shoot length (at the time of inoculation) and length of necrotic lesion were measured on 21 Jun 2001. The necrotic lesion length was divided by the current season's shoot length to calculate the percentage shoot length blighted (%SLB), and used as the measure of disease severity. Shoot length was used as a measure of plant growth. Final growth measurements were taken in the fall 2001. GLM (SAS Institute Inc.) and a Waller-Duncan K-ratio T test were used to analyze treatment effects.

Results and Discussion

On 'Gala', both the full rate of Apogee and the reduced dose of Apogee significantly reduced shoot growth by the time of inoculation with *E. amylovora* (June 5), 52% and 54%, respectively, in comparison to non-treated check trees. Both Apogee treatments provided excellent fire blight control and significantly reduced the severity of infection to 0% and 3% shoot length blighted (SLB), respectively, versus 38% SLB in the none-treated control. By the end of the growing season all four Apogee treatments (both rates on inoculated and non-inoculated trees) significantly reduced shoot growth and there was no significant difference in the growth effect of the Apogee treatments. Streptomycin had no effect on shoot growth and resulted in a slight but significant reduction in disease severity to 31% SLB.

The full rate of Apogee performed similarly on both 'Gala' and 'York', significantly reducing shoot growth on 'York" by 50% at the time of inoculation and significantly reducing disease severity by 95% in comparison to non-treated check trees, (99% SLB vs 5%). In contrast to the results on 'Gala', the reduced dose of Apogee allowed for a significantly greater amount of growth on 'York' (33% less than non-treated) but was significantly less effective in reducing disease severity (28% less than non-treated). Streptomycin had no effect on the severity of shoot blight infection on 'York'. By the end of the growing season there were no significant differences in total growth between the full rate of Apogee and the reduced rate of Apogee. This was probably due to inhibition of late season growth by reduced dose applications of Apogee made later in the summer (Table 1).

In this orchard trial on young trees, full growth suppression was necessary for good fire blight control on apple shoots. The reduced dose of Apogee provided excellent control of shoot blight on 'Gala' where the reduced dose of Apogee also provided growth reduction equivalent to the full rate. However, on 'York' where the reduced dose allowed for significantly more growth than the full rate, fire blight control was poor. Although these results are preliminary, they indicate that caution should be used when considering Apogee applications to young apple plantings. In cases of high fire blight risk when environmental conditions during bloom were highly favorable for blossom infection in young trees of highly susceptible cultivars, the use of Apogee may be warranted to prevent costly damage to the orchard. However, under situations of low disease pressure the use of Apogee in young plantings may have negative effects on canopy development. Because Apogee must be applied early in the season it may not be possible to determine the risk of shoot infection at the time of application.

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TABLE 1. Dates of treatment application and inoculation with *Erwinia amylovora.*

Treatment[z]		Cultivar	
#	Description	'Gala'	'York'
2	Full rate of Apogee (250)[y]	2 May	8 May
3	Reduced dose of Apogee (63)	2 May	8 May
2	Full rate of Apogee (125)	16 May	23 May
3	Reduced dose of Apogee (63)	16 May	
4	Streptomycin (50)	4 June	4 June
All	Inoculation[x]	5 June	5 June
4	Streptomycin	8 June	8 June
3	Reduced dose of Apogee (63)		8 June
3	Reduced dose of Apogee (63)	13 June	19 June
2	Reduced dose of Apogee (63)	27 June	29 June

[z] Treatment 1 was none treated check. See Materials and Methods for complete description of treatments.

[y] Amount of active ingredient applied in mg /l.

[x] Shoots were inoculated using scissors contaminated with *Erwinia amylovora.*

Demonstration of effectiveness of Apogee for fire blight shoot blight suppression in commercial apple orchards, 2001.

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In a Virginia Apple Research Program (VARP) project, eleven Apogee test plots were established in commercial orchard blocks where there was some indication of fire blight infection in 2000, or a planting of highly susceptible cultivars. In the more distant plot areas, the cooperating grower applied the treatment; A. E. Cochran, Virginia Tech AREC, made the applications in Frederick and Shenandoah county plots. In all test plots, the base treatment rates were Apogee 6 oz dilute + Choice 1 qt/ 100 gal + LI-700 1 pt /100 gal and the Apogee rate was adjusted by tree row volume calculation for each block. Adjuvant rates were based on the amount of water in the tank. The number of applications was adjusted as deemed necessary to test for an affect on shoot blight, based on growth pressure and evidence of fire blight infection in 2001. Reported here are results from three plot areas in Frederick and Shenandoah counties where blossom blight occurred and hail favored secondary spread in the month after the initial Apogee application.

Bowman Wunder Orchard, York / MM.111, Forestville, VA

Treated and non-treated five-tree plots, separated by a border tree, were alternated to give six replications in a single row. Treatments were applied to both sides of the tree with a Swanson Model DA-400 airblast sprayer at 100 gpa using spray water from Virginia Tech AREC, Winchester. The Apogee rate was adjusted to TRV for a 300 gal/acre dilute base to deliver Apogee 18 oz + Choice 1 qt + LI-700 1 pt per 100 gal per acre. The first Apogee application was made 1 May. Skybit records for this site indicate that blossom blight infection was possible 15 Apr, 21 Apr, 24 Apr, and 5-6 May. The commercial spray schedule applied to the entire test block included COCS at 5 lb/A, 6 Apr and 11 Apr (half sprays), and through the bloom period at 1 lb/A on 19 Apr, 1 May and 8 May. Streptomycin was not applied to the test block. Five vigorous shoots were selected soon after initial treatment for serial shoot measurements on each test tree. The first two weeks of May were relatively dry and the last two weeks were wet. Hail injury occurred in this orchard 26 May. Following heavy rains in June (5 in. total 21-23 June) and evidence of continued growth pressure and fire blight activity, Apogee was applied again 29 June.

York / MM.111

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

Averages of six replications. Mean separation by Duncan's Multiple Range Test.
* Shoots with cankers to the base on trunk and limbs > 2-inch diameter.

Results: The treatment gave highly significant reductions of shoot blight strikes in counts 8 June (94% control), 21 June (88% control) and 9 August (90% control). Differences in treated and non-treated shoot lengths were highly significant 18 May, 17 days after treatment, and continued to hold well into August. The second application 29 June probably prevented much of the water sprout infection seen on many non-treated trees, with a 96% reduction in potential overwintering cankers running to scaffold limbs >2 inch-diameter or to the trunk. There was no significant difference in the frequency of canker blight or blossom blight infection. The uniformity in the amounts of blossom blight and canker blight indicates uniform inoculum conditions for the test of Apogee effect on shoot blight.

Solenberger / Boyles Orchard, White Hall, VA

Treated and non-treated five-tree plots, separated by a border tree, were alternated to give five replications in a single row. The mature, but very vigorous, Greening and York on seedling rootstock are in parallel rows several rows apart. Treatments were applied to both sides of the tree row with a Swanson Model DA-400 airblast sprayer at 100 gpa using spray water from Virginia Tech AREC, Winchester. The Apogee rate was adjusted to TRV for a 400 gal/acre dilute base to deliver Apogee 24 oz + Choice 1 qt + LI-700 1 pt per 100 gal per acre. The first Apogee application was made 2 May. Blossom blight infection could have occurred 24 Apr and 5-6 May. The commercial spray schedule applied to the entire test block did not include any material directed at fire blight management. Five shoots selected soon after initial treatment for serial shoot measurements on each test tree. The first two weeks of May were relatively dry and the last two weeks were wet. Light hail injury also occurred with heavy rains in this orchard 26 May. Because of some sustained growth of shoot tips on scaffold limbs, and because of severity of fire blight in the test area, Greening and York were both treated again 2 July.

York / seedling

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

Fire blight data means of three reps; shoot length means of six..
Mean separation by Duncan's Multiple Range Test (p=0.05).
* Shoots with cankers to the base on trunk and limbs > 2-inch diameter.

Greening / seedling

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

Fire blight data means of four reps; shoot length means of six.
Mean separation by Duncan's Multiple Range Test.
* Shoots with cankers to the base on trunk and limbs > 2-inch diameter.

Results: Relatively heavy blossom blight occurred in four replications of Greening and three replications of York. Statistical analysis included only the replications where the strikes were observed. Apogee gave 94% control of shoot blight on York and 96% on Greening. On Greening there was also significant suppression (76%) of blight strikes rated as canker blight, those characterized by orange tips, occurring in close proximity to advancing remaining margins of overwintering cankers. In June and July there was rapid advance in infections which had occurred earlier, but not much new shoot tip infection was observed and no additional infection data were recorded after mid-June. Counts in October indicated a statistically significant 70% reduction in potential overwintering cankers on Greening and 61% (ns, p=0.05) in York.

Summary: These test plots demonstrate that Apogee application three weeks before hail injury can significantly suppress shoot tip infection where a blight epidemic is in progress on susceptible cultivars and may lead to reduction in amount of over-wintering cankers. In practice, at least two applications may be needed to reduce susceptibility of growing shoot tips during critical periods of the season. More frequent applications at lower rates might be more practical. Shoot blight incidence in several other plot areas was low, re-emphasizing the importance of other fire blight management practices such as timely streptomycin applications during bloom and the significance of trauma blight events in secondary fire blight spread.

APPLE (*Malus domestica* 'Rome Beauty')
Apple scab; *Venturia inaequalis*
Powdery mildew; *Podosphaera leucotricha*

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DISEASE INCIDENCE ON 'ROME BEAUTY' APPLE TREATED WITH FUNGICIDES APPLIED CONCENTRATE IN 2001: The fungicide programs commonly used in commercial orchards for control of early season diseases were evaluated for apple scab and powdery mildew efficacy under highly favorable condition for mildew development. The evaluation was conducted in a mature block of 'Rome Beauty'/seedling trees which were pruned to a tree-row-volume of 55% of a standard orchard. Trees were planted at 25 ft in rows 30 ft wide and pruned to height of 12-15 ft. 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 gal/A 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 7-11 day intervals between tight-cluster and first cover and at 14-day intervals during the cover sprays. The application dates and growth stages were as follows: 19 Apr (tight-cluster), 27 Apr (pink), 4 May (bloom), 11 May (petal-fall), first cover (1C) through seventh cover (7C) sprays on 22 May, 5, 19, Jun, 3, 16, 31 Jul, and 14 Aug, respectively. Environmental conditions were monitored by a Belfort hydrothermograph and a deWit wetness recorder. Apple scab and powdery mildew inoculum was moderately high. Most trees had 10-20 over-wintering mildew infected terminals which provided ample inoculum for secondary mildew spread. Incidence of scab and secondary mildew on nonfruiting vegetative shoots was recorded by observing all leaves on 10 shoots/tree (2-tree plots) for each replicate. Disease incidence was recorded by leaf developmental position from basal to the apical position on each shoot and correlated with specific fungicide application throughout the season. Leaf developmental positions and growth stages were: position 1-2 (tight-cluster), 3-5 (pink to bloom), 6-8 (petal-fall), 9-11 (first cover), 12-15 (second cover), 16-19 (third cover), and 20-23 (fourth cover). Mildew severity was estimated using the Barratt-Horsfall rating scale but was not recorded for each shoot. Data obtained were analyzed by analysis of variance using appropriate transformations and significance between means were determined by the Fisher Protected LSD test for significance ($P \leq 0.05$).

Apple scab incidence in the test orchard was very low because of infrequent wetting periods. Only four infection periods occurred between 11 Apr (half-inch green) and 22 Jun (third cover). Very few primary infections were evident and secondary spread was extremely light. Nontreated trees had only 0.3% leaves infected with most shoots showing no infection. Scab infections on leaves were not observed on any treated trees except those treated with Messenger which had 0.1% leaves infected. Scab infection on nontreated fruit at harvest (17-18 Oct) was only 4.5 percent. A relatively dry, high humidity season and moderately high levels of powdery mildew inoculum were favorable for powdery mildew development. The period for new leaf development on shoots was extended to the first week in Jul, three to four weeks longer than most years, and favored mildew development after usage of mildew-effective fungicides was discontinued. Infections on leaves at positions 1-15 occurred before the third cover spray was applied. Data taken on these leaves more accurately represent the performance of fungicides against mildew applied through the second cover period (Table 1). On nontreated trees first mildew infections were found on leaves in position 5 (pink -early-bloom). Mean temperatures below 50° F are unfavorable for mildew infections. Mildew incidence on the first 15 leaves (through second cover) on nontreated trees was 69%, increasing to 71% by the first of Jul (through fourth cover). Most of the spray programs provided fair to good control under the high favorable conditions for mildew development. Among the treatments evaluated, the best control of mildew was obtained with Procure 50WS 10.0 oz plus Dithane DF 75WG 3.0 lbs used at pink, bloom, and petal-fall followed by Sovran 50WG 4.0 oz in the first and second cover sprays. Messenger 3WG 9.0 oz provided only a slight reduction in mildew incidence which was not significantly different from the nontreated. Indar 75WSP was significantly less effective than the Nova 40WP plus Dithane DF standard, but about equal to several other treatments. The increased incidence between the second cover and fourth cover periods on the Nova plus Dithane standard was likely due to the lack of activity of Ziram on powdery mildew which was used in the cover sprays after second cover. Lack of effective mildewcides used after second cover in other programs was evident by increased amounts of mildew by the fifth cover period (early Jul).

Table 1. Percent Leaves Infected with Powdery Mildew on Vegetative Shoots and % Fruit Scab of 'Rome Beauty' Trees Treated with Fungicides Applied Concentrate in 2001.

			Percent P. mildew infection Growth Stages*		Percent fruit scab
	Fungicide and Rate/A	Application Timing	TC thru 2C	TC thru 4C	
1.	Nontreated		69.0 f**	71.4e	4.5 b
2.	Vangard 75WG 3.0 oz + Dithane DF 75WG 3.0 lb	TC			
	Nova 40WP 5.0 oz + Dithane DF 75WG 3.0 lb	P, B, PF, 1C			
	Captan 50W 3.0 lb + Benlate 50WP 9.0 oz	2C thru 7C	28.1 bcd	37.2 bc	0.1 a
3.	Vangard 75WG 3.0 oz + Dithane DF 75WG 3.0 lb	TC			
	Nova 40W 5.0 oz + Dithane DF 75WG 3.0 lb	P, B			
	Sovran 50WG 3.0 oz	PF, 1C			
	Captan 50WP 3.0 lb + Benlate 50W 9.0 oz	2C thru 7C	30.4 bcd	40.2 bc	0.0 a
4.	Dithane DF 75WG 4.0 lb	TC			
	Procure 50WS 10.0 oz + Dithane DF 75WG 3.0 lb	P, B, PF, 1C, 2C			
	Thiram Granuflo 75WDG 3.0 lb + Benlate 50WP 9.0 oz	3C, 4C, 5C, 6C, 7C	31.0 bcd	40.8 bc	0.0 a
5.	Dithane DF 75WG 4.0 lb	TC			
	Procure 50WS 10.0 oz + Dithane DF 75WG 3.0 lb	P, B, PF			
	Sovran 50WG 4.0 oz	1C, 2C			
	Ziram Granuflo 75WDG 3.0 lb + Benlate 50WS 9.0 oz	3C, 4C, 5C, 6C, 7C	11.3 a	24.7 a	0.0 a
6.	Syllit 65W 2.0 lb	TC			
	Nova 40W 5.0 oz + Polyram 80W 3.0 lb	P, B,			
	Sovran 50WP 3.0 oz	PF, 1C			
	Polyram 80W 3.0 lb + Nova 40W 5.0 oz	2C, 3C			
	Captan 50W 3.0 lb	4C, 5C, 6C, 7C			
	Benlate 50WP 6.0 oz	6C, 7C	20.8 ab	27.7 ab	0.0 a

Table 1 . Percent Leaves Infected with Powdery Mildew on Vegetative Shoots and % Fruit Scab of 'Rome Beauty' Trees Treated with Fungicides Applied Concentrate in 2001 (continued).

	Fungicide and Rate/A	Application Timing	Percent P. mildew infection Growth Stages* TC thru 2C	TC thru 4C	Percent fruit scab
7.	Syllit 65W 2.0 lb	TC			
	Syllit 65W 1.0 lb + Polyram 80W 3.0 lb	P, B,			
	Sovran 50WP 3.0 oz	PF, 1C			
	Polyram 80W 3.0 lb + Nova 40W 5.0 oz	2C, 3C			
	Captan 50WP 3.0 lb	4C, 5C, 6C, 7C			
	Benlate 50WP 6.0 oz	6C, 7C	33.8 cd	40.0 bc	0.0 a
8.	Messenger 3WG 9.0 oz	TC, P, PF, 2C thru 7C			
	Thiram Granuflo 75WDG 6.0 lb	B, 1C			
	Ziram Granuflo 75WDG 3.0 lb	2C, 3C, 4C, 5C, 6C...	56.4 ef	63.8 de	0.8 a
9.	Indar 75WSP 2.0 oz + Latron B-1956 1.0 pt	TC thru 7C	41.3 de	50.1 cd	0.1 a
10.	Dithane DF 75WG 4.0 lb	TC			
	Nova 40WP 4.0 oz + Dithane DF 75WG 3.0 lb	P, B, PF, 1C, 2C			
	Ziram Granuflo 75WDG 5.0 lb	3C, 4C, 5C			
	Ziram Granuflo 75WDG 3.0 lb + Benlate 50W 12.0 oz	6C, 7C	25.3 bc	41.3 bc	0.0 a

* Mildew incidence on leaves produced between 19 Apr and 5 Jun (tight cluster (TC) thru second cover (2C) period and TC thru fourth cover (3 Jul).

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

Not for Publication

APPLE (*Malus 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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DISEASE INCIDENCE ON APPLE TREATED WITH DILUTE FUNGICIDE SPRAYS IN 2001: Disease management programs composed of registered fungicides were evaluated for control of the disease complex occurring in the early season (green-tip through second cover) and through the summer months (third cover through seventh cover). Fungicide treatments were applied dilute to mature trees planted 30' X 36' and well-pruned to a height of 12-15 ft. Each tree was grafted to three cultivars ('Rome Beauty', 'Delicious', and 'Golden Delicious') each of which composed about one-third of the tree. Treatments were arranged in a randomized complete block design with four double-tree replicates and were applied with a high pressure orchard sprayer. The sprayer was operated at 400 psi and equipped with a nine-nozzle boom which delivered 3.75 gallons per tree (300 gallons/acre). Environmental conditions were not highly favorable for apple scab infections due to below normal temperatures and few wetting periods during April, thus, the first application was made on 19 Apr at the tight-cluster stage. Additional applications at respective growth stages were made on: 27 Apr (pink), 4 May (bloom), 11 May (petal-fall), first (1C) through seventh (7C) cover sprays on 22 May, 5, 19, Jun, 3, 16, 31 Jul and 14 Aug, respectively. Environmental data used in determining primary apple scab infection periods and favorable periods for other diseases were recorded with a Belfort hydrothermograph and a deWit wetness recorder. Four primary scab infection periods occurred between 11 Apr and 22 Jun. Inoculum levels in the test orchard were low for apple scab and moderate for powdery mildew. Infrequent wetting periods and maximum temperatures of 67-89° F (mean 52-75° F) beginning in early-bloom and an extended growing season for leaf development through June were highly favorable for powdery mildew infection. Incidence of scab and mildew on leaves of 'Rome Beauty' were recorded on 11-12 Jul by observing all leaves on 10 vegetative shoots per tree (double trees) for each of four replicates. Disease incidence on fruit was recorded at harvest on 200 fruit per replicate on each of the three cultivars. All data obtained were analyzed by analysis of variance using appropriate transformations and significance between means were determined by the Fisher Protected LSD test ($P \leq 0.05$).

Incidence of apple scab on leaves of nontreated 'Rome Beauty' trees was 25% by second cover (Table 2). Only trace amounts of scab were recorded on leaves and fruit for all fungicide treatments except Messenger, which was similar to the nontreated. The first powdery mildew infections occurred during the early-bloom stage and continued through the fourth cover period. Mildew incidence on the Nova/Dithane standard was somewhat higher because of infections that occurred between second and fourth cover periods when no fungicide effective against powdery mildew was applied. An analysis of the data obtained on leaves produced up through the second cover period is shown in the table and more accurately measures the efficacy of fungicides used during this period. Most of the treatments were highly effective against mildew with only minor differences in mildew levels. Programs having Sovran or Flint in the cover sprays were highly effective. The Messenger treatment provided poor control, but was significantly different from the nontreated. Observations of mildew severity on leaves, not shown here, revealed 50-75% of the lower leaf surface affected on the nontreated and Messenger treatments and less than 5% on other treatments. The program which alternated applications of Flint and Messenger was similar to the Nova standard. Flint alternated with Thiram in the cover sprays provided very good control of mildew. Incidence of flyspeck and white rot on fruit among the treatments were generally not significant except for Messenger which was similar to the nontreated. Russet affecting fruit finish ranged from 11 to 26% of the surface affected, but differences among treatments were not significant.

Table 2. Disease Incidence on Apple Leaves and Fruit Treated with Fungicides Applied Dilute in 2001.

			Percent Disease Incidence on Leaves and Fruit						
			Leaves		Fruit at Harvest			30-day Incubation[*]	
			'Rome Beauty'		'R. Del'	'G. Delicious'		' G. Delicious'	
	Fungicide and Rate/100 gal	Application Timing	Scab	P. mildew	Scab	S. blotch	Flyspeck	Flyspeck	w/rot
1.	Nontreated	--------------	24.8 c[**]	51.8 e	26.8 b	6.5 c	9.4 cd	34.4 bc	10.0 bc
2.	Nova 40WP 1.33 oz + Polyram 80WP 1.0 lb Sovran 50WG 1.33 oz Ziram Granuflo 75WDG 1.0 lb + Topsin-M 70WP 4.0 oz	TC, P, B, PF, 1C 2C, 3C, 4C, 5C 6C, 7C	0.1 a	12.4 a	0.9 a	1.4 ab	0.8 a	3.8 a	3.8 ab
3.	Nova 40WP 1.33 oz + Thiram Granuflo 75WDG 1.0 lb Sovran 50WG 1.0 oz + Thiram Granuflo 75WDG 1.0 lb Thiram Granuflo 75WDG 1.0 lb + Topsin-M 70WP 4.0 oz	TC, P, B, PF, 1C 2C, 3C, 4C, 5C 6C, 7C	0.0 a	13.1 a	0.1 a	1.0 ab	1.1 ab	4.4 a	2.5 a
4.	Nova 40WP 1.33 oz + Ziram Granuflo 75WDG 1.0 lb Sovran 50WG 1.0 oz + Captan 50W 1. 0 lb Captan 50W 1.0 lb + Topsin-M 70WP 4.0 oz	TC, P, B, PF, 1C 2C, 3C, 4C, 5C 6C, 7C	0.2 a	14.4 a	0.3 a	0.4 a	0.6 a	6.3 a	1.3 a
5.	Procure 50WS 3.3 oz + Thiram Granuflo 75WDG 1.0 lb Flint 50WG 0.67 oz Thiram Granuflo 75WDG 1.5 lb	TC, P, B, PF 1C, 3C, 5C, 7C 2C, 4C, 6C	0.2 a	15.0 ab	0.8 a	0.4 a	1.8 ab	1.9 a	2.5 a
6.	Messenger 3WG 9.0 oz	TC thru 7C	17.1 b	38.5 d	21.9 b	6.3 c	11.8 d	40.0 c	16.3 c
7.	Flint 50WG 0.67 oz Messenger 3WG 9.0 oz Ziram Granuflo 75WDG 1.5 lb	TC, P, PF, 2C B, 1C, 3C, 5C, 7C 4C, 6C	0.3 a	26.8 c	0.3 a	1.9 b	4.4 bc	22.5 b	2.5 a

Table 2 . Disease Incidence on Apple Leaves and Fruit Treated with Fungicides Applied Dilute in 2001 (continued).

		Percent Disease Incidence on Leaves and Fruit						
		Leaves		Fruit at Harvest			30-day Incubation*	
	Application	'Rome Beauty'		'R. Del'	'G. Delicious'		' G. Delicious'	
Fungicide and Rate/100 gal	Timing	Scab	P. mildew	Scab	S. blotch	Flyspeck	Flyspeck	w/rot
8. Nova 40WP 1.67 oz +								
Dithane DF 75WG 1.0 lb	TC, P, B, PF, 1C							
Dithane DF 75WG 2.0 lb	2C, 3C							
Dithane DF 75WG 1.0 lb	4C, 5C							
Captan 50W 1.0 lb	6C, 7C							
Topsin-M 70WP 4.0 oz	4C, 5C, 6C, 7C	0.4 a	22.2 bc	0.0 a	1.4 ab	0.6 a	1.3 a	1.3 a

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* Flyspeck and white rot incidence on a 20-symptomless fruit sample/tree after incubating for 30 days 70° F and 100% R. H.

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

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EVALUATION OF APOGEE™ AND MESSENGER® FOR CONTROL OF FIRE BLIGHT SHOOT INFECTION ON APPLE IN 2001

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Abstract: Apogee 27.5W and Messenger 3WDG were evaluated for prevention of fire blight shoot infection on 'Rome Beauty', 'Golden Delicious', and 'York Imperial' apple when apical leaves were inoculated with *Erwinia amylovora*. Significant control of shoot blight was obtained with a single dilute application at 12.0 oz/100 gal, two applications at 6.0 oz, three applications at 3.0 oz, or four applications at 3.0 oz/100 gal. Messenger treatments were not significantly different from the nontreated. The percent of infected shoots blighted was significantly lower on all Apogee treatments. The number of natural fire blight strikes per tree was low ranging from 0.5 to 13.3 and differences generally were not significant. Significant reduction in shoot growth compared to the nontreated was obtained on all three cultivars with Apogee 27.5W 6.0 oz in two applications, or with 4.0 oz in three applications. A single application at 12.0 oz/100 gal and four applications at 3.0 oz were not significantly different, but growth was substantially less with these treatments. Messenger treatments did not significantly affect shoot growth.

Introduction: Adequate control of fire blight on apple, caused by the bacterium *Erwinia amylovora*, requires the careful use of cultural measures to control tree vigor and the protection of blossoms and developing shoots when favorable conditions for infection occur. Protection of blossoms can be obtained with properly timed streptomycin sprays, but the protection of young shoots during trauma events such as high wind or hail storms has been less than satisfactory. The recent introduction of Apogee, a plant growth regulator, has brought new hope for better protection of highly susceptible cultivars against the shoot blight phase of fire blight. Results obtained in several orchard experiments and demonstrations in eastern orchards have shown that Apogee is highly effective in controlling tree growth and also induces a high level of resistance in the treated trees. This evaluation was initiated in 1999 (1, 2), continued in 2000 and 2001 to determine the effects of varying rates and number of applications of Apogee 27.5W on the level and severity of fire blight infection on developing shoots. In the 2001 evaluations a new compound, Messenger, was also tested on three apple cultivars. The active ingredient of Messenger is a harpin protein which has been shown to elicit, a complex natural defense mechanism in plants on a wide array of economical important crops.

Materials and Methods: Apogee 27.5W and Messenger 3WDG treatments were evaluated in two experimental orchards having moderate vigor and located at the Penn State Fruit Research and Extension center experimental farm at Biglerville, Pennsylvania. One of the orchards consisted of mature semi-dwarf trees ('Golden Delicious', 'Rome Beauty', and 'Delicious' planted on M. 7 rootstock) planted 30 X 35 ft and pruned to a height of 12-15 ft. Treatment plots contained three trees, one of each cultivar planted in a group at each site. The second orchard located nearby was a planting of 'York Imperial'/M.106 of similar size and planting distance. These orchards were used in the 2000 evaluations and treatments plots used in the 2001 evaluation were assigned at random disregarding the 2000 treatment locations. Treatments in both orchards were arranged in a complete randomized block design with four 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 3.0 gal/tree (300 gal/A). Application dates and respective growth stages were: 3 May (full bloom, shoots 6-12 cm), 10 May (late bloom, shoots 15-17 cm),17 May (petal-fall, shoots 19-20 cm), and 24 May (first cover, 21-26 cm). LI-700 Spreader 16.0 fl oz/100 gal was applied in all applications and ammonium sulfate used in combination at the same rates used for Apogee. No surfactant was used with Messenger. Inoculations were made on 10 vegetative shoots/replicate, selected at the time of the first application, by excising half of the youngest two apical leaves (cut made across the mid-rib) with scissors dipped into a suspension of *Erwinia amylovora (*1 X 10^8 cfu/ml). The interval between Apogee applications where two or three sprays were applied was a minimum of seven days after the last application and from 7-32 days after the initial application. *All* selected shoots were measured near the time of the first inoculation on 22 May, and at approximately 10-20 da intervals until 31 Jul. A separate set of 10 vegetative shoots was selected on each replicate and measured to determine growth response to the treatments. The incidence of infection and shoot blight development was observed at 3 and 9 weeks after inoculations and recorded if shoot necrosis was present. 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 tissues). The number of blighted shoots per tree from natural infections was recorded on 25 Jul. All data obtained were analyzed for significant differences among means by using appropriate transformations, analysis of variance, and the Fisher Protected Test ($P \leq 0.05$) for means separation.

Results: Fire blight symptoms on the inoculated shoots were recorded as tip or shoot infections. Tip infections were expressed as necrosis that was limited to the two youngest inoculated leaves or 0.5 - 1.5 cm of the shoot apex. These were first observed three weeks after inoculation and checked again six weeks later. The number of tip infections observed nine weeks after inoculation were substantially lower than at the first observation. The final observations, which are shown in Tables 3, 4, and 5, were generally lower on Apogee treated trees, but there were major differences on nontreated and the Messenger treatments. Shoot infections were recorded if the infection caused necrosis of more than 1.5 cm. Ten to 30% of the tip infections developed into shoot infections. All of the Apogee treatments provided excellent control of shoot blight. Shoot blight incidence across the three cultivars ranged from 0.0 to 17.5% infection. Apogee treatments resulted in significantly less fire blight than the nontreated. when applied in a single application at 12.0 oz/100 gals, two applications at 6.0 oz/100 gals, three applications at 4.0 or 6.0 oz/100 gals, or in four applications at 3.0 oz/100 gals. Messenger treatments in most cases were not significantly different from the nontreated.

Disease severity nine weeks after inoculation as measured by the percentage of the infected shoot that was blighted was significantly lower on all Apogee treatments when compared to the nontreated. Severity levels among the Messenger treatments were generally not significant from the nontreated. The number of natural fire blight strikes on nontreated trees during the season was very low with a range of 0.5 to 8.0 on 'Rome Beauty' and 'Golden Delicious' and from 1.7 to 13.3 on the 'York Imperial'. Differences among the treatments generally were not significant.

Mean seasonal shoot growth on nontreated trees was 39.7, 43.7, and 37.6 cm for 'Rome Beauty', 'Golden Delicious', and 'York Imperial', respectively. Shoot growth reduction on the three cultivars was significant among the Apogee 27.5W treatments.. On 'Rome Beauty' the Apogee 27.5W 6.0 oz (two applications) and 4.0 oz (three applications) treatments reduced growth by 43 and 56%, respectively. The 12.0 oz (one application) and 3.0 oz (two applications) treatments reduced growth by 48 and 44%, respectively. Similar effects on growth were produced on both 'Golden Delicious' and 'York Imperial'.

References Cited:

1. Hickey, K. D., N. O. Halbrendt, and J. W. Travis. 2000. Pennsylvania Fruit News 80 (2): 30-36.

2. Hickey, K. D., N. O. Halbrendt, and J. W. Travis. 2001. Efficacy of Apogee for Prevention of Fire Blight Shoot Infection on Apples in 2000. Pennsylvania Fruit News 81(2): 43-44.

Table 3. Fire Blight on Vegetative Shoots of 'Rome Beauty' Apple Treated with Apogee™ and Messenger® and Inoculated with *Erwinia amylovora* in 2001. Penn State University FREC, Biglerville, PA

Inoculation Date Trt. and Rate/100 gal	Applic. No.	Application Timing	Percent Infection Incidence[2]		Disease Severity Percent Shoot Blighted[3]	Number Natural Infec/tree	Shoot Growth (cm)[4]
			Tip Infection Final Count	Shoot Infection Final Count			
Inoculated on 22 May							
1. Nontreated Check 1	0		24.4 a[5]	73.3 a	74.3 a	0.5 a	21.2 a
3. Messenger 3WDG 9.0 oz	2	FB (5/3), PF (5/14)	32.5 a	50.0 a	67.8 a	3.5 ab	22.2 a
4. Messenger 3WDG 6.0 oz	2	FB (5/3), PF (5/14)	35.3 a	59.7 a	63.9 a	0.8 a	21.8 a
14. Nontreated Check 2[6]	0		25.0 a	57.5 a	65.5 a	7.3 b	14.7 a
Inoculated on 24 May							
2. Nontreated Check 1	0		10.0 a	87.5 c	90.2 c	3.3 abc	11.8 c
5. Messenger 3WDG 6.0 oz	2	FB (5/3), PF (5/17)	7.5 a	82.5 bc	77.2 bc	5.8 bc	10.8 bcd
7. Apogee 27.5W 12.0 oz[1]	1	FB (5/3)	12.5 a	5.0 a	5.1 a	2.3 ab	4.8 abc
8. Apogee 27.5W 6.0 oz[1]	2	FB (5/3), LB (5/10)	20.0 a	15.0 a	13.6 a	3.3 abc	3.0 ab
9. Apogee 27.5W 4.0 oz[1]	3	FB (5/3), LB (5/10), PF (5/17)	7.5 a	7.5 a	6.9 a	1.3 a	2.2 a
10. Apogee 27.5W 3.0 oz[1]	2	FB (5/3), LB (5/10)	5.0 a	17.5 a	18.0 a	4.3 abc	5.4 abc
14. Nontreated Check 2[6]	0		22.5 a	60.0 b	73.6 b	7.3 c	13.2 d
Inoculated 4 June							
3. Messenger 3WDG 9.0 oz	3	FB (5/3), PF (5/14), 1C (5/24)	10.0 a	82.5 b	87.3 b	2.5 ab	14.2 c
4. Messenger 3WDG 6.0 oz	3	FB (5/3), PF (5/14), 1C (5/24)	12.5 a	82.5 b	92.4 bc	0.8 a	11.4 bc
11. Apogee 27.5W 3.0 oz[1]	4	FB (5/3), LB (5/10), PF (5/17), 1C (5/24)	10.0 a	7.5 a	8.5 a	1.8 a	1.9 a
13. Nontreated Check 1	0		2.5 a	95.0 b	99.7 c	4.3 ab	11.0 bc
14. Nontreated Check 2[6]	0		2.2 a	92.5 b	99.2 c	7.3 b	7.5 b
Inoculated 12 June							
6. Messenger 3WDG 6.0 oz	4	FB (5/3), LB (5/10), PF (5/17), 1C (5/24)	0.0 a	85.0 a	81.9 a	4.8 a	2.2 a
13 Nontreated Check 1	0		5.0 a	87.5 a	86.5 a	4.8 a	6.0 a
14. Nontreated Check 2[6]	0		0.0 a	97.2 a	83.1 a	7.3 a	2.5 a

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[1] Applied in combination with equal amount of ammonium sulfate and LI-700 Spreader 16 fl oz/100 gal

[2] Obtain by observing 10 inoculated shoots/replicate approximately 3 weeks (First Count) and approximately 9 weeks (Final Count) after inoculation

[3] Mean percentage shoot blighted on infected shoots

[4] Mean length of shoot growth on noninoculated treated and nontreated shoots between 23 May and 31 July

[5] Means marked with the same letters are not significantly different according to the Fisher Protected LSD Test (P<-0.05)

[6] Nontreated Check 2 are trees located outside the treated block

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Table 4. Fire Blight on Vegetative Shoots of ' Golden Delicious' Apple Treated with Apogee™ and Messenger® and Inoculated with *Erwinia amylovora* in 2001. Penn State University FREC, Biglerville, PA

Inoculation Date Trt. and Rate/100 gal	Applic. No.	Application Timing	Percent Infection Incidence[2]		Disease Severity Percent Shoot Blighted[3]	Number Natural Infec/tree	Shoot Growth (cm)[4]
			Tip Infection Final Count	Shoot Infection Final Count			
Inoculated on 22 May							
1. Nontreated Check 1	0		20.3 a[5]	54.2 ab	52.0 ab	0.0 a	14.9 a
3. Messenger 3WDG 9.0 oz	2	FB (5/3), PF (5/14)	20.0 a	72.5 b	63.6 b	1.0 a	16.2 a
4. Messenger 3WDG 6.0 oz	2	FB (5/3), PF (5/14)	33.6 a	38.6 a	40.3 a	0.0 a	13.1 a
14. Nontreated Check 2[6]	0		18.6 a	55.3 b	63.0 b	4.5 b	22.6 a
Inoculated on 24 May							
2. Nontreated Check 1	0		27.5 b	42.5 bc	40.7 b	3.8 c	7.0 bcd
5. Messenger 3WDG 6.0 oz	2	FB (5/3), PF (5/17)	7.5 a	85.0 d	67.2 c	3.3 c	22.8 d
7. Apogee 27.5W 12.0 oz[1]	1	FB (5/3)	2.5 a	0.0 a	0.0 a	0.0 a	8.1 abc
8. Apogee 27.5W 6.0 oz[1]	2	FB (5/3), LB (5/10)	7.5 a	2.5 a	2.6 a	1.5 b	4.9 a
9. Apogee 27.5W 4.0 oz[1]	3	FB (5/3), LB (5/10), PF (5/17)	5.0 a	0.0 a	0.0 a	0.3 ab	4.2 a
10. Apogee 27.5W 3.0 oz[1]	2	FB (5/3), LB (5/10)	2.5 a	15.0 ab	12.5 a	1.0 ab	8.4 ab
14. Nontreated Check 2[6]	0		0.0 a	77.5 cd	68.6 c	4.5 c	18.7 cd
Inoculated 4 June							
3. Messenger 3WDG 9.0 oz	3	FB (5/3), PF (5/14), 1C (5/24)	10.6 ab	74.2 b	38.8 b	1.0 ab	10.8 ab
4. Messenger 3WDG 6.0 oz	3	FB (5/3), PF (5/14), 1C (5/24)	17.5 b	62.5 b	39.5 b	0.0 a	7.2 ab
11. Apogee 27.5W 3.0 oz[1]	4	FB (5/3), LB (5/10), PF (5/17), 1C (5/24)	5.0 ab	5.0 a	5.0 a	0.0 a	4.3 a
13. Nontreated Check 1	0		15.0 ab	72.5 b	57.5 c	3.5 bc	8.0 ab
14. Nontreated Check 2[6]	0		2.5 a	72.5 b	41.4 b	4.5 c	14.1 b
Inoculated 12 June							
6. Messenger 3WDG 6.0 oz	4	FB (5/3), LB (5/10), PF (5/17), 1C (5/24)	45.0 a	25.0 a	13.6 a	3.8 a	3.6 a
13 Nontreated Check 1	0		51.4 a	43.3 a	17.6 ab	3.5 a	6.4 ab
14. Nontreated Check 2[6]	0		46.3 a	46.3 a	25.1 b	4.5 a	17.2 b

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[1] Applied in combination with equal amount of ammonium sulfate and LI-700 Spreader 16 fl oz/100 gal

[2] Obtain by observing 10 inoculated shoots/replicate approximately 3 weeks (First Count) and approximately 9 weeks (Final Count) after inoculation

[3] Mean percentage shoot blighted on infected shoots

[4] Mean length of shoot growth on noninoculated treated and nontreated shoots between 23 May and 31 July

[5] Means marked with the same letters are not significantly different according to the Fisher Protected LSD Test (P<-0.05)

[6] Nontreated Check 2 are trees located outside the treated block

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Table 5. Fire Blight on Vegetative Shoots of ' York Imperial' Apple Treated with Apogee™ and Messenger® and Inoculated with *Erwinia amylovora* in 2001. Penn State University FREC, Biglerville, PA

Inoculation Date Trt. and Rate/100 gal	Applic. No.	Application Timing	Percent Infection Incidence [2]		Disease Severity Percent Shoot Blighted [3]	Number Natural Infec/tree	Shoot Growth (cm)[4]
			Tip Infection Final Count	Shoot Infection Final Count			
Inoculated on 22 May							
1. Nontreated Check 1	0		20.0 a[5]	70.0 ab	78.8 b	1.7 a	19.8 a
3. Messenger 3WDG 9.0 oz	2	FB (5/3), PF (5/14)	15.0 a	82.5 b	83.6 b	8.0 b	19.0 a
4. Messenger 3WDG 6.0 oz	2	FB (5/3), PF (5/14)	35.0 a	45.0 a	54.2 a	2.3 a	10.4 a
Inoculated on 24 May							
2. Nontreated Check 1	0		40.0 c	55.0 c	61.0 c	10.8 bc	15.9 b
5. Messenger 3WDG 6.0 oz	2	FB (5/3), PF (5/17)	12.5 a	72.5 c	74.3 c	15.8 c	16.0 b
7. Apogee 27.5W 12.0 oz[1]	1	FB (5/3)	12.5 a	0.0 a	2.5 a	6.8 ab	6.6 ab
8. Apogee 27.5W 6.0 oz[1]	2	FB (5/3), LB (5/10)	15.0 ab	0.0 a	0.1 a	4.0 a	4.8 a
9. Apogee 27.5W 4.0 oz[1]	3	FB (5/3), LB (5/10), PF (5/17)	28.3 abc	7.5 ab	7.6 ab	11.8 bc	5.9 a
10. Apogee 27.5W 3.0 oz[1]	2	FB (5/3), LB (5/10)	32.5 bc	20.0 b	20.1 b	10.5 abc	7.2 ab
2. Nontreated Check 1	0		27.5 b	80.0 c	61.8 c	3.3 c	15.4 b
3. Messenger 3WDG 9.0 oz	3	FB (5/3), PF (5/14), 1C (5/24)	5.0 a	80.0 c	68.0 c	8.0 b	14.5 b
4. Messenger 3WDG 6.0 oz	3	FB (5/3), PF (5/14), 1C (5/24)	10.0 ab	47.5 b	37.8 b	2.3 a	9.4 ab
11. Apogee 27.5W 3.0 oz[1]	4	FB (5/3), LB (5/10), PF (5/17), 1C (5/24)	10.0 ab	10.0 a	6.2 a	7.8 b	4.9 a
Inoculated 12 June							
2. Nontreated Check 1	0		17.5 a	82.5 a	47.8 a	13.3 a	7.5 a
6. Messenger 3WDG 6.0 oz	4	FB (5/3), LB (5/10), PF (5/17), 1C (5/24)	17.5 a	77.5 a	56.8 a	12.8 a	8.8 a

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[1] Applied in combination with equal amount of ammonium sulfate and LI-700 Spreader 16 fl oz/100 gal

[2] Obtain by observing 10 inoculated shoots/replicate approximately 3 weeks (First Count) and approximately 9 weeks (Final Count) after inoculation

[3] Mean percentage shoot blighted on infected shoots

[4] Mean length of shoot growth on noninoculated treated and nontreated shoots between 23 May and 31 July

[5] Means marked with the same letters are not significantly different according to the Fisher Protected LSD Test (P<-0.05)

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EFFICACY OF APOGEE™ FOR FIRE BLIGHT CONTROL ON YOUNG APPLE TREES IN 2001

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Abstract: The plant growth regulator, Apogee 27.5W applied in three applications on young apple trees in their third leaf in the orchard was highly effective against fire blight. In inoculated tests with *Erwinia amylovora* on five highly susceptible cultivars, three applications made during the blossom and petal fall periods at 3.0 and 4.0 oz/100 gals applied dilute significantly reduced infection incidence and severity on vegetative shoots. Fire blight incidence on trees treated with 4.0 oz/100 gals was 0.0 to 8.3% compared to a range of 12.0 on 'Sun Fuji' to 63.0% on 'Gala' on the nontreated. Disease severity on these trees ranged from 0.0 to 8.2% on the treated and 9.2 ('Sun Fuji') to 43% ('Braeburn') on the nontreated. Disease incidence on trees treated with Apogee 3.0 oz/100 gals was appreciably higher with a range of 0.0 ('Sun Fuji') to 33.5% ('Ginger Gold') and a severity range of 6.4 ('Braeburn') to 31% ('Ginger Gold'). Significant reduction in vegetative growth was obtained with both Apogee rates and differences in cultivar were significant.

Introduction: Recently published results obtained in Pennsylvania (1) and Virginia (2) have shown that Apogee™ reduces the susceptibility of apple trees to *Erwinia amylovora*, the fire blight pathogen, when used in one or more applications for tree growth control. Hickey, et al (1) also found Apogee to be highly effective when applied to newly planted apple trees of five highly susceptible cultivars. In these studies conducted in 1999 and 2000, Apogee applied in a single application at 12.0 oz/100 gals or in two sprays at 6.0 oz/100 gals significantly reduced fire blight incidence and severity on inoculated shoots. Shoot growth was also significantly reduced but did not adversely affect tree shape. The experiments conducted in 2001 were on the same trees treated in 1999 and 2000. The purpose of this study was to evaluate the efficacy of Apogee applied in three applications at two rates on fire blight and shoot growth reduction.

Materials and Methods: Experiments were conducted at two test sites located in an experimental orchard block at the Pennsylvania State Fruit Research and Extension Center, Biglerville, PA. In each of two nearby sites five susceptible apple cultivars were planted in 1999 in two adjacent rows at 15 ft between rows and 5 ft between trees. The experimental design was a randomized complete block with a single tree of each of the five cultivars planted in each of six replicates. Each of the following cultivars were grown on M.26 rootstocks: Ginger Gold, Gala (Mitchell), Sun Fuji, Braeburn, and Law Rome Beauty. In each test site one complete row was treated with Apogee 27.5W and the other served as a nontreated check. Apogee 27.5W 3.0 oz/100 gals was applied in test site one and the 4.0 oz/100 gals rate applied in test site two. It was applied in combination with equal amounts of ammonium sulfate and LI-700 Spreader at 16.0 fl oz/100 gals at full-bloom (3 May), late bloom (10 May), and petal-fall (17 May). Applications were made as dilute sprays applied with a single-nozzle spray gun at 300 psi under calm air conditions to minimize spray drift.

Ten vegetative shoots on each treated and nontreated tree in both test sites were inoculated by scissor-wound inoculation with a suspension of *E. amylovora* (1×10^8 cfu/ml) on 24 May, 7 days after the third Apogee application. Observations for fire blight development were made approximately three weeks (first count) and nine weeks (final count) after inoculation. Shoot necrosis measurements on infected shoots were made to establish blight severity at each observation time. A separate set of 10 noninoculated shoots were selected in mid-September and measured to determine treatment effects on shoot growth. The data obtained were analyzed by analysis of variance using appropriate transformations and significance between treated and nontreated means determined by t-test comparisons and differences among cultivars by the Fisher Protected Test ($P \leq 0.05$).

Results: Infection on inoculated nontreated shoots ranged from 66.0 ('Gala') to 91.7% ('Ginger Gold') at one test site and from 18.0 ('Sun Fuji') to 48.3% ('Ginger Gold') at the second site (Table 6). A significant difference between the treated and nontreated trees was obtained by the two rates of Apogee for both fire blight incidence and severity. Differences in disease incidence among the cultivars on the nontreated trees was not significant in one site but significantly lower infections occurred on the 'Sun Fuji' trees in the second site. Disease severity (canker length) on infected shoots varied more widely. 'Sun Fuji' had the lowest disease severity in one site and 'Gala' in the other site. On trees treated with Apogee 27.5W 4.0 oz/100 gals in three applications, the fire blight incidence ranged from 0.0 to 8.3% with no significant difference among the cultivars. Disease severity on infected shoots ranged from 0.2 to 8.2% with only 'Braeburn' showing a significantly higher severity (8.2%). On the trees treated with Apogee 3.0 oz/100 gals in three applications, significantly less disease incidence and severity occurred on 'Sun Fuji' and 'Braeburn' compared to the nontreated. The highest disease level was on 'Ginger Gold' which was not significantly different in severity from 'Gala' or "Law Rome Beauty'. Terminal growth measurements in mid-September indicated that both Apogee rates significantly reduced vegetative tree growth. Shoot growth on nontreated trees varied significantly among cultivars. Growth range in test site one on nontreated was 15.3 ('Sun Fuji') to 27.3 cm ('Law Rome') and from 9.5 ('Sun Fuji') to 18.4 cm ('Ginger Gold') in test site two. Shoot growth on the treated trees ranged from 0.6 ('Gala', site two) to 10.6 cm ('Law Rome', site one). The significant treatment effect on growth is likely to have been enhanced by the drought conditions during June and July.

References Cited:

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Yoder, K. S., R. E. Byers, A. E. Cochran II, A. DeMarsay, W. S. Royston, Jr. and S. W. Kilmer, 2000. Suppression of Fire Blight Infection on Apple Shoots by Apogee, 2000. Proc. 76th Cumberland-Shenandoah Fruit Workers Conf. Nov. 16-17, 2000. Winchester, VA pp 193-195.

Table 6 . Fire Blight on Vegetative Shoots of Three Year Old Apple Cultivars Treated with Apogee 27.5W and Inoculated with *Erwinia amylovora* in 2001. Penn State University FREC, Biglerville, PA

	Percent Shoots Infected[2]		Blight Severity Percent of Shoot Blighted[3]		Seasonal shoot growth[4] (cm)	
Cultivar/Apogee Rate	Nontreated	Apogee 3.0 oz	Nontreated	Apogee 3.0 oz	Nontreated	Apogee 3.0 oz
Apogee 27.5W 3.0 oz[1]	**(Test Site One)**					
Ginger Gold	91.7 a[5]	33.5 b	77.9 c	31.1 c	24.1 bc	1.4 a
Gala (Mitchell)	66.0 a	22.0 ab	45.5 a	20.2 c	15.8 a	4.0 b
Sun Fuji	78.3 a	0.0 a	67.5 bc	0.0 a	15.3 a	3.1 ab
Braeburn	86.7 a	6.7 a	74.4 c	6.4 ab	17.7 ab	4.2 b
Law Rome Beauty	81.7 a	0.0 a	51.1 ab	20.1 bc	27.3 c	10.6 c

	Percent Shoots Infected[2]		Blight Severity Percent of Shoot Blighted[3]		Seasonal shoot growth[4] (cm)	
Cultivar/Apogee Rate	Nontreated	Apogee 4.0 oz	Nontreated	Apogee 4.0 oz	Nontreated	Apogee 4.0 oz
Apogee 27.5W 4.0 oz[1]	**(Test Site Two)**					
Ginger Gold	51.7[5]	3.3 a	29.5 bc	1.5 ab	18.4 c	2.6 b
Gala (Mitchell)	62.9 b	1.7 a	41.9 c	1.8 ab	10.2 ab	0.6 a
Sun Fuji	12.0 a	0.0 a	9.2 a	0.0 a	9.5 a	2.2 ab
Braeburn	51.7 b	8.3 a	42.6 c	8.2 b	15.5 c	2.9 bc
Law Rome Beauty	36.0 ab	0.0 a	15.9 ab	0.2 a	15.3 bc	4.6 c

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[1] Applied in combination with equal amount of ammonium sulfate and LI-700 Spreader 16.0 fl oz/100 gal on full-bloom (5/3), late-bloom (5/10), and petal-fall (5/17).

[2] Obtained by observing 10 inoculated shoots/replicate approximately 9 weeks after inoculation (24 May).

[3] Mean percentage shoot blighted on infected shoots.

[4] Mean length of shoot growth on noninoculated shoots between 25 May and 14 Sep.

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

Not for Publication

EFFICACY OF PLANT ACTIVATORS AND A BIOCONTROL AGENT FOR MANAGEMENT OF BACTERIAL SPOT OF PEACH

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

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

MATERIALS AND METHODS

Treatments. The test block consisted of 6-year old 'Suncrest' trees planted at 25 ft x 25 ft row spacing. Treatments were replicated four times in a randomized complete block design with single tree plots. Non-sprayed buffer trees on all sides surrounded treatment trees.

A Rears Pak-Blast-Plot airblast sprayer calibrated to deliver 100 gal/A at 100 psi traveling at 2.1 mph was used to apply the bactericides. Treatment applications were made on the following dates and tree growth stages: 27 Apr (PF, petal fall); 8 May (SS, shuck split); 23 May, 4, 18 Jun, 2 Jul (1C-4C, first-forth cover). Insecticides and miticides were applied as needed to the entire block using a commercial airblast sprayer.

Environment. Rainfall occurred on five days during the bloom period from 15 Apr to 21 Apr for a total of 0.7 in. (mean temp 50F). However, no rain occurred for the next 27 days until 20-22 May (1.64 in total; mean temp 59F). Subsequent rains and daily average temperatures were: 26-27 May (2.04 in; 62F); 1-2 Jun (1.04 in; 62F); 7 Jun (0.20 in; 67F); 11 Jun (0.55 in; 75F); 16-17 Jun (2.20 in; 75F); 23 Jun (1.61 in; 73F); 4-5 Jul (0.82 in; 75F); and 11 Jul (0.59 in; 80F).

Assessment. Bacterial spot (*Xanthomonas arboricola* pv. *pruni*) on leaves was evaluated 16 Jul by examining all leaves on 10 shoots per replicate tree. Observations were made for lesions, shot-holes, and defoliation. Control trees were evaluated for bacterial spot on fruit on 16 Jul by examining 50 fruit per tree.

RESULTS AND DISCUSSION

Fruit Infection. Bacterial spot was not observed on non-treated fruit at any time during the growing season. Fruit are believed to be most susceptible during the four-week period following SS. Lack of rainfall and cool temperatures during this time, which occurred from early May through early June, most likely inhibited disease development on fruit.

Foliar Infection. Rainfall periods and warmer temperatures from mid-June into July provided conditions allowing foliar disease development of low to moderate severity (Table 1). Serenade and Mycoshield treatment trees were observed to have the lowest foliar disease incidence and lowest total injury, but neither was significantly different from nonsprayed trees. Serenade treated trees, however, did have significantly less defoliation than control trees. Trees receiving the plant activators Messenger and Actigard were not significantly different from nonsprayed trees in any disease assessment category.

Total injury and shot-holing on trees sprayed with Tenn-Cop, an organic copper compound, were significantly higher than observed on trees receiving any other treatment. This outcome was most likely due to copper phytotoxicity which, like bacterial spot, causes shot-holing. Nevertheless, unlike bacterial spot, copper did not appear to cause defoliation. Leaf drop on copper-treated trees was not significantly different from non-sprayed trees. The high percent of foliar infection for Tenn-Cop may be due to the difficulty of distinguishing bacterial spot lesions from copper-injured spots.

CONCLUSIONS

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

2. Under the conditions of the study, differences in foliar infection between treatments were marginal. The only difference showing benefit occurred for Serenade treated trees, which had significantly less defoliation than control trees.

3. The treatment application schedule was geared towards the plant activators. Consequently, sprays were applied on a regular basis, at 11- to 15-day intervals. Nevertheless, all treatments – including the activators - may have benefited from shorter intervals, particularly after 2C when weather became favorable. Also, the standard Mycoshield would certainly have provided better control with applications timed according to infection events; this may also be true for Serenade.

4. The copper compound Tenn-Cop enhanced plant injury by increasing the amount of shot-holing, but not defoliation. Thus, more frequent applications for improving disease control, as suggested above, will most likely augment the shot-holing symptom.

TABLE 1			Foliar Bacterial Spot[a]			
			% Leaves	% of Leaves Present[b]		Total %
Treatment	Rate / A	Timing	Defoliated	Infected	Shot-holed	Injury[c]
Nonsprayed	———	———	12.2 a	17.3 abc	24.3 b	48.5 bc
Messenger	9.0 oz	PF, SS, 1C, 2C, 3C, 4C	10.2 ab	28.5 ab	19.0 b	52.8 b
Actigard 50WG	6.0 oz	PF; SS, 1C, 2C, 3C, 4C	9.4 ab	21.9 abc	16.7 b	44.5 bc
Serenade	8.0 lb	PF, SS, 1C, 2C, 3C, 4C	6.9 b	12.0 bc	21.9 b	38.5 c
Mycoshield 17WP	1.5 lb	SS, 1C, 2C, 3C, 4C	10.1 ab	7.8 c	22.5 b	37.3 c
Tenn-Cop 5E	8.0 fl oz	SS, 1C, 2C, 3C, 4C	12.1 a	31.6 a	40.0 a	74.9 a

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

[b] Categories mutually exclusive: infected = leaves with either lesions or lesions plus shot-holes; shot-holed = leaves only with shot-holes.

[c] Total % injury = (# defoliated leaves + # infected leaves + # shot-holed leaves) / (# leaves present + # leaves defoliated) x 100.

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

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EVALUATION OF REGISTERED FUNGICIDE SCHEDULES FOR BROAD SPECTRUM DISEASE MANAGEMENT ON GINGER GOLD, IDARED AND STAYMAN APPLES, 2001: Eleven treatments involving recently registered fungicides and combinations designed for season-long disease and fungicide resistance management were compared on 15-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 2000 to stabilize mildew inoculum pressure for 2001. 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: 17 Apr (Ginger Gold-pink; Stayman- OC-pink; Idared- pink-10% bloom); 26 Apr (Bl, bloom; Stayman- full Bl-PF; Idared-PF; Ginger Gold- pink-PF); 1st-6th covers, 1C-6C (9 May, 23 May, 8 June, 25 June, 9 Jul, Stayman and Idared only, 31 Jul). Insecticides, applied separately to the entire test block with the same equipment, included Ambush, Lannate LV, Provado, and Imidan 70WSB. Cedar rust galls, quince rust cankers, and bitter rot mummies were placed over each Idared test tree 13 Apr, and wild blackberry canes with the sooty blotch and flyspeck fungi were placed over each Idared test tree 12 June. Other diseases developed from inoculum naturally present in the test area. Foliar data represent averages of counts of all leaves on 10 terminal shoots from each of four replicates 8 Aug (Idared), 10 Aug (Stayman) or 22 Aug (Ginger Gold). Ginger Gold samples of 25 fruit were taken from each replicate tree and rated 30 Aug. Idared trees were sampled 25 Sep and Stayman 11 Oct and the 25-fruit samples were rated after storage at 1C 36 days (Idared) and 22 days (Stayman). Percentage data were converted by the square root arcsin transformation for statistical analysis.

Mildew inoculum was relatively high in this test block and 18 days were favorable for infection from mid-Apr to mid-May. Under heavy mildew pressure, all treatments gave acceptable mildew suppression. The most effective schedule involved the SI fungicide, Nova, from open cluster or bloom through second cover (Table 1). Some treatments appeared to be more effective on one cultivar than another. For example Rubigan (trt. #2) and Procure (#3) were equally effective on Stayman but Rubigan was significantly weaker on Idared and Ginger Gold. Treatments involving Nova, Procure and Bayleton were generally effective on all cultivars although mildew pressure was highest on Ginger Gold. Treatments involving Sovran in combination with ziram or Polyram gave adequate control on Stayman and Idared but were weaker on Ginger Gold. Penncozeb alone at open cluster and second cover contributed to weaker mildew control in trt. #11. Early scab pressure was low due to delayed primary infection, but more fruit infection occurred on non-treated fruit with secondary infection periods the last two weeks in May. All treatments gave excellent scab control under moderate pressure. Cumulative wetting hours in May and June resulted in heavy summer disease pressure and the appearance of sooty blotch by 9 July. All treatments gave significant suppression of Brooks spot, sooty blotch, flyspeck and rot spots (Table 2). Treatment #4, which included Polyram bloom-1st cover, Sovran at 2nd cover, and Topsin-M + ziram 3rd – 6th covers gave the best summer disease control over all; treatment #10 with Flint at bloom-1st cover, Penncozeb at 2nd cover, and Flint + ziram at 3rd – 6th covers gave excellent control of flyspeck on Idared but was weaker on sooty blotch, apparently related to captan + ziram at 3rd – 4th covers. There was no significant difference in fruit finish on Stayman. On Idared, treatments #1, 5 and 7 significantly reduced non-mildew russet, and treatments #1, 2, 3, 5, and 7 significantly reduced opalescence.

Table 1. Early season disease control by registered fungicide treatments on Stayman, Idared and Ginger Gold apple

		Scab, Stayman		Powdery mildew, % leaves, % leaf area, or % fruit infected							
		%	%	Stayman			Idared			Ginger Gold	
	Treatment, rate/A, and timing (based on Stayman cv.)	leaves	fruit	leaves	lf. area	fruit	leaves	lf. area	fruit	% lvs	% area
0	No fungicide	16 c	25 b	72 d	82 e	15 c	79 g	91 e	78 d	74 f	83 d
1	Nova 40W 5 oz + Dithane RSNT 75DF 3 lb; OC–2C Captan 50W 3 lb + Ziram 76DF 3 lb; 3C–6C	0 a	0 a	8 ab	2 ab	5 a-c	6 a	2 a	17 a	20 bc	4 ab
2	Rubigan 9 fl oz + Polyram 80DF 3.0 lb; OC–2C Captan 50W 3 lb + Ziram 76DF 3 lb; 3C–6C	<1 ab	0 a	15 b	3 cd	6 a-c	24 e	4 c	18 a	35 de	8 bc
3	Procure 50WS 10 oz + Polyram 80DF 3.0 lb; OC–2C Topsin-M 70W 8 oz + Ziram 76DF 3 lb; 3C–6C	<1 ab	1 a	13 b	3 bc	9 a-c	8 ab	2 a	24 ab	21 bc	4 ab
4	Sovran 50WG 4 oz; OC, 2C Procure 50WS 10 oz + Polyram 80DF 3.0 lb; BI–1C Topsin-M 70W 8 oz + Ziram 76DF 3 lb; 3C–6C	0 a	0 a	10 ab	2 a-c	0 a	18 de	4 bc	29 ab	19 a-c	3 a
5	Procure 50WS 10 oz+Ferbam Granuflo 75WDG 3 lb; OC Procure 50WS 10 oz+Thiram Granuflo 75WDG 3 lb; BI, 2C Bayleton 50 DF 2 oz+ Thiram Granuflo 75WDG 3 lb; 1C Ferbam Granuflo 75WDG 6 lb; 3C–5C Topsin-M 70W 8 oz + Thiram Granuflo 75WDG 3 lb; 6C	1 b	1 a	12 b	3 a-c	3 a-c	7 ab	2 a	28 ab	12 a	2 a
6	Vangard 75WG 3 oz + Dithane RSNT 75DF 3 lb; OC Nova 40W 5 oz + Dithane RSNT 75DF 3 lb; BI–2C Topsin-M 70W 8 oz + Captan 50W 3 lb; 3C-6C	<1 ab	0 a	6 a	2 a	8 a-c	6 a	2 a	27 ab	14 ab	3 a
7	Vangard 75WG 3 oz + Dithane RSNT 75DF 3 lb; OC Nova 40W 5 oz + Dithane RSNT 75DF 3 lb; BI–1C Sovran 50WG 4 oz; 2C Topsin-M 70W 8 oz + Captan 50W 3 lb; 3C–6C	<1 ab	1 a	8 ab	2 ab	0 a	11 bc	3 a-c	36 bc	17 a-c	3 a
8	Sovran 50WG 3 oz + Polyram 80DF 3.0 lb; OC–2C Captan 50W 3 lb + Ziram 76DF 3 lb; 3C–6C	<1 ab	1 a	10 ab	2 a-c	5 a-d	10 a-c	2 ab	21 a	38 e	11 c
9	Sovran 50WG 3 oz + Ziram 76DF 3 lb; OC–2C Captan 50W 3 lb + Ziram 76DF 3 lb; 3C–6C	<1 ab	0 a	15 b	3 cd	7 a-c	15 cd	3 a-c	25 ab	27 cd	5 ab
10	Bayleton 50DF 2 oz + Penncozeb 75DF 3 lb; OC, 2C Bayleton 50DF 2 oz + Flint 50WG 1.5 oz; BI–1C Captan 50W 3 lb + Ziram 76DF 3 lb; 3C–4C Flint 50WG 1.5 oz + Ziram 3 lb; 5C–6C	<1 ab	1 a	11 ab	2 a-c	9 bc	12 bc	2 ab	17 a	16 ab	3 a
11	Penncozeb 75DF 3 lb; OC, 2C Flint 50WG 1.5 oz + Penncozeb 75DF 3 lb; BI–1C Flint 50WG 2 oz; 3C–4C Topsin-M 70W 8 oz+ Ziram 76DF 3 lb; 5C–6C	<1 ab	0 a	22 c	5 d	2 ab	36 f	10 d	49 c	35 de	13 c

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Four reps. Foliar counts 8 Aug (Idared), 10 Aug (Stayman) or 22 Aug (Ginger Gold). Fungicide treatments applied to both sides of the tree on each indicated application date with a Swanson Model DA-400 airblast sprayer at 100 gal/A as follows: 17 Apr (Ginger Gold- pink; Stayman- OC-pink; Idared- pink-10% bloom); 26 Apr (Bl, bloom; Stayman- full Bl-PF; Idared- PF; Ginger Gold- pink-PF); 1st-6th covers, 1C-6C (9 May, 23 May, 8 June, 25 June, 9 Jul, Stayman and Idared only, 31 Jul).

Table 2. Summer disease control by registered fungicide treatments on Stayman, Idared and Ginger Gold apple, 2001

		Sooty blotch, % fruit or % fruit area infected						Flyspeck, % fruit			Brooks	Rot spots, %	
		Stayman		Idared		Ginger Gold *		Stay-		Ginger	spot %	Stay-	
	Treatment, rate/A, and timing (based on Stayman cv.)	fruit	area	fruit	area	fruit	area	man	Idared	Gold *	Idared	man	Idared
0	No fungicide	100 e	25 e	100 e	32 e	91 d	13 d	91 e	99 g	78 f	9 c	10 b	12 b
1	Nova 40W 5 oz + Dithane RSNT 75DF 3 lb; OC–2C Captan 50W 3 lb + Ziram 76DF 3 lb; 3C–6C	65 d	7 d	60 b-d	8 cd	10 bc	<1 bc	30 d	48 d-f	33 e	2 ab	4 ab	0 a
2	Rubigan 9 fl oz + Polyram 80DF 3.0 lb; OC–2C Captan 50W 3 lb + Ziram 76DF 3 lb; 3C–6C	45 cd	4 cd	65 cd	6 a-d	11 bc	<1 bc	22 cd	48 ef	21 de	4 b	4 ab	0 a
3	Procure 50WS 10 oz + Polyram 80DF 3.0 lb; OC–2C Topsin-M 70W 8 oz + Ziram 76DF 3 lb; 3C–6C	27 a-c	2 a-c	37 a-d	3 a-d	4 ab	<1 ab	18 cd	29 b-d	5 a-c	0 a	4 ab	0 a
4	Sovran 50WG 4 oz; OC, 2C Procure 50WS 10 oz + Polyram 80DF 3.0 lb; Bl–1C Topsin-M 70W 8 oz + Ziram 76DF 3 lb; 3C–6C	15 a	1 ab	21 a	2 a	0 a	0 a	6 ab	22 bc	0 a	0 a	4 ab	1 a
5	Procure 50WS 10 oz+Ferbam Granuflo 75WDG 3 lb; OC Procure 50WS 10 oz+Thiram Granuflo 75WDG 3 lb; Bl, 2C Bayleton 50 DF 2 oz+ Thiram Granuflo 75WDG 3 lb; 1C Ferbam Granuflo 75WDG 6 lb; 3C–5C Topsin-M 70W 8 oz + Thiram Granuflo 75WDG 3 lb; 6C	39 bc	3 a-c	36 a-c	4 a-c	0 a	0 a	10 a-c	20 bc	5 a-c	0 a	1 a	0 a
6	Vangard 75WG 3 oz + Dithane RSNT 75DF 3 lb; OC Nova 40W 5 oz + Dithane RSNT 75DF 3 lb; Bl–2C Topsin-M 70W 8 oz + Captan 50W 3 lb; 3C-6C	23 a-c	2 a-c	38 a-d	3 a-c	0 a	0 a	20 cd	36 c-f	4 a-c	0 a	2 ab	1 a
7	Vangard 75WG 3 oz + Dithane RSNT 75DF 3 lb; OC Nova 40W 5 oz + Dithane RSNT 75DF 3 lb; Bl–1C Sovran 50WG 4 oz; 2C Topsin-M 70W 8 oz + Captan 50W 3 lb; 3C–6C	18 ab	1 a	30 ab	2 ab	3 ab	<1 ab	10 a-c	24 bc	7 a-c	1 ab	1 a	2 a
8	Sovran 50WG 3 oz + Polyram 80DF 3.0 lb; OC–2C Captan 50W 3 lb + Ziram 76DF 3 lb; 3C–6C	45 cd	3 a-d	44 a-d	4 a-d	3 ab	<1 ab	11 a-c	34 c-e	20 c-e	0 a	6 ab	0 a
9	Sovran 50WG 3 oz + Ziram 76DF 3 lb; OC–2C Captan 50W 3 lb + Ziram 76DF 3 lb; 3C–6C	32 a-c	3 a-c	67 d	8 d	16 c	1 c	17 bc	55 f	12 b-d	1 ab	5 ab	0 a
10	Bayleton 50DF 2 oz + Penncozeb 75DF 3 lb; OC, 2C Bayleton 50DF 2 oz + Flint 50WG 1.5 oz; Bl–1C Captan 50W 3 lb + Ziram 76DF 3 lb; 3C–4C Flint 50WG 1.5 oz + Ziram 3 lb; 5C–6C	44 cd	4 b-d	57 b-d	7 b-d	6 a-c	<1 ab	6 a	4 a	3 ab	0 a	2 ab	1 a
11	Penncozeb 75DF 3 lb; OC, 2C Flint 50WG 1.5 oz + Penncozeb 75DF 3 lb; Bl–1C Flint 50WG 2 oz; 3C–4C Topsin-M 70W 8 oz+ Ziram 76DF 3 lb; 5C–6C	30 a-c	2 a-c	65 cd	6 a-d	6 a-c	<1 a-c	14 bc	14 b	4 a-c	2 ab	3 ab	1 a

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Averages of 25-fruit samples from four single-tree replications counted after harvest 30 Aug Ginger Gold, or after storage at 1C 36 days (Idared) and 22 days (Stayman). * Application dates: 17 Apr (OC open cluster); 26 Apr (Bl, bloom); 1st-6th covers, 1C-6C (9 May, 23 May, 8 June, 25 June, 9 Jul, Stayman and Idared only, 31 Jul).

APPLE (*Malus domestica* 'Golden Delicious',
'Red Delicious', and 'Rome Beauty')
Scab; *Venturia inaequalis*
Powdery mildew; *Podosphaera leucotricha*
Brooks fruit spot; *Mycosphaerella pomi*
Sooty blotch; Disease complex
Fly speck; *Zygophiala jamaicensis*
Rot spots (unidentified)
Fruit finish

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EVALUATION OF BIO-RATIONAL AND ORGANIC PRODUCTION TREATMENTS ON THREE APPLE CULTIVARS, 2001: Treatments with potential for inclusion in an organic apple production schedule were tested for fungal disease effects on three apple cultivars. Nine treatments were evaluated on 12-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 2000 to allow buildup of powdery mildew inoculum. Treatments were applied dilute to the point of runoff with a single nozzle handgun at 400 psi as follows: 19 Apr, all treatments (Rome- TC-OC, tight–open cluster; Golden Delicious- OC-tight pink; Red Del. pink-early bloom); 23 Apr (B1, bloom, Trt. #4 only); 26 Apr, all treatments (B2, Rome 90% bloom, Golden Delicious- full bloom-petal fall; Red Del. - petal fall); 2 May (PF1, bloom, Trt. #4 only); 4 May (PF2, all treatments); 9 May, (PF3, trt. 4 only). First–sixth covers (1C-6C, all treatments): 14 May, 31 May, 14 June, 29 June, 16 July, and 7 Aug.. Maintenance sprays applied separately with a commercial airblast sprayer included Ambush, Spintor, Provado, Lannate LV, Imidan 70 WSB, and a dilute application of NAA or Ethrel +Sevin XLR +Regulaid (as thinners). Bitter rot mummies and wild blackberry canes with the sooty blotch and flyspeck fungi were placed over each Golden Delicious test tree 13 June. Other diseases developed from inoculum naturally present in the test area. Foliar counts are based on ten terminal shoots from each of four single-tree reps 27 June (Rome) or 12 July (Golden Del.). Fruit counts are means of 25-fruit samples picked from each of four single-tree reps 12 Sep (Red Delicious), 26 Sept (Golden Delicious), or 3 Oct (Rome). Red Delicious was rated 13 Sep; Golden Delicious rated after 42 days and Rome after 34 days' cold storage at 1C. Percentage data were converted by the square root arcsin transformation for statistical analysis.

Early scab pressure was low due to delayed primary infection, but secondary fruit infection occurred the last two weeks in May. Scab infection on foliage was relatively light but pressure was heavier on fruit. Microthiol Disperss (sulfur) 4 lb + Lime sulfur, also included with Surround gave good scab control on all three cultivars. Nova, included treatment #4 three times in late April and early May aided control by that treatment on Red and Golden Delicious, but was no longer available with continued growth during heavier scab pressure on the later developing Rome the last two weeks in May. QRD 131 gave significant scab suppression on Red Delicious but not on Golden or Rome. The 1 lb rate of Microthiol also gave some scab suppression on Red Delicious but not on Golden or Rome. Messenger apparently added little to the scab control provided by sulfur. Early season weather favored development of mildew, with 18 days favorable from mid-April to mid-May. Higher rates of sulfur and lime sulfur and Nova were most effective for mildew control under this heavy pressure. Cumulative wetting hours in May and June resulted in the appearance of sooty blotch by mid-July. Sulfur + lime sulfur, alone and combined with Surround, gave the only really effective control of sooty blotch, flyspeck and rot spots, although all other treatments significantly reduced sooty blotch on Red Delicious; other treatments gave some suppression of flyspeck on Golden Delicious and Rome but not on Red Delicious. Messenger + sulfur suppressed flyspeck slightly compared to sulfur alone. QRD 131 had more effect than QRD 137 on flyspeck on Golden Delicious. QRD 131 and QRD 137+ sulfur significantly reduced Brooks spot incidence on Golden Delicious. Neither QRD formulation nor Messenger had much effect on "rot spot" incidence. There were several effects on fruit finish. Sulfur+lime sulfur and Surround + sulfur + lime sulfur significantly reduced Golden Delicious russetting compared to fruit from non-treated trees. QRD 131 significantly increase russet on Golden Delicious and opalesence on Rome. Schedules involving QRD 137 in combination with sulfur and alternated with Nova + Agri-Mycin resulted in increased opalesence on Red Delicious and Rome. Surround+ Sulfur+lime sulfur increased opalesence on Rome compared to Sulfur+lime sulfur without Surround. The lower rate of Messenger + sulfur had significantly more opalesence than the same rate of sulfur alone.

Table 6. Early season diseases and fruit finish effects by bio-rational and organic production treatments on Red Delicious, Golden Delicious and Rome apples

		Scab, % of leaves or fruit infected					Mildew, % leaves or % leaf area infected				Fruit finish ratings *					
		leaves		fruit			Rome		Golden Del.		Russet rating (0-5) *			% X-fcy/fcy	Opalescence rating (0-5) *	
	Rate per 100 gal dilute and timing	Rome	G. Del	Rome	G. Del	R.Del	% lvs	%area	% lvs	area	R. Del	Rome	G. Del	G. Del	R. Del.	Rome
0	No fungicide	8 e	11 d	22 d	16 d	43 c	60 f	63 f	47 c	36 c	0.7 a	1.4 ab	2.1 cd	73 bc	0.8 ab	1.5 a
1	QRD137 WP 2.0 lb; TC-6C	6 c-e	6 cd	18 d	16 d	30 bc	54 ef	46 ef	43 c	24 bc	1.0 a	1.5 ab	2.4 de	68 bc	1.3 b-d	1.7 ab
2	QRD131 AS 5.3 pt; TC-6C	7 de	5 bc	12 cd	8 b-d	19 b	53 ef	37 de	34 b	14 ab	1.1 a	1.7 ab	2.9 e	50 c	1.0 a-c	2.1 b-d
3	QRD137 WP 1.33 lb + Microthiol Disperss 80W 1 lb; TC-6C	4 b-e	7 b-c	11 cd	4 b	25 b	44 de	11 ab	32 b	10 ab	1.0 a	1.5 ab	2.4 de	70 bc	1.4 cd	2.3 cd
4	QRD137 WP 1.33 lb; TC, B2, PF2,1-6C Nova 40W 1.25 oz; B1, PF1 & 3 (+ Agri-Mycin17 4 oz); B1&2, PF1, 2,&3	1 a	3 ab	8 bc	0 a	3 a	30 b	5 a	14 a	3 a	1.0 a	1.9 b	2.1 cd	76 bc	1.6 d	2.5 de
5	Messenger 3% 4.4 oz + Microthiol Disperss 80W 1 lb; TC-6C	3 a-c	6 bc	7 bc	12 cd	23 b	46 de	27 b-d	33 b	9 a	0.8 a	1.4 ab	1.6 a-c	89 ab	1.1 a-d	1.9 a-c
6	Messenger 3% 2.2 oz + Microthiol Disperss 80W 1 lb; TC-6C	3 a-d	3 abc	14 cd	8 b-d	29 bc	48 de	27 cd	32 b	6 a	0.6 a	1.8 ab	1.9 a-d	83 ab	0.9 ab	2.5 de
7	Microthiol Disperss 80W 1 lb; TC-6C	5 b-e	4 bc	22 d	11 b-d	27 b	41 cd	12 a-c	34 b	10 ab	0.6 a	1.3 a	2.0 b-d	79 bc	0.9 ab	1.5 a
8	Surround 95WP 25 lb + Microthiol Disperss 80W 4 lb+ Lime sulfur 2 qt; TC-6C	1 a	2 a	1 a	9 bc	3 a	30 bc	9 a	27 b	10 ab	0.9 a	1.4 ab	1.4 ab	91 ab	0.8 a	2.8 e
9	Microthiol Disperss 80W 4 lb + Lime sulfur 2 qt; TC-6C	1 ab	1 a	3 ab	1 a	1 a	18 a	4 a	18 a	3 a	0.7 a	1.3 a	1.3 a	96 a	1.1 a-d	1.9 a-c

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Four replications with one tree of each cultivar per replicate set.

Foliar counts based on ten terminal shoots from each of four single-tree reps 27 June (Rome) or 12 July (Golden Del.). Means of 25-fruit samples picked from each of four single-tree reps 12 Sep (Red Delicious), 26 Sept (Golden Delicious), or 3 Oct (Rome). Red Delicious was rated 13 Sep; Golden Delicious rated after 42 days and Rome after 34 days' storage at 1C.

Treatments applied to Rome trees not treated in 2000. Treatments applied dilute to the point of runoff with a single nozzle handgun at 450 psi.

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

Treatment application dates:

19 Apr, all treatments (Rome- TC-OC, tight–open cluster; Golden Delicious- OC-tight pink; Red Del. pink-early bloom); 23 Apr (B1, bloom, Trt. #4 only); 26 Apr, all treatments (B2, Rome 90% bloom, Golden Delicious- full bloom-petal fall; Red Del. - petal fall); 2 May (PF1, bloom, Trt. #4 only); 4 May (PF2, all treatments); 9 May, (PF3, trt. 4 only). First–sixth covers (1C-6C, all treatments): 14 May, 31 May, 14 June, 29 June, 16 July, and 7 Aug.

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

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FIREBLIGHT TREATMENTS ON GOLDEN DELICIOUS AND ROME BEAUTY APPLES, 2001

Objectives of this year's test were 1) to test experimental materials in comparison to streptomycin Agri-Mycin 17 for blossom blight control; 2) To test experimental materials as streptomycin in a schedule with Apogee, which has given a synergistic effect in several test years. For this objective Apogee was applied and then followed 7 days later (one day before the first shoot inoculation) with the experimental application. Blossom and shoot blight tests were conducted on the same trees; pairs of adjacent 29 yr-old trees of each cultivar in four randomized blocks. Both Golden Delicious and Rome were treated at the same time with a dilute handgun application to run-off at 400 psi. Specific treatment and inoculation information is listed below the data tables. In the blossom blight experiment, blossom condition was recorded at the time of inoculation and percent infection was based on the number deemed to be susceptible at that time. Percent control compared to non-treated trees is shown in bold figures on Table 8. We rated both % flowers infected and % blossom clusters infected. (Clusters are more commercially relevant because those would indicate greater potential for canker progression into older branches). There was considerable variation in this year's test because the weather turned very cool two days after inoculation. The following maintenance schedule was applied airblast to the entire test block: 10 Apr (Ambush+Nova+Syllit); 19 Apr (Nova); 5 May (Nova+Dipel); 15 May (NAA 10 ppm+Sevin XLR+Regulaid+Nova+Provado); 29 May and 19 June and 27 July (Nova+Provado+Spintor); 3 July and 13 July (Sovran+Provado+Spintor) and 21 Aug (Ziram+Topsin-M+Imidan).

Summary of results

Blossom blight– Numerically, the highest protective (pre-inoculation treatment) % blossom control was with S-0208 (Stamer) 10 oz/100gal (Table 8), and a rate effect was suggested, but due to variation, the results were not statistically significant (p=0.05). A rate effect was not evident with GWN-9200. As the commercial standard, we might have expected streptomycin to perform more effectively than it did. The rather poor performance of streptomycin is more likely explained by weather conditions this year rather than by the possibility of resistance because the inoculum came from refrigerated stock cultures which are used year after year and are never exposed to streptomycin. Experimental treatments were tested under the same conditions as the standard.

Shoot blight– In the shoot blight tests (Tables 9 and 10) 8 DAT refers to 1-day preventive application for the bactericide treatments which were inoculated 1 May. In this type of test there was more control differential shown in % shoots infected on Golden Delicious but more difference in mean canker lengths on Rome. Some infected shoots on Rome had very short cankers that had to be included as "infected" but showed considerable suppression of canker length, especially on treatments that involved Apogee at 17 DAT (Table 10). GWN-9200 (treatment #7 on Golden Delicious, Table 9) seems to have had a positive effect in the shoot blight test as indicated by the fewest shoots infected when inoculated 17 DAT (10 days after GWN-9200 treatment). There was no significant effect by any treatment on fruit finish of either cultivar compared to non-treated trees, an important attribute for materials that must be applied during bloom as for fire blight blossom blight control. In summary, both S-0208 and GWN-9200 showed some positive effect under these test conditions, and all treatments, including streptomycin, might perform better in a different test year.

Table 8. 2001 Fireblight Blossom Blight Treatments on Golden Delicious apples, Virginia Tech AREC, Winchester, VA

				Post-inoculation treatment, % infected (% control)		Pre-inoculation treatment, % infected (% control)	
	Bloom treatment; rate/100 gal dilute	Application dates	Blossom inoculation dates	flowers	clusters	flowers	clusters
0	No treatment	---	Apr 22&23	8.0 a ---	28.3 a ---	2.7 a ---	12.5 a ---
1	S-0208 20W 5 oz + Regulaid 4 fl oz	Apr 23&30	Apr 22&23	5.0 a (38)	27.5 a (3)	2.1 a (22)	10.0 a (20)
2	S-0208 20W 10 oz + Regulaid 4 fl oz	Apr 23&30	Apr 22&23	6.1 a (24)	27.5 a (3)	0.6 a (78)	2.5 a (80)
3	S-0208 20W 10 oz + Regulaid 4 fl oz + Apogee 27.5DF 6 oz + Amm. sulfate 6 oz	Apr 23	Apr 22&23	3.9 a (51)	17.5 a (38)	1.7 a (37)	7.5 a (40)
	S-0208 20W 10 oz + Regulaid 4 fl oz	Apr 30					
4	GWN-9200 10W 20 oz+ Regulaid 4 fl oz	Apr 23&30	Apr 22&23	6.1 a (24)	27.5 a (3)	1.2 a (56)	5.0 a (60)
5	GWN-9200 10W 30 oz + Regulaid 4 fl oz	Apr 23&30	Apr 22&23	7.0 a (13)	26.1 a (8)	1.6 a (41)	7.5 a (40)
6	GWN-9200 10W 40 oz +Regulaid 4 fl oz	Apr 23&30	Apr 22&23	5.7 a (29)	30.0 a (0)	1.6 a (41)	7.8 a (38)
7	GWN-9200 10W 40 oz +Regulaid 4 fl oz + Apogee 27.5DF 6 oz + Amm. sulfate 6 oz	Apr 23	Apr 22&23	4.1 a (49)	20.6 a (27)	1.5 a (44)	7.5 a (40)
	GWN-9200 10W 40 oz +Regulaid 4 fl oz	Apr 30					
8	Agri-Mycin 17 8 oz + Regulaid 4 fl oz	Apr 23&30	Apr 22&23	5.8 a (28)	27.5 a (3)	2.2 a (19)	10.0 a (20)
9	Agri-Mycin 17 8 oz + Regulaid 4 fl oz + Apogee 27.5DF 6 oz + Amm. sulfate 6 oz	Apr 23&30	Apr 22&23	4.6 a (43)	20.0 a (29)	2.7 a (0)	5.0 a (60)
10	Apogee 27.5DF 6 oz + Ammonium sulfate 6 oz+ Regulaid 4 fl oz	Apr 23 only	Apr 22&23	4.1 a (49)	20.8 a (27)	3.6 a (0)	17.5 a (0)
11	Agri-Mycin 17 8 oz + Regulaid 4 fl oz+ Apogee 27.5DF 12 oz + Am. sulfate 12 oz	Apr 23	Apr 22&23	5.1 a (36)	23.1 a (18)	1.5 a (44)	7.5 a (40)
	Agri-Mycin 17 8 oz + Regulaid 4 fl oz	Apr 30					

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Means of four replications and ten blossom clusters per rep for each inoculation date. Per cent flowers infected is based on susceptible flowers open at the time of inoculation. Blossom infection was rated on individual clusters 2-3 May. Final cluster infection assessment was done 7 June.

Both cultivars were treated at the same time with a dilute handgun application to run-off at 450 psi. Weather conditions favored inoculation of Golden Delicious but Rome bloom was delayed and was not inoculated. Golden Delicious blossoms were inoculated at nearly full bloom in the evening with 1X10^5 cells/ml, pre-treatment 22 Apr and post-treatment 23 Apr. The first application was in the morning 23 Apr. Follow-up bactericide treatments (without Apogee and ammonium sulfate) were applied as indicated 30 Apr. Shoots were inoculated on both cultivars as indicated in Tables 2 and 3 (1 May and 10 May).

Table 9. 2001 Shoot Blight Treatments on Golden Delicious apples: Effects of bactericides in association with Apogee applied for suppression of fire blight on apple shoots, inoculated 8 or 17 days after Apogee treatment (DAT), Winchester, VA

Bloom treatment; rate/100 gal dilute	Timing for shoot inoc. test	Application dates	% shoots Inf., Inoculated DAT		Mean canker length (cm)		Shoot vigor at inoc., rated 1-5		cm shoot length
			8 DAT	17 DAT	8 DAT	17 DAT	8 DAT	17DAT	22 May
0 No treatment	---	---	100 a	75 bcd	9.5 a	6.3 ab	1.6 a	2.2 ab	18.7 b-d
1 S-0208 20W 5 oz + Regulaid 4 fl oz	mid & late bl.	Apr 23&30	98 a	93 de	9.4 a	7.0 ab	1.6 a	2.1 ab	21.7 d
2 S-0208 20W 10 oz + Regulaid 4 fl oz	mid & late bl.	Apr 23&30	100 a	95 e	10.8 a	6.6 ab	1.8 a	1.7 ab	18.3 b-d
3 S-0208 20W 10 oz + Regulaid 4 fl oz + Apogee 27.5DF 6 oz + Am. sulfate 6 oz	mid bloom	Apr 23	98 a	76 cde	9.2 a	5.1 ab	1.6 a	2.4 ab	12.4 ab
S-0208 20W 10 oz + Regulaid 4 fl oz	1 day pre-inoc	Apr 30							
4 GWN-9200 10W 20 oz+ Regulaid 4 fl oz	mid & late bl.	Apr 23&30	98 a	83 cde	9.0 a	2.9 ab	1.8 a	2.7 b	17.9 a-d
5 GWN-9200 10W 30 oz + Regulaid 4 fl oz	mid & late bl.	Apr 23&30	100 a	80 cde	8.8 a	4.5 ab	1.9 a	2.4 ab	13.4 a-c
6 GWN-9200 10W 40 oz +Regulaid 4 fl oz	mid & late bl.	Apr 23&30	95 a	83 cde	10.3 a	5.3 ab	1.4 a	2.0 ab	16.1 a-d
7 GWN-9200 10W 40 oz +Regulaid 4 fl oz + Apogee 27.5DF 6 oz + Am. sulfate 6 oz	mid bloom	Apr 23	98 a	33 a	8.5 a	0.8 a	1.8 a	2.5 ab	9.9 a
GWN-9200 10W 40 oz +Regulaid 4 fl oz	1 day pre-inoc	Apr 30							
8 Agri-Mycin 17 8 oz + Regulaid 4 fl oz	mid & late bl.	Apr 23&30	95 a	85 cde	10.5 a	7.8 b	1.8 a	1.6 a	22.6 d
9 Agri-Mycin 17 8 oz + Regulaid 4 fl oz + Apogee 27.5DF 6 oz + Am. sulfate 6 oz	mid bloom	Apr 23	98 a	84 cde	8.6 a	6.8 ab	1.6 a	1.8 ab	20.5 cd
Agri-Mycin 17 8 oz + Regulaid 4 fl oz	1 day pre-inoc	Apr 30							
10 Apogee 27.5DF 6 oz + Am. sulfate 6 oz+ Regulaid 4 fl oz	mid bl. only	Apr 23	98 a	48 ab	9.2 a	0.9 a	1.8 a	2.3 ab	11.6 ab
11 Agri-Mycin 17 8 oz + Regulaid 4 fl oz+ Apogee 27.5DF 12 oz +Am. sulfate 12 oz	mid bloom	Apr 23	95 a	65 bc	8.7 a	6.1 ab	1.6 a	2.0 ab	15.7 a-d
Agri-Mycin 17 8 oz + Regulaid 4 fl oz	1 day pre-inoc	Apr 30							

Averages of four 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 450 psi. Bactericide and/or Apogee treatments as indicated applied 23 Apr to Goldens and Romes (at Golden Del. mid-bloom); bactericide applications without Apogee 30 Apr (mid-bloom, Rome; late bloom, Golden) (1-day pre-inoculation treatments on all treatments but #10) for first inoculation 21 Apr.

Ten apparently vigorous shoots / tree were selected 26-27 Apr for inoculation 1 and 10 May. Shoot tip inoculations were done with a hypodermic needle using 1X10^8 cells/ml at 8 days (1 May) and 17 days after Apogee applications (10 May). Actual shoot infection data are based on 9 or 10 Golden shoots per tree for each inoculation, a few of the intended shoots having been excluded due to deer damage, mildew infection, or production of a late blossom cluster instead of an actively growing terminal shoot.

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

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EVALUATION OF FUNGICIDES FOR DISEASE CONTROL ON PEACH AND NECTARINE, 2001: Several registered fungicides and Flint were compared for broad spectrum disease control on 9-yr-old trees. The test planting is composed of 3-tree sets, each including Redhaven peach and Redgold nectarine (which were not treated with fungicides in 2000 to allow the buildup of scab inoculum), and Loring peach which was not treated with fungicides since 1998. Brown rot inoculum was standardized in the orchard by placing three mummified fruit in each test tree before bloom. Dilute treatments were applied to the point of run-off (approximately 200 gal/A) with a single nozzle handgun at 300 psi in a randomized block design with five replications. Applications were as follows: 12 March (BS, bud swell, treatments #1-6 only, including Redhaven; later applications were to Loring and Redgold only: 9 April (P, pink); 17 April (Bl, full bloom); 24 April (PF, petal fall); 10 May (SS, shuck split); 1st-4th covers, (1C-4C), 24 May, 7 June, 25 June, and 9 July; pre-harvest sprays (2PH, 31 Jul; 1PH, 9 Aug) were intended to be 2 weeks and 1 week before Loring harvest. Actual harvest dates were14 Aug for Loring and 17 and 20 Aug for Redgold. Commercial insecticides, applied to the entire test block at 2-3 wk intervals with a commercial airblast sprayer, included Asana XL, Imidan WSB, Lannate LV and Sevin XLR. Samples of 40 apparently rot-free Loring fruit per replicate tree were harvested 14 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 20,000 *M. fructicola* conidia/ml which had been obtained from freshly sporulating fruit from the test orchard. All were incubated in polyethylene bags at ambient temperature 22-30C (mean 26.1C) for the indicated interval before assessing rot development. Redgold was sampled twice, each with 25 fruit per replication, 17 and 20 Aug. Because of heavy brown rot incidence, especially on the non-treated Redgold trees (93%), brown rot was counted on the tree and rot-free non-treated samples were not available for post-harvest incubation. Apparently rot-free fruits were collected from treated trees and samples incubated as indicated for Loring but were not inoculated after harvest. Ambient temperatures during Redgold incubation were also 20-30C (mean 26.1C).

Following a year without fungicides, leaf curl infection was most severe on non-treated nectarine trees, moderate on Loring, and light on Redhaven peach. All treatments applied at bud swell gave excellent control (Table 11). Among treatments applied first at pink, Bravo and Ziram Granuflo+Tenn-Cop gave adequate commercial control; Indar gave 56% suppression on nectarine but very little on peach. Weather during the early cover spray period was favorable for scab infection. Under severe inoculum conditions, and with 40% of untreated fruit infected, all treatments gave acceptable control on Loring. On Redgold, 92% of untreated fruit were infected, and significant differences were noted, with superior control provided by the Bravo/Abound and Ziram + Kocide schedules (trts. #5 and 6). Captan during the cover sprays (trt. #1) allowed more fruit infected with scab than Thiram Granuflo (trt. #2), Thiram +captan (trt. #3) or Ziram Granuflo (trt. #4) all at equivalent formulation rates. Bravo followed by Indar (trt. #8) was significantly weaker than the Bravo followed by Abound (trt. #7) or Bravo followed by Flint (trt. #9). Shothole and defoliation of older leaves was observed on trt. #5 in July, resulting in 50-75% defoliation on Loring and 10-25% defoliation on Redgold. Treatment #11 also had some shothole injury but little defoliation. A firmness rating of nectarine fruit on the tree 16 Aug (rating scale 1-3; three =very firm) showed differences: fruit from treatment #5 (mean rating 3.0) were significantly more firm than from non-treated trees (mean rating 1.8), Indar/captan treated trees (#10, mean rating 1.6) and treatment #11 which involved another copper material on the same schedule, Tenn-cop rather than Kocide with mean rating 1.6. Hail injury 26 May led to early appearance of brown rot in the test area, particularly on nectarines. Post-harvest inoculation increased disease incidence on most treatments, providing a good test of residual effectiveness as indicated by ratings on Loring after 6 days incubation (Table 12). The apparent control advantage by trt. #5 on both peach and nectarine is more appropriately explained by reduced rot susceptibility due to delayed fruit ripening as a result of leaf injury than by direct fungicidal effects. On non-inoculated fruit, Indar gave stronger brown rot control as a pre-harvest treatment than either Abound or Flint (trt. #8 vs. 7&9). Among treatments which were not affected by delayed fruit ripening on nectarine, Indar stood out as a pre-harvest spray both in on-tree counts as well as in fruit without rots 8 or 10 days after incubation. In combination with Indar in the pre-harvest sprays, Thiram gave more residual protection than captan. Thiram as a mid-season cover spray resulted in less brown rot in on-tree counts than ziram (trt. #2 vs. #4).

Table 11. Treatment effects on leaf curl and scab. Loring and Redhaven peach and Redgold nectarine

			Leaf curl strikes/tree*			Scab**		
						Loring	Redgold	
	Treatment and rate/100 gal dilute	Timing	Loring	Red haven	Redgold	% fruit	% fruit	lesions
0	No fungicide	—	28 d	2 a	133 d	40 c	92 f	31.8 c
1	Ferbam Granuflo 76WDG 2 lb	BS	0 a	0 a	0 a			
	Captan 50W 2 lb (+Tactic 4 fl oz, 1C-4C)	P-4C				3 ab	63 e	7.8 b
	Captan 50W 1 lb+							
	Indar 75W 0.5 oz + Tactic 4 fl oz	2 PH, 1PH						
2	Thiram Granuflo 2 lb (+Tactic 4 fl oz, 1-4C)	BS-4C	0 a	0 a	0 a	1 ab	26 a-d	1.7 ab
	Thiram Granuflo 75WDG 1 lb+							
	Indar 75W 0.5 oz + Tactic 4 fl oz	2PH, 1PH						
3	Thiram Granuflo 75WDG 1 lb+ COCS 2 lb	BS	0 a	0 a	0 a			
	Thiram Granuflo 1 lb + Captan 50W1b +	P-4C				1 a	28 a-d	2.2 ab
	(+Tactic 4 fl oz, 1C-4C)							
	Thiram Granuflo 1 lb+							
	Indar 75W 0.5 oz + Tactic 4 fl oz	2PH, 1PH						
4	Ziram Granuflo 2 lb (+Tactic 4 fl oz, 1C-4C)	BS-4C	0 a	0 a	0 a	6 b	35 cd	2.7 ab
	Thiram Granuflo 75WDG 1 lb+							
	Indar 75W 0.5 oz + Tactic 4 fl oz	2PH, 1PH						
5	COCS 50WDG 4lb	BS	0.6 ab	0.0 a	0.0 a			
	Ziram Granuflo 76WDG 1.5 lb +							
	Kocide DF 12 oz	Pink-PF						
	Ziram Granuflo 76WDG 1.5 lb +							
	Kocide DF 8 oz	SS						
	Ziram Granuflo 76WDG 1.5 lb +							
	Kocide DF 4 oz	1C-4C				4 ab	12 ab	0.8 a
	Indar 75W 1 oz + Tactic 4 fl oz	2PH, 1PH						
6	Bravo Weather Stik 6F 1 pt.	BS- PF	<1 ab	0 a	0 a			
	Captan 50W 2 lb	2C-4C				3 ab	11 a	0.6 a
	Abound 2.08F 6 fl oz	SS-1C, 2&1PH						
7	Bravo Weather Stik 6F 1 pt.	Pink- PF	1 ab	1 a	7 b			
	Captan 50W 2 lb	2C-4C				3 ab	22 a-d	1.4 ab
	Abound 2.08F 6 fl oz	SS-1C, 2&1PH						
8	Bravo Weather Stik 6F 1 pt.	Pink-PF	2 bc	3 a	2 ab			
	Captan 50W 2 lb	2C-4C				5 ab	42 de	3.2 ab
	Indar 75W 1 oz+ Tactic 4 fl oz	SS-1C, 2&1PH						
9	Bravo Weather Stik 6F 1 pt.	Pink- PF	4 c	3 a	5 ab			
	Captan 50W 2 lb	2C-4C				2 ab	20 a-c	6.3 ab
	Flint 50WG 1 oz	SS-1C, 2&1PH						
10	Indar 75W 1 oz+ Tactic 4 fl oz	P-1C, 2PH, 1PH	26 d	1 a	58 c			
	Captan 50W 2 lb	2C-4C				1 a	33 b-d	2.6 ab
11	Ziram Granuflo 76WDG 1.5 lb +							
	Tenn-Cop 5E 12 fl oz	Pink-PF	<1 ab	<1 a	1 ab			
	Ziram Granuflo 76WDG 1.5 lb +							
	Tenn-Cop 5E 8 fl oz	SS						
	Ziram Granuflo 76WDG 1.5 lb +							
	Tenn-Cop 5E 4 fl oz	1C-4C				4 ab	28 a-d	1.6 ab
	Indar 75W 1 oz + Tactic 4 fl oz	2PH, 1PH						

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

* Leaf curl was counted 16 May; **scab was rated on 40 Loring fruit and 50 Redgold fruit per rep at harvest. Treatments applied dilute to runoff at 300 psi as follows: 12 March (BS, bud swell, treatments #1-6 only, including Redhaven); later apps. to Loring and Redgold only: 9 April (P, pink); 17 April (full bloom); 24 April (PF, petal fall); 10 May (SS, shuck split); 1st-4th covers, 1C-4C, 24 May, 7 June, 25 June, and 9 July; Pre-harvest sprays (2PH, 31 Jul and 1PH, 9 Aug) were aimed at 2 weeks and 1 week before Loring harvest.

Table 11. Treatment effects on leaf curl and scab. Loring and Redhaven peach and Redgold nectarine

			Leaf curl strikes/tree*			Scab**		
						Loring	Redgold	
	Treatment and rate/100 gal dilute	Timing	Loring	Red haven	Redgold	% fruit	% fruit	lesions
0	No fungicide	—	28d	2a	133d	40c	92f	31.8c
1	Ferbam Granuflo 76WDG 2 lb	BS	0a	0a	0a			
	Captan 50W 2 lb (+Tactic 4 fl oz, 1C-4C)	P-4C				3ab	63e	7.8b
	Captan 50W 1 lb+							
	Indar 75W 0.5 oz + Tactic 4 fl oz	2 PH, 1PH						
2	Thiram Granuflo 2 lb (+Tactic 4 fl oz, 1-4C)	BS-4C	0a	0a	0a	1ab	26a-d	1.7ab
	Thiram Granuflo 75WDG 1 lb+							
	Indar 75W 0.5 oz + Tactic 4 fl oz	2PH, 1PH						
3	Thiram Granuflo 75WDG 1 lb+ COCS 2 lb	BS	0a	0a	0a			
	Thiram Granuflo 1 lb + Captan 50W1b +	P-4C				1a	28a-d	2.2ab
	(+Tactic 4 fl oz, 1C-4C)							
	Thiram Granuflo 1 lb+							
	Indar 75W 0.5 oz + Tactic 4 fl oz	2PH, 1PH						
4	Ziram Granuflo 2 lb (+Tactic 4 fl oz, 1C-4C)	BS-4C	0a	0a	0a	6b	35cd	2.7ab
	Thiram Granuflo 75WDG 1 lb+							
	Indar 75W 0.5 oz + Tactic 4 fl oz	2PH, 1PH						
5	COCS 50WDG 4lb	BS	0.6ab	0.0a	0.0a			
	Ziram Granuflo 76WDG 1.5 lb +							
	Kocide DF 12 oz	Pink-PF						
	Ziram Granuflo 76WDG 1.5 lb +							
	Kocide DF 8 oz	SS						
	Ziram Granuflo 76WDG 1.5 lb +							
	Kocide DF 4 oz	1C-4C				4ab	12ab	0.8a
	Indar 75W 1 oz + Tactic 4 fl oz	2PH, 1PH						
6	Bravo Weather Stik 6F 1 pt.	BS- PF	<1ab	0a	0a			
	Captan 50W 2 lb	2C-4C				3ab	11a	0.6a
	Abound 2.08F 6 fl oz	SS-1C, 2&1PH						
7	Bravo Weather Stik 6F 1 pt.	Pink- PF	1ab	1a	7b			
	Captan 50W 2 lb	2C-4C				3ab	22a-d	1.4ab
	Abound 2.08F 6 fl oz	SS-1C, 2&1PH						
8	Bravo Weather Stik 6F 1 pt.	Pink-PF	2bc	3a	2ab			
	Captan 50W 2 lb	2C-4C				5ab	42de	3.2ab
	Indar 75W 1 oz+ Tactic 4 fl oz	SS-1C, 2&1PH						
9	Bravo Weather Stik 6F 1 pt.	Pink- PF	4c	3a	5ab			
	Captan 50W 2 lb	2C-4C				2ab	20a-c	6.3ab
	Flint 50WG 1 oz	SS-1C, 2&1PH						
10	Indar 75W 1 oz+ Tactic 4 fl oz	P-1C, 2PH, 1PH	26d	1a	58c			
	Captan 50W 2 lb	2C-4C				1a	33b-d	2.6ab
11	Ziram Granuflo 76WDG 1.5 lb +							
	Tenn-Cop 5E 12 fl oz	Pink-PF	<1ab	<1a	1ab			
	Ziram Granuflo 76WDG 1.5 lb +							
	Tenn-Cop 5E 8 fl oz	SS						
	Ziram Granuflo 76WDG 1.5 lb +							
	Tenn-Cop 5E 4 fl oz	1C-4C				4ab	28a-d	1.6ab
	Indar 75W 1 oz + Tactic 4 fl oz	2PH, 1PH						

Averages of five single tree replications. Mean separation by Waller-Duncan K-ratio t-test (p=0.05).
* Leaf curl was counted 16 May; **scab was rated on 40 Loring fruit and 50 Redgold fruit per rep at harvest. Treatments applied dilute to runoff at 300 psi as follows: 12 March (BS, bud swell, treatments #1-6 only, including Redhaven); later apps. to Loring and Redgold only: 9 April (P, pink); 17 April (full bloom); 24 April (PF, petal fall); 10 May (SS, shuck split); 1st-4th covers, 1C-4C, 24 May, 7 June, 25 June, and 9 July; Pre-harvest sprays (2PH, 31 Jul and 1PH, 9 Aug) were aimed at 2 weeks and 1 week before Loring harvest.

Table 12. Treatment effects on postharvest rot development on Loring peach

		Non-inoculated fruit inf. / days incubation				Inoculated fruit inf. with brown rot after days incubation		
		% fruit with brown rot			Rhizopus,			
	Treatment, rate/100 gal dilute, and timing	3 days	6 days	8 days	8 days	3 days	6 days	8 days
0	No fungicide	80 d	100 f	100 f	3 a	97 d	100 d	100 e
1	Ferbam Granuflo 76WDG 2 lb, BS Captan 50W 2 lb, P-4C (+Tactic 4 fl oz, 1C-4C) Captan 50W 1 lb +Indar 75W 0.5 oz +Tactic 4 fl oz, 2PH & 1PH	4 bc	56 e	87 de	5 a	5 ab	66 c	94 cd
2	Thiram Granuflo 75WDG 2 lb, BS-4C (+Tactic 4 fl oz, 1C-4C), Thiram Granuflo 1 lb + Indar 75W 0.5 oz+Tactic 4 fl oz, 2PH & 1PH	6 bc	61 e	91 e	9 a	8 bc	70 c	93 c-e
3	Thiram Granuflo 75WDG 1 lb + COCS 50WDG 2 lb, BS Thiram Granuflo 1 lb +Captan 50W 1 lb, P-4C (+Tactic 4 fl oz, 1C-4C) Thiram Granuflo 1 lb + Indar 75W 0.5 oz +Tactic 4 fl oz, 2PH & 1PH	4 bc	55 e	87 c-e	3 a	4 ab	69 c	93 de
4	Ziram Granuflo76WDG 2 lb, BS-4C (+Tactic 4 fl oz, 1C-4C), Thiram Granuflo 1 lb + Indar 75W 0.5 oz + Tactic 4 fl oz, 2PH & 1PH	0 a	53 de	88 de	6 a	2 ab	72 c	93 cd
5	COCS 50WDG 4lb, BS Ziram Granuflo 76WDG 1.5 lb + Kocide DF 12 oz, Pink-PF Ziram Granuflo 76WDG 1.5 lb + Kocide DF 8 oz, SS Ziram Granuflo 76WDG 1.5 lb + Kocide DF 4 oz, 1C-4C Indar 75W 1 oz + Tactic 4 fl oz, 2PH & 1PH	0 a	5 a	19 a	3 a	1 a	5 a	18 a
6	Bravo Weather Stik 6F 1 pt, BS- PF Captan 50W 2 lb, 2C-4C Abound 2.08F 6 fl oz, SS-1C, 2PH & 1PH	0 a	21 b	71 bc	3 a	1 a	55 bc	89 b-d
7	Bravo Weather Stik 6F 1 pt, P-PF Captan 50W 2 lb, 2C-4C Abound 2.08F 6 fl oz, SS-1C, 2PH & 1PH	0 a	49 de	80 c-e	10 a	1 a	53 bc	89 b-d
8	Bravo Weather Stik 6F 1 pt, P- PF Captan 50W 2 lb, 2C-4C Indar 75W 1 oz+ Tactic 4 fl oz, SS-1C, 2PH & 1PH	0 a	32 bc	75 b-d	10 a	3 ab	54 bc	93 de
9	Bravo Weather Stik 6F 1 pt, P-PF Captan 50W 2 lb, 2C-4C Flint 50WG 1 oz, SS-1C, 2PH & 1PH	9 c	57 e	86 de	3 a	15 c	63 bc	90 cd
10	Indar 75W 1 oz+ Tactic 4 fl oz, P-1C, 2PH & 1PH Captan 50W 2 lb, 2C-4C	1 ab	39 cd	79 c-e	0 a	0 a	55 bc	80 bc
11	Ziram Granuflo 76WDG 1.5 lb + Tenn-Cop 5E 12 fl oz, P-PF Ziram Granuflo 76WDG 1.5 lb + Tenn-Cop 5E 8 fl oz, SS Ziram Granuflo 76WDG 1.5 lb + Tenn-Cop 5E 4 fl oz, 1C-4C Indar 75W 1 oz + Tactic 4 fl oz, 2PH & 1PH	1 ab	30 bc	60 b	2 a	2 ab	44 b	78 b

Averages of five single tree replications. Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Treatments applied dilute to runoff at 300 psi as follows: 12 March (BS, bud swell, treatments #1-6 only, including Redhaven); later apps. to Loring and Redgold only: 9 April (P, pink); 17 April (full bloom); 24 April (PF, petal fall); 10 May (SS, shuck split); 1st-4th covers, 1C-4C, 24 May, 7 June, 25 June, and 9 July; Pre-harvest sprays (2PH, 31 Jul and 1PH, 9 Aug) were aimed at 2 weeks and 1 week before Loring harvest. Actual harvest date for Loring was 14 Aug, 5 days after the last application.

Table 13. Treatment effects on postharvest brown rot development on Redgold nectarine

		% of fruit with brown rot or not rotted after indicated days incubation postharvest										
		% rot	Samples harvested 17 Aug					Samples harvested 20 Aug				
		on tree	% fruit with brown rot				No rot	% fruit with brown rot				No rot
	Treatment, rate/100 gal dilute, and timing	16 Aug	5 days	6 days	7 days	9 days	10 days	3 days	4 days	6 days	8 days	8 days
0	No fungicide	93 e	--	--	--	--	--	--	--	--	--	--
1	Ferbam Granuflo 76WDG 2 lb, BS Captan 50W 2 lb, P-4C (+Tactic 4 fl oz, 1C-4C) Captan 50W 1 lb +Indar 75W 0.5 oz +Tactic 4 fl oz, 2PH & 1PH	5 b-d	31 b	50 c	67 c	78 e	2 c	15 c	24 c	58 d	76 d	3 e
2	Thiram Granuflo 75WDG 2 lb, BS-4C (+Tactic 4 fl oz, 1C-4C), Thiram Granuflo 1 lb + Indar 75W 0.5 oz+Tactic 4 fl oz, 2PH & 1PH	2 a-c	10 ab	17 a-c	29 ab	51 b-d	41 ab	3 ab	3 ab	26 ab	44 c	23 cd
3	Thiram Granuflo 75WDG 1 lb + COCS 50WDG 2 lb, BS Thiram Granuflo 1 lb +Captan 50W 1 lb, P-4C (+Tactic 4 fl oz, 1C-4C) Thiram Granuflo 1 lb + Indar 75W 0.5 oz +Tactic 4 fl oz, 2PH & 1PH	3 a-c	11 ab	26 a-c	36 a-c	64 c-e	22 b	2 ab	6 ab	28 a-c	44 c	20 cd
4	Ziram Granuflo76WDG 2 lb, BS-4C (+Tactic 4 fl oz, 1C-4C), Thiram Granuflo 1 lb + Indar 75W 0.5 oz + Tactic 4 fl oz, 2PH & 1PH	8 d	12 ab	23 a-c	30 ab	54 b-e	18 b	5 ab	7 ab	36 a-c	38 bc	15 d
5	COCS 50WDG 4lb, BS Ziram Granuflo 76WDG 1.5 lb + Kocide DF 12 oz, Pink-PF Ziram Granuflo 76WDG 1.5 lb + Kocide DF 8 oz, SS Ziram Granuflo 76WDG 1.5 lb + Kocide DF 4 oz, 1C-4C Indar 75W 1 oz + Tactic 4 fl oz, 2PH & 1PH	3 ab	4 a	6 a	17 a	28 ab	56 a	1 ab	1 a	11 a	23 ab	67 a
6	Bravo Weather Stik 6F 1 pt, BS- PF Captan 50W 2 lb, 2C-4C Abound 2.08F 6 fl oz, SS-1C, 2PH & 1PH	3 a-d	10 ab	23 a-c	31 ab	58 c-e	33 ab	0 a	10 a-c	52 cd	72 d	14 de
7	Bravo Weather Stik 6F 1 pt, P-PF Captan 50W 2 lb, 2C-4C Abound 2.08F 6 fl oz, SS-1C, 2PH & 1PH	3 a-c	9 ab	19 a-c	31 ab	49 b-d	34 ab	1 ab	13 bc	45 b-d	75 d	15 d
8	Bravo Weather Stik 6F 1 pt, P- PF Captan 50W 2 lb, 2C-4C Indar 75W 1 oz+ Tactic 4 fl oz, SS-1C, 2PH & 1PH	<1 a	3 a	15 ab	25 ab	35 a-c	42 ab	1 ab	5 ab	21 a	20 a	52 ab
9	Bravo Weather Stik 6F 1 pt, P-PF Captan 50W 2 lb, 2C-4C Flint 50WG 1 oz, SS-1C, 2PH & 1PH	7 cd	17 ab	37 bc	49 bc	62 de	25 b	6 b	24 c	62 d	77 d	17 d
10	Indar 75W 1 oz+ Tactic 4 fl oz, P-1C, 2PH & 1PH Captan 50W 2 lb, 2C-4C	2 ab	5 ab	6 a	10 a	15 a	47 ab	0 a	1 a	18 a	37 bc	40 bc
11	Ziram Granuflo 76WDG 1.5 lb + Tenn-Cop 5E 12 fl oz, P-PF Ziram Granuflo 76WDG 1.5 lb + Tenn-Cop 5E 8 fl oz, SS Ziram Granuflo 76WDG 1.5 lb + Tenn-Cop 5E 4 fl oz, 1C-4C Indar 75W 1 oz + Tactic 4 fl oz, 2PH & 1PH	4 b-d	9 ab	32 a-c	40 a-c	53 b-e	24 b	1 ab	0 a	24 ab	42 bc	30 b-d

Averages of five single tree replications. Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Treatments applied dilute to runoff at 300 psi as follows: 12 March (BS, bud swell, treatments #1-6 only, including Redhaven; later apps. to Loring and Redgold only: 9 April (P, pink); 17 April (full bloom); 24 April (PF, petal fall); 10 May (SS, shuck split); 1st-4th covers, 1C-4C, 24 May, 7 June, 25 June, and 9 July; Pre-harvest sprays (2PH, 31 Jul and 1PH, 9 Aug) Redgold harvest dates 17 and 20 Aug, were 8 and 11 days after the last application.

PEACH (*Prunus persica* 'Loring')
Brown rot; *Monilinia fructicola*)
Rhizopus rot; *Rhizopus sp.*

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Effectiveness of Scholar as a post-harvest dip treatment on Loring peaches, 2001. An experiment was conducted to test the effectiveness of fludioxonil (Scholar 50W) as a post-harvest dip treatment on brown rot and Rhizopus rot. Uniformly ripe fruit, all of which had been treated with Thiram during the cover spray period and Indar + Thiram 18 and 8 days before harvest, were picked at advanced ripeness, sorted into experimental units of 15 fruit, placed on fiber packing trays. Each replicate unit was dipped into the fungicide treatment 5 sec. and placed on the trays to dry. When dry, fruit were inoculated with the indicated inoculum by misting with a suspension containing 20,000 *M. fructicola* conidia/ml or 10,000 spores/ml of *Rhizopus*. The inoculum had been prepared by trying to select fruit in the orchard which appeared to be primarily infected with the indicated fungus. Brown rot conidia were re-suspended from a frozen suspension which had been prepared earlier, and was standardized to 2X10^4 conidia per ml. Rhizopus inoculum was made up fresh and was standardized to 1X10^4 conidia per ml. All were incubated in polyethylene bags at ambient temperature 22-30C (mean 26.1C) for the indicated interval before assessing rot development.

Treatment and rate/100 gal	Post-harvest inoculum	% fruit with brown rot, days after treatment			% fruit with Rhizopus, days after treatment			% fruit healthy
		3 days	5 days	6 days	3 days	5 days	6 days	6 days
Water dip	None	15 a	43 c	65 c	0 a	10 bc	15 bc	17 bc
Scholar 50W 8 oz	None	0 a	2 ab	3 a	0 a	0 a	2 ab	87 a
Water dip	Monilinia	3 a	10 b	23 b	13 b	33 d	53 d	25 b
Scholar 50W 8 oz	Monilinia	0 a	0 a	0 a	0 a	0 a	0 a	97 a
Water dip	Rhizopus	2 a	35 c	62 c	12 b	22 cd	32 cd	5 c
Scholar 50W 8 oz	Rhizopus	0 a	0 a	3 a	0 a	3 ab	2 ab	88 a

Four replications, 15 fruit/rep. Mean separation by Waller-Duncan K-ratio t-test (p=0.05).

Compared to the water dip treatment, Scholar still gave good suppression of *Monilinia* and *Rhizopus* after 6 days incubation. Intentional inoculation of fruit with *Rhizopus* increased *Rhizopus* incidence following inoculation, but the effort to inoculate fruit with M. fructicola actually resulted in significantly less brown rot incidence on water-treated fruit. The misting with the brown rot inoculum did increase the amount of *Rhizopus*, apparently because the inoculum source fruit from the orchard also contained *Rhizopus*.

APPLE (*Malus domestica* 'Golden Delicious')
Scab; *Venturia inaequalis*
Powdery mildew; *Podosphaera leucotricha*
Brooks fruit spot; *Mycosphaerella pomi*
Sooty blotch; disease complex
Fly speck; *Zygophiala jamaicensis*
Rot spots (unidentified)
Fruit russet

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CONCENTRATE APPLICATIONS OF EXPERIMENTAL FUNGICIDES AND MIXTURES ON GOLDEN DELICIOUS APPLE, 2001: Sixteen treatments involving experimental compounds, mixtures with Sovran and the protectants captan and ziram were compared on 29-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: 13 Apr (TC, tight cluster); 23 Apr (Bl, pink-bloom); first – 6th covers (1C-6C): 9 May, 23 May, 6 June, 13 June, 3 July, and 25 July. The 6 June applications were interrupted by an unexpected shower before trt. #9 had dried. After weather cleared this treatment was re-applied and thre remaining treatments, #10-16, were also applied. The next application interval was shortened to 7 days to help compensate for any application inconsistencies. Insecticides applied to the entire test block with the same equipment included Ambush, Lannate LV, Imidan 70WSB and Provado. Cedar rust galls, quince rust cankers and bitter rot mummies were placed over each test tree 19 Apr and wild blackberry canes with the sooty blotch and flyspeck fungi were placed over each test tree 12 June. Foliar data represent averages of counts of all leaves on 10 terminal shoots from each of four replicate trees 10 July. A 25-fruit sample from each replicate tree was harvested 26 Sep and rated after 33 days' storage at 1C.

Although scab pressure was low due to delayed primary infection, results were quite uniform. With ziram and the lower rate of captan, slight but statistically significant weaknesses were noted with foliar scab compared to more effective treatments; fruit scab control was significantly weaker with ziram than captan at 6 lb/A. Under low mildew susceptibility but favorable early season weather conditions, the higher rate of BAS 516 was the most effective mildew treatment; the lower rate gave significantly weaker control. Treatments involving higher rates and more frequent applications of Sovran generally gave better mildew control. Cumulative wetting hours in May and June resulted in heavy summer disease pressure and the appearance of sooty blotch by 9 July. While all treatments gave significant suppression of Brooks spot, sooty blotch, flyspeck and rot spots, BAS 516 gave superior control of these diseases. The 3 lb/A rate of ziram was significantly weaker on sooty blotch, flyspeck and rot spots than 6 lb/A, but captan and ziram were comparable at 6 lb/A. Sovran 3 oz + captan 3 lb gave significantly stronger control of sooty blotch and flyspeck than Sovran 3 oz + ziram 3 lb. MANA 131, compared to captan at equivalent ai rates, resulted in numerically better, but not significantly different than captan alone or in combination with Sovran 1.5 oz/A. Control of sooty blotch and flyspeck was comparable by Sovran 4 oz/A and captan or MANA 131; supplementing the lower rate of MANA 131 with Sovran 1.5 oz/A acre significantly improved control of both sooty blotch and flyspeck. There were no significant effect on fruit finish (russet) between any treatments or treated versus non-treated trees (p=0.05).

Table 3. Early and late season disease control by experimental fungicides and mixtures on Golden Delicious apple

			Scab, %		Powdery mildew		Brooks	Sooty blotch		Flyspeck		% rot
	Treatment and rate/acre	Timing	lvs. inf.	fruit	% lvs. inf.	% area	spot	% fruit	% area	% fruit	% area	spots
0	No fungicide	---	11 d	22 d	32 h	8 g	10 c	100 h	26 f	99 h	5 f	40 e
1	MANA 131 80WDG 3.75 lb	TC-6C	<1 ab	1 ab	14 d-g	2 c-f	2 ab	40 c-e	7 c-e	27 c-e	1 b-d	0 a
2	MANA 131 80WDG 1.88 lb	TC-6C	<1 ab	2 ab	16 g	3 ef	0 a	59 e-g	9 de	50 e-g	3 d-f	1 ab
3	Captan 50W 6 lb	TC-6C	<1 ab	2 ab	13 e-g	2 d-f	3 ab	51 d-f	8 c-e	33 d-f	2 c-e	1 ab
4	Captan 50W 3 lb	TC-6C	1 b	3 b	20 g	3.3 f	2 ab	75 fg	11 e	57 fg	4 ef	2 a-c
5	Sovran 50WG 1.5 oz + MANA 131 80WDG 1.88 lb	TC-6C	0 a	1 ab	13 d-g	2 b-f	0 a	25 b-d	4 b-d	18 b-d	<1 a-c	0 a
6	Sovran 50WG 3.0 oz + Captan 50W 3 lb	TC-6C	<1 ab	1 ab	6 a-d	1 a-d	0 a	24 bc	4 bc	9 a-c	<1 ab	0 a
7	Sovran 50WG 1.5 oz + Captan 50W 3 lb	TC-6C	<1 ab	0 a	7 a-e	1 a-e	3 b	45 c-e	6 c-e	34 d-f	2 cd	2 a-c
8	Sovran 50WG 3.0 oz	TC-P, PF-1C	<1 ab	1 ab	11 c-g	2 b-f						
	Captan 50W 6 lb	Bl										
	Captan 50W 3 lb+ Benlate 6 oz	2C-6C					0 a	53 d-f	10 de	32 d-f	2 b-d	1 ab
9	Captan 50W 6 lb	TC-pink	<1 ab	3 b	12 c-g	2 c-f						
	Sovran 50WG 3.0 oz	Bl-1C										
	Captan 50W 3 lb+ Benlate 6 oz	2C-6C					1 ab	47 c-f	7 c-e	35 d-f	2 cd	8 cd
10	Ziram Granuflo 76WDG 6 lb	TC-6C	3 c	6 c	18 g	3 ef	2 ab	45 c-e	7 c-e	32 d-f	1 b-d	3 a-c
11	Ziram Granuflo 76WDG 3 lb	TC-6C	3 c	1 ab	15 fg	2 d-f	0 a	80 g	20 f	69 g	4 f	10 d
12	Sovran 50WG 3.0 oz + Ziram Granuflo 76WDG 3.0 lb	TC-6C	0 a	0 a	4 ab	<1 a-c	3 ab	64 e-g	9 de	43 d-f	2 c-e	5 cd
13	Sovran 50WG 3.0 oz + Polyram 80DF 3.0 lb	TC–2C	0 a	0 a	5 a-c	<1 a-d	0 a					
	Sovran 50WG 3.0 oz + Ziram Granuflo 76WDG 3.0 lb	3C-6C						53 d-f	6 c-e	28 c-e	1 b-d	1 ab
14	Sovran 50WG 4.0 oz	TC-6C	0 a	0 a	4 ab	<1 ab	0 a	62 e-g	7 c-e	32 c-e	2 b-d	4 b-d
15	BAS 516 UD F 38% 14.7 oz	TC-6C	0 a	0 a	3 a	<1 a	0 ab	4 a	<1 a	3 a	<1 a	0 a
16	BAS 516 UD F 38% 8.4 oz	TC-6C	0 a	1 ab	8 b-f	2 a-e	1 ab	7 ab	<1 ab	6 ab	<1 a	0 a

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Means of four single-tree replications. Foliar counts based on ten terminal shoots from each of four single-tree reps 10 July. Post-harvest counts of 25 fruit per single-tree rep 29 Oct after 33 days cold storage. Treatments dates: 13 Apr (TC, tight cluster); 23 Apr (Bl, pink-bloom); first – 6th covers (1C-6C): 9 May, 23 May, 6 June, 13 June, 3 July, and 25 July (Note: 6 June applications were interrupted by an unexpected shower before trt. 9 had dried. After weather cleared this treatment was re-applied and the re remaining treatments, #10-16, were also applied. The next application interval was shortened to 7 days to help compensate for any application inconsistencies).

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

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COMPARISON OF EXPERIMENTAL AND STROBILURIN FUNGICIDES ON RED DELICIOUS APPLE, 2001: Ten treatments involving three experimental materials were compared to recently registered strobilurin compounds and Nova on 24-yr-old trees. The test was conducted in a randomized block design with four single-tree replicates separated by untreated border rows between treatment rows. Tree-row-volume was determined to require a 400 gal/A dilute base for adequate spray coverage. 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: 13 Apr (OC, open cluster); 26 April (petal fall); 1st-3rd covers(1C-3C) 10 May, 24 May, and 8 June. Treatments #1-15 were covered with Captan 50W 5 lb/A 10 July. Insecticides applied to the entire test block with the same equipment included Ambush, Lannate LV, Imidan 70WSB, Provado and Sevin XLR (applied with Ethrel as a thinner). All 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 7 Aug. A 25-fruit sample from each replicate tree was harvested 24 Sep and rated after 43 days' storage at 1C.

Early scab pressure was low due to delayed primary infection, but more fruit infection occurred with secondary infection periods the last two weeks in May. All treatments gave excellent scab control, with no significant differences between treatments. Mildew pressure was also light on the relatively non-susceptible Red Delicious cultivar. Nearly all treatments gave significant mildew control and the standard Nova was most effective. There were trends toward rate effects on mildew with XF-00049 and XF-00182 for mildew control but not for XF-00183. Cumulative wetting hours in May and June resulted in strong summer disease pressure and some sooty blotch development by 9 July. This test was aimed primarily at scab control and the treatments (excluding non-treated trees) were covered with captan 10 July, but XF-00049 and XF-00182, last applied 8 June, still gave rate responses on harvested fruit indicating activity against sooty blotch and flyspeck comparable to commercial rates of Flint and Sovran. All treatments suppressed "rot spot" development which was relatively light under these test conditions. Although there were minor differences in fruit russet or opalescence, there were no significant treatment effects compared to non-treated fruit.

Table 4. Comparison of experimental and strobilurin fungicides on Redspur Delicious

Treatment and		Scab infection		Mildew infection		Sooty blotch		Flyspeck		% fruit with rot	Finish ratings *	
formulation rate per acre*	Timing	leaves	fruit	% lvs	% area	% fruit	% area	% fruit	% area	spots	Opal-esence	russet
0 No fungicide	---	9 b	25 b	16 d	2 d	82 d	10 e	70 f	4 g	6 b	0.8 ab	0.6 ab
1 XF-00049 1SC 84 ml	OC-3C	1 a	0 a	8 cd	2 cd	33 a-c	3 a-d	31 de	2 ef	0 a	1.3 b	1.1 ab
2 XF-00049 1SC 168 ml	OC-3C	<1 a	2 a	4 a-c	<1 a-d	16 a	1 a	19 a-e	<1 a-d	0 a	0.8 ab	0.7 ab
3 XF-00049 1SC 252 ml	OC-3C	<1 a	1 a	3 a-c	1 a-d	18 a	1 a	10 a	<1 a	0 a	1.2 b	1.0 ab
4 XF-00183 1EC 84 ml	OC-3C	1 a	1 a	3 a-c	<1 a-d	32 a-c	3 b-d	33 de	2 f	0 a	1.0 ab	0.8 ab
5 XF-00183 1EC 168 ml	OC-3C	<1 a	0 a	6 a-c	2 a-d	41 bc	4 cd	22 a-e	1 b-f	0 a	1.0 ab	1.1 b
6 XF-00183 1EC 252 ml	OC-3C	<1 a	0 a	3 a-c	1 a-d	31 a-c	2 a-d	27 c-e	1 c-f	0 a	0.8 ab	0.7 ab
7 XF-00182 1EC 42 ml	OC-3C	2 a	0 a	4 a-c	1 a-d	48 c	4 d	23 b-e	1 b-f	0 a	1.0 ab	0.9 ab
8 XF-00182 1EC 84 ml	OC-3C	<1 a	0 a	5 a-c	1 a-d	32 a-c	2 a-d	26 c-e	1 c-f	1 a	0.9 ab	0.8 ab
9 XF-00182 1EC 168 ml	OC-3C	<1 a	0 a	6 bc	1 b-d	17 a	1 ab	22 a-e	1 b-f	0 a	0.9 ab	0.8 ab
10 XF-00182 1EC 252 ml	OC-3C	<1 a	1 a	2 ab	<1 a-c	28 ab	2 a-d	17 a-c	<1 a-c	0 a	0.7 a	0.6 a
11 Flint 50WG 20 g	OC-3C	2 a	2 a	3 a-c	<1 a-d	32 a-c	2 a-d	37 e	2 f	1 a	1.0 ab	0.9 ab
12 Flint 50WG 40 g	OC-3C	1 a	0 a	3 a-c	<1 a-c	40 bc	3 cd	33 de	2 d-f	1 a	1.0 ab	0.8 ab
13 Flint 50WG 60 g (2.1 oz)	OC-3C	<1 a	0 a	2 ab	<1 ab	26 ab	2 a-c	10 ab	<1 ab	0 a	0.8 ab	0.7 ab
14 Nova 40W 142 g (5 oz)	OC-3C	<1 a	0 a	<1 a	<1 a	40 bc	3 b-d	32 de	2 d-f	1 a	0.9 ab	0.8 ab
15 Sovran 50WG 120 g (4.2oz)	OC-3C	<1 a	3 a	3 a-c	<1 a-c	27 ab	2 a-d	17 a-d	<1 a-e	1 a	1.0 ab	0.9 ab

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Means of four single-tree replications.
Foliar counts represent averages of ten terminal shoots from each of four single-tree replications 2 July.
Post-harvest counts of 25 fruit per single-tree rep 29 Oct after 33 days cold storage.
* Fruit finish 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: 13 Apr (OC, open cluster); 26 April (petal fall); 1st-3rd covers(1C-3C) 10 May, 24 May, and 8 June. Treatments #1-15 were covered with Captan 50W 5 lb/A 10 July.

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

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SEASON-LONG EVALUATION OF BIO-CONTROL, OIL-RELATED AND CONVENTIONAL MATERIALS FOR DISEASE CONTROL ON IDARED APPLE, 2001: Eight treatments involving bio-control, oil-related and conventional materials were evaluated for control of powdery mildew and summer diseases on 19-yr-old trees. The test was conducted in a randomized block design with four single-tree replicates separated by border trees in the row and by border rows between treatment rows. The test rows were not treated with mildewcides in 2000. 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: 24 Apr (Bl, bloom, all treatments); 2 May (PF, petal fall); 1st–7th covers (1C-7C): 10 May, 24 May, 5 June, 26 June, 10 July, 31 July and 29 Aug. Note: The Syllit rate in the first application of treatment #4 was 1.0 oz/A. Border rows were treated with dilute applications of Bayleton 50DF 0.5 oz /100 gal 26 Apr, 4 May, 14 May, 23 May, 6 June, 25 June. Other applications applied to the entire test block with the same equipment included Ambush, Lannate LV, Imidan and Provado. Bitter rot mummies and wild blackberry canes with the sooty blotch and fly speck fungi were placed over each test tree 13 June. Other diseases developed from inoculum naturally present in the test area. Foliar data represent averages of counts of all leaves on 10 terminal shoots from each of four replicate trees 22 Jun. A 25-fruit sample was harvested from each replicate tree 26 Sept and rated after 33 days' storage at 1C. Percentage data were converted by the square root arcsin transformation for statistical analysis.

Mildew inoculum was high on this susceptible cultivar and 18 days were favorable for infection from mid-April to mid-May. Under heavy mildew pressure, all treatments reduced mildew incidence and % foliage area infected compared to non-treated trees and those treated only with water. Nova gave the best mildew control on foliage and effectively reduced mildew infection of fruit. AQ10 alternated with Flint + sulfur was more effective for foliar mildew control than sulfur alone. Accumulation of wetting hours in May and June resulted in heavy summer disease pressure and the appearance of sooty blotch by 9 July. All treatments gave significant suppression of sooty blotch and flyspeck with captan + ziram giving superior control of these diseases. Significant differences in the amounts of sooty blotch on treatments #2-6 apparently were related to the material used before 4th^{h} cover when all of these treatments were switched to Basic Copper. Flint + sulfur included at 2nd cover followed by AQ10 at 3rd cover (Trt. #3) and AQ10 (Trt. #2) or AQ10 + Syllit (Trt. #4) alternated with sulfur were significantly more effective than sulfur (Trt. #6) or Trilogy (Trt. #5) applied alone through 3rd cover. Similar trends but not as statistically significant were observed with flyspeck. JMS Stylet Oil was weaker for sooty blotch and flyspeck control than captan + ziram and several schedules followed by copper. The water spray, applied at the same time as all other treatments, reduced flyspeck incidence but did not significantly affect any other disease. All treatments but Trilogy followed by Basic Copper suppressed rot spot development; Captan + ziram and the schedule involving AQ10 // Flint followed by Basic Copper suppressed Brooks spot. No treatments significantly affected fruit finish compared to non-treated trees, but Nova+ Dithane // captan + ziram (Trt. #1), sulfur (Trt. #6) and AQ10 + Syllit // sulfur (Trt.#4) had significantly less opalescence than fruit treated with water.

Table 5. Powdery mildew and summer disease management by bio-control, oil-related and conventional fungicides on Idared apple

			Mildew infection (%)				Sooty blotch		Flyspeck				Fruit finish rating (0-5) *	
	Treatment and rate/A	Timing	% leaves	leaf area	% fruit	fruit area	% fruit	fruit area	% fruit	fruit area	Brooks spot %	% rot spots	russet	opal
0	No fungicide	---	88 e	95 e	91 b	14 b	97 e	15 c	77 d	5 e	10 b	18 d	0.9 a	1.1 a-c
1	Nova 40W 4 oz + Dithane RSNT 75DF 3 lb	Bl – 3C	13 a	3 a	66 a	9 a							0.7 a	0.8 a
	Captan 50W 3 lb + Ziram 76DF 3 lb	4C – 7C					4 a	1 a	2 a	<1 a	0 a	0 a		
2	AQ10 1.0 oz + Nu-Film 17 1.0 pt //	Bl, 1C, 3C	43 bc	11 ab	82 ab	15 bc							1.2 a	1.3 a-c
	Microfine Sulfur 95W 8.0 lb	PF, 2C												
	Basic Copper "53" 4 lb + Hydrated Lime 8 lb	4C – 7C					19 b	1 a	10 ab	<1 a-c	1 ab	0 a		
3	AQ10 1.0 oz + Nu-Film 17 1.0 pt //	Bl, 1C, 3C	32 b	8 ab	78 ab	13 ab							0.8 a	1.0 a-c
	Flint 50WG 1.5 oz + Microfine Sulfur 95W 4.0 lb	PF, 2C												
	Basic Copper "53" 4 lb + Hydrated Lime 8 lb	4C – 7C					11 b	1 a	2 a	<1 ab	0 a	1 a		
4	AQ10 1.0 oz + Syllit 65W 1.0 lb* + Nu-Film 17 1.0 pt //	Bl, 1C, 3C	53 cd	30 c	72 a	10 ab							1.0 a	1.0 ab
	Microfine Sulfur 95W 8.0 lb	PF, 2C												
	Basic Copper "53" 4 lb + Hydrated Lime 8 lb	4C – 7C					16 b	1 a	18 b	<1 c	1 ab	1 a		
5	Trilogy 4.0 qt	Bl – 3C	64 d	59 d	85 ab	21 c							1.2 a	1.5 bc
	Basic Copper "53" 4 lb + Hydrated Lime 8 lb	4C – 7C					56 d	5 b	11 b	<1 c	3 ab	11 cd		
6	Microfine Sulfur 95W 8.0 lb	Bl – 3C	50 cd	21 bc	68 a	11 ab							0.7 a	0.9 ab
	Basic Copper "53" 4 lb + Hydrated Lime 8 lb	4C – 7C					37 c	4 b	12 b	<1 bc	6 ab	3 ab		
7	JMS Stylet Oil 5.0 qt	Bl – 2C	59 cd	41 cd	76 a	12 ab							1.1 a	1.3 a-c
	JMS Stylet Oil 6.0 qt	4C – 7C					61 d	6 b	40 c	2 d	3 ab	4 a-c		
8	Water spray	Bl – 7C	85 e	95 e	83 ab	12 ab	92 e	14 c	51 c	3 d	3 ab	12 b-d	1.3 a	1.6 c

Mean separation by Waller-Duncan K-ratio t-test (p=0.05). Foliar counts of ten terminal shoots from each of four single-tree reps 22 Jun, or a 25-fruit sample from each replicate tree was harvested 25 Sept and rated after 33 days' storage at 1C.

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

Treatments applied to both sides of the tree on each indicated application date with a Swanson Model DA-400 airblast sprayer at 100 gal/A as follows: 24 Apr (Bl, bloom, all treatments); 2 May (PF, petal fall); 1st–7th covers (1C-7C): 10 May, 24 May, 5 June, 26 June, 10 July, 31 July and 29 Aug. * Note: Syllit rate in first application was 1.0 oz/A.

PEACH DISEASE CONTROL USING STROBILURIN, STEROL INHIBITOR, AND ANILINOPYRIMIDINE FUNGICIDES

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Fungicide application timing for management of peach rusty spot and scab overlap considerably. However, there is currently no one fungicide that can control both diseases. In this experiment, strobilurin (Abound) and sterol inhibitor fungicides (Elite and Indar) were compared for efficacy against these two diseases. An Abound – Bravo alternation treatment was also examined. In addition, the anilinopyrimidine Vangard was compared to (i) Abound and Rovral for early season management of blossom blight and (ii) the sterol inhibitors Elite, Orbit, and Indar for preharvest brown rot control.

MATERIALS AND METHODS

Treatments. The test block consisted of 6-year old 'Autumnglo' trees planted at 25 ft x 25 ft row spacing. Treatments were replicated four times in a randomized complete block design with single tree plots. Non-sprayed buffer trees surrounded treatment trees. A Rears Pak-Blast-Plot airblast sprayer calibrated to deliver 100 gal/A at 100 psi traveling at 2.1 mph was used to apply the fungicides.

Treatment applications were made on the following dates and tree growth stages: 14 Apr (P, pink); 24 Apr (B, bloom); 2 May (PF, petal fall); 10 May (SS, shuck split); and 23 May, 5, 19 Jun, 2, 23, Jul (1C-5C, first-fifth cover). Two applications were made for fruit rot control: 13 and 22 Aug (17 and 8 days preharvest (PH)). Insecticides and miticides were applied as needed to the entire block using a commercial airblast sprayer.

Environment. Weather conditions were favorable for scab. A total of 17 rain periods >0.10 in occurred from bloom on 24 Apr. to 22 Jul. The number of rain periods following each spray after bloom were: B, 0; PF, 0; SS, 3; 1C, 4; 2C, 4; 3C, 1; and 4C, 5. Conditions were also favorable for the development of brown rot during the preharvest ripening period. A total of 5 rain periods >0.10 in occurred during the 21 days prior to harvest: 11 Aug (0.54 in); 12 Aug (0.44 in); 14 Aug (0.12 in); 19 Aug (0.47 in); and 27 Aug (1.0 in). One rain period occurred between the early and late harvests on 4 Sep (0.31 in).

Assessment. Blossom blight (*Monilinia fructicola*) was evaluated on 11 Jun by examining 40 fruit bearing shoots. Rusty spot (*Podosphaera leucotricha?*) was evaluated on 15 Jun by examining 50 fruit per tree. Scab (*Cladosporium carpophilum*) incidence was evaluated on 30 Aug by examining 50 fruit per tree. Brown rot (*M. fructicola*) incidence was evaluated at early (30 Aug) and late harvest (5-6 Sep) by examining all fruit on two or more branches per replicate tree; a minimum of 100 fruit per tree was examined at both harvests.

RESULTS AND DISCUSSION

Rusty Spot. Rusty spot incidence was moderately severe with 43% of the non-treated fruit infected (Table 1). Of the fungicides applied during the critical PF to 2C timings, Elite and Indar had significantly less disease incidence than the control, although neither kept fruit infection below 5%. Abound alone or in combination with Bravo did not provide adequate management of rusty spot.

Scab. Scab incidence was 100% on non-treated fruit with 99% of these fruit having more than 10 lesions (Table 2). Under these severe conditions, none of the treatments provided acceptable control. Typically, the critical scab control period in NJ occurs between SS and 3C. However, in 2001, the high incidence of scab was likely due to late-season infection when all treatments were receiving Captan sprays at extended intervals. A total of five rains occurred during the 21-days between 4C and 5C sprays.

Brown Rot. Brown rot infection pressure was low to moderate (Table 3). At early harvest, approximately 17% fruit infection was observed on non-sprayed trees, which increased to 44% by late harvest (6-7 days later). Under these conditions, all preharvest fungicide treatments of Elite, Orbit, Vangard, and Indar provided excellent and equivalent brown rot control, maintaining disease well below 5%. Blossom blight infection levels were very low, attaining only 5.6% canker development on control trees.

CONCLUSIONS

1. Although Elite and Indar significantly reduced rusty spot, neither material appeared as effective as Nova. In other experiments on the same cultivar, Nova has attained higher levels of control under more severe infection pressure. Nevertheless, these materials (Elite in particular) should provide adequate protection for orchards that regularly experience low levels of fruit infection.

2. Peach scab control was poor for all treatments, including Abound and/or Bravo, which have given good to excellent control in past experiments. Unusual late season infection periods may be responsible for this uniform lack of control. At this time, spray intervals were longer and all treatments were receiving Captan. Consequently, in future studies, consideration should be given to application of test materials during these late cover sprays, or using Captan at higher rates and/or shorter intervals.

3. Although brown rot disease pressure was low to moderate, Vangard performed as well as the sterol inhibitors Elite, Orbit, and Indar. Vangard's excellent performance was maintained even at late harvest, which occurred 14-15 days after the final preharvest spray. Past studies (1999) have shown good post-harvest brown rot control with Vangard when applied as the final spray (following Orbit). These results suggest that Vangard, currently only registered for brown rot control in California, may be useful for eastern U.S. orchards as well. Its different chemistry would be beneficial for resistance management, integrating well with both sterol inhibitors and strobilurins.

TABLE 1. Peach Rusty Spot Incidence and Severity[1]				
Treatment[2]	**Rate / A**	**Timing**	**% Infected fruit[3]**	**# Lesions / fruit[3]**
Nontreated control	———	———	43.0 a	0.77 a
Rovral 4F **Elite 45DF + Induce** Captan 50WP Elite 45DF + Induce	1.5 pt **6.0 oz** 4.0 lb 6.0 oz	P, B **PF, SS, 1C, 2C, 3C** 4C, 5C 17, 8 PH	10.5 c	0.14 d
Vangard 75 WG Orbit 3.6 EC **Abound 2.08SC** Captan 50WP Orbit 3.6 EC	5.0 oz 4.0 fl oz **12.8 fl oz** 4.0 lb 4.0 fl oz	P B **PF, SS, 1C, 2C, 3C** 4C, 5C 17, 8 PH	32.5 ab	0.44 bc
Vangard 75 WG **Abound 2.08SC** **Bravo WeatherStik 6F** Captan 50WP Vangard 75WG	5.0 oz **12.8 fl oz** **4.0 pt** 4.0 lb 5.0 oz	P, B **PF, 2C, 3C** **SS, 1C** 4C, 5C 17, 8 PH	42.5 a	0.60 ab
Abound 2.08SC **Indar 75WSP + Latron** Captan 50WP Indar 75WSP + Latron	12.8 fl oz **2.0 oz** 4.0 lb 2.0 oz	P, B **PF, SS, 1C, 2C, 3C** 4C, 5C 17, 8 PH	18.5 bc	0.23 cd

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

TABLE 2. Peach Scab Incidence and Severity[1]			**% Fruit[2]**		
Treatment[3]	**Rate / A**	**Timing**	**Infected**	**1-10 lesions**	**>10 lesions**
Nontreated control	———	———	100 a	1.0 c	99.0 a
Rovral 4F **Elite 45DF + Induce** Captan 50WP Elite 45DF + Induce	1.5 pt **6.0 oz** 4.0 lb 6.0 oz	P, B **PF, SS, 1C, 2C, 3C** 4C, 5C 17, 8 PH	95.0 ab	31.0 b	64.0 bc
Vangard 75 WG Orbit 3.6 EC **Abound 2.08SC** Captan 50WP Orbit 3.6 EC	5.0 oz 4.0 fl oz **12.8 fl oz** 4.0 lb 4.0 fl oz	P B **PF, SS, 1C, 2C, 3C** 4C, 5C 17, 8 PH	82.0 b	51.0 a	31.0 d
Vangard 75 WG **Abound 2.08SC** **Bravo WeatherStik 6F** Captan 50WP Vangard 75WG	5.0 oz **12.8 fl oz** **4.0 pt** 4.0 lb 5.0 oz	P, B **PF, 2C, 3C** **SS, 1C** 4C, 5C 17, 8 PH	77.5 b	35.6 b	41.9 cd
Abound 2.08SC **Indar 75WSP + Latron** Captan 50WP Indar 75WSP + Latron	12.8 fl oz **2.0 oz** 4.0 lb 2.0 oz	P, B **PF, SS, 1C, 2C, 3C** 4C, 5C 17, 8 PH	95.0 ab	26.0 b	69.0 b

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

TABLE 3. Brown Rot Incidence at Harvest[1]

			% Fruit Infected[2]	
Treatment[3]	**Rate / A**	**Timing**	**Early Harvest**	**Late Harvest**
Nontreated control	———	———	16.6 a	44.1 a
Rovral 4F	1.5 pt	P, B		
Elite 45DF + Induce	6.0 oz	PF, SS, 1C, 2C, 3C		
Captan 50WP	4.0 lb	4C, 5C		
Elite 45DF + Induce	**6.0 oz**	**17, 8 PH**	1.2 b	0.7 b
Vangard 75 WG	5.0 oz	P		
Orbit 3.6 EC	4.0 fl oz	B		
Abound 2.08SC	12.8 fl oz	PF, SS, 1C, 2C, 3C		
Captan 50WP	4.0 lb	4C, 5C		
Orbit 3.6 EC	**4.0 fl oz**	**17, 8 PH**	0.9 b	1.0 b
Vangard 75 WG	5.0 oz	P, B		
Abound 2.08SC	12.8 fl oz	PF, 2C, 3C		
Bravo WeatherStik 6F	4.0 pt	SS, 1C		
Captan 50WP	4.0 lb	4C, 5C		
Vangard 75WG	**5.0 oz**	**17, 8 PH**	0.7 b	4.7 b
Abound 2.08SC	12.8 fl oz	P, B		
Indar 75WSP + Latron	**2.0 oz**	**PF, SS, 1C, 2C, 3C**		
Captan 50WP	4.0 lb	4C, 5C		
Indar 75WSP + Latron	**2.0 oz**	**17, 8 PH**	0.9 b	3.0 b

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

EXAMINATION OF MID AND LATE SEASON DISEASE CONTROL ON NECTARINE

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The relative importance of mid-season and late-season fungicide application timings for control of brown rot were examined on Redgold nectarine. Treatments having only mid-season, only late-season, and both mid- and late-season fungicide applications were investigated. In addition, the plant activator Messenger was examined for efficacy against scab and brown rot. A full-season Messenger program and one integrating Messenger with standard fungicides were studied. Finally, the experimental fungicide BAS 516 was examined for scab control at two different application rates.

MATERIALS AND METHODS

Treatments. The test block consisted of 5-year old trees planted at 25 ft x 25 ft row spacing. Treatments were replicated four times in a randomized complete block design with single tree plots. Treatment trees were surrounded by non-sprayed buffer trees on all sides. A Rears Pak-Blast-Plot airblast sprayer calibrated to deliver 100 gal/A at 100 psi traveling at 2.1 mph was used to apply fungicides. Treatment applications were made on the following dates and tree growth stages: 27 Apr (PF, petal fall); 8 May (SS, shuck split); 23 May, 4, 19 Jun, 2 July (1C-4C, first-fourth cover). Three applications were made for fruit rot control: 27 Jul, 6, 16 Aug (21, 11, 1 days preharvest (PH)). Miticides and insecticides were applied as needed to the entire block using a commercial airblast sprayer.

Environment. Weather conditions were very favorable for scab. Thirteen rain periods >0.10 in occurred between petal fall on 27 Apr and 9 Jul (40 days before harvest). The number of rain periods following each spray during this time period were: PF, 0; SS, 3; 1C, 4; 2C, 3; 3C, 1 and 4C, 2. Weather conditions were also favorable for brown rot development. There were 5 rain periods in the 21 days before harvest: 30 Jul (0.11 in), 5 Aug (0.97 in), 11 Aug (0.54 in), 12 Aug (0.44 in), and 14 Aug (0.12 in).

Assessment. Scab (*Cladosporium carpophilum*) incidence was evaluated at harvest (17 Aug) by examining 50 fruit per tree. Brown rot (*Monilinia fructicola*) incidence was evaluated at harvest by examining all fruit on two or more branches per replicate tree; a minimum of 100 fruit per tree was examined. For postharvest evaluations, 50 fruit without rot were harvested from each tree on 17 Aug and placed on benches at room temperature. Brown rot disease incidence was assessed at 3 and 6 days postharvest (dph).

RESULTS AND DISCUSSION

Scab. Scab incidence and severity was extremely high; many non-treated fruit had >50% of surface area infected (Table 1). These severe disease levels could be attributed to favorable weather and the buildup of large amounts of lesions on twigs, as the block had never been sprayed for scab since planting. Although fruit receiving the Bravo/Captan treatments had significantly less disease than the non-sprayed fruit, no treatments provided acceptable control. Spray intervals during the critical SS to 3C period, which ranged from 12 to 15 days, were perhaps too long for proper disease control under the conditions of the test. Furthermore, during the 15 days between the SS and 1C sprays, no rain occurred until the last three days just prior to the 1C spray; 1.64 in rain fell from 20-22 May. Fungicide residues would have been lowest and no re-distribution would have occurred prior to these rains.

Brown Rot. Brown rot disease pressure was also intense (Table 2). All treatments significantly reduce brown rot incidence at harvest, but no treatment kept disease levels acceptably low (<5%). The best brown rot control occurred when both mid-season and preharvest sprays were applied, as indicated by the standard Bravo/Captan/Orbit treatment. Application of only early-season (Bravo/Captan) or late-season (Orbit) components of this program resulted in a significant increase in brown rot at harvest. Treatments that had BAS 516 during mid-season followed by Orbit preharvest performed as well as the standard treatment. Messenger alone or alternating with Orbit did not provide adequate management of brown rot at harvest. Postharvest results were affected by lack of availability of ripe, uninfected fruit for some treatments, particularly the non-sprayed trees; less mature fruit were used for these treatments. Consequently, the control trees had significantly less post-harvest brown rot than the Bravo/Captan treatment trees, which had ripe but unprotected fruit. Rhizopus rot at harvest and postharvest was negligible.

CONCLUSIONS

1. Brown rot control was dependent on fungicide applications during both the mid-season [scab] and late-season preharvest periods. Omission of fungicide applications during either one of these periods resulted in a significant increase in brown rot at harvest. When fungicides were omitted during the mid-season [scab] control period, higher brown rot at harvest may have been due to: (i) lack of control of latent infections by *M. fructicola* during the period prior to pit hardening (SS – 2C) or (ii) high scab severity causing epidermal cracking during final fruit swell.

2. Peach scab control, performed during the critical SS to 3C period, was poor for all treatments, including the standard Bravo/Captan. Addition of a 4C spray to all treatments did not improve control. Given the intense inoculum pressure and favorable weather conditions, shorter application intervals and/or a higher Captan rate may have provided better control. Messenger and BAS 516 did not appear capable of controlling scab, although firm conclusions cannot be made given the poor results with the standard.

TABLE 1. Peach Scab Incidence and Severity[1]			% Fruit[2]		
Treatment[3]	**Rate / A**	**Timing**	**Infected**	**1-10 lesions**	**>10 lesions**
Nontreated control	———	———	100.0 a	0.0 c	100.0 a
Bravo WeatherStik 6F **Captan 50WP** Orbit 3.6EC	**4.0 pt** **4.0 lb** 4.0 fl oz	SS, 1C 2C, 3C, 4C 21, 11, 1 PH	88.4 b	54.3 a	34.1 c
Bravo WeatherStik 6F **Captan 50WP**	**4.0 pt** **4.0 lb**	SS, 1C 2C, 3C, 4C	86.0 b	60.0 a	26.0 c
Orbit 3.6EC	4.0 fl oz	21, 11, 1 PH	100.0 a	0.0 c	100.0 a
BAS 516 38WG Captan 50WP Orbit 3.6EC	**10.5 oz** 4.0 lb 4.0 fl oz	SS, 1C, 2C, 3C 4C 21, 11, 1 PH	100.0 a	2.5 c	97.5 a
BAS 516 38WG Captan 50WP Orbit 3.6EC	**14.7 oz** 4.0 lb 4.0 fl oz.	SS, 1C, 2C, 3C 4C 21, 11, 1 PH	100.0 a	17.9 b	82.1 b
Messenger Captan 50WP Messenger	**6.75 oz** 4.0 lb 6.75 oz	PF, SS, 1C, 2C, 3C 4C 21, 11, 1 PH	100.0 a	0.0 c	100.0 a
Messenger **BravoWeatherStik 6F** **Captan 50WP** Messenger Orbit 3.6EC	**6.75 oz** **4.0 pt** **4.0 lb** 6.75 oz 4.0 fl oz	PF, 1C, 3C SS 2C, 4C 21, 1 PH 11 PH	100.0 a	0.0 c	100.0 a

[1] Peach scab treatments, rates, and application timings in boldface.
[2] Means in the same column with the same letter do not differ significantly according to the Waller-Duncan K-ratio T test ($p<0.05$, K=100).
[3] Messenger treatments initiated at PF to allow time for activation of plant defense mechanisms.

TABLE 2. Brown Rot Harvest and Post-harvest Incidence[1]			% Fruit Infected[2]		
Treatment	**Rate / A**	**Timing**	**Harvest**	**3-dph**	**6-dph**
Nontreated control	———	———	96.1 a	29.8 cde	48.7 bcd
Bravo WeatherStik 6F Captan 50WP **Orbit 3.6EC**	4.0 pt 4.0 lb **4.0 fl oz**	SS, 1C 2C, 3C, 4C **21, 11, 1 PH**	10.7 d	14.2 e	32.8 cd
Bravo WeatherStik 6F Captan 50WP	4.0 pt 4.0 lb	SS, 1C 2C, 3C, 4C	68.4 bc	67.0 a	89.9 a
Orbit 3.6EC	**4.0 fl oz**	**21, 11, 1 PH**	75.6 b	42.6 bc	51.2 bc
BAS 516 38WG Captan 50WP **Orbit 3.6EC**	10.5 oz 4.0 lb **4.0 fl oz**	SS, 1C, 2C, 3C 4C **21, 11, 1 PH**	18.5 d	20.2 de	31.9 cd
BAS 516 38WG Captan 50WP **Orbit 3.6EC**	14.7 oz 4.0 lb **4.0 fl oz**	SS, 1C, 2C, 3C 4C **21, 11, 1 PH**	12.3 d	12.0 e	26.0 d
Messenger Captan 50WP **Messenger**	6.75 oz 4.0 lb **6.75 oz**	PF, SS, 1C, 2C, 3C 4C **21, 11, 1 PH**	77.5 b	51.9 ab	64.0 b
Messenger BravoWeatherStik 6F Captan 50WP **Messenger** **Orbit 3.6EC**	6.75 oz 4.0 pt 4.0 lb **6.75 oz** **4.0 fl oz**	PF, 1C, 3C SS 2C, 4C **21, 1 PH** **11 PH**	54.6 c	39.3 bcd	56.9 b

[1] Brown rot treatments, rates, and application timings in boldface.

[2] Means in the same column with the same letter do not differ significantly according to the Waller-Duncan K-ratio T test ($p<0.05$, K=100).

MANAGEMENT OF BROWN ROT, SCAB, AND RUSTY SPOT OF PEACH USING STROBILURIN AND STEROL INHIBITOR FUNGICIDES

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Strobilurin fungicides applied alone (Flint) or in mixtures with materials of different chemistry (Flint + Elite; BAS 516) were examined for their efficacy at controlling brown rot, scab, and rusty spot on *Prunus persica* 'Autumnglo'. In addition, the efficacy of these materials was compared to sterol inhibitor and standard protectant fungicides.

MATERIALS AND METHODS

Treatments. The experiment was conducted during the spring and summer of the 2001 growing season. The test block consisted of mixed-cultivar orchard of 6-year-old Autumnglo peach, Suncrest peach, and Redgold nectarine. Trees of each cultivar alternated within the rows and were planted at 20 ft x 25 ft spacing. Only the Autumnglo trees were used in the experiment.

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

Fungicide applications were made on the following dates and tree growth stages: 17 Apr (P, pink); 24 Apr (B, bloom); 3 May (PF, petal fall); 10 May (SS, shuck split); 22 May, 5, 19 Jun, 2, 23 Jul (1C-5C, first-fifth cover). Three applications were made for fruit rot control: 13, 22, 30 Aug (18, 9, 1 days preharvest (PH)). Insecticides and miticides were applied as needed to the entire block using a commercial airblast sprayer.

Environment. Weather conditions were highly favorable for scab. A total of 17 rain periods >0.10 in occurred from bloom on 24 Apr to 19 Jul (42 days PH). The number of rain periods following each spray during this time were: B, 0; PF, 0; SS, 3; 1C, 4; 2C, 4; 3C, 1 and 4C, 5. Conditions were also favorable for brown rot during the preharvest period. Five rain periods >0.10 in occurred during the 21 days prior to harvest: 11 Aug (0.54 in); 12 Aug (0.44 in); 14 Aug (0.12 in); 19 Aug (0.47 in); and 27 Aug (1.0 in).

Assessment. Blossom blight (*Monilinia fructicola*) was evaluated on the 14 Jun by examining 50 fruit bearing shoots per tree. Rusty spot (*Podosphaera leucotricha?*) was evaluated on 21 Jun by examining 50 fruit per tree. Scab (*Cladosporium carpophilum*) was evaluated on 27 Aug by examining 50 fruit per tree. Brown rot (*M. fructicola*) was evaluated on 31 Aug by examining all fruit on two or more branches per replicate tree; a minimum of 100 fruit / tree was examined. For postharvest evaluations, 50 healthy fruit were harvested from each tree on 31 Aug and placed on benches at room temperature. Brown and Rhizopus rot were assessed at 3 and 6 days postharvest (dph).

RESULTS AND DISCUSSION

Rusty Spot. Rusty spot incidence was moderately severe; control trees had 53% infected fruit (Table 1). All treatments during the critical petal fall to second cover period significantly reduced disease levels. However, the five standard Nova treatments provided significantly better control (ave 5% incidence) than either BAS 516 treatment. Disease levels for the Flint treatment were intermediate between Nova and BAS 516.

Scab. Scab disease pressure was extremely high; ~100% of the control fruit had >10 lesions (Table 2). Under these conditions, none of the scab fungicide treatments (SS-5C) provided acceptable control. However, this result may be due to much late season infection between fourth and fifth cover sprays, which consisted of captan for all treatments; five rains, for a total of 1.63 in, occurred during this 21-day period.

Brown Rot. Brown rot disease pressure was moderately high, with approximately half of the non-treated fruit rotted at harvest (Table 3). Significant rainfall events occurred on each of the two days prior to the first preharvest spray, as well as between each of the subsequent two sprays. Nevertheless, all fungicide treatments at harvest provided excellent and commercially acceptable control of brown rot (<5% fruit rotted). Most likely, very few fruit were ripe enough for infection during the two days prior to the first spray. Early season blossom blight canker incidence was low (2.5% on control).

Postharvest Disease. Excellent brown rot disease control was also maintained by all fungicides after three days postharvest incubation; disease levels ranged from 1.0 to 3.5% incidence (Table 3). After six days postharvest incubation, all fungicide treatments were still significantly less than the control, although incidence levels increased to 10-24% fruit infection. Rhizopus rot at harvest and postharvest was negligible (<1% fruit infection).

CONCLUSIONS

1. Strobilurin alone (Flint) or in mixture with other fungicides (Flint+Elite; BAS 516) provided reliable, highly effective control of brown rot. Efficacy of these materials was equivalent to the sterol inhibitors Indar and Elite. Therefore, alternation or mixing of these different chemistries should allow for an effective disease resistance management strategy without sacrificing control.

2. Rusty spot management was reasonably good for Flint and BAS516, the former appearing somewhat more effective. However, neither material appeared to be as effective as the standard Nova.

3. Peach scab control was poor for all treatments, including the standard utilizing Bravo. Unusual late season infection periods, occurring after the critical SS to 3C control period, may be responsible for this uniform lack of control. At this time, spray intervals were longer and all treatments were receiving Captan. In contrast, similar materials (Flint, Captan) provided much better control (9.0-17% fruit infection) under similar disease pressure (99% infection on control) during the 2000 season.

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

Treatment[2]	Rate / A	Timing	% Infected fruit[3]	# Lesions / fruit[3]
Nontreated Control	————	————	53.0 a	0.80 a
Orbit 3.6EC	4.0 fl oz	P, B		
Nova 40W	**5.0 oz**	**PF**		
Nova 40W + Bravo 6F	**5.0 oz + 4.0 pt**	**SS, 1C**		
Nova 40W + Captan 50WP	**5.0 oz + 4.0 lb**	**2C**		
Captan 50WP	4.0 lb	3C, 4C, 5C		
Indar 75WSP + Latron	2.0 oz	18, 9, 1 PH	6.0 cde	0.08 bc
BAS 516 38WG	10.5 oz	P, B		
Nova 40W	**5.0 oz**	**PF**		
Nova 40W + Bravo 6F	**5.0 oz + 4.0 pt**	**SS, 1C**		
Nova 40W + Captan 50WP	**5.0 oz + 4.0 lb**	**2C**		
Captan 50WP	4.0 lb	3C, 4C, 5C		
BAS 516 38WG	10.5 oz	18, 9, 1 PH	6.5 cde	0.08 bc
BAS 516 38WG	14.7 oz	P, B		
Nova 40W	**5.0 oz**	**PF**		
Nova 40W + Bravo 6F	**5.0 oz + 4.0 pt**	**SS, 1C**		
Nova 40W + Captan 50WP	**5.0 oz + 4.0 lb**	**2C**		
Captan 50WP	4.0 lb	3C, 4C, 5C		
BAS 516 38WG	14.7 oz	18, 9, 1 PH	3.5 e	0.04 c
Orbit 3.6EC	4.0 fl oz	P, B		
BAS 516 38WG	**10.5 oz**	**PF, SS, 1C, 2C, 3C**		
Captan 50WP	4.0 lb	4C, 5C		
Indar 75WSP + Latron	2.0 oz	18, 9, 1 PH	14.0 b	0.17 b
Orbit 3.6 EC	4.0 fl oz	P, B		
BAS 516 38WG	**14.7 oz**	**PF, SS, 1C, 2C, 3C**		
Captan 50WP	4.0 lb	4C, 5C		
Indar 75 WSP + Latron	2.0 oz	18, 9, 1 PH	14.5 b	0.18 b
Flint 50WG	3.0 oz	P, B		
Flint 50 WG	**3.0 oz**	**PF, SS, 1C, 2C, 3C**		
Captan 50WP	4.0 lb	4C, 5C		
Flint 50 WG	4.0 oz	18, 9, 1 PH	10.5 bcd	0.14 bc
Elite 45DF + Induce	6.0 oz	P, B		
Flint 50WG	**3.0 oz**	**PF, SS, 1C, 2C**		
Captan 50WP	4.0 lb	3C, 4C, 5C		
Elite 45DF + Induce	6.0 oz	18, 9, 1 PH	12.5 bc	0.17 b
Orbit 3.6EC	4.0 fl oz	P, B		
Nova 40W	**5.0 oz**	**PF**		
Nova 40W + Bravo 6F	**5.0 oz + 4.0 pt**	**SS, 1C**		
Nova 40W + Captan 50WP	**5.0 oz + 4.0 lb**	**2C**		
Captan 50WP	4.0 lb	3C, 4C, 5C		
Elite 45DF + Flint 50WG	2.9 oz + 2.6 oz	18, 9, 1 PH	3.5 e	0.04 c
Orbit 3.6EC	4.0 fl oz	P, B		
Nova 40W	**5.0 oz**	**PF**		
Nova 40W + Bravo 6F	**5.0 oz + 4.0 pt**	**SS, 1C**		
Nova 40W + Captan 50WP	**5.0 oz + 4.0 lb**	**2C**		
Captan 50WP	4.0 lb	3C, 4C, 5C		
Elite 45DF + Flint 50WG	3.5 oz +3.1 oz	18, 9, 1 PH	5.5 de	0.08 bc

[1] Rusty spot treatments, rates, and application timings are indicated in boldface.

[2] Latron B-1956 spreader-sticker and Induce wetter-spreader at .06% v/v ratio, equivalent to 8 fl oz/ 100 gal.

[3] Means in the same column with the same letter do not differ significantly according to the Waller-Duncan K-ratio T test ($p<0.05$, K=100).

TABLE 2. Peach Scab Incidence and Severity[1]			**% Fruit**[2]		
Treatment[3]	**Rate / A**	**Timing**	**Infected**	**1-10 lesions**	**>10 lesions**
Nontreated Control	————	————	100 a	0.5 d	99.5 a
Orbit 3.6EC Nova 40W **Nova 40W + Bravo 6F** **Nova 40W + Captan 50WP** **Captan 50WP** Indar 75WSP + Latron	4.0 fl oz 5.0 oz **5.0 oz + 4.0 pt** **5.0 oz + 4.0 lb** **4.0 lb** 2.0 oz	P, B PF **SS, 1C** **2C** 3C, 4C, 5C 18, 9, 1 PH	81.5 abc	43.0 ab	38.5 cd
BAS 516 38WG Nova 40W **Nova 40W + Bravo 6F** **Nova 40W + Captan 50WP** **Captan 50WP** BAS 516 38WG	10.5 oz 5.0 oz **5.0 oz + 4.0 pt** **5.0 oz + 4.0 lb** **4.0 lb** 10.5 oz	P, B PF **SS, 1C** **2C** 3C, 4C, 5C 18, 9, 1 PH	79.5 abc	57.5 a	22.0 d
BAS 516 38WG Nova 40W **Nova 40W + Bravo 6F** **Nova 40W + Captan 50WP** **Captan 50WP** BAS 516 38WG	14.7 oz 5.0 oz **5.0 oz + 4.0 pt** **5.0 oz + 4.0 lb** **4.0 lb** 14.7 oz	P, B PF **SS, 1C** **2C** 3C, 4C, 5C 18, 9, 1 PH	67.0 cd	45.0 ab	22.0 d
Orbit 3.6EC **BAS 516 38WG** Captan 50WP Indar 75WSP + Latron	4.0 fl oz **10.5 oz** 4.0 lb 2.0 oz	P, B **PF, SS, 1C, 2C, 3C** 4C, 5C 18, 9, 1 PH	96.5 ab	23.5 c	73.0 b
Orbit 3.6 EC **BAS 516 38WG** Captan 50WP Indar 75 WSP + Latron	4.0 fl oz **14.7 oz** 4.0 lb 2.0 oz	P, B **PF, SS, 1C, 2C, 3C** 4C, 5C 18, 9, 1 PH	91.5 ab	39.5 b	52.0 c
Flint 50WG **Flint 50 WG** Captan 50WP Flint 50 WG	3.0 oz **3.0 oz** 4.0 lb 4.0 oz	P, B **PF, SS, 1C, 2C, 3C** 4C, 5C 18, 9, 1 PH	77.0 bcd	38.5 bc	38.5 cd
Elite 45DF + Induce **Flint 50WG** **Captan 50WP** Elite 45DF + Induce	6.0 oz **3.0 oz** **4.0 lb** 6.0 oz	P, B **PF, SS, 1C, 2C** 3C, 4C, 5C 18, 9, 1 PH	58.5 d	37.0 bc	21.5 d
Orbit 3.6EC Nova 40W **Nova 40W + Bravo 6F** **Nova 40W + Captan 50WP** **Captan 50WP** Elite 45DF + Flint 50WG	4.0 fl oz 5.0 oz. **5.0 oz + 4.0 pt** **5.0 oz + 4.0 lb** **4.0 lb** 2.9 oz + 2.6 oz	P, B PF **SS, 1C** **2C** 3C, 4C, 5C 18, 9, 1 PH	86.5 abc	44.5 ab	42.0 c
Orbit 3.6EC Nova 40W **Nova 40W + Bravo 6F** **Nova 40W + Captan 50WP** **Captan 50WP** Elite 45DF +Flint 50WG	4.0 fl oz 5.0 oz **5.0 oz + 4.0 pt** **5.0 oz + 4.0 lb** **4.0 lb** 3.5 oz +3.1 oz	P, B PF **SS, 1C** **2C** 3C, 4C, 5C 18, 9, 1 PH	84.0 abc	51.0 ab	33.0 cd

[1] Peach scab treatments, rates, and application timings are indicated in boldface.

[2] Means in the same column with the same letter do not differ significantly according to the Waller-Duncan K-ratio T test ($p<0.05$, K=100).

[3] Latron B-1956 spreader-sticker and Induce wetter-spreader at .06% v/v ratio, equivalent to 8 fl oz/ 100 gal.

TABLE 3. Brown Rot Harvest and Post-harvest Incidence[1]			**% Fruit Infected**[2]		
Treatment[3]	**Rate / A**	**Timing**	**Harvest**	**3-dph**	**6-dph**
Nontreated Control	————	————	52.7 a	43.2 a	84.4 a
Orbit 3.6EC Nova 40W Nova 40W + Bravo 6F Nova 40W + Captan 50WP Captan 50WP **Indar 75WSP + Latron**	4.0 fl oz 5.0 oz 5.0 oz + 4.0 pt 5.0 oz + 4.0 lb 4.0 lb **2.0 oz**	P, B PF SS, 1C 2C 3C, 4C, 5C **18, 9, 1 PH**	1.7 b	2.0 b	10.5 c
BAS 516 38WG Nova 40W Nova 40W + Bravo 6F Nova 40W + Captan 50WP Captan 50WP **BAS 516 38WG**	10.5 oz 5.0 oz 5.0 oz + 4.0 pt 5.0 oz + 4.0 lb 4.0 lb **10.5 oz**	P, B PF SS, 1C 2C 3C, 4C, 5C **18, 9, 1 PH**	1.5 b	2.5 b	17.5 bc
BAS 516 38WG Nova 40W Nova 40W + Bravo 6F Nova 40W + Captan 50WP Captan 50WP **BAS 516 38WG**	14.7 oz 5.0 oz 5.0 oz + 4.0 pt 5.0 oz + 4.0 lb 4.0 lb **14.7 oz**	P, B PF SS, 1C 2C 3C, 4C, 5C **18, 9, 1 PH**	1.0 b	2.5 b	17.5 bc
Orbit 3.6EC BAS 516 38WG Captan 50WP **Indar 75WSP + Latron**	4.0 fl oz 10.5 oz 4.0 lb **2.0 oz**	P, B PF, SS, 1C, 2C, 3C 4C, 5C **18, 9, 1 PH**	4.1 b	2.5 b	14.5 bc
Orbit 3.6 EC BAS 516 38WG Captan 50WP **Indar 75 WSP + Latron**	4.0 fl oz 14.7 oz 4.0 lb **2.0 oz**	P, B PF, SS, 1C, 2C, 3C 4C, 5C **18, 9, 1 PH**	1.5 b	1.0 b	10.0 c
Flint 50WG Flint 50 WG Captan 50WP **Flint 50 WG**	3.0 oz 3.0 oz 4.0 lb **4.0 oz**	P, B PF, SS, 1C, 2C, 3C 4C, 5C **18, 9, 1 PH**	2.5 b	3.0 b	24.0 b
Elite 45DF + Induce Flint 50WG Captan 50WP **Elite 45DF + Induce**	6.0 oz 3.0 oz 4.0 lb **6.0 oz**	P, B PF, SS, 1C, 2C 3C, 4C, 5C **18, 9, 1 PH**	1.5 b	3.5 b	16.0 bc
Orbit 3.6EC Nova 40W Nova 40W + Bravo 6F Nova 40W + Captan 50WP Captan 50WP **Elite 45DF + Flint 50WG**	4.0 fl oz 5.0 oz. 5.0 oz + 4.0 pt 5.0 oz + 4.0 lb 4.0 lb **2.9 oz + 2.6 oz**	P, B PF SS, 1C 2C 3C, 4C, 5C **18, 9, 1 PH**	2.3 b	2.0 b	14.5 bc
Orbit 3.6EC Nova 40W Nova 40W + Bravo 6F Nova 40W + Captan 50WP Captan 50WP **Elite 45DF + Flint 50WG**	4.0 fl oz 5.0 oz 5.0 oz + 4.0 pt 5.0 oz + 4.0 lb 4.0 lb **3.5 oz + 3.1 oz**	P, B PF SS, 1C 2C 3C, 4C, 5C **18, 9, 1 PH**	1.7 b	2.5 b	15.0 bc

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

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APPLE TRAINING SYSTEM TRIALS WITH FRESH AND PROCESSING CULTIVARS

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Intensive orchard planting systems are becoming more common in the mid-Atlantic apple production region. The need to increase labor efficiency and reduce the number of unproductive years have stimulated grower interest in these systems. Orchard systems are the result of combining the cultivar and rootstock at a particular spacing and then training and pruning the trees to achieve maximum production. Traditionally high density systems for apples have been only utilized for fruit destined for fresh market. Pennsylvania growers are interested in learning if high density can also be justified for use on the processing cultivar 'York Imperial'. We were also interested in exploring the response of some high density training systems based upon tree growth habit. This paper reports the preliminary first 2-3 cropping years' results.

Materials & Methods

1997 Plantings

'York Imperial' /M.9 was planted in the spring of 1997 at a commercial orchard (Bream Orchards) by the grower using a tree planter. Trees were planted in a randomized complete block with replications running across the rows. Each experimental unit consisted of 14 to 28 trees with four replications of each system. The following systems were used: Offset V-axe (V), Slender Spindle (SS), Hytec (H), Vertical Axe (A) and an Unpruned (U)Spacing within row was 3 feet for the Offset V-axe and 6 feet for the other systems. Distance between rows was 20 feet to accommodate the grower's existing equipment. Immediately after planting an individual metal conduit pole was set by each tree for all the systems and attached to the top of the support system at a height of approximately 9.5 feet. The grower erected the support system based upon our supplied specifications. For the V system the angle of the trees was 60° from horizontal.

Fresh Market Cultivars: Ginger Gold, Crimson Gala and Fuji (BC#2) all propagated on M.9-T.337 rootstock were planted in 1997 by individually auguring holes for each tree. Trees were trained to the following four systems: Offset V-axe (V), Slender Spindle (SS), Vertical Axe (A) and Penn State 4-Wire Low Hedgerow Trellis (T). The experimental design was a randomized complete block within a split plot with systems being the main effect and cultivars the subeffect. There were 8 replications of each system consisting of 5 tree plots. Spacing within rows was 3 feet for the V and 6 feet for the other systems. Distance between rows was varied according to system widths. Immediately after planting an individual Best Angle® steel stake was placed next to all the trees in the V, SS, and A systems.

1998 Planting

'York Imperial/B.9' was planted in the spring of 1998 at a commercial orchard (Knouse Fruitlands) by the grower using a tree planteer. Trees were planted in a randomized complete block with replications running down the rows. Systems design, construction, tree spacing and number of trees were the same as in the 1997 planting of 'York Imperial'.

Tree Maintenance and Data Collection: All trees were pruned and trained by the authors. Trees training was as described previously (Crassweller & Smith, 1999). Tree size as measured by trunk cross sectional area was taken on an individual tree basis in the fall of each year. Flower numbers were counted on individual trees for the Fresh market cultivars in 1998 & 1999. Flower density was estimated on the processing cultivar blocks in all years and on the fresh market planting in 2000 & 2001. In the processing blocks trees were hand thinned in their third leaf and chemically thinned thereafter based upon the grower's expertise. In the fresh market block trees were hand thinned each year. Harvest data for the processing blocks was collected on either the middle 14 (V system) or 7 (all other systems) trees and pooled for a single value for each system/replication. Harvest data for the fresh market blocks was collected as a total for each cultivar/system/replication. Harvest data consisted of counting all fruit on the trees and weighing them. In the processing blocks a separate random 30 to 50 apple sample was collected from each section and graded on a Greefa® rotary size grader as a representative value for each system/replication. All the fruit in the fresh market blocks were graded on the same grader. After the first growing season time for pruning and training each system by cultivar/system/replication was collected by the senior author each year in an effort to determine if any system was easier to prune and train.

Results and Discussion

Tree Size as Trunk Cross Sectional Area (TCSA)

Bream Orchards: There were no statistical differences in trunk cross sectional area for the first three years of the planting. However, by the fourth leaf trees in the V system had significantly smaller TCSA (Table 1) and trees in the A system were the largest. The smaller size in the V system maybe a manifestation of two factors; the first being increased competition due to density and the second due to the 60° angle at which the trees were positioned.

Fresh Market Cultivars. At planting the 'Fuji' and trees in the T system were larger than the other two cultivars and the other systems (Table 2). These differences were maintained until the end of the fourth growing season when there was a system by cultivar interaction. At the end of the fifth growing season similar to the 'York Imperial'/M.9 the trees in the A system were smallest. Those in the A however were not larger than the other systems and the 'Fuji' remained the largest trees of the three cultivars.

Knouse Fruitlands Orchards: Unlike the other plantings there was no significant difference in TCSA between any of the systems at the end of the fourth growing season (data not shown).

Flowering

There were no significant differences in flowering between systems in any year for either 'York Imperial' planting. In the Fresh Market planting, trees in the T system had the greatest number of flower clusters and bloom density per tree in 1998 with no differences by cultivar (Table 3). The greater flowering of the T system is probably related to their larger size. In 1999 there were no differences in the number of flowers per tree by system but flower density was lowest on the T and highest on the A system. Both 'Ginger Gold' and 'Gala' had greater numbers and density of flowers than 'Fuji'. In 2000 and 2001 flowering was evaluated on a numerical rating scale and there were no differences between systems.

Yield

<u>Bream Orchards:</u> There was no difference in yields on either basis for the 'York Imperial'/M.9 planting in 1999 or 2000. In 2001there was no difference on a per linear length basis for any of the systems, however, trees in the V system had the lowest yield per tree (Table 4). Previous studies have shown that early per acre yield is more related to tree density (Robinson, 1997 and Clayton-Green, 1993).

<u>Fresh Market Systems:</u> Since there was a significant interaction between systems and cultivars in 2000 and 2001 yields are expressed for all three years as yields by systems for each cultivar (Table 5) and by cultivars for each system (Table 6).

'Ginger Gold' had no significant differences in yield per tree by system for any. For 'Gala' there were no differences in 1999 or 2000. In 2001, trees trained to the A system had significantly greater yield than those trained to the V system. There were differences in all three years for 'Fuji' by system. The V system each year consistently had the lowest per tree yields but the highest yielding system varied each year.

In comparing cultivars by systems there was little difference between cultivars trained to the V system except for 1999 (Table 6). In all the other systems, 'Fuji' had higher yields in eight out of nine possible comparisons. The lone exception was in 2000 for the A system.

There was also a system by cultivar interaction for number of fruit per tree in 1999 and 2001 (data not shown). In general 'Fuji' had the highest per tree yields.

Since the V system was planted at a higher density it is also necessary to compare the per acre yields between systems and cultivars (Table 7). There were no differences between per acre yields by system in 1999 and 2000. In 2001, the V system by virtue of having more trees per acre had a significantly higher yield per acre than the T system. In years that there were significant differences by cultivars, 1999 and 2001, 'Fuji' had the highest yields. Yields increased in all three years indicating that there was no alternate bearing cycle appearing.

<u>Knouse Fruitlands Orchards:</u> Yield of 'York Imperial/B.9 was not significantly different in 2000 on a per tree basis but on an area basis the V system had significantly better yield than the SS, H, or A systems (Table 4). In 2001 there was no significant differences between any of the systems although the trend was the same as in the previous year

Summary and Conclusions

As in previous studies early yields seem to be more related to planting tree density but not significantly in all cases. Tree size as measured by trunk cross sectional area may be influenced by both planting density and tree inclination. Yields of 'York Imperial' on an area basis were only affected at one site in one year (Knouse Fruitlands in 2000). Palmer and Warrington (2000) have indicated that there are three main constraints on apple production systems; one being biological. One of their biological conc [illegible] was the necessity of adequate sunlight within a training system to maintain high colored fruit. Since processing fruit is not graded upon surface color this becomes a secondary concern. Profitability of processing orchards is primarily a function of tonnage, fruit size and freedom from bruising. Therefore evaluation of any training system utilized for fruit primarily grown for processing should only be based upon those criteria. To date there has been no difference in tonnage so in the first three years any system would be acceptable. This current study does not compare less dense plantings on less precocious rootstocks, however, from experience these higher density plantings seem to produce higher tonnage sooner than a more traditional system. The important factor will be if the plantings can maintain and increase their early production.

'Ginger Gold' yield did not seem to be affected by any training system. 'Gala' yield was not affected in the first two cropping years but was in the third. 'Fuji' seemed to be the cultivar that was most affected by training system but there was not a consistent affect.

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Acknowledgements

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The State Horticultural Association of Pennsylvania and Adams County Nursery provided monetary support and in-kind assistance, respectively for this project.

Table 1.Trunk cross sectional area of 'York Imperial'/M.9 in 2000 and 2001 at Bream Orchards.

	Fall 00 cm^2	Fall 01 cm^2
Offset-V	9.64 a	11.60 a
Slender Spindle	12.27 ab	15.18 ab
Hytec	11.48 ab	14.50 ab
French Axe	13.46 b	16.93 b
Unpruned	12.32 ab	15.35 ab
P - Value	0.0374	0.0385

Letters within rows and years refer to Tukey-Kramer mean separation, P= 0.05

Table 2. Trunk cross sectional area of Fresh Market Systems planting at Rock Springs.

System	Spring '97 cm^2	Fall '00 cm^2	Fall '01 cm^2
Offset-V	0.99 a	11.5	15.8 a
S. Spindle	1.01 a	14.9	21.1 b
French Axe	1.04 a	13.7	19.5 b
Low Trellis	1.26 b	14.2	20.0 b
P-Value	0.0001	**	0.0003
Cultivar			
Ginger Gold	1.00 a	11.5	16.2 a
Crimson Gala	0.97 a	12.5	17.3 a
Fuji	1.21 b	16.7	21.9 b
P-Value	0.0001	**	0.0001

***Indicates a cultivar by system interaction*

Letters within rows and years refer to Tukey-Kramer mean separation, P= 0.05

Table 3. Number of flowers per tree and flower density (clusters/tcsa) of Fresh Market Systems at Rock Springs in 1998 and 1999.

System/Cultivar	# Clusters per tree	Clusters per TCSA	# Clusters per tree	Clusters per TCSA
Offset-V	3 a	1.7 a	86 a	18.6 ab
S. Spindle	4 a	2.2 a	109 a	21.7 bc
French Axe	4 a	2.3 a	108 a	22.7 c
Low Trellis	11 b	5.0 b	92 a	17.2 a
P - Value	0.0002	0.0001	0.0590	0.0005
Ginger Gold	5 a	3.1 a	123 b	26.1 b
Crimson Gala	5 a	2.7 a	111 b	24.2 b
Fuji	5 a	2.0 a	54 a	8.8 a
P - Value	0.8417	0.1263	0.0005	0.0001

Letters within rows and years refer to Tukey-Kramer mean separation, P= 0.05

Table 4. Early yields of 'York Imperial' on M.9 and B.9 as influenced by system from two grower orchards in Adams County, PA.

Bream Orchards

Yield/tree (kg)

Year	Offset V	S Spindle	Hytec	Axe	UnPruned	P-value
1999	4.45a	6.19 a	4.08 a	7.30 a	6.47 a	0.4194
2000	1.27 a	1.66 a	1.73 a	0.55 a	0.43 a	0.2106
2001	10.20 a	18.03 b	17.72 b	17.68 b	20.75 b	0.0148
			Yield/ 48' section			
1999	71.15a	49.47 a	32.61 a	58.39 a	51.79 a	0.3123
2000	17.07 a	13.28 a	13.87 a	4.43 a	3.41 a	0.1796
2001	163.19 a	144.27 a	141.80 a	141.48 a	165.97 a	0.4835

Knouse Fruitlands Orchards

Yield/ tree (kg)

	Offset V	S Spindle	Hytec	Axe	UnPruned	P-value
2000	.5.66 a	5.59 a	4.40 a	5.64 a	7.76 a	0.3022
2001	5.40 a	6.77 a	5.65 a	6.49 a	8.19 a	0.4350
			Yield/ 48' section			
2000	90.62 b	44.68 a	35.20 a	45.08 a	62.04 ab	0.0161
2001	86.35 a	54.15 a	45.15 a	51.88 a	65.52 a	0.1623

Letters within rows and years refer to Tukey-Kramer mean separation, P= 0.05

Table 5. Yield per tree (kg) of training systems by cultivar for 1999-2001 at Rock Springs, PA

	Ginger Gold	Crimson Gala	Fuji
System		1999	
Offset-V	5.42 a	3.12 a	4.84 a
Slender Spindle	5.90 a	2.29 a	7.32 ab
French Axe	5.11 a	3.09 a	7.88 ab
Low Trellis	5.06 a	3.47 a	8.87 b
P - Value	0.8384	0.3038	0.0438
		2000	
Offset-V	7.39 a	7.36 a	7.82 a
Slender Spindle	9.70 a	7.19 a	13.39 b
French Axe	9.67 a	9.05 a	7.35 a
Low Trellis	8.28 a	8.29 a	10.27 ab
P - Value	0.2785	0.6179	0.0022
		2001	
Offset-V	11.84 a	11.30 a	15.15 a
Slender Spindle	12.69 a	12.41 ab	23.09 b
French Axe	13.05 a	15.70 b	26.34 b
Low Trellis	9.63 a	12.84 ab	23.23 b
P - Value	0.2299	0.0311	0.0020

Letters within rows and years refer to Tukey-Kramer mean separation, P= 0.05

Table 6. Early yields per tree (kg) comparing cultivars by system in 1999-2001 at Rock Springs.

Cultivar	1999			
	Offset-V	Slender Spindle	French Axe	Low Trellis
Ginger Gold	5.42 b	5.90 ab	5.11 a	5.06 ab
Crimson Gala	3.12 a	2.29 a	3.09 a	3.47 a
Fuji	4.84 ab	7.32 b	7.88 b	8.87 b
P - Value	0.0344	0.0315	0.0007	0.0135
	2000			
Ginger Gold	7.39 a	9.70 ab	9.67 a	8.28 a
Crimson Gala	7.36 a	7.19 a	9.05 a	8.29 a
Fuji	7.82 a	13.39 b	7.35 a	10.27 a
P - Value	0.8541	0.0126	0.4091	0.4756
	2001			
Ginger Gold	11.84 a	12.69 a	13.05 a	9.63 a
Crimson Gala	11.30 a	12.41 a	15.70 a	12.84 a
Fuji	15.15 a	23.09 b	26.34 b	23.23 b
P - Value	0.0483	0.0005	0.0001	0.0001

Letters within rows and years refer to Tukey-Kramer mean separation, P = 0.05

Table 7. Yield of Ginger Gold, Gala and Fuji trained to four different systems expressed on kilogram per acre basis for 1999-2001 at Rock Springs

System	1999	2000	2001
Off set V	4043 a	6824 a	11576 b
Slender Spindle	3128 a	6105 a	9719 ab
French Axe	3244 a	5255 a	11111 ab
Low Trellis	3508 a	5414 a	9214 a
P- Value	0.0859	0.0715	0.0157
Cultivar			
Ginger Gold	3661 b	5858 a	8033 a
Crimson Gala	2044 a	5377 a	8756 a
Fuji	4737 c	6464 a	14425 b
P-Value	0.0001	0.1053	0.0001

Letters within columns and system or cultivar refer to Tukey-Kramer mean separation, P= 0.05

TWO-YEAR RESPONSE OF APPLE AND PEACH TREES TO SCORING AND RESTRICTION OF TRUNKS

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Management of tree size and excess vegetative growth is a significant expense to orchardists. Scoring tree trunks has been used to inhibit shoot growth but response to scoring has varied, possibly due to imprecision of cutting a tree with a saw blade or knife. Restricting trunk diameter enlargement with a band tightened to a specified tension could allow more precise trunk restriction for controlling vegetative growth. An experiment was initiated during the 2000 growing season to compare the effects of scoring with banding of tree trunks on growth, and photosynthesis in apple and peach trees. In the 2000 growing season scoring suppressed growth of peach early in the growing season and growth of apple for the entire season. Banding did not significantly suppress shoot growth in either species but it reduced photosynthesis and altered carbohydrate partitioning. The objectives of this experiment in the 2001 growing season were to determine (1) responses of apple and peach trees to trunk scoring and trunk banding treatments applied in the 2000 growing season and (2) apple and peach tree growth with banding applied at greater tensions over longer time than that used during the 2000 growing season.

Apple (*Malus domestica* Borkh., 'Ace Spur Delicious' on M.7) and peach (*Prunus persica* (L.) Batsch, 'Redhaven' on Lovell) trees were planted together near Kearneysville, WV with a 2-by-5 m spacing in April 1997. In May 2000, 3 treatments were installed 20 cm above the graft union: (1) the trunk was cut to the secondary xylem with a hacksaw blade in a double spiral pattern that did not girdle the trunk (score); (2) the trunk was completely encircled by a hose clamp with a 2-cm band width tightened to 10 inch pounds which was removed in Aug. 2000 (band); and (3) untreated control. In April 2001, 4 treatments were installed 20 cm above the graft union of different trees than those used in 2000: (1) score as described above; (2) band as described above but tightened to 25 inch pounds; (3) band as described above but tightened to 50 inch pounds; and (4) untreated control. Length of 2001 season growth was measured on 10 vigorous sprouts at the end of the growing season. Photosynthesis was measured as CO_2 gas exchange on 3 leaves per tree in August 2001.

Peach shoot growth during the 2001 season was reduced nearly 40% by banding and 26% by scoring treatments that were applied in April 2000. In contrast, apple shoot growth during the 2001 season was not affected by either trunk restriction treatment applied in April 2000. In addition, apple fruit number, weight, or quality were not affected in 2001 by treatments applied in 2000. Results in 2001 from trunk restriction treatments applied in 2001 were similar to results obtained during the 2000 growing season; scoring reduced apple but not peach tree growth and banding did not reduce growth in apple or peach. Banding reduced photosynthesis in apple and peach trees. Yield of apple and peach trees during the 2001 season was increased by scoring or banding applied in April 2001. In conclusion, it appeared that banding disrupted the physiology of both apple and peach trees by interfering with photosynthesis and carbohydrate partitioning but this altered physiology did not affect growth during the season of treatment. Scoring reduced shoot growth of apple trees during the first season but not the second season after treatment.

Environmental Modifications Using a Web Based Forecasting Service for the Production of Annual Plasticulture Strawberries

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Objectives: Growing plasticulture strawberries can be a very productive and profitable system compared to ground-culture matted row systems. However, even if everything is done correctly, the crop is still subject to good 'ol mother nature. Desiccating winds, severe winters, spring freezes, frost, and early spring heat waves can be detrimental to maximized yields.

Floating row covers can help minimize the destructiveness of some of these events. Sprinkler irrigation can also be used to prevent frost damage and cool the plants and fruits during hot spells through evaporative cooling. These techniques are not new, however new localized weather forecasting services are now available that can be a useful tool in determining when we should irrigate and/or use the row covers.

"Skybit" is a fee based service that uses plant phenology and localized meteorological conditions to assist in IPM decisions, irrigation scheduling and frost predictions for certain crops. The purpose of this study is to further evaluate the use of "Skybit", a commercially available forecasting service, to aid in the decision making process for frost protection and evaporative cooling in the plasticulture system of growing strawberries.

Materials and Methods: The field was prepared for planting in August 2000. Raised beds 8 inches high x 29 inches wide were planted on September 12, 2000 with a twin row of plug plants on a 12 inch x 12 inch spacing. Each of the 4 treatments had four varieties; Sweet Charlie, Honeoye, Chandler and Camarosa and were planted with 10 plants of each variety x 4 replications. The entire planting was covered with a 2 ounce/sq. yd. floating row cover in December 2000 and first removed on March 14, 2001. Treatments were implemented to provide different measures of frost/freeze protection based on "Skybit" predictions. The four treatments were: 1) sprinkler irrigated only for frost protection, 2) row cover + sprinkler irrigation, 3) row cover only, 4) winter straw and heavy foam cover.

Temperature thermocouples to measure flower bud temperature, and soil and air thermometers were installed and data was collected with a data logger. These measurements allowed us to observe micro-climate effects of the treatments during frost/freeze events.

Results and Discussions: Initial observations indicate that "Skybit" can reasonably forecast events. We had temperatures on the morning of April 19, 2001 to warrant frost protection. Figure 1. shows the frost event temperatures.

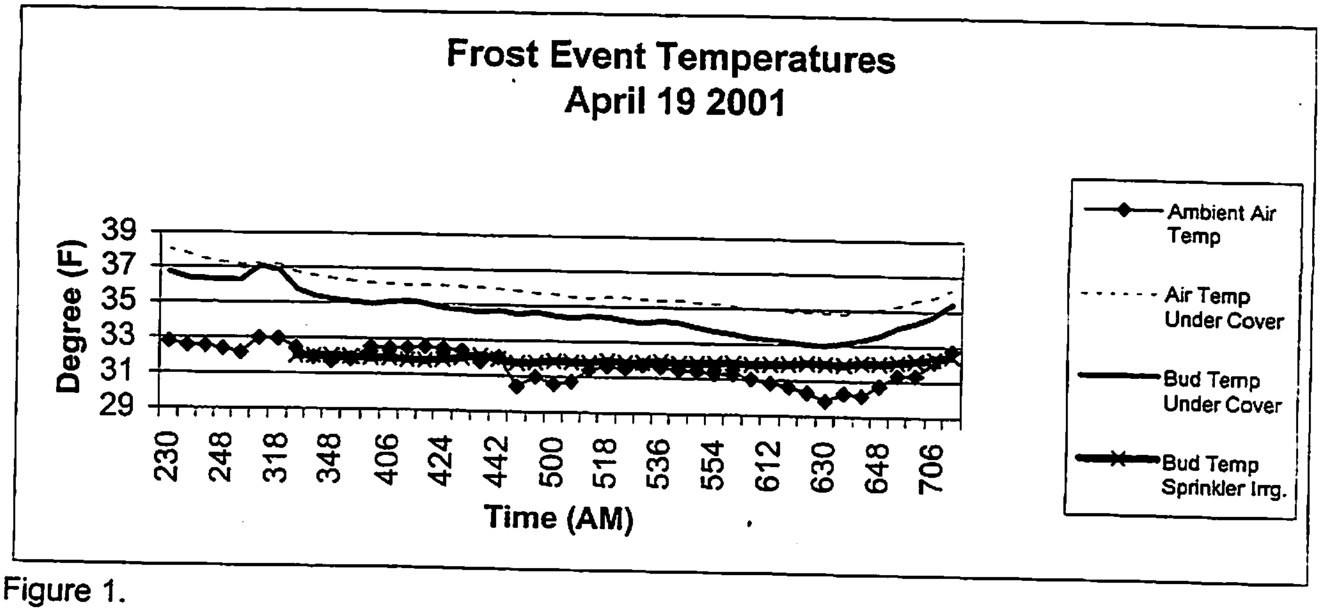

Figure 1.

The E-Weather strawberry canopy forecast gives a seven-day outlook and provides the following information, or intelligence, in the frost protection wars: 1) Sky cover for the next 24-hour period; 2) Projected wind speed and direction for the next 24-hour period; 3) Canopy temperature range for the next 24-hour period; and 4) A seven-day forecast which includes all of the following: air temperatures; canopy temperatures; (all temperatures are maximum and minimums); average dew point; relative humidity; average wind speed; solar radiation percent; and precipitation in inches. This, plus the wet bulb temperature and your blossom critical temperature, are about all one needs to start to plan your frost protection strategy for an upcoming adverse weather event, i.e. frost or freeze.

This knowledge, coupled with a working frost protection system, frost alarm and proper site recorders, bloom thermocouples so you can tell blossom temperatures and we have most of the tools.

Table 1. Yield results of this experiment

Treatment # and yields in lbs/acre

Variety	**#1**	**#2**	**#3**	**#4**
Camarosa	18,133 ^{BC*}	19,058 ^{AB}	18,838 ^{AB}	20,316 ^{AB}
Chandler	18,634 ^{ABC}	19,724 ^{AB}	20,900 ^{A}	16,225 ^{CD}
Honeye	13,674 ^{EF}	11,392 ^{FGH}	14,873 ^{DE}	12,749 ^{EFG}
Sweet Charlie	9,469 ^{HI}	10,166 ^{HI}	8,478 ^{I}	10,557 ^{GHI}

* No statistical difference @.05 level if followed by same letter

Treatments:

1. Sprinkler irrigated only for frost protection
2. Row cover plus sprinkler irrigation
3. Row cover only
4. Winter straw and heavy foam cover

In our radiant frost protection event on the morning of April 19, 2001, bud temperatures under the row covers did not go low enough to trigger treatment (#2), so sprinkler irrigation on top of the covers was not turned on.

Treatments had no effect on the yields of Camarosa and Sweet Charlie. The variety Chandler seemed to show a yield suppression to the use of a light layer of straw under the foam cover (treatment #4), compared to the other varieties and treatments. The only other major significant differences were based on variety and mean yield and number of crowns, as shown below:

Variety	**Mean Crown #**	**Mean Yield Lbs/A**
Camarosa	3.7 ^{A*}	19,086 ^{A*}
Chandler	3.7 ^{A}	18,870 ^{A}
Honeoye	2.8 ^{B}	13,172 ^{B}
Sweet Charlie	2.1 ^{C}	9,667 ^{C}

* No statistical difference @.05 level if followed by same letter

Conclusion: We are continuing to field test the strawberry E-weather product from Skybit in the 2002 season. Our feeling, from having looked at the product in 2000 and 2001, is that the Skybit weather forecasting service is an additional management tool that growers can use to help manage their strawberry crops for frost protection or evaporative cooling.

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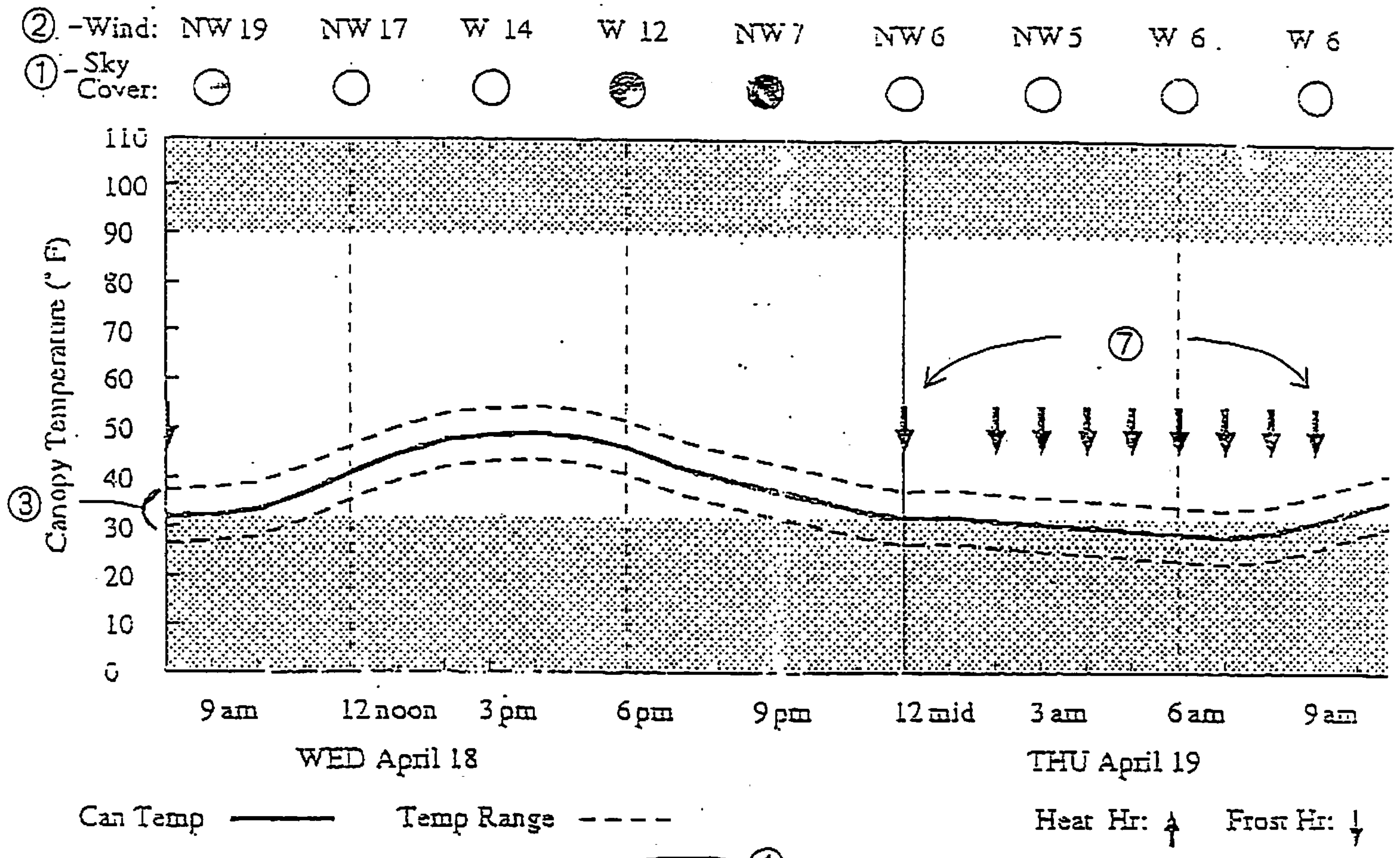
E-Weather Strawberry Canopy Forecast

Location: MD-Queen Anne Wye Straw
Beginning : 8 am EDT WED April 18 2001

Key:
① - Sky Cover
② - Wind speed and direction
③ - Canopy temperature range
④ - 7 Day forecast - temperatures
⑤ - Average dew point
⑥ - Average relative humidity
⑦ - Event timing frost hours



④

7 Day Forecast

	Apr 18 WED	Apr 19 THU	Apr 20 FRI	Apr 21 SAT	Apr 22 SUN	Apr 23 MON	Apr 24 TUE
Strawberry Canopy Inside Field							
③ Min Can Temp (F)	32	28	41	46	52	53	54
Max Can Temp (F)	48	61	62	69	78	77	77
Local Area Outside Field							
④ Min Air Temp (F)	35	34	44	48	54	55	56
Max Air Temp (F)	52	58	59	65	72	71	71
⑤ Av Dew Point (F)	24	28	42	50	54	55	54
⑥ Av Rel Hum (%)	47	47	67	74	71	73	72
Av Wnd Spd (mph)	16	7	8	9	9	9	9
Solar Rad (%)	81	100	76	71	71	72	72
Precip (in)	0.00	0.00	0.11	0.38	0.00	0.00	0.00

Note: We turned on our irrigation at 2:30 AM on 4/19/2001 for frost protection and ran the system until ice slough off at 8:00 AM. Based on blossom temperatures, system could have been safely turned off at 7:30 AM; lowest unprotected temperature at frost alarm was 29°F at 6:30 AM

(Not for publication or distribution, CSFWC Meeting 2001)

Return Bloom and Fruit Set as Influenced by Subsequent Season(s) Gibberellin, Ethephon, Foliar Nutrient, and Fruit Thinning Sprays (1997-2001)

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Abstract. Sprays of GA_3 provided some control of alternate bearing of 'York'/M.7 trees when applied in the "off year" (1997) of the biennial bearing cycle. Trees sprayed with 160 mg/liter GA_3 or 320 mg/liter GA_3 had significantly less return bloom in the 1998 ("on year") with 61% and 46% spurs flowering, respectively, compared to control trees that had 99% of spurs flowering. Trees sprayed with GA_3 in the "off year" in 1997 returned bloom and cropped again in 1999, 2000, 2001. Trees in the "off year" in 1997 that were not sprayed with GA_3, heavily cropped in 1998 and 2000 but not in 1999 and 2001. These data show that 'York'/M.7 trees sprayed with GA3 to in the "off year" of the biennial bearing cycle continued to bear on a more annual cycle for 4 years after a single spray.

In 1999, 3 applications of ethephon (135 ppm) or urea + ethephon did not promoted return bloom in 2000 beyond normal hand thinning at 21 mm fruit diameter (trt# 2). Defruiting trees at 21 mm caused increased flowering when compared to hand thinning at the same time. Hand thinning trees at 21 mm promoted more return bloom than hand thinning two weeks later at 33 mm. In 1999, fruit on trees treated with ethephon had slightly reduced fruit firmness and slightly improved fruit color during the season of application. In 2001, return bloom was not different between treatments, probably due to the freeze in April of 2000 that sufficiently thinned trees so that return bloom in the controls was not statistically different in 2001 even though wide differences in flowering were recorded in 2000.

In 1999, GA_3 or GA_{4+7} applied to 'York'/MM.111 trees in the "off year" at petal fall, 12.5 mm, or at 24 mm fruit diameters (airblast at 100 gal/acre) inhibited return bloom in 2000. The gibberellins also caused an increase in average length of the longest shoots, but flower cluster numbers on the most vigorous annual shoots were not affected. A freeze in April of 2000 significantly thinned trees so that return bloom of the treatments and control trees were not statistically different in 2001.

In 1999, GA_3 applied at 320 ppm + Oil + Silwet L-77 applied (airblast at 100 gal/acre) to 'Golden Delicious'/MM.111 trees inhibited return bloom in 2000 as indicated

by flowering cluster/cm2 limb cross sectional area on pre-tagged limbs. Gibberellic acid caused an increase in average shoot length of the 5 longest shoots at 1.5m height around the periphery of the tree, but the number of flower clusters on these most vigorous annual shoots was not affected. GA_3 applied when fruit were 15 mm fruit diameter reduced flower clusters on the lower and upper portions of vigorous annual shoots; however a visual bloom rating taken on 4 April 2000 indicated that all trees of all treatments returned bloom very strongly. Data on fruit/limb were collected, but the data were likely compromied significantly by a freeze on 10 April 00 which killed many flowers and the April 2000 freeze significantly thinned trees so that return bloom of the treatments and control trees were not statistically different in 2001.

In 2000, Promolin or ProGib was applied to young deflowered 'Golden Delicious'/M.26, 'York'/M.26, or 'Idared'/M.26 apple trees that had been planted in 1998 or 1999. Promolin or ProGib, typically, slightly increased shoot length of the 5 longest scaffold shoots and/or terminal shoots. In 2001, flowering, fruit set, and tree growth did not adequately provide the reduced flowering reduced fruit set and/or increased tree growth desirable for young trees.

In 2000, defruiting of 'York'/M.27 trees at 21 mm fruit diameter caused trees to flower profusely in 2001; whereas if trees were hand thinned trees did not flower adequately for a full crop. All of the applications of ethephon, Urea, Urea + ethephon, and/or NAA in 2000 numerically increased flowering and fruit set but were not significantly. The wide variation between trees within treatments probably caused the data to be non-significant.

In 2000, GA_3 applied to 6-year-old 'Fuji'/M.9 trees in the "off year" of the biennial bearing cycle inhibited flowering and fruit set, decreased canopy density in 2001. Applications at PF were more effective for reducing flowering and fruiting of trees; however, the most effective treatment appeared to be two applications of 320ppm at PF and PF+28 days or one application of 640 ppm at petal fall (PF) was equally effective.

In 2000, 'Fuji'/M.27 trees defruited or sprayed with ethephon at various times intervals from June to October will be evaluated for return bloom and fruit set in 2002. In 2001 a 10-fruit sample from each tree indicated that ethephon did not affect fruit diameter, L/D ratio, fruit firmness, starch, or soluble solids on 4 Oct 01.

In 2000, 'Starkrimson'/Mark trees defruited or sprayed with ethephon at various times will be evaluated for return bloom and fruit set in 2002. In 2001, a 10-fruit sample from each tree indicated that ethephon did not affect fruit diameter, L/D ratio, fruit firmness, starch, but ethephon application increased soluble solids. The latest ethephon application on 22 Aug more effectively removed fruit than the 8 August application.

In 2000, 'York'/M.27 trees defruited or sprayed with ethephon at various times will be evaluated for return bloom and fruit set in 2002. In 2001, a 10-fruit sample from each tree indicated that ethephon did not affect fruit diameter, L/D ratio, reduced fruit firmness and starch and slightly increased soluble solids. Ethephon application on 8 Aug or 22 Aug was equally effective for fruit removal (approx. 50%).

In a 1999 thinning trial, pollination inhibitors applied at bloom and hormone thinners applied at petal fall or 8 mm fruit diameter caused good fruit thinning. In 2000, trees bloomed very well, but fruit set was poor due to cool temperatures during and after bloom. In April 2000, the flower clusters/cm2 LCSA and visual spurs flowering were inversely related to cropping in 1999; thus the control (33.6% visual spurs flowering) and certain treatment trees had a "fair" return bloom in 2000 that resulted in a below desirable fruit set (1.84 fruit/cm2 LCSA). Thus in 2001, control trees and trees that were over thinned in 1999 flowered more heavily in 2000 than trees with a good crop of 5-6 fruit/cm2 LCSA in 1999.

In a 2000 thinning trial, all hormone thinners caused good fruit thinning when applied alone to 'Golden Delicious'/MM.111 trees. NAA caused more thinning than Carbaryl. 6-BA and Accel caused more thinning than Carbaryl. 6-BA + Oil caused more thinning than Sevin XLR. Oil potentiated the Sevin XLR + Accel combination. Oil potentiated Sevin + 30 g Accel (or + 30g RiteSize) when compared to Sevin + 45 g Accel (or + 45g RiteSize). RiteSize may have given more thinning than Accel over all combinations. Fruit injury was slightly increased by certain thinner combinations. The L/D ratio was increased by Accel (90g) + Oil. In 2001, the amount of flowering was inversely related to cropping in 2000. In 2001, Control trees (trt#s 1) and trees that were not adequately thinned in 2000, flowered less than trees with a crop of 5 fruit/cm2 LCSA or less. A crop load between 4 and 5 fruit/cm2 LCSA in 2000 produced an ideal return bloom in the range of 40 to 60% of the spurs flowering in 2001.

In a 2000 thinning trial, Sevin WP or XLR Plus caused good fruit thinning of 'Starkrimson Delicious'/Mark trees when applied at 17 mm fruit diameter. Sevin WP or XLR Plus were equally effective alone and in combinations with other thinners. The use of Oil with Sevin WP and XLR Plus increased fruit thinning. 6-BA and Accel caused more thinning than Carbaryl alone. Sevin XLR + 6-BA + Oil caused more thinning and lower injury than Sevin XLR + Accel + Oil. Oil did not increase injury to fruit. Fruit diameter was increased when thinning was the greatest. Sevin + Accel + Oil promoted a greater L/D ratio. Over all combinations, Sevin XLR caused more fruit injury than Sevin 50WP, but this difference was small and of no practical significance. Thinning increased fruit diameter; thus the fruit finish was poorer due to increased lenticel enlargement. In 2001, the amount of flowering was inversely related to cropping in 2000. Control trees flowered less than trees with a crop of 5 fruit/cm^2 LCSA. Because trees did not set well in 2001, even the non-thinned control trees with a 7 fruit/cm^2 LCSA in 2000, produced an ideal return bloom in the range of 50% of the spurs flowering in 2001.

In a 2000 thinning trial, Sevin XLR did not thin older 'Starkrimson Delicious'/Mark trees The best thinning was obtained by Sevin XLR + Oil or Sevin XLR + Accel + Oil. The adjuvant, Oil, was superior for promoting fruit thinning and lower fruit injury when compared with other adjuvants or pesticides used. Fruit injury was not significant with any treatment, but fruit finish (lenticel enlargement) was poorer in combinations involving Vydate + Oil, Sevin XLR + Oil, Sevin XLR + 6-BA, Sevin XLR + Lorsban 50W, or Sevin XLR + Ammonium sulfate. The L/D ratio was increased by many of the Seven + Accel treatments. In 2001, the amount of flowering was inversely related to cropping in 2000. Control trees flowered less than trees with a crop of 6 fruit/cm^2 LCSA. Because trees did not set well in 2001, even the non-thinned control trees with a 8.8 fruit/cm^2 LCSA and other treatments in 2000, produced an adequate return bloom in the range of 40% to 60% of the spurs flowering in 2001.

In a 2000 thinning trial, the adjuvants NH_4SO_4, Silwet-77, or Oil tank mixed with NAA increased thinning by NAA, but Li-700 nor Urea promoted thinning by NAA of 'Golden Delicious'/M.27. The adjuvants L-I 700, Urea, NH_4SO_4, Silwet-77, or Oil tank mixed with Sevin increased thinning by Sevin. In addition, the adjuvant combination of NH_4SO_4+ Silwet-77 + Oil caused thinning alone and thinning was further increased if Fruitone-N or Sevin were added to the adjuvant mix. Fruit injury was variable but may have been somewhat higher when thinning occurred. In 2001, the amount of flowering was inversely related to cropping in 2000. Control trees flowered less than trees with a crop of 13 fruit/cm^2 LCSA. Because Golden Delicious trees set well in 2001, non-thinned control trees with a 21.8 fruit/cm^2 LCSA and other treatments in 2000, produced a poor return bloom in the range of 18% to 35% of the spurs flowering in 2001. Even though some treatments did not thin adequately in 2000, the return bloom was in the ideal range of 40 to 60% of the spurs flowering in 2001.

In a 2000 thinning trial, ethephon applied to 'Ace Delicious'/MM.106 at 35.8 mm fruit diameter at 5 or 10 pt/acre in a water volume of 400 gal/acre did not cause fruit thinning (Table 20). In 2001, flowering also was not affected by the 2000 treatments.

In a 2000 thinning trial, ethephon applied at 5 pt/acre to 'Rome'/MM.106 when fruit were 17.1 mm in diameter caused more fruit thinning than at 2.5 pt/acre regardless of water volume (Table 21). While keeping the chemical rate/acre constant, the water rates of 100 gal/acre or 400 gal/acre were equally effective. In 2001, the amount of flowering was inversely related to cropping in 2000. Because Rome set reasonably well in 2001, non-thinned control trees with a 12.8 fruit/cm^2 LCSA, produced a poor return bloom (25% of the spurs flowering in 2001). Even though some treatments did not thin adequately in 2000, the return bloom was in the ideal range of 40 to 60% of the spurs flowering in 2001. Because ethephon over thinned in one treatment. Extremely heavy flowering will likely cause the trees to be biennial for several years thereafter.

In a 2000 thinning trial, ethephon applied at 5 pt/acre to 'Rome'/MM.106 when fruit were 28.1 mm in diameter did not cause fruit thinning. While keeping the chemical rate/acre constant, the water rates of 100 gal/acre or 400 gal/acre were not effective. In 2001, flowering also was not affected by the 2000 treatments.

Introduction

Ethephon has been used in the apple industry as a thinning agent, flower promoter, and color enhancer (Abeles 1992). Multiple low dose applications of ethephon during the thinning period have been used to promote return bloom of apple while avoiding fruit abscission from higher rates (Byers 1993). Olien and Bukovac (1978) have reported that temperature may greatly influence ethylene evolution in cherry leaves. Jones and Koen (1985) found that, in growth chambers, application and post application temperatures greatly contribute to increased fruit abscission. Our data from 1999, indicated that low levels of ethylene evolved from trees for more than 14 days after application; and that the rate of ethylene evolution was temperature dependent (Byers, unpublished). In addition, Jones et al. (1991) found that ethephon thinning was greater when an increased spray water volume was used while keeping the chemical rate constant/hectar.

Since heavy flowering in one year inhibits the growth and development of the bourse flowers in the subsequent season, partial inhibition of flowering with gibberellin sprays may promote fewer and larger flowers. McArtney (1994) demonstrated that a single spray of GA_3 or GA_{4+7} at full bloom reduced the subsequent season's flowering and the severity of biennial bearing of 'Braeburn' trees. Increasing concentrations of a gibberellin spray linearly decreased flowering the following year and promoted flowering two years after application. Several experiments have shown GA_7 to be more effective than GA_3, and that GA_4 is ineffective for inhibition of flower bud formation (Dennis and Edgerton, 1966; Tromp, 1982; McArtney and Shao-Hua Li, 1998; Tromp, 1982). Tromp (1982) found that GA_{4+7} more effectively reduced flowering than did GA_3 on both spurs and one-year-old shoots. However, Marino and Greene (1981) found that GA_3 was more effective on one-year-old shoots, and GA_{4+7} was more effective on spurs to decrease flower bud formation. Applications of gibberellins must be made at bloom or shortly thereafter to be effective on spurs; but applications up to 60 days AFB are effective on one-year-old shoots (Tromp, 1982). Gibberellins used to reduce russeting of 'Golden Delicious' fruit has also shown some inhibition of flower bud formation (Meador and Taylor, 1987; Greene, 1993). It is believed that gibberellins interfere with the early phases of bud primordia development long before flower buds are microscopically visible. Although less effective for flower bud inhibition, GA_3 may be a better choice economically since the price of GA_{4+7} may be five times that of GA_3.

To maximize tree growth, Unrath and Whitworth (1991) attempted to completely inhibit flowering of young non-bearing 'Red Chief Delicious' trees. In one experiment, multiple applications GA_{4+7} at rates of 250 mg liter^{-1} or 500 mg liter^{-1} reduced flowering by 95% to 99%, respectively. In two other experiments, similar treatments gave very little or no suppression of return bloom; however, the timing of GA_{4+7} applications may have been too late.

The objectives of the experiments reported here were: 1) to follow the return bloom and fruiting of biennial bearing 'York'/M.7 trees sprayed with GA_3 in 1997, 2) to investigate foliar nutrient sprays, multiple applications of ethephon, defruiting, and hand thinning on return bloom and fruiting of heavily set apple trees, and 3) to follow return bloom of 1999 and 2000 chemical thinning experiments.

Materials and Methods

Chemicals were applied to whole trees with a low-pressure hand-wand sprayer, a high pressure hand gun, or a Swanson 3-pt hitch airblast sprayer. The experimental designs for all experiments were randomized complete block designs (RCBD). Apple trees were selected for uniform flowering at bloom and were blocked according to row and terrain into replicate blocks for each of the treatments listed in the tables.

The number of flower clusters or the crop density (CD), was determined by counting the flower clusters or fruit on 2 or 3 pre-selected limbs per tree or on the entire tree. Two or three limbs per tree were tagged during the late pink stage; and at the point where limbs were tagged, limb circumferences were measured. The number of fruit on each limb were counted about 50 to 55 days after bloom, well after unfertilized fruit had dropped. Crop density (CD) on sample limbs was expressed as fruit•cm^2 limb cross-sectional area (LCSA). In the event that all the fruit on a tree was counted, crop density was expressed as fruit•cm^2 trunk cross-sectional area (TCSA). Past experience has indicated that when using these techniques the desirable crop load was approximately 4 to 6 fruit•cm^2 cross-sectional area limb (or trunk) after thinning (Byers and Carbaugh 1991; Byers, 1997); but this may vary by pruning style and type of limbs selected.

Data were analyzed with SAS (Sas Institute, Cary, N. C.), general linear model (GLM procedures) to evaluate the linear and quadratic effects, pre-planned single-degree of freedom contrasts of interest, or Duncan's New Multiple range tests.

Expt. 1. In 1997, forty 8-year-old 'York'/MM. 7 trees were selected for 0 to 20 % of spurs flowering (visual estimate) except for one of the control treatments that had 90 to 100 % of the spurs flowering. Trees were blocked by row and terrain into 10 blocks of 4 treatments (Table 1). Trees were not hand or chemically thinned in 1997. Trees were either sprayed or not with GA_3 at a rates of 160 ppm or 320 ppm. In 1997, the number of fruit on limbs that were pre-tagged at bloom were counted and expressed as fruit•cm^2 limb cross-sectional area (LCSA). The percentage of spurs flowering in 1998 were visually estimated and fruit set on limbs tagged in 1997, were counted on 26 May 1998. In 1999, 2000, and 2001 visual estimates of the number of spurs flowering, flower clusters and fruit were counted on 2 representative limbs per tree. Trees were over sprayed with chemical thinners in 1998,1999, 2000, and 2001.

Expt. 2. In 1999, seventy-two 4-year-old 'Fuji'/M.9 trees were selected for 90 to 100 % spurs flowering and used for 8 treatments, and an additional nine trees were selected for only 40 to 60% spurs flowering for treatment 9 (Table 2). Trees were blocked by row and terrain into 8 blocks with 9 treatments. Three multiple low doses of ethephon (135ppm) were applied alone or in combination with urea foliar nutrient spray during the period from petal fall to 21 mm fruit diameter or 25.1 to 34 mm fruit diameter. Treatments 2-9 were hand thinned at 21 mm fruit diameter, except for treatment 1 which was thinned at 33 mm, treatment 3 which was bloom thinned, and treatment 8 which was defruited at 21 mm. On Oct 13, 1999, 10 fruit from each tree of treatments 2, 5,and 7 were evaluated for fruit diameter, firmness, percent soluble solids, starch, and color. In 2000, a visual estimate of the percentage spurs flowering was made, but fruit/tree were not counted due to a freeze on 10 April 00 which affected fruit set. In 2001, return bloom was not different between treatments, probably due to the freeze in April of 2000 that sufficiently thinned trees that return bloom was not affected.

Expt. 3. In 2000, forty-eight 10-year-old 'York'/M.27 trees in the "on year" of the biennial bearing cycle were selected for 90 to 100% of spurs flowering and were blocked according to row and terrain into 8 blocks of 6 treatments (Table 3). Five multiple low doses of ethephon (135ppm) were applied alone or in combination with an urea foliar nutrient spray when fruit were 7.5 mm to 34 mm in diameter. All fruit were removed from Treatment 1 when fruit were 23 mm in diameter, and trees of treatment 2 were hand thinned when fruit were 23 mm in diameter. On Oct. 13, 1999, 10 fruit from each tree of treatments 2-7 were evaluated for fruit diameter, firmness, percent soluble solids, starch, and color. In 2001, a visual estimate of the percentage of spurs flowering and the number of fruit set were made.

Expt. 4. In 1999, one hundred eighty-four 16-year-old 'York'/MM.111 trees in the "off year" of the biennial bearing cycle were selected for uniformity of flowering and were blocked according to row and terrain into 8 blocks of 23 treatments. GA_3 applied at the rate of 0ppm, 80ppm, 320ppm, or 640 ppm, or GA_{4+7} at 105ppm or 405 ppm at petal fall and at fruit diameters of 12.5 mm and 24 mm (airblast at 100 gal/acre) (Table 4). The silicon surfactant, L-77, and Superior Oil were added to certain gibberellin treatments to compare the efficacy of GA_3 or GA_{4+7} with or without an adjuvant. In 2000, the number of flower clusters/cm^2 (LCSA) on pre-tagged limbs, flower clusters/shoot on the 5 longest periphery shoots/tree at 1.5 meter tree height and average shoot length of those 5 shoots was recorded. Fruit/limb data were collected but a freeze on 10 April 00 may have affected fruit set. In 2001, the number of flower clusters/cm^2 (LCSA) on 1999 pre-tagged limbs was not different, probably due to the freeze in 2000.

Expt..5. In 1999, forty 16-year-old 'Golden Delicious'/MM.111 trees in the "off year" of the biennial bearing cycle were selected for uniformity of flowering and were blocked according to row and terrain into 8 blocks for 5 treatments (Table 5). Four treatments were selected for 0-10% spurs flowering, and an additional treatment with 95-100% spurs flowering was selected. GA_3 at a rate of 320 ppm was applied at Petal fall, 15 mm and.30 mm fruit diameter with an airblast at 100 gal/acre. Oil+Silwet L-77 was added to the gibberellin sprays to increase effectiveness. In 1999, data were collected on fruit diameter, L/D ratio, as well as side and stem-end russet. In 2000, a visual bloom rating of the percentage of spurs flowering, the number of flower clusters/cm^2 LCSA on pre-tagged limbs, flower clusters/shoot on the 5 longest periphery shoots/tree at 1.5 meter in tree height, average length of these 5 shoots, and the number of flower clusters/on the lower and upper half of the periphery shoots was recorded. Fruit/limb data were collected even though a freeze on 10 April 00 affected fruit set. In 2001, the number of flower clusters/cm^2 (LCSA) on 1999 pre-tagged limbs was not different, probably due to the freeze in 2000. However differences in the controls (trts#1,5) were significantly different in 2001.

Expt. 6. In 2000, seventy five 6-year-old 'Fuji'/M.9 trees in the "off year" of the biennial bearing cycle were selected for uniformity of flowering and were blocked according to row and terrain into 5 blocks of 15 treatments. GA_3 applied at the rate of 0ppm, 160ppm, 320ppm, or 640 ppm at petal fall (PF) and at PF+14, PF+28, PF+42 with a low pressure hand wand sprayer (Table 6). The surfactant, Li-700, was added to all gibberellin treatments. In 2001, the number of flower clusters/cm^2 (LCSA) on pre-tagged limbs, visual % of spurs flowering canopy density and fruit/cm limb cross sectional area was recorded.

Expt. 7. In 2000, sixty-four 'Golden Delicious'/M.26 trees (planted in 1998) were blocked according to row and terrain into 16 blocks for 4 treatments, and deflowered and/or sprayed with Promolin (GA_{4+7}+ 6-BA) or ProGib (GA_3) to reduce flowering and promote tree growth (Table 7). The length of the five longest scaffold shoots/tree was determined in June and November 2000. In 2001, the number of flower clusters and fruit/cm^2 trunk cross sectional area was recorded.

Expt. 8. In 2000, eighty 'York'/M.26 trees (planted in 1998) were blocked according to row and terrain into 20 blocks for 4 treatments, and deflowered and/or sprayed with Promolin (GA_{4+7}+ 6-BA) or ProGib (GA_3) to reduce flowering and promote tree growth (Table 8). The length of the five longest scaffold shoots/tree was determined in June and November 2000. In 2001, the number of flower clusters and fruit/cm^2 trunk cross sectional area was recorded.

Expt. 9. In 2000, forty-eight 'Idared'/M.26 trees (planted in 1998) were blocked according to row and terrain into 16 blocks for 3 treatments, and deflowered and/or sprayed with Promolin (GA_{4+7}+ 6-BA) or ProGib (GA_3) to reduce flowering and promote tree growth (Table 9). The length of the five longest scaffold shoots/tree was determined in June and November 2000. In 2001, the number of flower clusters and fruit/cm^2 trunk cross sectional area was recorded.

Expt. 10. In 2000, forty-eight 'Idared'/M.26 trees (planted in 1999) were blocked according to row and terrain into 16 blocks for 3 treatments, and deflowered and/or sprayed with Promolin (GA_{4+7}+ 6-BA) or ProGib (GA_3) to reduce flowering and promote tree growth (Tables 10). The length of the five longest scaffold shoots/tree was determined in June and November 2000. In 2001, the number of flower clusters and fruit/cm^2 trunk cross sectional area was recorded.

Expt. 11. In 2000, forty-eight 'York'/M.26 trees (planted in 1999) were blocked according to row and terrain into 16 blocks for 3 treatments, and deflowered and/or sprayed with Promolin (GA_{4+7}+ 6-BA) or ProGib (GA_3) to reduce flowering and promote tree growth (Tables 11). The length of the five longest scaffold shoots/tree was determined in June and November 2000. In 2001, flower clusters/cm^2 trunk cross sectional area were collected.

Expt. 12. In 2001, seventy 10-year-old 'Fuji'/M.27 trees were blocked according to row and terrain into 5 blocks for 14 treatments, and were defruited or sprayed with ethephon at various times from June to October 2001 (Table 12A). A 10-fruit sample from each tree (of trts# 1, 10, 13) was evaluated for maturity and fruit size on 4 Oct 01 (Table 12B). In 2002, the numbers of flower clusters/cm^2 limb cross sectional area will be collected.

Expt. 13. In 2001, thirty 14-year-old 'Starkrimson'/Mark trees were blocked according to row and terrain into 6 blocks for 5 treatments, and were defruited or sprayed with ethephon at various times from August to September 2001 (Table 13). A 10-fruit sample from each tree was evaluated for maturity and fruit size on 4 Oct 01. In 2002, the numbers of flower clusters/cm^2 limb cross sectional area will be collected.

Expt. 14. In 2001, thirty 10-year-old 'York'/M.27 trees were blocked according to row and terrain into 6 blocks for 5 treatments, and were defruited or sprayed with ethephon at various times from August to October 2001 (Table 13). A 10-fruit sample from each tree was evaluated for maturity and fruit size on 4 Oct 01. In 2002, the numbers of flower clusters/cm^2 limb cross sectional area will be collected.

Expt. 15. In 1999, eighty-eight 11-year-old 'Ace Delicious'/MM.111 trees (8 blocks) were used for 16 treatments (Table 15). 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 at bloom, hormone thinner applications were delayed until Petal fall. In 2000, the number of flower clusters/cm^2 limb cross sectional area (6 April 00), a visual rating of the percentage of spurs flowering (6 April 00) and fruit set (22 May 00) were recorded. In 2001, the number of flower clusters/cm^2 limb cross sectional area (18 April 01) and a visual rating of the percentage of spurs flowering (6 April 01) were recorded.

Expt. 16. One hundred twenty-eight 7-year-old 'Golden Delicious'/MM.111 trees (8 blocks) were selected for 16 treatments (Table 16). Spray treatment #s 1-9 were applied May 8, and treatment #s 10-16 were applied May 9 when fruit were 11.7 mm and 13.9 mm in fruit diameter, respectively. Treatments were applied with Swanson 3-point-hitch airblast sprayer at 100 gal/acre. In 2001, flower clusters/cm2 limb cross sectional area, visual % of spurs flower, flowering clusters on annual wood of 5 shoots per tree, and nodes/cm were collected.

Expt. 17. Fifty-two 8-year-old 'Starkrimson Delicious'/Mark trees (4 blocks) were selected for 13 treatments (Table 17). Sevin XLR Plus and Sevin 50 WP were compared alone or in combination with Oil, Accel, or 6-BA, and additionally selected combinations. All treatments were shaded 1 day with 92 percent artificial shading to promote injury and thinning. Treatments were compared for thinning, fruit diameter, pigmy fruit, and fruit injury. Sprays were applied with a low pressure hand-wand sprayer. In 2001, a visual % of spurs flowering was collected.

Expt. 18 Fifty-six 12-year-old 'Starkrimson Delicious'/Mark trees (4 blocks) were selected for 14 treatments (Table 18). Sevin XLR Plus was compared alone or in combination with Accel, 6-BA, Oil, Silwet L-77, Lorsban 50W, Captan, Ammonium Sulfate and additionally selected combinations such as Vydate+Accel+Oil. Treatments were compared for thinning, fruit diameter, pigmy fruit, and fruit injury. Sprays were applied with a low pressure hand-wand sprayer. In 2001, a visual % of spurs flowering was collected.

Expt. 19 Ninty-six 6-year-old 'Golden Delicious'/M.27 trees (6 blocks) were used for 16 treatments (Table 19). NAA or Sevin XLR Plus were applied alone or with Li-700, Urea, NH_4SO_4, Silwet 77, Oil or a combination of NH_4SO_4 + Silwet 77 + Oil. Treatments were compared for thinning, fruit diameter, fruit russet and stem-end russet, and fruit injury. Sprays were applied with a low pressure hand-wand sprayer. In 2001, a visual % of spurs flowering was collected.

Expt. 20. Twenty-seven 15-year-old 'Ace Delicious'/MM.106 trees (9 blocks) were used for 3 treatments (Table 20). Ethephon was applied at 5.0 pt. or 10 pt./acre on June 7 when fruit diameter was 35.8 mm. Treatments were compared to unsprayed control trees for thinning, fruit diameter, fruit russet and stem-end russet. Treatments were applied with a Swanson 3-point-hitch airblast sprayer.

Expt. 21. Thirty 15-year-old 'Law Rome'/MM.106 trees (6 blocks) were used for 5 treatments (Table 21). Ethephon was applied at two chemical rates of 2.5 and 5.0 pt./acre and two water rates at 100 or 400 gal/acre on May 17 when fruit diameter was 17.1 mm. Treatments were compared for thinning, fruit diameter, fruit russet and stem-end russet. Treatments were applied with a Swanson 3-point-hitch airblast sprayer.

Expt. 22. Twenty-seven 15-year-old 'Law Rome' trees (9 blocks) were used for 3 treatments (Table 22). Ethephon was applied at 5.0 pt./acre and two water rates at 100 or 400 gal/acre on June 7 when fruit diameter was 28.1 mm. Treatments were compared for fruit thinning. Treatments were applied with a Swanson 3-point-hitch airblast sprayer. In 2001, a visual % of spurs flowering was collected.

Results and Discussion

Expt. 1. 'York'/M.7 trees selected for heavy bloom in 1997 had a heavy crop in 1997 and had only 3% of the spurs returning bloom in 1998 (trt #1) (Table 1, Figure 1). 'York' trees selected for very little bloom in 1997 ("off year" of the biennial bearing cycle) and sprayed with 160 ppm GA_3 or 320 ppm GA_3 had significantly less return bloom in the

1998 ("on year") (61% and 46% spurs flowering, respectively, compared to control trees that had 99% of spurs flowering). This flower inhibition allowed more resting spurs and adequate bloom for a full crop in 1998. In 1999, trees sprayed in 1997 ("off year") with GA_3 returned bloom cropped better than trees not sprayed with GA_3.In 2000, GA3 sprayed trees cropped lighter than those not sprayed. In 2001, trees sprayed in 1997 ("off year") with GA_3 returned bloom cropped better than trees not sprayed with GA_3. Data in the period of 1998 to 2001 demonstrate that treatment of alternate bearing 'York'/M.7 trees with GA_3 in the "off year" continued to provide some control of the biennial bearing for 4 years after a single spray in 1997.

Expt. 2. Applications of ethephon or Urea + ethephon in 1999 did not promote return bloom in 2000 when compared to hand thinning at 21 mm fruit diameter (trt# 2) although differences in the controls (trt#s 1,2,8,9) were significant (Table 2A). Defruiting trees at 21 mm in fruit diameter in 1999 caused increased flowering in 2000 (trt#8) when compared to hand thinning at the same time. Trees hand thinned at 21 mm fruit diameter (trt#2) promoted more return bloom than hand thinning two weeks later at 50 days AFB (33 mm) (trt#1). In 1999, ethephon applications slightly reduced fruit firmness and slightly improved fruit color in the year of application (Table 2B).

In 2001, return bloom was not different between treatments, probably due to the freeze in April of 2000 that sufficiently thinned trees so that return bloom in the controls was not statistically different in 2001 even though wide differences in flowering were recorded in 2000 (Table 2A).

Expt. 3. In 2000, defruiting of 'York'/M.27 trees at 23 mm fruit diameter caused trees to flower profusely in 2001 whereas if trees were hand thinned trees did not flower adequately for a full crop. All of the applications of ethephon, Urea, Urea + ethephon, and NAA in 2000 numerically increased flowering and fruit set but were not significantly. The wide variation between trees within treatments probably caused the data to be non-significant (Table 3).

Expt. 4. In 1999, GA_3 or GA_{4+7} applied to 'York'/MM.111(airblast at 100 gal/acre) in the "off year" at petal fall, 12.5 mm, or at 24 mm fruit diameters to 'York'/MM.111 trees inhibited return bloom in 2000 as measured by flowering cluster/cm^2 limb cross sectional area (Table 4). The gibberellins also caused an increase in average shoot of the longest shoots at 1.5m tree height, but flower cluster numbers on the most vigorous annual shoots were not affected. A freeze in April of 2000 significantly thinned trees so that return bloom of the treatments and control trees were not statistically different in 2001 (Table 4A).

Expt. 5. In 1999, GA_3 at 320 ppm + Oil + Silwet L-77 applied (airblast at 100 gal/acre) to 'Golden Delicious'/MM.111 trees inhibited return bloom in 2000 as measured by flowering cluster/cm2 limb cross sectional area of pre-tagged limbs (Table 5A); but did not increase fruit set in 1999 (Table 5B). Gibberellic acid caused an increase in average shoot length of the 5 longest shoots at 1.5m height around the periphery of the tree, but the number of flower clusters on these, most vigorous annual shoots were not affected (Table 5A). The GA_3 application at 15 mm fruit diameter reduced the number of flower clusters on the lower, upper portions of vigorous annual shoots; however the visual bloom rating 4 April 2000 indicated that all trees returned bloom very strongly for all treatments (Table 5A). A freeze in April of 2000 significantly thinned trees so that return bloom of the treatments and control trees were not statistically different in 2001 (Table 5A).

Expt. 6. In 2000, GA_3 applied to 6-year-old 'Fuji'/M.9 trees in the "off year" of the biennial bearing cycle inhibited the number of flower clusters/cm^2 (LCSA) on pre-tagged limbs, visual % of spurs flowering, fruit/cm limb cross sectional area, decreased canopy density such that the % visual spurs flowering was not easily comparable between treatments in 2001 (Table 6). Applications at PF were more effective for reducing flowering and fruiting of trees; however, the most effective treatment appeared to be two applications of 320 ppm at PF and PF+28 days based on fruit set, but one application of 640 ppm at petal fall (PF) was equally effective (Table 6). The surfactant Li-700 was added to all gibberellin treatments.

Expt. 7. In 2000, Promolin (GA_{4+7}+ 6-BA) applied to deflowered 'Golden Delicious'/M.26 trees (planted in 1998) reduce flowering somewhat but ProGib (GA_3) did not. Promolin, ProGib, and deflowering promoted terminal and scaffold shoot growth by 20 June 2000 but was not different by 15 Nov 00 (Table 7). Since the numbers of fruit/tree in 2000 was low on the non-deflowered trees, these trees grew less, flowered less, but set more fruit by June 01 than deflowered trees (Table 7).

Expt. 8. In 2000, ProGib (GA_3) applied to deflowered 'York'/M.26 trees (planted in 1998) reduce flowering somewhat but Promolin (GA_{4+7}+ 6-BA) did not. Promolin, ProGib, and deflowering promoted terminal and scaffold shoot growth by 20 June 2000 but was not different by 15 Jan 01 (Table 8). Since the numbers of fruit/tree in 2000 was low on the non-deflowered trees, these trees grew less, flowered more, but set approximately the same numbers of fruit in May 2001 as deflowered trees (Table 7).

Expt. 9. In 2000, Promolin (GA_{4+7}+ 6-BA) or ProGib (GA_3) applied to deflowered 'Idared'/M.26 trees (planted in 1998) reduce flowering but did not affect fruit set on 28 June 01. Promolin and ProGib promoted terminal and scaffold shoot growth by 20 June 2000 and slightly different in Jan 2001 (Table 9).

Expt. 10. In 2000, Promolin (GA_{4+7}+ 6-BA) or ProGib (GA_3) applied to deflowered 'Idared'/M.26 trees (planted in 1999) did not reduce flowering in April or fruit set in June 01. ProGib promoted scaffold shoot growth by 20 June 2000 but not in Jan 2001 (Table 10).

Expt. 11. In 2000, Promolin (GA_{4+7}+ 6-BA) or ProGib (GA_3) applied to deflowered 'York'/M.26 trees (planted in 1999) did reduce flowering in May 2001. ProGib promoted terminal shoot growth but not scaffold shoot growth by 20 June 2000 but by Jan 2001

Promolin (GA_{4+7}+ 6-BA), but not ProGib (GA_3), had reduced terminal and scaffold shoot growth (Table 11).

Expt. 12. In 2001, 'Fuji'/M.27 trees defruited or sprayed with ethephon at various times will be evaluated for return bloom and fruit set in 2002 (Table 12A). In 2001 a 10-fruit sample from each tree (of trts# 1, 10, 13) indicated that ethephon did not affect fruit diameter, L/D ratio, fruit firmness, starch, or soluble solids on 4 Oct 01 (Table 12B).

Expt. 13. In 2001, 'Starkrimson'/Mark trees defruited or sprayed with ethephon at various times will be evaluated for return bloom and fruit set in 2002 (Table 13). In 2001, a 10-fruit sample from each tree (of trts# 1, 4, 5) indicated that ethephon did not affect fruit diameter, L/D ratio, fruit firmness, starch, but the Aug 22 ethephon application increased soluble solids on 24 Sept 01 (Table 13). As expected the late ethephon application on 22 Aug more effectively removed fruit than the 8 August application.

Expt. 14. In 2001, 'York'/M.27 trees defruited or sprayed with ethephon at various times will be evaluated for return bloom and fruit set in 2002 (Table 14). In 2001, a 10-fruit sample from each tree (of trts# 1, 4, 5) indicated that ethephon did not affect fruit diameter, L/D ratio, reduced fruit firmness and starch and slightly increased soluble solids on 16 Oct 01 (Table 14). Ethephon application on 8 Aug or 22 Aug was equally effective for fruit removal (approx. 50%).

Expt. 15. In 1999, cool weather delayed the application of hormone thinners which were intended for comparison with pollination/fertilization thinners at bloom. Pollination inhibitors applied at bloom and hormone thinners applied at petal fall or 8 mm fruit diameter caused good fruit thinning (Table 15, Figure 15). 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. In April 2000, the flower clusters/cm^2 LCSA and visual spurs flowering were inversely related to cropping in 1999; thus the control (33.6% visual spurs flowering) and certain treatment trees (trt# 14) had a "fair" return bloom in 2000 that resulted in a below desirable fruit set (1.84 fruit LCSA). Thus in 2001, control trees and trees that were over thinned in 1999 flowered more heavily in 2000 than trees with a good crop of 5-6 fruit/cm2 LCSA in 1999 (trt#s 4, 7, 13, 16).

Expt. 16. In 2000, all hormone thinners caused good fruit thinning when applied alone to 'Golden Delicious'/MM.111 trees on May 8 or May 9 at 11.7 or 13.9 mm fruit diameter, respectively, with an airblast sprayer (Table 16, Figure 16). NAA caused more thinning than Carbaryl. 6-BA and Accel caused more thinning than Carbaryl. 6-BA + Oil caused more thinning than Sevin XLR. Oil potentiated the Sevin XLR + Accel combination. Oil potentiated Sevin + 30 g Accel (or + 30g RiteSize) when compared to Sevin + 45 g Accel (or + 45g RiteSize). RiteSize may have given more thinning than Accel over all combinations. Fruit injury was slightly increased by certain thinners (NAA, Sevin, Accel, and their combinations). The L/D ratio was increased by Accel (90g) + Oil.

In 2001, the amount of flowering was inversely related to cropping in 2000. In 2001, control trees (trt#s 1) and trees that were not adequately thinned in 2000 (trt#s 10, 11), flowered less than trees with a crop of 5 fruit/cm^2 LCSA or less (trt#s 4, 7, 13, 16). A crop load between 4 and 5 fruit/cm^2 LCSA in 2000 produced an ideal return bloom in the range of 40 to 60% of the spurs flowering in 2001.

Expt. 17. In 2000, Sevin WP or XLR Plus caused good fruit thinning of 'Starkrimson Delicious'/Mark when applied with a hand-wand sprayer to trees on 11 May at 17 mm fruit diameter (Table 17, Figure 17). Sevin WP or XLR Plus were equally effective alone and in combinations with other thinners. The use of Oil with Sevin WP and XLR Plus increased fruit thinning. 6-BA and Accel caused more thinning than Carbaryl alone. Sevin XLR + 6-BA + Oil caused more thinning and lower injury than Sevin XLR + Accel + Oil. Oil did not increase injury to fruit. Fruit diameter was increased when thinning was the greatest. Sevin + Accel + Oil promoted a greater L/D ratio. Over all combinations, Sevin XLR caused more fruit injury than Sevin 50WP, but this difference was small and of no practical significance. Thinning increased fruit diameter; thus the fruit finish was poorer due to increased lenticel enlargement.

In 2001, the amount of flowering was inversely related to cropping in 2000. In 2001, control trees (trt#s 1), flowered less than trees with a crop of 5 fruit/cm^2 LCSA. Because trees did not set well in 2001 even the non-thinned control trees with a 7 fruit/cm^2 LCSA in 2000, produced an ideal return bloom in the range of 50% of the spurs flowering in 2001.

Expt. 18. In 2000, Sevin XLR did not thin older 'Starkrimson Delicious'/Mark trees as in Expt. 2 (younger trees) (Table 18). The best thinning was obtained by Sevin XLR + Oil or Sevin XLR + Accel + Oil. The adjuvant, Oil, was superior for promoting fruit thinning and lower fruit injury when compared with other adjuvants or pesticides used. Fruit injury was not significant with any treatment, but fruit finish (lenticel enlargement) was poorer in combinations involving Vydate + Oil, Sevin XLR + Oil, Sevin XLR + 6-BA, Sevin XLR + Lorsban 50W, or Sevin XLR + Ammonium sulfate. The L/D ratio was increased by many of the Seven + Accel treatments.

In 2001, the amount of flowering was inversely related to cropping in 2000. In 2001, control trees (trt#s 1), flowered less than trees with a crop of 6 fruit/cm^2 LCSA. Because trees did not set well in 2000 even the non-thinned control trees with a 8.8 fruit/cm^2 LCSA and other treatments (trt#s 11, 12, 13, 14) in 2000, produced an adequate return bloom in the range of 40% to 60% of the spurs flowering in 2001.

Expt. 19. In 2000, the adjuvants NH_4SO_4, Silwet-77, or Oil tank mixed with NAA increased thinning by NAA, but Li-700 nor Urea promoted thinning by NAA of 'Golden Delicious'/M.27 (Table 19, Figure 4). The adjuvants L-I 700, Urea, NH_4SO_4, Silwet-77, or Oil tank mixed with Sevin increased thinning by Sevin. In addition, the adjuvant combination of NH_4SO_4+ Silwet-77 + Oil caused thinning alone and thinning was further increased if Fruitone-N or Sevin were added to the adjuvant mix. Fruit injury was variable but may have been somewhat higher when thinning occurred.

In 2001, the amount of flowering was inversely related to cropping in 2000. In 2001, control trees (trt#s 1), flowered less than trees with a crop of 13 fruit/cm2 LCSA. Because 'Golden Delicious' trees set well in 2000, non-thinned control trees with a 21.8 fruit/cm^2 LCSA and other treatments (trt#s 2, 3) in 2000, produced a poor return bloom in the range of 18% to 35% of the spurs flowering in 2001. Even though some treatments (trt#s 2-9, 11, 13,16) did not thin adequately in 2000, the return bloom was in the ideal range of 40 to 60% of the spurs flowering in 2001.

Expt. 20. Ethephon applied to 'Ace Delicious'/MM.106 at 35.8 mm fruit diameter at 5 or 10 pt/acre in a water volume of 400 gal/acre did not cause fruit thinning (Table 20). In 2001, flowering also was not affected by the 2000 treatments.

Expt. 21. In 2000, ethephon applied at 5 pt/acre to 'Law Rome'/MM.106 when fruit were 17.1 mm in diameter caused more fruit thinning than at 2.5 pt/acre regardless of water volume (Table 21). While keeping the chemical rate/acre constant, the water rates of 100 gal/acre or 400gal/acre were equally effective.

In 2001, the amount of flowering was inversely related to cropping in 2000. Because 'Law Rome' set reasonably well in 2000, non-thinned control trees with a 12.8 fruit/cm2 LCSA, produced a poor return bloom (25% of the spurs flowering in 2001). Even though some treatments (trt#s 3, =47%) did not thin adequately in 2000, the return bloom was in the ideal range of 40 to 60% of the spurs flowering in 2001. Because ethephon over thinned trt# 5, the extremely heavy flowering likely will cause the trees to be biennial for several years thereafter.

Expt. 22. In 2000, ethephon applied at 5 pt/acre to 'Law Rome'/MM.106 when fruit were 28.1 mm in diameter did not cause fruit thinning (Table 22). While keeping the chemical rate/acre constant, the water rates of 100 gal/acre or 400gal/acre were not effective. In 2001, flowering also was not affected by the 2000 treatments.

Expected Significance to the Virginia Apple Industry

Chemical thinning promoted return bloom when substantial thinning occurred. The return bloom caused by a single ethephon thinning spray was probably caused by a reduction of crop load related to thinning and not as a direct effect of ethylene on flower bud differentiation. Spraying of individual trees in biennially bearing block with either 1) ethephon + a foliar N source in the "on year" (to promote flowering) or spraying trees in the "off year" with GA_3 (to reduce flowering) successfully altered flowering and fruit set the following year in some experiments and not others. In some experiments when the bearing cycle was interrupted, the alternate bearing habit of trees became more annual for several seasons thereafter from a single application in the first year.

Table 1. Effect of GA3 on return bloom of 'York'/M.7 (1997-2001).

No.	Color	Treatment[z]	Spurs flowering (visual estimate, 0-100%)	Flower clusters/ cm^2 limb cross sectional area	Fruit/ cm^2 limb cross sectional area	Visual estimate of crop load (%)
			1997 (Apr 27)[Y]	1997 (Apr 27)	1997 (June 17)	
1.	W	Control - no treatment	0 to 20	0.7 b	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
			2000 (Apr 20)	2000 (Apr 20)	2000 (July 12)	2000 (July 12)
1.	W	Control - no treatment	99 a	16.3 a	12.8 a	163 a
5.	LG	GA3 160 ppm at 10 mm	61 b	9.8 b	8.6 b	104 b
6.	DP	GA3 320 ppm at 10 mm	46 b	11.9 ab	7.5 b	117 ab
7.	W2	Control – no treatment	3 c	0.5 c	0.4 c	1.5 c
			2001 (May 4)	2001 (May 4)	2001 (Aug 3)	2001 (Aug 3)
1.	W	Control - no treatment	5 c	2.41 b	0.32 c	9 b
5.	LG	GA3 160 ppm at 10 mm	35 b	7.73 b	4.22 b	44 b
6.	DP	GA3 320 ppm at 10 mm	27 bc	8.30 b	3.49 b	42 b
7.	W2	Control – no treatment	93 a	20.83 a	8.92 a	133 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, $P \leq 0.05$.

EFFECT OF GA3 ON CROPPING OF 'YORK'/M.7 (1997-2001)

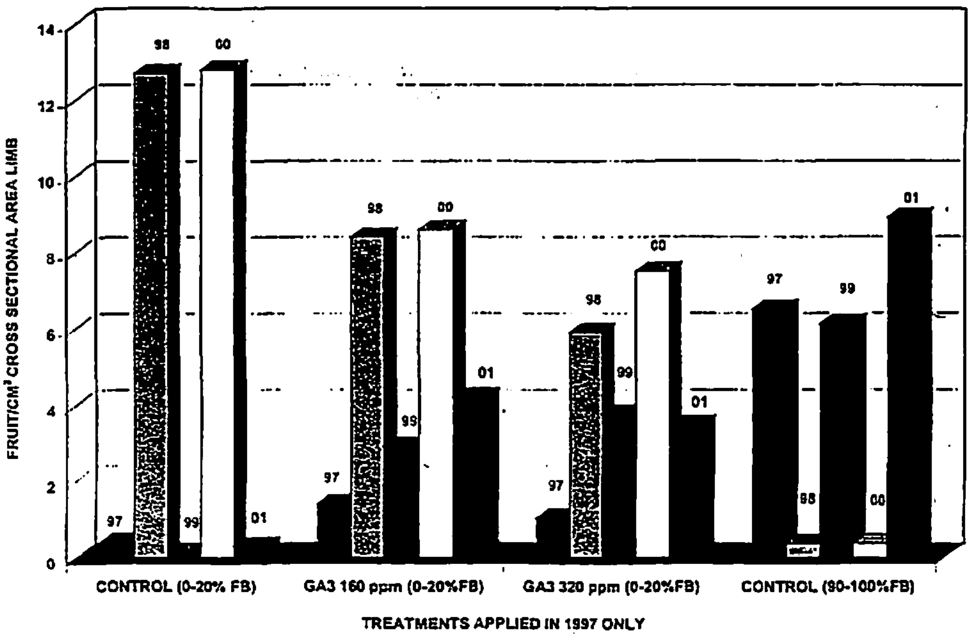

Table 2A. Effect of ethephon, urea, defruiting, and hand-thinning on return bloom 'Fuji'/M.9 (1999-2001).

No.	Color	Treatment^{ZY}	Spurs Flowering (%) 1999	Rate/ 100 gal	Rate/ 3.5 liter	Fruit diameter and date (1999)							Visual spurs flowering (0-100%)	Fruit/cm^{2} cross sectional area tree after thinning	Visual % o spurs flowering (0-100%)	Visual % of spurs flowering (0-100%)
						Full bloom May 1	7.1 mm May 11	13.3 mm May 17	21.0 mm May 25	25.1 mm June 3	33.0 mm June 10	34.0 mm June 17	29 Apr 99	21 May 99	11 Apr 00	25 Apr 01
1.	W	Control—hand thinning 50 days AFB	90 to 100								T		93 a^{x}	5.993 b	14.4 c	71.4 a
2.	Y	Control--Hand Thinning at 21 mm	90 to 100						T				94 a	6.003 ab	35.6 b	80.3 a
3.	RCK	Hand Thinning at bloom and adjusted again at 21 mm	90 to 100			T			T				93 a	6.007 a	42.2 b	83.7 a
4.	YS	Ethephon 135 ppm + H. Thinning at 21 mm	90 to 100	237 ml	2.19ml		x	x	Tx				93 a	6.001 ab	43.3 b	82.0 a
5.	YRS	Ethephon 135 ppm + H. Thinning at 21 mm	90 to 100	237 ml	2.19ml				T	x	x	x	92 a	6.003 ab	36.3 b	85.0 a
6.	GD	Ethephon 135 ppm + Urea + H. Thinning at 21 mm	90 to 100	237 ml 5 lb (2518g)	2.19ml 21g		x x	x x	Tx x				94 a	6.005 a	30.0 bc	80.3 a
7.	BD	Ethephon 135 ppm + Urea + H. Thinning at 21 mm	90 to 100	237 ml 5 lb (2518g)	2.19ml 21g				T	x x	x x	x x	94 a	6.009 a	32.2 b	84.4 a
8.	BS	Defruit at 21 mm	90 to 100						T				93 a	0.000 c	73.3 a	84.4 a
9.	PBKD	Control	40 to 60						T				58 b	6.005 a	37.8 b	72.2 a

^{Z}(T)= Thinning was done by hand 21 May 99 when fruit diameter was approximately 17.5mm.

^{Y}Full bloom = May 1,1999 .

^{X}Mean separation within columns by Duncan's New Multiple Range Test (P≤ 0.05).

Table 2B. Effect of ethephon, urea, defruiting, and hand-thinning on return bloom 'Fuji'/M.9 (1999-2000).

No.	Color	Treatment^{ZY}	Spurs Flowering (%) 1999	Rate /100 gal	Rate 3.5 liter	Fruit diameter and date (1999)							Visual spurs flowering (0-100%)	Fruit/cm^{2} cross sectional area tree after thinning	Fruit diameter (cm)	Length/ diameter ratio (cm)	Fruit firmness (lb)	Soluble solids	Starch (0-8)	Color (%)
						Full bloom May 1	7.1 mm May 11	13.3 mm May 17	21.0 mm May 25	25.1 mm Jun 3	33.0 mm Jun 10	34.0 mm Jun 17	29 Apr 99	21 May 99	13 Oct 99	13 Oct 99	13 Oct 99	13 Oct 99	13 Oct 99	13 Oct 99
2.	Y	Control--Hand Thinning at 21 mm	90 to 100						T				94 a^{X}	6.003 ab	7.38 b	0.846 a	16.8 a	14.7 a	5.8 a	69.1 b
5.	YRS	Ethephon 135 ppm + H. Thinning at 21 mm	90 to 100	237 ml	2.19ml				T	x	x	x	92 a	6.003 ab	7.45 b	0.848 a	16.3 b	15.0 a	5.9 a	73.3 a
7.	BD	Ethephon 135 ppm + Urea + H. Thinning at 21 mm	90 to 100	237 ml 5 lb (2518g)	2.19ml 21g				T	x x	x x	x x	94 a	6.009 a	7.69 a	0.831 b	15.9 c	15.1 a	6.0 a	74.5 a

^{Z}(T)= Thinning was done by hand.

^{Y}Full bloom = May 1,1999 .

^{X}Mean separation within columns by Duncan's New Multiple Range Test (P≤ 0.05).

Table 3. Effect of various factors on return bloom of 'York'/M27 (2000-01).

No.	Color	Treatment[z][y]	Spurs Flowering (%) (2000)	Rate /100 gal	Rate/ gallon	Fruit diameter and date (2000)					Fruit/cm² trunk cross sectional area before thinning 15 May	Fruit/cm² trunk cross sectional area after thinning 16 May	Fruit diameter (short side) (cm) 21 Sept	Length diameter ratio (short side) (cm) 21 Sept	Fruit diameter (long side) (cm) 21 Sept	Length diameter ratio (long side) (cm) 21 Sept	York cork spot (%) 21 Sept	Visual % of spurs flowering (0-100%) 26 Apr 01	Fruit/cm² trunk cross sectional area 5 June 01
						7.5 mm May 2	15.0 mm May 9	23.3 mm May 17	28.0 mm May 24	34.1 mm May 31									
1.	W	Defruiting at 21 mm--	90 to 100					T			31.1 a[x]	0.00 a	---	---	---	---	---	92 a	17.30 a
2.	R	Hand Thinning at 21 mm	90 to 100					T ·			21.3 b	6.25 a	7.98 ab	0.811 ab	8.43 a	0.768 a	42.5 a	4 b	2.96 b
3.	B	Ethephon 135 ppm + H. Thinning at 21 mm	90 to 100	237 ml	2.37 ml	x	x	xT	x	x	21.0 b	6.28 a	7.79 b	0.820 a	8.39 a	0.761 a	26.3 a	11 b	5.23 b
4.	FO	Ethephon 135 ppm + Urea + H. Thinning at 21 mm	90 to 100	237 ml 5 lb (2270g)	2.37ml 22.70g	x x	x x	xT x	x x	x x	20.5 b	6.17 ab	7.91 ab	0.794 bc	8.39 a	0.749 a	38.8 a	16 b	7.04 b
5.	HP	Urea + H. Thinning at 21 mm	90 to 100	5. lb (2270g)	22.7g	x	x	xT	x	x	21.9 b	6.30 a	8.12 a	0.802 abc	8.53 a	0.764 a	41.3 a	16 b	8.99 b
6.	Y	Fruitone N NAA 5 ppm + H. Thinning at 21 mm	90 to 100	61g	0.61g	x	x	xT	x	x	17.6 b	6.00 b	8.15 a	0.783 c	8.57 a	0.746 a	27.5 a	14 b	4.84

[z](T) = Thinning was done by hand (May 16, 2000). In 2001 trees were thinned to 6 FTCSA on June 13 (35-37mm).

[y]Full bloom = April 12, 2000. Spray treatments were applied with a low pressure hand wand sprayer.

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

INFLUENCE OF ETHEPHON, HAND THINNING, AND FOLIAR FERTILIZERS ON RETURN BLOOM OF 'YORK'/M.27 (2000-01)

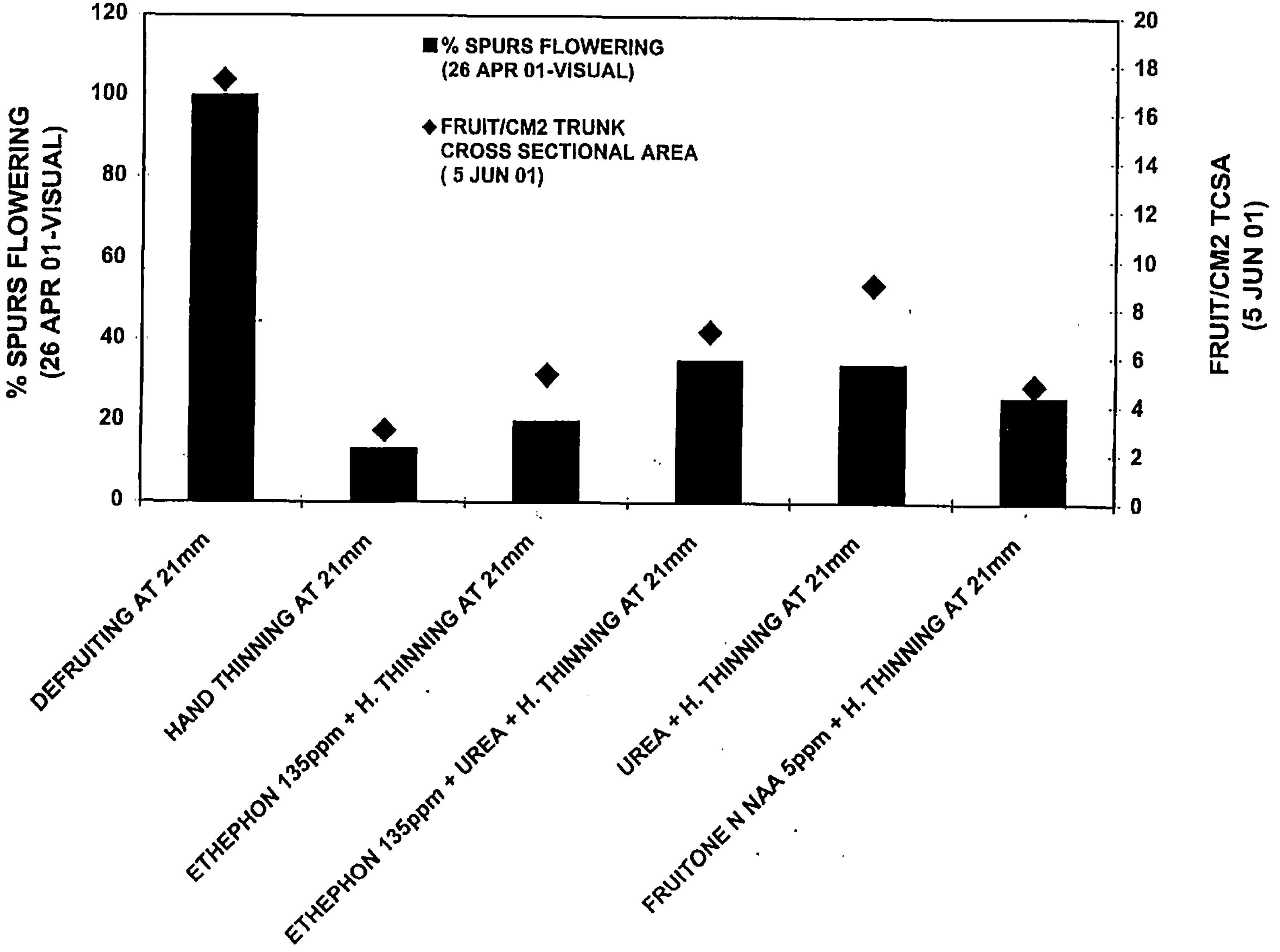

Table 4. Effect of GAs, rate, and timing on fruit set, croping, and return bloom of 'York'/MM. 111 (1999-2001).

No.	Color	Treatment[z][y]	Adjuvant	Tree type % spurs flowering	Spray timing	Spurs flowering (visual rating, 0-100%) 28 Apr 99	Flowering clusters /cm^2 limb cross sectional area 28 Apr 99	Fruit/cm^2 limb cross sectional area 7 July 99	Spurs flowering (visual estimate 0-100%) 10 Apr 00	Flowering clusters /cm^2 limb cross sectional area 10 Apr 00	Flowering cluster density (visual rating, 0-10) 10 Apr 00	Total flowering clusters per shoot 11 Apr 00	Flowering clusters per upper half of shoot 11 Apr 00	Flowering clusters per lower half of shoot 11 Apr 00	Average shoot length (cm) 11 Apr 00	Fruit/cm^2 limb cross sectional area 5 June 00	Visual spurs flowering (0-100%) 30 Apr 01	Flowering clusters /cm^2 limb cross sectional area 30 Apr 01
1.	W	Control		0 to 10%		5.06 abc[x]	0.791 a	0.676 a	97.0 a	14.2 ab	9.6 abc	7.6 abcd	4.3 abc	3.3 abcd	17.2 gh	2.88 ab	21.3 b	3.23 b
2.	RBKD	Control	L-77	0 to 10%	PF	5.39 abc	0.736 a	0.147 bc	98.8 a	14.5 a	9.8 ab	9.2 ab	5.0 ab	4.2 ab	16.9 h	2.43 ab	38.3 ab	5.13 ab
3.	CKP-W	Control	Oil+L77	0 to 10%	PF	3.57 bc	0.469 a	0.273 abc	97.1 a	13.1 abc	10.0 a	6.9 bcd	3.7 bcde	3.2 abcd	16.7 h	1.85 b	32.8 ab	5.31 ab
4.	O	GA_3 80 ppm		0 to 10%	PF	4.11 abc	0.623 a	0.367 abc	92.8 abc	11.2 cdef	9.0 bcde	10.3 a	5.5 a	4.8 a	19.7 efgh	2.31 ab	26.1 b	4.12 ab
5.	PBKS	GA_3 320 ppm		0 to 10%	PF	5.90 ab	0.598 a	0.164 bc	91.7 abcd	8.8 efgh	8.1 ef	9.1 ab	4.6 abc	4.5 ab	25.4 bcd	3.14 ab	30.3 ab	4.56 ab
6.	RD	GA_3 80 ppm	L-77	0 to 10%	PF	4.23 abc	0.605 a	0.458 abc	97.2 a	12.1 abcd	9.7 abc	9.3 ab	4.7 abc	4.6 ab	19.1 fgh	3.55 a	38.9 ab	4.89 ab
7.	GD	GA_3 320 ppm	L-77	0 to 10%	PF	4.40 abc	0.498 a	0.143 bc	89.4 abcd	8.2 fgh	7.0 h	8.4 ab	4.2 abcd	4.2 ab	25.1 bcd	2.60 ab	36.1 ab	4.05 ab
8.	G	GA_3 80 ppm	Oil	0 to 10%	PF	5.33 abc	0.509 a	0.143 bc	97.0 a	12.6 abcd	9.3 abcd	7.4 abcd	3.8 abcde	3.6 abc	17.1 gh	3.09 ab	38.0 ab	4.67 ab
9.	BK	GA_3 320 ppm	Oil	0 to 10%	PF	5.41 abc	0.629 a	0.210 abc	77.8 ef	8.1 fgh	7.1 h	7.9 abc	4.0 abcde	3.9 ab	27.1 ab	2.58 ab	27.2 b	3.72 ab
10.	Y	GA_3 80 ppm	Oil+L77	0 to 10%	PF	5.61 abc	0.751 a	0.117 c	94.8 a	11.4 bcde	8.8 cdef	8.3 ab	4.3 abc	4.0 ab	18.7 gh	2.12 ab	46.5 a	6.22 a
11.	R	GA_3 320 ppm	Oil+L77	0 to 10%	PF	4.96 abc	0.591 a	0.465 abc	83.3 cde	6.3 h	6.7 hi	9.0 ab	4.5 abc	4.5 ab	26.6 abc	2.15 ab	32.2 ab	4.46 ab
12.	RYS	GA_{4+7} 105 ppm		0 to 10%	PF	5.34 abc	0.600 a	0.607 ab	93.9 ab	10.3 cdefg	9.0 bcde	6.7 bcd	3.4 bcde	3.3 abc	17.7 gh	2.63 ab	31.7 ab	4.11 ab
13.	CKO	GA_{4+7} 420 ppm		0 to 10%	PF	5.46 abc	0.473 a	0.103 c	75.6 ef	6.3 h	5.0 k	7.1 abcd	3.6 bcde	3.5 abc	29.8 a	1.93 b	32.5 ab	4.81 ab
14.	BD	GA_{4+7} 105 ppm	L-77	0 to 10%	PF	3.40 c	0.569 a	0.349 abc	96.3 a	9.9 defg	9.2 abcd	8.9 ab	4.7 abc	4.2 ab	17.9 gh	2.67 ab	26.0 b	3.21 b
15.	RS	GA_{4+7} 420 ppm	L-77	0 to 10%	PF	6.17 a	0.565 a	0.213 abc	78.9 e	7.7 gh	6.8 hi	8.4 ab	4.2 abcd	4.2 ab	25.7 bcd	3.03 ab	33.9 ab	4.85 ab
16.	OBKD	GA_{4+7} 105 ppm	Oil	0 to 10%	PF	4.79 abc	0.637 a	0.213 abc	90.8 abcd	8.8 efgh	8.4 def	6.5 bcde	3.3 bcdef	3.2 abcd	17.8 gh	1.82 b	30.0 ab	3.75 ab
17.	CYO	GA_{4+7} 420 ppm	Oil	0 to 10%	PF	5.26 abc	0.672 a	0.254 abc	83.9 bcde	7.5 gh	7.2 gh	6.2 bcde	3.1 cdef	3.1 bcd	23.1 cde	2.91 ab	36.7 ab	5.17 ab
18.	OBKS	GA_{4+7} 105 ppm	Oil+L77	0 to 10%	PF	5.18 abc	0.849 a	0.533 abc	90.6 abcd	8.4 efgh	8.6 def	8.8 ab	4.5 abc	4.3 ab	20.8 efg	2.55 ab	31.5 ab	4.16 ab
19.	BS	GA_{4+7} 420 ppm	Oil+L77	0 to 10%	PF	3.49 bc	0.512 a	0.149 bc	78.3 e	6.2 h	6.0 ji	8.6 ab	4.4 abc	4.2 ab	25.9 bcd	2.55 ab	22.2 b	3.14 b
20.	YS	GA_3 640 ppm	Oil+L77	0 to 10%	PF	4.40 abc	0.760 a	0.234 abc	68.8 f	7.2 gh	5.3 jk	6.2 bcde	3.1 cdef	3.1 bcd	28.6 abc	1.91 b	38.9 ab	5.07 ab
21.	B	GA_3 320 ppm	Oil+L77	0 to 10%	12.5 mm	3.78 abc	0.472 a	0.236 abc	90.0 abcd	7.6 gh	7.9 fg	4.7 de	2.4 ef	2.3 cd	20.2 efgh	1.69 b	32.2 ab	3.79 ab
22.	PBKD	GA_3 640 ppm	Oil+L77	0 to 10%	12.5 mm	4.67 abc	0.756 a	0.289 abc	81.5 de	7.4 gh	6.8 hi	3.6 e	1.8 f	1.8 d	22.5 def	1.97 b	29.4 ab	4.27 ab
23.	HP	GA_3 320 ppm	Oil+L77	0 to 10%	24.0 mm	4.52 abc	0.606 a	0.291 abc	96.1 a	10.2 cdefg	9.1 abcd	4.7 cde	2.5 def	2.2 cd	17.4 gh	2.39 ab	32.7 ab	4.43 ab
Contrasts		**Comparisons**							Pr>F	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F
1,2,3 vs 4,6,8,10		No gibberellin vs 80 ppm GA_3							ns	**	*	ns	ns	***	ns	ns	ns	ns
1,2,3 vs 5,7,9,11		No gibberellin vs 320 ppm GA_3							***	***	***	ns	*	***	***	ns	ns	ns
1,2,3 vs 12,14,16,18		No gibberellin vs 105 ppm GA_{4+7}							*	***	***	**	ns	***	**	ns	ns	ns
1,2,3 vs 13,15,17,19		No gibberellin vs 420 ppm GA_{4+7}							***	***	***	*	ns	***	***	ns	ns	ns
1,2,3 vs 11		No gibberellin vs 320 ppm GA_3 + Oil + L-77 (PF)							***	***	***	ns	ns	***	***	ns	ns	ns
1,2,3 vs 21		No gibberellin vs 320 ppm GA_3 + Oil + L-77(12.5 mm)							*	***	***	***	***	***	*	ns	ns	ns
1,2 3 vs 23		No gibberellin vs 320 ppm GA_3 + Oil + L-77(24 mm)							ns	***	*	***	***	***	ns	ns	ns	ns
4,6,8,10 vs 5,7,9,11		80 ppm vs 320 ppm (GA_3)							ns	ns	**	*	**	ns	***	ns	ns	ns
12,14,16,18 vs 13,15,17,19		105 ppm vs 420 ppm (GA_{4+7})							***	***	***	ns	ns	**	***	ns	ns	ns
4,5,12,13 vs 8,9,16,17		Oil vs none (GA_3 and GA_{4+7})							ns	ns	ns	*	ns	**	**	ns	ns	ns
4,5,12,13 vs 6,7,14,15		L-77 vs none (GA_3 and GA_{4+7})							ns	ns	ns	ns	ns	ns	*	ns	ns	ns
4,5,12,13 vs 10,11,18,19		Oil + L-77 vs none (GA_3 and GA_{4+7})							ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
20 vs 22		PF vs 12.5 mm (GA_{4+7})							***	ns	***	**	**	ns	*	ns	ns	ns
11 vs 21		PF vs 12.5 mm (320 ppm GA_3)							ns	ns	**	**	***	ns	***	ns	ns	ns
11 vs 23		PF vs 24 mm (320 ppm GA_3)							ns	**	***	**	***	**	***	ns	ns	ns

[z] Full bloom occurred April 26,1999; petal fall May 4,1999.

[y] Treatments were applied 4 May, 19 May, 31 May, with an airblast sprayer at 100 gal water/A. Trees were 14 ft wide 15 feet high and 26 ft. between rows (65% TRV). Chemical rates were as follows: GA_3=10.0 ml/L (320 ppm), 5.0 ml/L (160 ppm), 2.5 ml/L (80 ppm); GA_{4+7}=20.0 ml/L (420 ppm), 10.0 ml/L (210 ppm), 5.0 ml/L (105 ppm); Oil= 5.0 ml/L; L-77= 0.62 ml/L.

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

Table 5A. Effect of GAs, rate, and timing on fruit set, croping, and return bloom of 'Golden Delicious'/MM. 111 (1999-2001).

No.	Color	Treatment[zy]	Adjuvant	Tree type % spurs flowering (1999)	Spray timing (1999)	Flowering clusters/ cm^2 limb cross sectional area (29 Apr 99)	Fruit/cm^2 limb cross sectional area (24 Jun 99)	Flowering clusters/ cm^2 limb cross sectional area (4 Apr 00)	Flowering clusters/ shoot (lower half) (4 Apr 00)	Flowering clusters/ shoot (upper half) (4 Apr 00)	Total flowering clusters/ shoot (4 Apr 00)	Average shoot length (cm) (4 Apr 00)	Visual bloom rating (%) (4 Apr 00)	Fruit/cm^2 cross limb cross sectional aroa (7 June 00)	Flowering clusters/ cm^2 limb cross sectional area (Apr 01)	% Spurs flowering (visual) (0-100%) (Apr 01)
1.	W	Control		0 to 10%		0.297 b[X]	0.575 b	7.21 a	16.8 a	26.1 a	42.9 a	32.6 b	100 a	2.99 a	1.4 b	5.6 b
2.	R	GA_3 320 ppm	Oil+L77	0 to 10%	PF	0.297 b	0.449 b	5.31 b	7.9 b	28.1 a	36.0 a	38.8 a	100 a	2.55 a	1.8 b	5.9 b
3.	B	GA_3 320 ppm	Oil+L77	0 to 10%	15 mm	0.257 b	0.315 b	6.69 ab	3.7 c	8.2 c	11.9 c	35.9 ab	100 a	3.16 a	2.3 b	7.8 b
4.	HP	GA_3 320 ppm	Oil+L77	0 to 10%	30 mm	0.280 b	0.572 b	6.77 ab	9.7 b	14.2 b	23.9 b	33.4 b	100 a	3.62 a	1.9 b	4.6 b
5.	W2	Control		95 to 100%		15.004 a	6.013 a	0.97 c	0.0 c	0.5 d	0.5 d	32.9 b	1 b	1.33 b	15.4 a	99.5 a

[z] Full bloom occurred April 28, 1999; petal fall May 4, 1999. A freeze on Apr 13, 2000 affected fruit set data.

[y] Treatments were applied with an airblast sprayer at 100 gal water/A. Trees were 14 ft wide 15 feet high and 26 ft. between rows (65% TRV).

Chemical rates were as follows: GA_3=3.785 ml/L; Oil=5.0 ml/L; L-77=0.62 ml/L.

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

Table 5B. Effect of GAs, rate, and timing on fruit set, croping, and return bloom of 'Golden Delicious'/MM. 111 (1999).

No.	Color	Treatment[zy]	Adjuvant	Tree type (% spurs flowering)	Spray timing	Flowering clusters/cm^2 limb cross sectional area (29 Apr 99)	Fruit/cm^2 limb cross sectional area (24 Jun 99)	Fruit diameter (cm) (6 Sep 99)	Length/ diameter ratio (6 Sep 99)	Net fruit side russet rating (0-5)[x] (6 Sep 99)	Stem-end russet rating (0-5)[x] (6 Sept 99)
1.	W	Control		0 to 10%		0.297 b[W]	0.575 b	7.25 b	0.969 c	1.76 a	2.09 a
2.	R	GA_3 320 ppm	Oil+L77	0 to 10%	PF	0.297 b	0.449 b	7.22 b	0.977 bc	1.70 ab	1.92 a
3.	B	GA_3 320 ppm	Oil+L77	0 to 10%	15 mm	0.257 b	0.316 b	7.22 b	0.996 a	1.61 b	1.77 a
4.	HP	GA_3 320 ppm	Oil+L77	0 to 10%	30 mm	0.280 b	0.572 b	7.41 a	0.983 ab	1.79 a	1.98 a
5.	W2	Control		95 to 100%		15.004 a	6.013 a	6.15 c	0.946 d	1.58 b	1.43 b

[z] Full bloom occurred April 28, 1999; petal fall May 4, 1999.

[y] Treatments were applied with an airblast sprayer at 100 gal water/A. Trees were 14 ft wide 15 feet high and 26 ft. between rows (65% TRV).

Chemical rates were as follows: GA_3=3.785 ml/L; Oil=5.0 ml/L; L-77=0.62 ml/L.

[x] 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 GA_3 rate and timing on 'Fuji'/M.9 return bloom and fruit set (2000-01).

No.	Color	Treatment[z,y]	GA3/ one gallon	Tree type % spurs flowering	Spray timing	Flowering clusters/cm^2 limb cross sectional area (25 Apr 01)	Visual % of spurs flowering (0-100%) (25 Apr 01)	Canopy density (visual) (0-100%) (25 Apr 01)	% Spurs flowering x Canopy density /1000 (25 Apr 01)	Fruit/cm^2 cross sectional area limb (18 Jun 01)
1.	W	Control		0 to 10%		5.83 a[x]	73 a	72 ab	5.26 ab	4.74 abc
2.	R	GA_3 160 ppm	18.93 ml	0 to 10%	PF	2.88 cd	53 bc	61 abc	3.39 bcd	3.68 abcd
3.	B	GA_3 320 ppm	37.85 ml	0 to 10%	PF	1.95 d	42 cd	55 bc	2.44 d	2.25 cd
4.	FO	GA_3 640 ppm	75.70 ml	0 to 10%	PF	2.44 d	35 d	51 c	1.90 d	2.84 bcd
5.	HP	GA_3 160 ppm	18.93 ml	0 to 10%	PF + 14	3.77 abcd	71 a	66 abc	4.70 abc	2.46 cd
6.	Y	GA_3 320 ppm	37.85 ml	0 to 10%	PF + 14	3.36 bcd	63 ab	68 abc	4.32 abc	2.58 cd
7.	BK	GA_3 640 ppm	75.70 ml	0 to 10%	PF + 14	3.58 abcd	67 ab	65 abc	4.37 abc	3.35 abcd
8.	DG	GA_3 160 ppm	18.93 ml	0 to 10%	PF + 28	3.13 bcd	74 a	78 a	5.75 a	2.26 cd
9.	RS	GA_3 320 ppm	37.85 ml	0 to 10%	PF + 28	3.82 abcd	73 a	67 abc	4.95 ab	4.20 abcd
10.	BS	GA_3 640 ppm	75.70 ml	0 to 10%	PF + 28	5.19 abc	72 a	64 abc	4.64 abc	5.88 a
11.	BKS	GA_3 160 ppm	18.93 ml	0 to 10%	PF + 42	5.33 ab	79 a	76 a	6.09 a	5.40 ab
12.	GD	GA_3 320 ppm	37.85 ml	0 to 10%	PF + 42	3.19 bcd	76 a	77 a	5.90 a	3.18 bcd
13.	RD	GA_3 640 ppm	75.70 ml	0 to 10%	PF + 42	5.25 abc	74 a	70 ab	5.39 a	3.65 abcd
14.	BD	GA_3 320 ppm	37.85 ml	0 to 10%	PF	2.04 d	45 cd	61 abc	2.97 cd	1.68 d
		+ 320 ppm	37.85 ml		PF + 28					
15.	BKD	GA_3 160 ppm	18.93 ml	0 to 10%	PF	2.32 d	39 cd	60 abc	2.41 d	3.28 bcd
		+ 160 ppm	18.93 ml		PF + 14					
		+ 160 ppm	18.93 ml		PF + 28					
		+ 160 ppm	18.93 ml		PF + 42					
Contrasts		Comparisons				Pr>F	Pr>F	Pr>F	Pr>F	Pr>F
2,3,4 vs 5,6,7		Petal fall vs petal fall+14 days				ns	***	*	***	ns
2,3,4 vs 8,9,10		Petal fall vs petal fall+28 days				**	***	**	***	ns
2,3,4 vs 11,12,13		Petal fall vs petal fall+42 days				***	***	***	***	ns
4 vs 7		Petal fall vs petal fall+14 days				ns	***	ns	**	ns
4 vs 10		Petal fall vs petal fall+28 days				**	***	ns	**	**
4 vs 13		Petal fall vs petal fall+42 days				**	***	*	***	ns
5,6,7 vs 8,9,10		Petal fall+14 days vs petal fall+28 days				ns	ns	ns	ns	*
8,9,10 vs 11,12,13		Petal fall+28 days vs petal fall+42 days				ns	ns	ns	ns	ns
5,6,7 vs 11,12,13		Petal fall+14 days vs petal fall+42 days				ns	*	ns	**	*
14 vs 4		2 applications (320ppm) vs one application (640)				ns	ns	ns	ns	ns
15 vs 4		4 applications (160ppm) vs one application (640ppm)				ns	ns	ns	ns	ns

[z] Full bloom occurred April 14 2000;

[y] Treatments were applied at PF (24 Apr), PF+14, PF+28, PF+42 days with a low pressure hand-wand sprayer . Chemical rates were as follows: 1,893 ml/100gal=160 ppm GA_3; 3,785 ml/100gal=320 ppm GA_3; 7,570 ml/100gal=640 ppm GA_3. Li-700 was added to all GA_3 treatments at 9.46ml/gallon.

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

EFFECT OF GA_3 RATE AND TIME ON 'FUJI'/M.9 RETURN BLOOM AND FRUIT SET IN 2001 (TREATMENTS APPLIED TO TREES WITH 0-10% SPURS FLOWERING IN 2000)

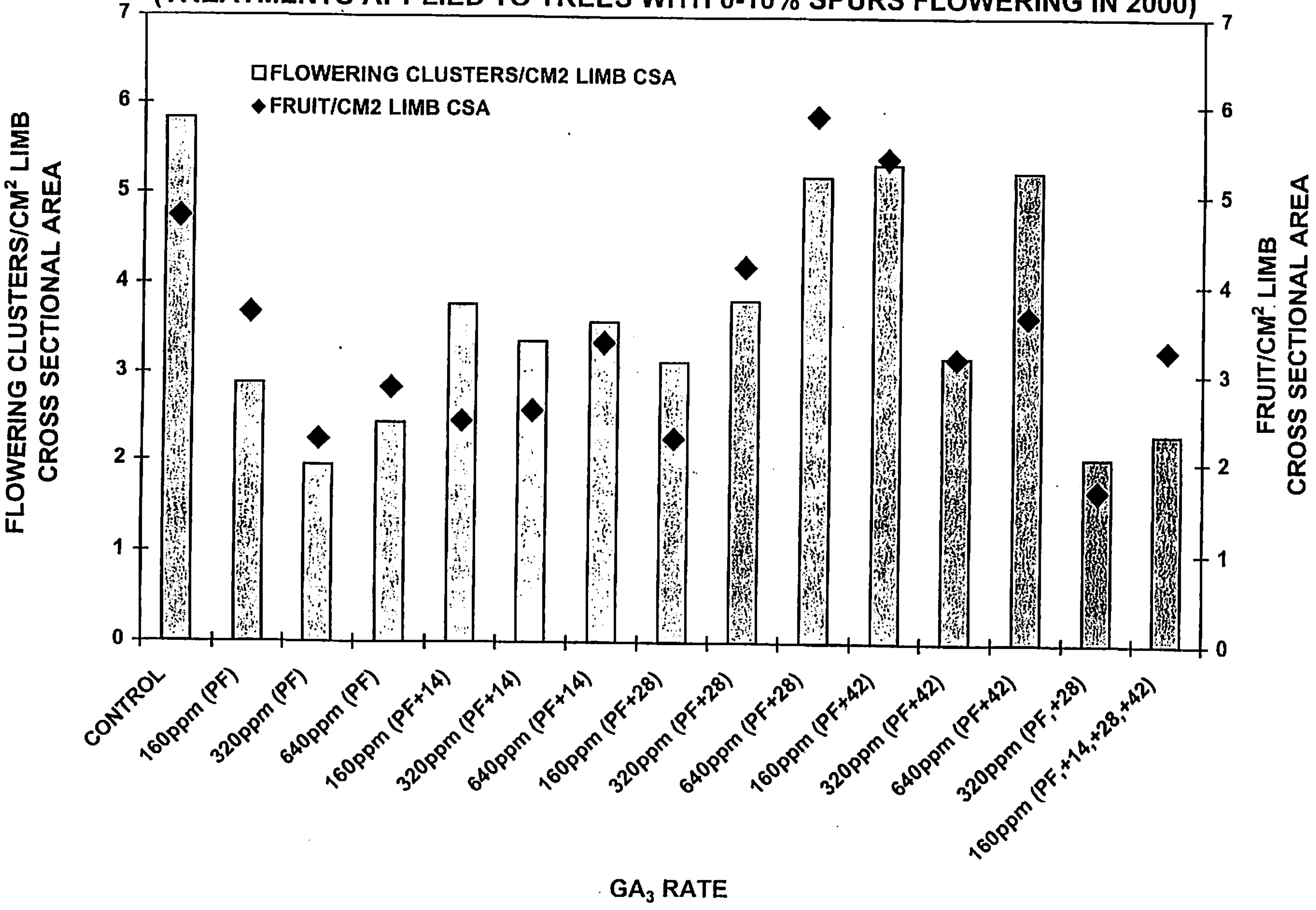

Table 7. Effect of gibberellins on 'Golden Delicious'/M. 26 planted in 1998 and applied in 2000 (2001).

No.	Color	Treatment GA3 (ppm)[z,y] PF, 21,42	Rate/ 100 gal	Rate/ gallon		Trunk diameter (26 Apr 00)	Average number of flowering clusters per tree (26 Apr 00)	Average number of fruit per tree (20 June 00)	Average shoot length of longest top 2 terminal shoots per tree (cm) (20 June 00)	Average shoot length of 5 longest scaffold shoots per tree (cm) (20 June 00)	Average shoot length of longest top 2 terminal shoots per tree (cm) (15 Nov 00)	Average shoot length of 5 longest scaffold shoots per tree (cm) (15 Nov 00)	Flowering clusters/cm^2 trunk cross sectional area (19 Apr 01)	Fruit/cm^2 trunk cross sectional area (29 Jun 01)
1.	W	Control			Deflowered	24.73 a[x]	0.00 b	0.00 b	49.0 b	45.8 b	80.0 a	82.8 a	19.9 a	5.28 b
2.	OBKD	Promolin (1.8% GA4+7 and 6-BA)	2 gal	75.5 ml	Deflowered	24.78 a	0.00 b	0.00 b	56.4 a	52.3 a	83.8 a	83.4 a	11.6 b	4.22 b
3.	YRD	ProGib (GA3–4%)	1 gal	37.9 ml	Deflowered	24.06 b	0.00 b	0.00 b	60.0 a	54.3 a	88.9 a	86.4 a	17.9 a	6.89 ab
4.	W	Control			Not deflowered	25.00 a	31.9 a	17.6 a	41.7 c	39.5 c	56.5 b	58.7 b	14.0 b	8.67 a

[z] Full bloom occurred Apr 15. Petal fall occurred April 27, 2000.

[y] Treatments were applied at PF, PF+21, PF+42 days with a low pressure hand-wand sprayer.

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

Table 8. Effect of Gibberellins on York/M. 26 apple trees planted in 1998 and applied in 2000 (2001).

No.	Color	Treatment GA3 (ppm)[z,y] PF, 21,42	Rate/ 100 gal	Rate/ gallon		Trunk diameter (26 Apr 00)	Average number of flowering clusters per tree (26 Apr 00)	Average number of fruit per tree (20 June 00)	Average shoot length of longest top 2 terminal shoots per tree (cm) (20 June 00)	Average shoot length of 5 longest scaffold shoots per tree (cm) (20 June 00)	Average shoot length of longest top 2 terminal shoots per tree (cm) (15 Jan 01)	Average shoot length of 5 longest scaffold shoots per tree (cm) (15 Jan 01)	Flowering clusters/cm^2 trunk cross sectional area (3 May 01)	Fruit/cm^2 trunk cross sectional area (29 May 01)
1.	W	Control			Deflowered	26.4 b[x]	0.00 b	0.00 b	55.2 b	51.2 b	80.0 a	82.0 a	18.0 a	2.29 a
2.	OBKD	Promolin (1.8% GA4+7 and 6-BA)	2 gal	75.5 ml	Deflowered	26.7 ab	0.00 b	0.00 b	57.9 ab	51.8 b	76.8 ab	69.6 c	14.7 ab	2.56 a
3.	YRD	ProGib (GA3–4%)	1 gal	37.85 ml	Deflowered	26.8 ab	0.00 b	0.00 b	58.7 a	54.4 a	79.5 a	77.3 ab	13.5 b	2.34 a
4.	W	Control			Not deflowered	27.3 a	33.19 a	16.44 a	48.5 c	48.5 c	71.0 b	71.3 bc	18.4 a	3.02 a

[z] Full bloom occurred Apr 15. Petal fall occurred April 27, 2000.

[y] Treatments were applied at PF, PF+21, PF+42 days with a low pressure hand-wand sprayer.

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

Table 9. Effect of Gibberellins on Idared/M. 26 planted in 1998 and applied in 2000 (2001).

No.	Color	Treatment GA3 (ppm)^{zy} PF, 21, 42	Rate/ 100 gal	Rate/ gallon		Trunk circum. (cm) 26 Apr 00	Trunk circum. (cm) 17 Apr 01	Average shoot length of longest top 2 terminal shoots per tree (cm) 20 Jun 00	Average shoot length of 5 longest scaffold shoots per tree (cm) 20 Jun 00	Average shoot length of longest top 2 terminal shoots per tree (cm) 11 Jan 01	Average shoot length of 5 longest scaffold shoots per tree (cm) 11 Jan 01	Flowering clusters per cm^2 trunk cross sectional area 17 Apr 01	Fruit/cm^2 trunk cross sectional area 28 Jun 01
1.	W	Control			Deflowered	7.51 c^x	10.8 a	51.0 b	50.0 b	60.8 b	68.7 a	13.8 a	5.77 a
2.	OBKD	Promolin (1.8% GA4+7 and 6-BA)	2 gal	75.5 ml	Deflowered	7.93 a	11.2 a	59.1 a	55.3 a	73.2 a	69.3 a	9.2 b	5.62 a
3.	YRD	ProGib (GA3--4%)	1 gal	37.85 ml	Deflowered	7.67 b	11.0 a	61.1 a	56.8 a	72.8 a	71.3 a	8.1 b	4.95 a

^{z}Full bloom occurred Apr 15. Petal fall occurred April 27, 2000.

^{y}Treatments were applied at PF, PF+21, PF+42 days with a low pressure hand-wand sprayer.

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

Table 10. Effect of Gibberellins on Idared/M. 26 planted in 1999 and applied in 2000 (2001).

No.	Color	Treatment^{xy} GA3 (ppm)^{zy} PF, 21,42	Rate/ 100 gal	Rate/ gallon		Trunk circumference (cm) (26 Apr 00)	Trunk circumference (cm) (17 Apr 01)	Average shoot length of longest top terminal shoot per tree (cm) (20 June 00)	Average shoot length of 5 longest scaffold shoots per tree (cm) (20 June 00)	Average shoot length of longest top terminal shoot per tree (cm) (12 Jan 01)	Average shoot length of 5 longest scaffold shoots per tree (cm) (12 Jan 01)	Flowering clusters/ cm^2 trunk cross sectional area (17 Apr 01)	Fruit/ cm^2 trunk cross sectional area (28 Jun 01)
1.	W	Control			Deflowered	5.84 a^x	9.77 a	42.4 a	37.4 b	81.6 a	76.3 a	7.78 ab	1.60 b
2.	OBKD	Promolin (1.8% GA4+7 and 6-BA)	2 gal	75.5 ml	Deflowered	5.81 ab	9.56 ab	45.8 a	39.1 ab	81.0 a	76.3 a	8.73 a	2.68 a
3.	YRD	ProGib (GA3--4%)	1 gal	37.85 ml	Deflowered	5.74 b	9.23 b	46.6 a	43.5 a	80.1 a	74.8 a	5.95 b	1.99 ab

^{z}Full bloom occurred Apr 15. Petal fall occurred April 27, 2000.

^{y}Treatments were applied at PF, PF+21, PF+42 days with a low pressure hand-wand sprayer.

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

Table 11. Effect of Gibberellins on York/M. 26 planted in 1999 and applied in 2000 (2001).

No.	Color	Treatment^{xy} GA3 (ppm)^{zy} PF, 21,42	Rate/ 100 gal	Rate/ gallon		Trunk diameter (mm) (20 June 00)	Trunk diameter (mm) (11 Jan 01)	Average shoot length of longest top terminal shoot per tree (cm) (20 June 00)	Average shoot length of 5 longest scaffold shoots per tree (cm) (20 June 00)	Average shoot length of longest top terminal shoot per tree (cm) (11 Jan 01)	Average shoot length of 5 longest scaffold shoots per tree (cm) (11 Jan 01)	Flowering clusters/cm^2 trunk cross sectional area (3 May 01)
1.	W	Control			Deflowered	16.8 a^x	26.8 a	55.3 b	51.1 a	75.5 a	70.6 a	15.4 a
2.	OBKD	Promolin (1.8% GA4+7 and 6-BA)	2 gal	75.5 ml	Deflowered	16.8 a	25.2 b	55.7 b	54.0 a	58.4 b	57.5 b	6.3 c
3.	YRD	ProGib (GA3--4%)	1 gal	37.85 ml	Deflowered	16.7 a	26.4 ab	62.8 a	54.3 a	68.0 ab	68.9 a	11.0 b

^{z}Full bloom occurred Apr 15. Petal fall occurred April 27, 2000.

^{y}Treatments were applied at PF, PF+21, PF+42 days with a low pressure hand-wand sprayer.

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

Table 12A. Effect of defruiting 'Fuji'/M27 trees with ethephon sprays or by hand on fruit removal and return bloom (2001-02).

No.	Color	Treatment[zy]	Rate/gal	Fruit/cm² limb cross sectional area (12 Jun, 2001)	Defruit tree by hand												
					Jun 13	Jun 20	Jun 27	Jul 4	Jul 11	Jul 18	Jul 25	Aug 1	Aug 8	Aug 15	Aug 22	Sep 5	Oct 4
					31.6 mm	36.4 mm	39.0 mm	39.2 mm	40.2 mm	40.4 mm	42.4 mm	46.1 mm	46.5 mm	49.9 mm	51.4 mm	52.8 mm	57.8 mm
1.	W	Defruited		16.82 a[x]													DF/H
1.	R	Defruited		16.69 a	DF												
2.	B	Defruited		15.87 a		DF											
3.	FO	Defruited		17.04 a			DF										
4.	HP	Defruited		15.80 a				DF									
5.	Y	Defruited		15.90 a					DF								
6.	BK	Defruited		17.01 a						DF							
7.	RD	Defruited		16.01 a							DF						
8.	BD	Defruited		17.33 a								DF					
9.	GD	Defruited		16.37 a									DF				
10.	RS	Ethephon	9.46ml	16.20 a									S				DF/H
11.	BS	Defruited		16.16 a										DF			
12.	GS	Defruited		15.80 a											DF		
13.	OBKS	Ethephon	9.46ml	15.62 a											S		DF/H
14.	YBKS	Defruited		16.97 a												DF	

[z]DF = Defruiting was done by hand . Spray treatments (S) were applied with a low-pressure hand-wand sprayer.

[y]Full bloom = April 22, 2001.

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

Table 12B. Effect of defruiting 'Fuji'/M27 trees with ethephon sprays or by hand on fruit removal and return bloom (2001-02).

No.	Color	Treatment[zy]	Rate /gal	Defruit tree by hand			Fruit dropped/cm² limb cross sectional area (cumulative)		Percent of total fruit dropped	Fruit diameter (cm)	Length/ diameter ratio (cm)	Fruit firmness (lb)	Starch (0-8)	Soluble solids	Visual spurs flowering (0-100%)
				Aug 8	Aug 22	Oct 4	Sep 12	Oct 4	(4 Oct)	(4 Oct)	(4 Oct)	(4 Oct)	(4 Oct)	(4 Oct)	(2002)
1.	W	Control				DF	0.59 a[x]	0.61 a	4 a	5.78 ab	0.837 a	21.4 a	7.9 a	13.2 a	
10.	RS	Ethephon	9.46ml	S		DF	0.39 a	0.53 a	5 a	6.10 a	0.833 a	22.3 a	8.0 a	12.7 a	
13.	OBKS	Ethephon	9.46ml		S	DF	0.64 a	1.52 a	14 a	5.66 b	0.832 a	22.0 a	8.0 a	12.8 a	

[z](DF)=Defruiting was done by hand. Spray treatments (S) were applied with a low-pressure hand-wand sprayer.

[y]Full bloom=April 17, 2001.

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

Table 13. Effect of defruiting trees by hand or ethephon sprays on fruit removal and return bloom of 'Starkrimson'/Mark(Old) (2001-02).

No.	Color	Treatment[z,y]	Rate/gal	Defruit tree by hand			Fruit dropped/cm^2 limb cross sectional area (cumulative)		Percent of total fruit dropped	Fruit diameter (cm)	Length/ diameter ratio (cm)	Fruit firmness (lb)	Starch (0-8)	Soluble solids	Visual spurs flowering (0-100%)
				Aug 8	Aug 22	Sep 22	Aug 31	Sep 12	(24 Sep)	(24 Sep)	(24 Sep)	(24 Sep)	(24 Sep)	(24 Sep)	2002)
1.	W	Control				DF	0.1 b[x]	0.1 b	3 b	7.31 a	0.948 a	19.1 a	4.6 a	12.0 b	
2.	R	Defruited		DF			--	--	--	--	--	--	--	--	
3.	B	Defruited			DF		--	--	--	--	--	--	--	--	
4.	FO	Ethephon	9.46ml	S			0.3 b	0.4 b	10 b	7.07 a	0.962 a	19.7 a	4.4 a	12.4 ab	
5.	HP	Ethephon	9.46ml		S		1.0 a	1.7 a	40 a	7.18 a	0.956 a	19.2 a	4.6 a	12.7 a	

[z] (DF)=Defruiting was done by hand. Spray treatments (S) were applied with a low-pressure hand-wand sprayer

[y] Full bloom=April 17, 2001.

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

Table 14. Effect of defruiting trees by hand or ethephon sprays on fruit removal and return bloom of 'York'/M.27 (2001-02).

No.	Color	Treatment[z,y]	Rate/gal	Defruit tree by hand			Fruit dropped/cm^2 limb cross sectional area		Percent fruit dropped	Fruit diameter (short side) (cm)	Fruit diameter (long side) (cm)	Length/ diameter ratio (short side) (cm)	Length/ diameter ratio (long side) (cm)	Fruit firmness (lb)	Starch (0-8)	Soluble solids	Color (%)	Visual spurs flowering (0-100%)
				Aug 8	Aug 22	Oct 15	Aug 31	Sep 12	(12 Sep)	(16 Oct)	(16 Oct)	(16 Oct)	(16 Oct)	(16 Oct)	(16 Oct)	(16 Oct)	(16 Oct)	(2002)
1.	W	Control				DF	0.5 b[x]	0.6 b	5 b	7.62 a	8.01 a	0.774 a	0.737 ab	20.1 a	4.4 b	13.3 b	90 a	
2.	R	Defruited		DF			--	--	--	--	--	--	--	--	--	--	--	
3.	B	Defruited			DF		--	--	--	--	--	--	--	--	--	--	--	
4.	FO	Ethephon	9.46ml	S			2.7 a	3.1 a	51 a	7.60 a	7.96 a	0.786 a	0.751 a	18.4 b	5.2 ab	14.4 a	90 a	
5.	HP	Ethephon	9.46ml		S		3.4 a	4.5 a	57 a	7.29 a	7.63 a	0.763 a	0.729 b	18.8 b	5.6 a	13.7 ab	87 a	

[z] (DF)=Defruiting was done by hand. Spray treatments (S) were applied with a low-pressure hand-wand sprayer.

[y] Full bloom=April 22, 2001.

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

Table 15. Effect of various chemicals on thinning of 'Ace Delicious'/MM.111 (1999-2001).

No.	Color	Treatment[z][y]	Rate/acre /100 gal	Rate/ 25 gal	Spray Timing	Fruit/cm^2 limb cross sectional area (1 Jun 99)	% fruit injury /cm^2 limb cross sectional area (1 Jun 99)	Fruit diameter (cm) (30 Aug 99)	Length/ diameter ratio (30 Aug 99)	Net fruit side russet rating[x] (0-5) (30 Aug 99)	Flowering clusters/cm^2 limb cross sectional area (6 Apr 00)	Flowering clusters/cm^2 limb cross sectional area (18 Apr 01)	Fruit/cm^2 limb cross sectional area (22 May 00)	Visual spurs flowering (0-100%) (6 Apr 00)	Visual spurs flowering (0-100%) (6 Apr 01)
1.	W	Control			--	4.83 a[w]	0.00 a	6.98 b	0.934 bcd	0.45 cd	1.80 b	7.00 abc	1.84 c	33.6 e	89 abc
2.	R	Endothal	4 pt	473	Bloom	3.07 cdef	0.00 a	7.08 ab	0.927 cdef	0.54 abc	3.67 ab	7.73 ab	4.00 abc	73.6 abc	78 abcd
3.	HP	Wilthin + Regulaid	16 pt 1 pt	1888 118	Bloom	3.13 cdef	0.00 a	7.21 a	0.923 def	0.56 ab	3.67 ab	7.20 ab	4.12 abc	62.5 abcd	83 abc
4.	B	ATS	6 gal	5664	Bloom	2.46 ef	0.00 a	7.22 a	0.932 bcde	0.52 abcd	4.64 a	4.38 c	5.04 ab	80.7 ab	55 d
5.	FO	Ethrel 400 ppm	3 pt	355	PF	3.67 bcd	0.00 a	7.09 ab	0.915 fg	0.46 cd	4.85 a	6.55 abc	5.30 ab	63.8 abc	70 abcd
6.	LG	Ethrel 600 ppm	4.5pt	532	PF	3.13 cdef	0.00 a	7.21 a	0.900 g	0.48 bcd	3.24 ab	6.17 abc	4.00 abc	53.1 cde	75 abcd
7.	Y	Sevin XLR Plus + Accel 30g + Oil 1qt	2 pt 1578 1/2 gal	236 395 473	PF	2.16 f	0.00 a	7.19 ab	0.955 a	0.47 bcd	4.92 a	5.86 bc	6.06 a	80.0 ab	73 abc
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	3.55 ab	8.17 ab	3.44 abc	37.1 de	89 abc
9.	PBKS	Fruitone-N 7.5ppm + Ethrol 400 ppm	183.2 3pt	46 355	8 mm	3.58 bcd	0.00 a	7.00 ab	0.916 efg	0.48 bcd	3.35 ab	8.76 a	3.48 abc	55.0 bcde	84 abc
10.	OBKS	Fruitone-N 7.5 ppm + Sevin XLR Plus	183.2g 2 pt	46 236	8 mm	3.43 bcde	0.00 a	7.12 ab	0.941 abc	0.43 d	3.97 a	8.00 ab	4.72 ab	60.0 abcd	78 abcd
11.	PBKD	901 7.5 ppm + Sevin XLR Plus	183.2g 2 pt	46 236	8 mm	3.05 cdef	0.00 a	7.11 ab	0.934 bcd	0.43 d	3.97 a	6.64 abc	5.53 a	81.4 a	69 bcd
12.	OBKD	Sevin XLR Plus + Oil 1qt	2 pt 1/2 gal	236 473	8 mm	4.01 abc	0.00 a	6.98 b	0.945 ab	0.43 d	4.20 a	8.32 ab	3.35 abc	53.6 cde	92 ab
13.	RD	Sevin XLR Plus + Accel 30g + Oil 1qt	2 pt 1578 1/2 gal	236 395 473	8 mm	2.81 def	0.00 a	7.11 ab	0.943 abc	0.45 cd	3.00 ab	6.02 abc	6.12 a	73.9 abc	67 cd
14.	BD	Vydate	2 pt	236	8 mm	4.45 ab	0.00 a	6.99 b	0.943 abc	0.45 cd	4.35 a	8.64 a	2.62 bc	47.9 cde	94 a
15.	CKR	Vydate + NAA 7.5ppm	2 pt 183.2g	236 46	8 mm	3.47 bcde	0.00 a	7.11 ab	0.918 def	0.44 cd	3.18 ab	7.66 ab	3.63 abc	50.6 cde	86 abc
16.	CKO	Vydate + Accel	2 pt 1578	236 395	8 mm	2.86 def	0.00 a	7.06 ab	0.941 abc	0.58 a	2.94 ab	6.71 abc	4.25 abc	66.4 abc	76 abcd

[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($P \leq 0.05$).

Table 16. Effect of various chemicals on thinning of 'Golden Delicious'/MM.111 (2000-01).

No.	Color	Treatment^{zy}	Rate/acre /100 gal	Rate/ gal	Spray Timing	Fruit/cm^2 limb cross sectional area (30 May 00)	Estimated visual cropload (%) (11 July 00)	Fruit diameter (cm) (21 Aug 00)	Length/ diameter ratio (21Aug 00)	Net fruit stem end russet rating^x (0-5) (21Aug 00)	Net fruit side russet rating^x (0-5) (21Aug 00)	Flowering clusters/cm^2 limb cross sectional area (24 Apr 01)	Visual % of spurs flowering (0-100%) (24 Apr 01)	Flowering clusters (annual wood) /cm of 5 shoots (2 May 01)	Nodes /cm of 5 shoots (annual wood) (2 May 01)
1.	W	Control			--	13.4 a^w	277 a	5.65 h	0.920 bcd	1.00 a	1.26 f	0.9 d	7 f	0.01 e	0.48 a
2.	R	Fruitone-N (7.5ppm) + LI-700	183.2g 473 ml	1.832g 4.73 ml	11.7 mm	4.7 cde	148 cde	6.07 g	0.911 d	0.84 ab	1.46 def	10.2 ab	62 abcd	0.06 bcd	0.40 bcd
3.	B	901 (NAA) (7.5ppm) + LI-700	183.2g 473 ml	1.832g 4.73 ml	11.7 mm	4.4 cde	148 cde	6.35 efg	0.921 bcd	0.98 ab	1.47 cdef	8.2 abc	54 abcd	0.06 bcd	0.46 ab
4.	HP	Fruitone-N (7.5ppm) + LI-700 + Sevin XLR Plus	183.2g 473 ml 946 ml	1.832g 4.73 ml 9.46 ml	11.7 mm	3.5 ed	116 efg	6.69 bcd	0.923 bcd	0.96 ab	1.84 abcd	9.8 ab	79 a	0.12 a	0.36 d
5.	FO	901 (NAA) (7.5 ppm) + Sevin XLR Plus	183.2g 946 ml	1.832g 9.46 ml	11.7 mm	2.4 e	100 fg	6.72 abc	0.915 cd	0.86 ab	1.81 abcd	12.3 a	80 a	0.08 ab	0.37 cd
6.	LG	Pace NAA (24%) + LI-700	7.88 ml 1 pt	0.0788 4.73 ml	11.7 mm	7.0 bc	172 c	6.33 efg	0.930 abcd	0.91 ab	1.39 ef	9.6 ab	58 abcd	0.06 bcd	0.39 bcd
7.	Y	Pace NAA (24%) + LI-700 + Sevin XLR Plus	7.88 ml 473 ml 946 ml	0.0788 4.73 ml 9.46 ml	11.7 mm	4.4 cde	127 defg	6.56 cde	0.910 d	0.97 ab	2.03 a	11.2 a	74 ab	0.09 ab	0.39 bcd
8.	BK	6-BA 90g + Oil	4732 ml 4 pt (1892)	47.32 ml 19 ml	11.7 mm	4.1 de	129 cdefg	6.60 cde	0.923 bcd	0.76 ab	1.62 bcdef	5.5 bcd	46 cde	0.04 bcde	0.47 ab
9.	PUR	Accel 90g + Oil	4732 ml 4 pt (1892)	47.32 ml 19 ml	11.7 mm	3.1 de	90 g	7.00 a	0.947 a	0.72 ab	1.49 cdef	13.5 a	68 abc	0.09 ab	0.39 bcd
10.	RBKD	Sevin XLR Plus	946 ml	9.46 ml	13.9 mm	7.5 b	236 b	6.14 fg	0.920 bcd	1.10 a	1.64 abcd	3.3 cd	27 ef	0.03 cde	0.44 abcd
11.	YBKD	Sevin XLR Plus + Accel 30g	946 ml 1578	9.46 ml 15.78 ml	13.9 mm	5.5 bcd	164 cd	6.39 def	0.938 ab	0.58 b	1.47 cdef	3.3 cd	25 ef	0.03 cde	0.44 abcd
12.	PBKD	Sevin XLR Plus + RiteSize 30g	946 ml 1578	9.46 ml 15.78 ml	13.9 mm	3.1 de	104 efg	6.79 abc	0.928 abcd	0.99 a	1.75 abcde	10.8 ab	78 a	0.06 bcd	0.45 abc
13.	RYD	Sevin XLR Plus + Accel 45g	946 ml 2,367	9.46 ml 15.78 ml	13.9 mm	4.8 cde	169 cd	6.55 cde	0.932 abc	0.98 a	1.91 ab	6.4 bcd	37 de	0.02 de	0.46 ab
14.	OBKD	Sevin XLR Plus + RiteSize 45g	946 ml 2,367	9.46 ml 15.78 ml	13.9 mm	4.4 cde	138 cdef	6.56 cde	0.933 abc	0.90 ab	1.80 abcd	9.2 ab	51 bcd	0.07 bcd	0.40 abcd
15.	BKD	Sevin XLR Plus + Accel 30g + Oil	946 ml 1578 4 pt (1892)	9.46 ml 15.78 ml 19 ml	13.9 mm	2.5 e	108 efg	6.96 ab	0.945 a	0.71 ab	1.59 bcdef	13.4 a	79 a	0.09 ab	0.39 bcd
16.	OD	Sevin XLR Plus + RiteSize 30g + Oil	946 ml 1578 4 pt (1892)	9.46 ml 15.78 ml 19 ml	13.9 mm	2.4 e	95 fg	6.96 ab	0.937 ab	0.82 ab	1.88 abc	9.3 ab	63 abcd	0.08 abc	0.42 abcd

Table 16. (cont.)

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	Fruitone-N (NAA) vs none	***	***	**	ns	ns	ns	***	***	*	*
1 vs 3	901 (NAA) vs none	***	***	***	ns	ns	ns	**	***	**	ns
1 vs 6	Pace (NAA) vs none	***	***	***	ns	ns	ns	***	***	*	*
1 vs 7	Pace (NAA) + Sevin XLR Plus vs none	***	***	***	ns	ns	***	***	***	***	*
1 vs 8	6-BA + Oil vs none	***	***	***	ns	ns	ns	ns	**	ns	ns
1 vs 9	Accel + Oil vs none	***	***	***	**	ns	ns	***	***	***	*
1 vs 10	Sevin XLR Plus vs none	***	ns	***	ns	ns	***	ns	ns	ns	ns
2,3 vs 4,5	Fruitone-N and 901 (NAA) vs Fruitone-N and 901 (NAA) + Sevin XLR Plus	ns	**	***	ns	ns	**	ns	**	**	*
2,4 vs 3,5	Fruitone-N vs 901 (NAA)	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
2,4 vs 6,7	Fruitone-N vs Pace (NAA)	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
2,3,6 vs 10	NAA (all formulations) vs Sevin XLR Plus	*	***	ns	ns	ns	**	**	**	ns	ns
3,5 vs 6,7	Pace (NAA) vs Sevin XLR Plus	*	ns	ns	ns	ns	ns	ns	ns	ns	ns
8 vs 9	6-BA + Oil vs Accel + Oil	ns	*	ns	**	ns	ns	**	ns	*	*
8,9 vs 10	6-BA + Oil and Accel + Oil vs Sevin XLR Plus	***	***	***	*	*	ns	**	**	ns	ns
8,9 vs 2,3	6-BA + Oil and Accel + Oil vs Fruitone-N and 901 (NAA)	ns	**	***	**	ns	ns	ns	ns	ns	ns
8,9 vs 3,4	6-BA + Oil and Accel + Oil vs 901 (NAA) + Sevin XLR Plus and Fruitone-N+ Sevin XLR Plus	*	***	*	*	ns	ns	ns	***	**	ns
8,9 vs 6,7	6-BA + Oil and Accel + Oil vs Pace NAA + Sevin XLR Plus	*	**	*	*	ns	ns	ns	ns	ns	ns
10 vs 11	Sevin XLR Plus vs Sevin XLR Plus + Accel	ns	***	ns	*	**	*	ns	ns	ns	ns
10 vs 12	Sevin XLR Plus vs Sevin XLR Plus + RiteSize	***	***	***	ns	ns	ns	**	***	ns	ns
11,12 vs 13,14	30g vs 45g (Sevin XLR Plus + Accel and Sevin XLR Plus + RiteSize)	ns	ns	ns	ns	ns	*	ns	ns	ns	ns
11,12 vs 15,16	Oil vs none (Sevin XLR Plus + Accel 30g and Sevin XLR Plus + RiteSize 30g)	*	*	**	ns	ns	ns	*	*	*	ns
13,14 vs 15,16	45g vs 30g + Oil (Sevin XLR Plus + Accel and Sevin XLR Plus + RiteSize)	*	***	***	ns	ns	ns	*	**	*	ns
11,13,15 vs 12,14,16	Accel vs RiteSize (30g and 45g + or- Oil)	ns	***	*	ns	ns	ns	ns	*	ns	ns

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[z] Full bloom occurred 12 Apr 2000 (90% open); petal fall (April 25).

[y] Treatments were applied May 8 (11.7mm) and May 9 (13.9mm).
The average daytime high temperatures for the 2 day period after application was 85°F, 76°F, and the night time low was 74°F, 55°F (May 8 trts.): average daytime high temperatures 76°F, 75°F, and the night time low was 55°F, 63°F (May 9 trts.). 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 and stem 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 17. Effect of carbaryl formuations and combinations on fruit injury and fruit set of 'Starkrimson Delicious'/Mark (Young)(2000-01).

No.	Color	Treatment^{zy}	Rate /gallon	Spray Timing	Shading 1 day	Fruit/cm^2 limb cross sectional area (2 June 00)	% fruit injury/ cm^2 trunk cross sectional area^x (7 June 00)	Pigmy fruit /cm^2 limb cross sectional area (20 June 00)	Deformed fruit/cm^2 limb cross sectional area (20 June 00)	Fruit diameter (cm) (29 Aug 00)	Length/ diameter ratio (29 Aug 00)	Red color (%) (29 Aug 00)	Fruit finish (0-5) (29 Aug 00)	Visual % of spurs flowering (0-100%) (17 Apr 01)
1.	W	Control	--	--	--	7.37 a^w	0.37 c	1.07 a	0.28 ab	7.59 f	0.902 bc	90.5 a	0.48 d	48 b
2.	R	Sevin XLR Plus	14.2 ml	17mm	x	2.80 defg	1.17 c	0.17 bcd	0.20 ab	8.25 bcd	0.884 c	91.1 a	1.98 a	91 a
3.	B	Sevin 50 WP	13.62 g	17mm	x	4.26 bcde	3.26 c	0.20 bcd	0.28 ab	8.11 cde	0.904 abc	88.6 a	1.64 abc	85 ab
4.	FO	Sevin XLR Plus + Oil	14.2 ml 18.9 ml	17mm	x	2.44 efg	2.27 c	0.03 d	0.12 b	8.58 ab	0.904 abc	90.6 a	1.94 a	83 ab
5.	HP	Sevin 50WP + Oil	13.62 g 18.9 ml	17mm	x	1.69 g	0.28 c	0.05 cd	0.22 ab	8.71 a	0.902 bc	91.4 a	1.64 abc	79 ab
6.	Y	Sevin XLR Plus + Accel	14.2 ml 10.51 ml	17mm	x	5.02 bc	13.46 a	0.88 ab	0.57 a	7.96 def	0.910 abc	90.4 a	1.24 bc	73 ab
7.	BK	Sevin 50WP + Accel	13.62g 10.51 ml	17mm	x	4.60 bcd	1.14 c	1.12 a	0.33 ab	7.92 def	0.899 bc	89.6 a	1.49 abc	75 ab
8.	BS	Sevin XLR Plus + Accel + Oil	14.2 ml 10.51 ml 18.9 ml	17mm	x	3.93 bcdef	8.25 b	0.63 abcd	0.52 a	7.87 def	0.920 ab	90.0 a	1.23 bc	86 ab
9.	RS	Sevin 50WP + Accel + Oil	13.62g 10.51 ml 18.2 ml	17mm	x	4.45 bcde	11.89 ab	0.44 abcd	0.50 ab	7.84 ef	0.934 a	89.5 a	1.28 bc	90 a
10.	GS	Sevin XLR Plus + 6-BA + Oil	4.73 ml 10.51 ml 18.9 ml	17mm	x	3.31 cdefg	1.31 c	0.02 d	0.28 ab	8.40 abc	0.895 bc	89.6 a	1.88 ab	89 ab
11.	BKS	Sevin 50WP + 6-BA + Oil	4.54 g 10.51 ml 18.9 ml	17mm	x	2.21 fg	0.27 c	0.10 cd	0.11 b	8.25 bcd	0.922 ab	90.6 a	1.63 abc	59 ab
12.	RD	Sevin XLR Plus + Accel + Regulaid	4.54 g 10.51 ml 4.73 ml	17mm	x	5.66 ab	1.65 c	0.61 abcd	0.39 av	7.97 def	0.922 ab	89.4 a	1.44 abc	60 ab
13.	BD	Accel Oil	10.51 ml 18.9 ml	17mm	x	4.96 bc	0.40 c	0.83 abc	0.31 ab	7.90 def	0.911 abc	87.9 a	1.09 c	56 ab

Contrasts:	Comparisons:	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F
1 vs 2	Sevin XLR Plus vs none	***	ns	**	ns	***	ns	ns	***	*
1 vs 3	Sevin 50WP vs none	**	ns	*	ns	**	ns	ns	***	*
1 vs 4,5	Oil vs none (Sevin XLR Plus and Sevin 50WP)	***	ns	***	ns	***	ns	ns	***	*
1 vs 8,9	Sevin (XLR Plus and 50WP) + Accel + Oil vs none	***	***	ns	ns	ns	*	ns	**	*
1 vs 10,11	6-BA + Oil vs none (Sevin XLR Plus and Sevin WPl)	***	ns	**	ns	***	ns	ns	***	ns
1 vs 13	Accel +Oil vs none	**	ns	ns	ns	ns	ns	ns	*	ns
2,4 vs 3,5	Sevin XLR Plus vs Sevin 50WP (Oil and none)	ns	ns	ns	ns	ns	ns	ns	ns	ns
2,4,6,8,10 vs 3,5 7,9,11	Sevin XLR Plus vs Sevin 50WP (all treatments)	ns	*	ns	ns	ns	ns	ns	ns	ns
2,3,6,7 vs 4,5,8,9	Oil vs no Oil (all Sevin, 6-BA, and Accel treatments)	*	ns	ns	ns	*	*	ns	ns	ns
8 vs 13	Sevin XLR Plus + Accel + Oil vs Accel + Oil	ns	***	ns	ns	ns	ns	ns	ns	ns
8,9 vs 10,11	6-BA vs Accel (Sevin XLR Plus and 50WP + Oil)	*	***	ns	*	***	ns	ns	*	ns

[z] Full bloom occurred 11 April 2000; petal fall 21 April 2000.

[y] Treatments were applied at 17 mm (11 May). 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 83°,82° F, and the night time low was 71°,61°F. Treatments were applied with a low pressure hand wand sprayer.

[x] Percent of fruit with caylx-end injury (typical of Sevin injury) .

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

EFFECT OF CARBARYL FORMULATIONS AND COMBINATIONS ON FRUIT INJURY AND FRUIT SET OF 'STARKRIMSON DELICIOUS'/ MARK

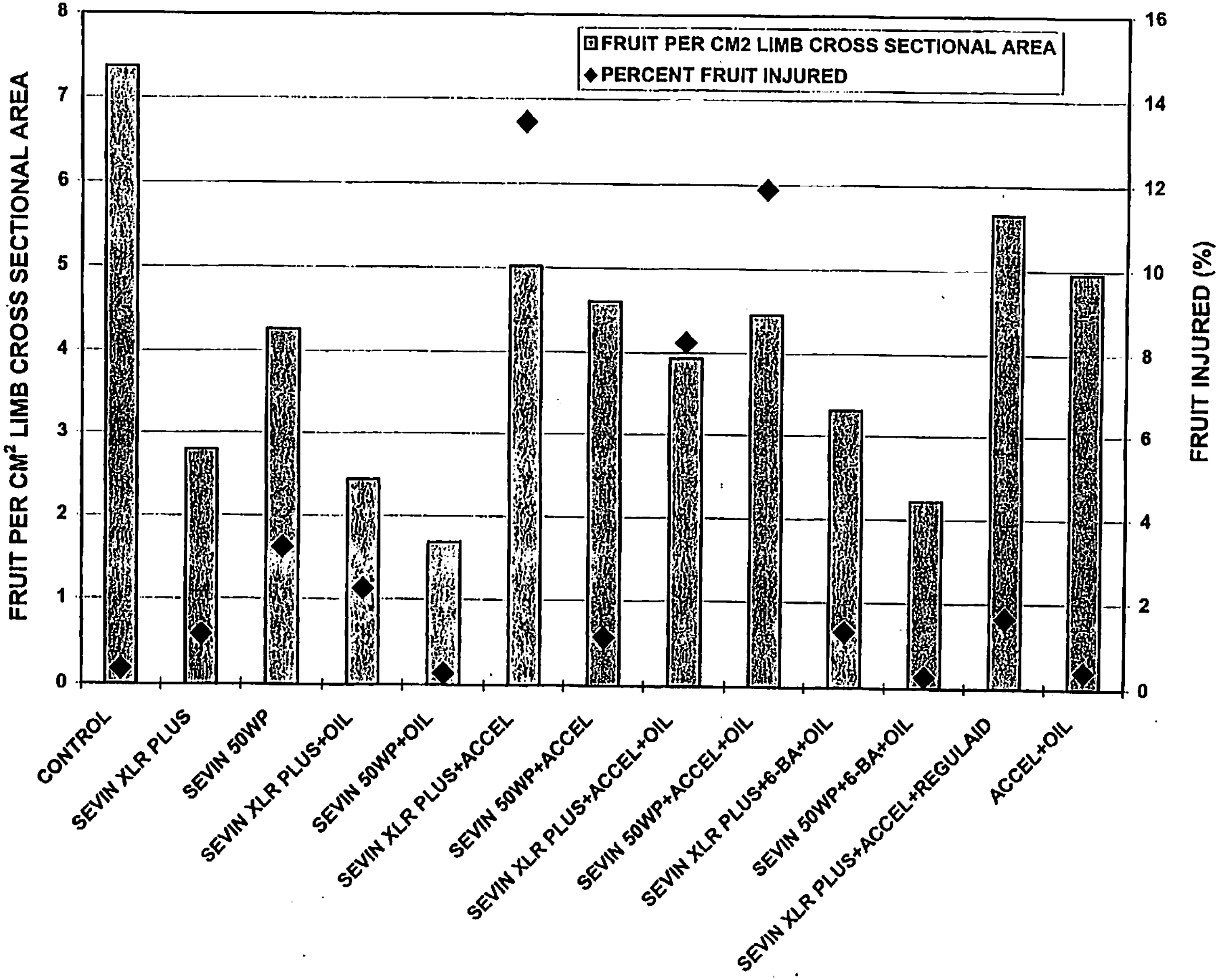

Table 18. Effect of Carbaryl, Accel, adjuvants on fruit injury and fruit set of 'Starkrimson/Mark (older trees) (2000-01).

No.	Color	Treatment[zy]	Rate/100 Gallons (ml)	Rate / gal (ml or g)	Fruit/cm^2 limb cross sectional area (31 May)	% fruit injury/cm^2 trunk cross sectional area[x] (8 Jun)	Pigmy fruit /cm^2 limb cross sectional aroa (21 Jun)	Deformed fruit /cm^2 limb cross sectional area (21 Jun)	Fruit diameter (cm) (10 Sep)	Length/ diameter ratio (10 Sep)	Red color (%) (10 Sep)	Fruit finish (0-5) (10 Sep)	Visual % of spurs flowering (0-100%) (17 Apr 01)
1.	W	Control			8.80 a[w]	0.6 a	0.10 ab	0.07 c	7.89 abc	0.867 b	89.2 b	0.64 c	40 e
2.	R	Sevin XLR	1pt (473ml)	4.73 ml	7.26 abcd	0.0 a	0.10 ab	0.34 abc	7.97 abc	0.899 ab	91.3 ab	0.98 bc	73 abcd
3.	B	Sevin XLR + Oil	1pt (473ml) 946 ml	4.73 ml 18.9 ml	4.63 e	0.0 a	0.03 b	0.25 abc	7.93 abc	0.923 a	89.6 ab	1.46 ab	75 abcd
4.	FO	Sevin XLR + Accel	1pt (473ml) 1051 ml	4.73 ml 10.51 ml	6.21 bcde	0.0 a	0.17 ab	0.18 abc	7.83 bc	0.922 a	88.7 b	0.94 bc	84 abc
5.	HP	Sevin XLR + Accel + Oil	1pt (473ml) 1051 ml 946 ml	4.73 ml 10.51 ml 18.9 ml	4.44 e	0.0 a	0.06 b	0.16 abc	8.06 abc	0.926 a	88.3 b	0.84 bc	93 a
6.	Y	Sevin XLR + Accel + Silwet L-77	1pt (473ml) 1051 ml	4.73 ml 10.51 ml 1.18 ml	6.06 cde	0.0 a	0.13 ab	0.21 abc	8.05 abc	0.929 a	93.6 a	1.20 abc	84 abc
7.	BK	Sevin XLR + Accel + Lorsban 50W	1pt (473ml) 1051 ml	4.73 ml 10.51 ml 3.4g	5.94 cde	1.5 a	0.04 b	0.39 ab	8.07 ab	0.901 ab	87.5 b	1.77 a	78 abc
8.	BS	Sevin XLR + Accel + Captan	1pt (473ml) 1051 ml	4.73 ml 10.51 ml 9.08g	6.73 abcde	0.0 a	0.27 a	0.42 a	8.15 ab	0.917 a	90.9 ab	1.16 abc	89 ab
9.	RS	Sevin XLR + Accel + Ammonium Sulfate	1pt (473ml) 1051 ml	4.73 ml 10.51 ml 4.54g	6.21 bcde	3.0 a	0.20 ab	0.25 abc	8.23 a	0.904 ab	90.0 ab	1.39 ab	84 abc
10.	GS	Vydate + Accel + Oil	1pt (473ml) 1051 ml 946 ml	4.73 ml 10.51 ml 18.9 ml	5.18 de	0.0 a	0.09 ab	0.12 bc	8.20 ab	0.919 a	88.8 b	1.69 a	98 a
11.	BKS	Accel low rate	1051 ml	10.51 ml	8.64 ab	0.0 a	0.19 ab	0.13 abc	7.69 c	0.928 a	90.1 ab	0.80 bc	46 de
12.	RD	6-BA low rate	1051 ml	10.51 ml	7.99 abc	1.9 a	0.16 ab	0.29 abc	7.83 bc	0.925 a	87.7 b	1.42 ab	60 bcde
13.	BD	Accel high rate	4204 ml	42.04 ml	7.67 abcd	0.0 a	0.16 ab	0.31 abc	7.84 bc	0.921 a	89.3 b	1.12 abc	56 cde
14.	GD	6-BA high rate	4204 ml	42.04 ml	7.31 abcd	4.3 a	0.05 b	0.15 abc	7.92 abc	0.922 a	88.9 b	1.42 ab	63 bcde
Contrasts		Comparisons			Pr>F	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F
1 vs 2		Sevin XLR vs none			ns	ns	ns	*	ns	ns	ns	ns	*
1 vs 3		Sevin XLR + Oil vs none			***	ns	ns	ns	ns	**	ns	**	**
1 vs 4		Sevin XLR + Accel vs none			*	ns	ns	ns	ns	**	ns	ns	**
1 vs 5		Sevin XLR + Accel Oil vs none			***	ns	ns	ns	ns	**	ns	ns	***
1 vs 11		Accel low rate vs none			ns	ns	ns	ns	ns	***	ns	ns	ns
1 vs 12		6-BA low rate vs none			ns	ns	ns	ns	ns	**	ns	**	ns
1 vs 13		Accel high rate vs none			ns	ns	ns	ns	ns	**	ns	ns	ns
1 vs 14		6-BA high rate vs none			ns	ns	ns	ns	ns	**	ns	**	ns
2 vs 3		Sevin XLR vs Sevin XLR + Oil			*	ns	ns	ns	ns	ns	ns	ns	ns
2 vs 4		Sevin XLR vs Sevin XLR + Accel			ns	ns	ns	ns	ns	ns	ns	ns	ns
2 vs 5		Sevin XLR vs Sevin XLR + Accel + Oil			*	ns	ns	ns	ns	ns	ns	ns	ns
2 vs 6		Sevin XLR vs Sevin XLR + Accel + Silwet L-77			ns	ns	ns	ns	ns	ns	ns	ns	ns
2 vs 7		Sevin XLR vs Sevin XLR + Accel + Lorsban 50W			ns	ns	ns	ns	ns	ns	*	**	ns
2 vs 8		Sevin XLR vs Sevin XLR + Accel + Captan			ns	ns	ns	ns	ns	ns	ns	ns	ns
2 vs 9		Sevin XLR vs Sevin XLR + Accel + NH4SO4 + L-77			ns	ns	ns	ns	ns	ns	ns	ns	ns
2,4 vs 3,5		Oil vs none (Sevin XLR and Sevin XLR + Accel)			**	ns	ns	ns	ns	ns	ns	ns	ns
4 vs 5		Sevin XLR + Accel vs Sevin XLR + Accel + Oil			ns	ns	ns	ns	ns	ns	ns	ns	ns
4 vs 6		Sevin XLR + Accel vs Sevin XLR + Accel + Silwet L-77			ns	ns	ns	ns	ns	ns	*	ns	ns
4 vs 7		Sevin XLR + Accel vs Sevin XLR + Accel + Lorsban 50W			ns	ns	ns	ns	ns	ns	ns	**	ns
4 vs 8		Sevin XLR + Accel			ns	ns	ns	ns	*	ns	ns	ns	ns
4 vs 9		Sevin XLR + Accel			ns	ns	ns	ns	*	ns	ns	ns	ns
5 vs 6		Oil vs Silwet L-77 (Sevin XLR + Accel)			ns	ns	ns	ns	ns	ns	**	ns	ns
5 vs 7		Oil vs Lorsban 50W (Sevin XLR + Accel)			ns	ns	ns	ns	ns	ns	ns	**	ns
5 vs 8		Oil vs Captan (Sevin XLR + Accel)			*	ns	*	*	ns	ns	ns	ns	ns
5 vs 9		Oil vs NH4SO4 (Sevin XLR + Accel)			ns	ns	ns	ns	ns	ns	ns	ns	ns
5 vs 6,7,8,9		Oil vs all other additives (Sevin XLR + Accel + Oil)			*	ns	ns	ns	ns	ns	ns	*	ns
5 vs 10		Oil vs (Sevin XLR + Accel + Oil)			ns	ns	ns	ns	ns	ns	ns	**	ns
11 vs 12		Accel vs 6-BA (Low rate)			ns	ns	ns	ns	ns	ns	ns	ns	ns
11,12 vs 13,14		Low rate vs High rate (Accel and 6-BA)			ns	ns	ns	ns	ns	ns	ns	ns	ns
11,13 vs 12,14		Accel vs 6-BA (Low rate and High rate)			ns	ns	ns	ns	ns	ns	ns	*	ns
13 vs 14		Accel vs 6-BA (High rate)			ns	ns	ns	ns	ns	ns	ns	ns	ns

[zy] Full bloom occurred 11 Apr 00; petal fall, 21 April 00. Treatments were applied on 9 May at 15.5 mm with a low pressure hand wand sprayer. The average daytime high temperatures for the 2 day period after application was 76°,75° F, and the night time low was 55°,63°F .

[x] Percent of fruit with caylx-end injury (typical of Sevin injury).

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

Table 19. Effect of various growth regulators and adjuvants on thinning of 'Golden Delicious'/M.27 (2000-01).

No.	Color	Treatment^{zy}	Rate/acre /100 gal	Rate/ gal	Spray Timing	Fruit/cm^2 trunk cross sectional area before thinnng (May 30)	Fruit/cm^2 trunk cross sectional area after thinning (June 1)	Fruit diameter (cm) (Sept 8)	Length/ diameter ratio (Sept 8)	Net fruit side russet rating^x (0-5) (Sept 8)	Net fruit stem end russet rating^x (0-5) (Sept 8)	Visual % of spurs flowering (0-100%) (18 Apr 01)
1.	W	Control			--	21.8 a^w	7.96 ab	6.67 c	0.909 cd	1.04 c	1.23 a	18 f
2.	R	Fruitone-N (7.5ppm)	91.6g	0.916g	15 mm	16.4 bcde	7.85 ab	7.15 ab	0.919 abcd	1.28 abc	1.26 a	28 ef
3.	B	Fruitone-N (7.5ppm) + LI-700	91.6g 473 ml	0.916g 4.73 ml	15 mm	18.4 abc	7.98 ab	7.21 ab	0.933 a	1.45 abc	1.33 a	34 ef
4.	FO	Fruitone-N (7.5ppm) + Urea	91.6g 2 lb	0.916g 9.08g	15 mm	17.1 abcde	7.79 ab	7.17 ab	0.9.00 d	1.32 abc	1.51 a	43 cdef
5.	HP	Fruitone-N (7.5ppm) + NH4SO4	91.6g 2 lb	0.916g 9.08g	15 mm	14.6 bcdef	8.33 a	7.16 ab	0.914 abcd	1.44 abc	1.38 a	45 bcdef
6.	Y	Fruitone-N (7.5ppm) + Silwet 77	91.6g 118 ml	0.916g 1.18 ml	15 mm	13.4 def	7.90 ab	7.16 ab	0.924 abc	1.65 a	1.48 a	75 ab
7.	BK	Fruitone-N (7.5ppm) + Oil	91.6g 1892 ml	0.916g 18.9 ml	15 mm	13.6 cdef	8.00 ab	7.32 a	0.928 abc	1.30 abc	1.21 a	50 abcde
8.	DG	Sevin XLR Plus	473 ml	4.73 ml	15 mm	19.2 ab	8.00 ab	7.45 a	0.927 abc	1.52 abc	1.44 a	42 cdef
9.	BS	Sevin XLR Plus + LI-700	473 ml 473 ml	4.73 ml 4.73 ml	15 mm	15.9 bcde	7.99 ab	7.06 ab	0.928 abc	1.41 abc	1.18 a	42 cdef
10.	RS	Sevin XLR Plus + Urea	473 ml 2 lb	4.73 ml 9.08g	15 mm	16.2 bcde	8.01 ab	7.10 ab	0.932 ab	1.39 abc	1.23 a	50 abcde
11.	GS	Sevin XLR Plus + NH4SO4	473 ml 2 lb	4.73 ml 9.08g	15 mm	18.2 abcd	7.99 ab	7.19 ab	0.928 abc	1.51 abc	1.13 a	57 abcde
12.	BKS	Sevin XLR Plus + Silwet 77	473 ml 118	4.73 ml 1.18ml	15 mm	13.0 ef	7.83 ab	7.22 ab	0.914 abcd	1.38 abc	1.28 a	50 abcde
13.	RD	Sevin XLR Plus + Oil	473 ml 1892 ml	4.73 ml 18.9 ml	15 mm	13.3 def	7.51 b	7.21 abc	0.919 abcd	1.47 abc	1.09 a	62 abcd
14.	BD	Fruitone-N (7.5ppm) + NH4SO4 + Silwet 77 + Oil	91.6g 2 lb 118 1892 ml	0.916g 9.08g 1.18ml 18.9 ml	15 mm	9.9 f	7.55 b	6.86 bc	0.914 abcd	1.09 bc	1.03 a	80 a
15.	GD	Sevin XLR Plus + NH4SO4 + Silwet 77 + Oil	473 ml 2 lb 118 1892 ml	4.73 ml 9.08g 1.18ml 18.9 ml	15 mm	12.2 ef	7.98 ab	7.31 a	0.931 ab	1.35 abc	1.03 a	67 abc
16.	BKD	NH4SO4 + Silwet 77 + Oil	2 lb 118 1892 ml	9.08 g 1.18ml 18.9 ml	15 mm	16.9 abcde	7.99 ab	7.24 ab	0.912 bcd	1.61 ab	1.37 a	50 abcde

Table 19 (cont.)

Contrasts	Comparisons	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F
1 vs 2	Fruitone-N vs none	*	ns	**	ns	ns	ns	ns
1 vs 8	Fruitone-N vs Sevin XLR Plus	ns	ns	***	*	ns	*	ns
1 vs 16	NH4SO4+ Silwet 77+ Oil vs none	*	ns	***	ns	ns	*	*
2 vs 3	LI-700 vs none (Fruitone-N)	ns	ns	ns	ns	ns	ns	ns
2 vs 4	Urea vs none (Fruitone-N)	ns	ns	ns	*	ns	ns	ns
2 vs 5	NH4SO4vs none (Fruitone-N)	ns	*	ns	ns	ns	ns	ns
2 vs 6	Silwet L-77vs none (Fruitone-N)	ns	ns	ns	ns	ns	ns	**
2 vs 7	Oil vs none (Fruitone-N)	ns	ns	ns	ns	ns	ns	ns
2 vs 14	NH4SO4+Silwet 77+Oil vs none (Fruitone-N)	**	ns	*	ns	ns	ns	***
8 vs 9	LI-700 vs none (Sevin XLR Plus)	ns	ns	*	ns	ns	ns	ns
8 vs 10	Urea vs none (Sevin XLR Plus)	ns	ns	ns	ns	ns	ns	ns
8 vs 11	NH4SO4vs none (Sevin XLR Plus)	ns	ns	ns	ns	ns	ns	ns
8 vs 12	Silwet L-77 vs none (Sevin XLR Plus)	**	ns	ns	ns	ns	ns	ns
8 vs 13	Oil vs none (Sevin XLR Plus)	**	ns	ns	ns	ns	ns	ns
8 vs 15	NH4SO4+Silwet 77+Oil vs none (Sevin XLR Plus)	**	ns	ns	ns	ns	ns	ns
14 vs 16	Fruitone-N vs none (NH4SO4+Silwet 77+Oil)	**	ns	*	ns	ns	*	*
15 vs 16	Sevin XLR Plus vs none (NH4SO4+Silwet 77+Oil)	*	ns	ns	*	ns	ns	ns
2,8 vs 3,9	LI 700 vs none	ns	ns	ns	ns	ns	ns	ns
2,8 vs 4,10	Urea vs none (Fruitone-N and Sevin XLR Plus)	ns	ns	ns	ns	ns	ns	ns
2,8 vs 5,11	NH4SO4vs none (Fruitone-N and Sevin XLR Plus)	ns	ns	ns	ns	ns	ns	ns
2,8 vs 6,12	Silwet L-77vs none (Fruitone-N and Sevin XLR Plus)	*	ns	ns	ns	ns	ns	*
2,8 vs 7,13	Oil vs none (Fruitone-N and Sevin XLR Plus)	**	ns	ns	ns	ns	ns	*
2,3,4,5,6,7,14 vs 8,9,10,11, 12,13,15	Fruitone-N vs Sevin XLR Plus (all treatments)	ns	ns	ns	ns	ns	ns	ns

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^{z}Full bloom occurred 12 Apr 2000 (90% open); petal fall (22 Apr 2000).

^{y}Treatments were applied at 15 mm on May 10, 2000. The average daytime high temperatures for the 2 day period after application was 75°F, 83°F, and the night time low was 63°F, 71°F. Treatments were applied with an low pressure hand wand sprayer dilute.

^{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 20. Effect of ethephon on fruit thinning of 'Ace Delicious' /MM.106 (2000-01).

No.	Color	Treatment[zy]	Water volume /acre	Chemical Rate/ acre	Rate/ 100 gal	Visual % of spurs flowering (0-100%) (13 Apr 01)	Fruit/cm^2 cross sectional area limb (29 Jun 01)	Visual crop load estimate (%) (29 Jun 01)	Visual % of spurs flowering (0-100%) (23 Apr 01)	Flowering clusters /cm^2 limb cross sectional area (23 Apr 01)
1.	W	Control				88 a[w]	6.24 a	253 a	65 a	4.73 a
2.	FOBKS	ethephon	400	10 pt	1182.5ml	88 a	6.91 a	228 a	61 a	5.49 a
3.	YRD	ethephon	400	5 pt	591.25ml	87 a	5.76 a	217 a	56 a	4.15 a

[zy] Full bloom occurred April 15, 2000 . Treatments were applied June 7, 2000 when fruit diameter was 35.8 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; ($P \leq 0.05$).

Table 21. Effect of ethephon on fruit thinning of 'Law Rome' /MM.106 (Early Application) (2000-01).

No.	Color	Treatment[zy]	Water volume /acre	Chemical Rate/ acre	Rate/ 100 gal	Fruit/cm^2 limb cross sectional area (29 June)	Visual crop load estimate (%) (29 June)	Fruit diameter (cm) (7 Sept)	Length/ diameter ratio (cm) (7 Sept)	Visual % of spurs flowering (0-100%) (23 Apr 01)
1.	W					12.8 a[x]	225 a	6.29 c	0.837 a	25 b
2.	R	ethephon	100	2.5 pt	1182.5	5.2 c	104 c	7.22 b	0.833 a	87 a
3.	B	ethephon	400	2.5 pt	296	9.6 b	153 b	7.07 b	0.836 a	47 b
4.	FO	ethephon	100	5 pt	2365	5.9 c	65 d	7.66 a	0.838 a	94 a
5.	RYS	ethephon	400	5 pt	591.25	2.2 d	26 e	8.08 a	0.837 a	100 a
Contrasts:		Comparisons:				Pr>F	Pr>F	Pr>F	Pr>F	Pr>F
2,3 vs 4,5		Ethephon rate (2.5pt vs 5 pt)				***	***	***	ns	**
2,4 vs 3,5		Water rate (100 gal vs 400 gal/acre)				ns	ns	ns	ns	ns

[zy] Full bloom occurred 23 April 2000 .Treatments were applied May 17, 2000 when fruit diameter was 17.1 mm. Trees were 24 feet between rows, tree width was 13 feet, and tree height was 18 ft (75% TRV).

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

Table 22. Effect of ethephon on fruit thinning of 'Law Rome' /MM.106 (Late Application) (2000-01).

No.	Color	Treatment[zy]	Water volume /acre	Chemical Rate/ acre	Rate/ 100 gal	Fruit/cm^2 limb cross sectional area (29 June)	Visual crop load estimate (%) (29 June)	Visual % of spurs flowering (0-100%) (27 Apr 01)
1.	W					13.1 a[x]	242 a	24 a
2.	FOBKS	ethephon	100	5 pt	2365	12.0 a	233 a	17 a
3.	YRD	ethephon	400	5 pt	591.25	14.7 a	250 a	12 a

[z] Full bloom occurred 23 April 2000 .

[y] Treatments were applied June 7, 2000 when fruit diameter was 28.1 mm. Trees were 24 feet between rows, tree width was 13 feet, and tree height was 18 ft (75% TRV).

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

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Chemical Sprays for Control of Apple Fruit Drop, and Chemical Dips for Inhibition of Peach and Apple Maturity

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Abstract. In 2000,ReTain inhibited 'Arlet' fruit drop and increased pull force. ReTain delayed the loss of fruit firmness, starch, fruit shriveling, and red color. EthylBloc, applied as a gas or spray, did not affect fruit drop or pull force. The combination of ReTain + EthylBloc (spray or gas) provided the better control of fruit drop, loss of fruit firmness, starch degradation, and pull force decrease than ReTain alone. Thirty five days past the optimum harvest date, fruit firmness from trees sprayed with ReTain + EthylBloc was maintained at 16.7 lbs pressure. Fruit of the control was measured at 13.8 lbs pressure. The delay in harvest caused untreated control fruit stems to turn brown die, but ReTain fruit stems remained green and fruit continued to grow. Eventually, treated fruit increased 2.5 cm fruit diameter in the 35 days after the optimum harvest date.

In 2000, NAA, dicamba, tryclopyr salt, tryclopyr ester, and ReTain inhibited 'Ace Delicious' fruit drop and increased pull force. ReTain combined with any of the auxins inhibited the loss of fruit firmness, starch, and water core, but ReTain depressed soluble solids. Dicamba + ReTain provided the best control of fruit drop. ReTain + EthylBloc maintained firmness of fruit for 30 days (Oct 3) past the optimum harvest date (Sept 3) to above 14.3 lbs pressure. Control fruit was measured at 13.0 lbs pressure.

In 2000, NAA, dicamba, and ReTain inhibited 'Redspur Delicious' fruit drop, but neither cyclanilide nor EthylBloc affected fruit drop or pull force. Dicamba + ReTain + EthylBloc provided the best control of fruit drop and the strongest pull force. The use of ReTain with any of the auxins inhibited the loss of firmness, starch, and water core, but only ReTain depressed soluble solids.

In 2000, Dicamba, floroxypyr, tryclopyr, and ReTain inhibited 'Golden Delicious' fruit drop and increased pull force, but cyclanilide or EthylBloc did not. Dicamba + ReTain + EthylBloc provided the best control of fruit drop and the strongest pull force. ReTain or ReTain + dicamba + EthylBloc inhibited the loss of firmness, starch, fruit shriveling, and ethylene evolution.

In 2000, ReTain or cyclanilide did not control fruit drop of 'York' apples and did not influence fruit flesh firmness, starch, or water core.

In 2000, NAA, dicamba, floroxypyr, cyclanilide, and ReTain inhibited 'Law Rome' fruit drop, but EthylBloc did not. Dicamba + ReTain + EthylBloc provided the best control of fruit drop. Several of the treatments containing ReTain inhibited the loss of firmness, starch, and the amount and % of fruit with red bleeding into the cortex.

In 2001, ReTain and/or NAA inhibited fruit drop of 'Golden Supreme'/MM.111. EthylBloc did not affect fruit drop alone or when combined with ReTain. Cyclanilide increase the rate of fruit drop and when combined with ReTain. Cyclanilide inhibited the influence ReTain on fruit drop. The combination of ReTain + NAA + EthylBloc provided superior control of fruit drop. A delay in harvest date allowed ReTain fruit to increase in fruit diameter without loss of fruit quality until at least Sept 29. ReTain delayed fruit softening, NAA hastened softening, and EthylBloc had no effect. ReTain maintained starch but NAA, EthylBloc, and Cyclanilide did not. ReTain delayed the starch:sugar conversion as indicated by lower soluble solids and higher starch levels. ReTain delayed the development of background color, fruit shriveling, and fruit cracking.

In 2001, ethephon nor its combination with ReTain or NAA+ReTain affected the rate of fruit drop of 'Gala'/M.9 trees; however, little drop occurred by Sept 18. A delay in harvest from 22 Aug to 5 Sept allowed fruit to increase in diameter without loss of fruit quality. Ethephon caused fruit to have about the same firmness, less starch, and more color than control fruit. ReTain delayed fruit maturity, soluble solids, red color development, loss of starch, and loss of firmness. Ethephon+ ReTain sprayed trees had higher firmness and more starch than the control on 5 Sept and better red color than ReTain alone on 5 Sept and 19 Sept.

In 2001, ReTain and/or NAA inhibited fruit drop, 10-year-old 'Law Rome'/MM.111 trees. On 18 Oct NAA, EthylBloc, Kinetin, or Cyclanilide did not affect fruit drop, firmness, starch, soluble solids, or red color alone. ReTain delayed fruit drop loss of fruit firmness, and starch. The combination of ReTain + NAA + EthylBloc provided superior control of fruit drop.

Dip Studies:

In 2000, when 'NuRed Rome 262' fruit were picked, dipped in Mertect and stored at 70°F, Mertect had no influence on fruit firmness, starch, % rots, but Mertect increased soluble solids when compared to untreated fruit. EthylBloc (gas or dip), EthylBloc (gas or dip)+ Mertect, or ReTain + Mertect inhibited loss of fruit firmness and starch and reduced fruit rots, but cyclanilide + Mertect did not. Approximately 56 days after harvest, fruit dipped in ReTain + EthylBloc + Mertect on Sept 26, were still showing 20.1 lbs pressure; whereas, untreated fruit were only 12 lbs. firmness.

In 2000, Fruit dipped in ReTain + EthylBloc (gas or dip) and stored at 35°F maintained 20.7 lbs. fruit firmness for 8 weeks compared to the control of 14.4 lbs. However, after 16 weeks, ReTain + EthylBloc (gas or dip) softened to 15.3 lbs. compared to the control at 12.1 lbs. Fruit rots were substantially inhibited by EthylBloc and/or ReTain in combination with Mertect fungicide. These data suggest fruit firmness retention helped inhibit fungus disease development in cold storage.

In 2001, ReTain and/or EthylBloc dipped 'Sunrise' apples stored at 70°F delayed the loss of fruit firmness in tests on Aug 23 and Sept. 2.

Peach Studies:

In 2001, Kinetin applied to 'Cresthaven' tree limbs on either 9 Aug or 16 Aug did not affect firmness, soluble solids, red color and background color on Aug. 23 or Aug. 29 testing dates.

In 2001, 'Cresthaven' fruit dipped in ReTain on August 20 and stored at 70°F greatly slowed the loss of firmness when evaluated on Aug 25, Aug. 30., and Sept. 4. ReTain and/or EthylBlock was as effective as Scholar for control of fruit rots. At 40°F EthylBloc was more effective than ReTain for slowing the loss of fruit firmness, but not at 70°F.

Introduction

Fruits of many apple cultivars may abscise before adequate color or maturity develops. Because adequate labor often is unavailable to harvest large orchards of a single cultivar, growers may begin to harvest earlier than the optimum maturity date. Early harvest may lead to poorer fresh and processed fruit quality and poorer fruit storability. In addition, early and short harvest periods may present several practical problems such as inadequate numbers of picking bins, trucks, and cold storage equipment to handle more fruit in a short period of time. Early harvest can also result in lower yields, because fruit that remains on the tree may continue to increase in size (Shallenberger et al., 1961; Curtis, 1961). Chemical sprays that delay pre-harvest fruit drop and maturity for an additional 2 to 4 weeks may increase crop value by increasing yield, fruit size, quality, and price by as much as 20% (Byers, unpublished).

Chemical control of pre-harvest fruit drop has been studied for many years (Batjer and Moon, 1945; Batjer, L. P. and A. H. Thompson, 1946; Batjer and Thompson, 1947; Edgerton and Hoffman, 1948; Edgerton, 1947; Gardner et al., 1940; Harley et al., 1946; Mattus and Moore, 1954; Mattus et al., 1956; Smock et al., 1954; Southwick et al., 1953; Thompson 1952).

NAA, 2,4,5-TP, and daminozide (Alar) have been registered to delay pre-harvest abscission of apples. The registration of daminozide was withdrawn in 1989. This compound hastened red color development, delayed fruit maturity and fruit drop (Batjer and Williams et al., 1966; Edgerton and Blanpied; 1970; Pollard, 1974). When daminozide (Alar) + NAA or 2,4,5-TP was used to control preharvest drop, a 2- to 4-week extension of the harvest period was possible for many red cultivars.

The registration of 2,4,5-TP was cancelled in 1986. This material controlled fruit drop better than daminozide or NAA, but it caused a hastening of maturity (Mattus and Moore, 1954; Mattus et al., 1956; Smock et al., 1954; Southwick et al., 1953). The optimum harvest period was shortened by 2,4,5-TP even though fruit were held on the tree adequately. Combinations of daminozide and 2,4,5-TP minimized fruit drop, caused negligible fruit ripening (Batjer and Williams, 1966; Edgerton and Blanpied, 1970; Pollard, 1974; Schomer et al., 1971; Smock et al., 1954), increased fruit color, and extended the harvest season substantially. A survey of Virginia apple growers in 1989 (after the cancellation of 2,4,5-TP but before the cancellation of daminozide (Alar)), indicated 5 to 25% of the total crop was lost to preharvest drop.

NAA was considered to be less effective than 2,4,5-TP or daminozide (Looney and Cochrane, 1981; Southwick, et al 1953; Thompson 1952). More recent studies indicate that NAA is more effective when applied 3 to 4 weeks before the optimum harvest date followed by a second application 14 to 21 days afterward for cultivars grown in Virginia (Marini, et al., 1993).

A wider harvest window (over a 2 – 4 week period) is needed to allow each cultivar to be harvested without loss of yield or fruit quality. Ideally, fruit of each cultivar should be harvested in a 3 to 5 day picking window for maximum fruit quality; however, a shortage of labor, bins, poor picking weather, as well as early ripening or coloring sequence of cultivars may frequently alter the anticipated harvest window.

Other chemicals that have auxin-like activity will also delay pre-harvest fruit drop. They include: 1) phenoxys (fenoprop, 2,4-DP), chloroxuron (Looney and Cochrane, 1981; Looney and Hogue, 1987; Marini and Byers, 1988a; Marini et al., 1988b; Marini et al., 1989), 2) benzoic acides (dicamba) (Marini and Byers, 1988a; Marini et al., 1988c; Marini et al., 1989), and pyridines (triclopyr, lontrel, and fluroxypyr). Among these 2,4-DP and dicamba appeared be superior to NAA because they are longer lasting and have little negative affects on fruit ripening (Marini and Byers, 1988a; Marini et al., 1988b; Marini et al., 1988c)

Aminoethoxyvinylglycine (AVG, ReTain) is an ethylene-biosynthesis inhibitor (Yu and Yang, 1979, Shafer et al., 1995) that suppresses ethylene production in apple fruit and other plant tissues (Autio and Bramlage, 1982; Bangerth, 1978). When applied within 1 month of harvest, AVG delays fruit ripening, suppresses preharvest and postharvest flesh softening, reduces watercore, reduces pre-harvest fruit drop, and increases fruit removal force (Autio and Bramlage, 1982; Bangerth, 1978; Williams, 1980; Byers, 1997a,b,c).

Due to the temporary lack of transportation and/or cold storage facilities at harvest, apple growers, packers, and processors need methods to store large quantities of apples for short periods in outside non-refrigerated storage shelters, or as a pre-treatment for long term regular cold or CA storage. At harvest, rapidly cooling large quantities of fruit is both expensive and/or requires additional refrigeration capacity to cool fruit to 32°F rapidly. In addition, during peak loading of cold storages, core temperatures may not reach 32°F for a week or more due to inadequate refrigeration capacity. Occasionally, if cold storages are full, some fruit may set for several weeks at temperatures of 50°F to 75°F before processing. During these periods, fruit may deteriorate rapidly due to the loss of firmness, starch, fruit rots, and/or insect damage.

Since short-term cold storage before processing can be expensive, any treatment that would dramatically maintain fruit firmness and eating quality (shelf-life) at 75°F could be of great importance for both fresh and processed apple marketability. A chemical drench that would inhibit fruit maturity, fruit rots, and insect damage could be useful in many certain circumstances. Many cold storages and processors have quick fruit dip or drench capacity for treating trucks loads of fruit.

In 1997, AVG (ReTain) was registered for control of fruit drop. Orchard sprays or fruit dips of AVG were found to inhibit loss of firmness, ethylene evolution, and starch degradation (Byers, 1997abc; and Byers, unpublished). In 1995, ethylene production of York and Rome fruit dipped in AVG was greatly inhibited during the 21 days after harvest when compared to untreated control fruit. In another AVG dip experiment, fruit rots were inhibited to 9% by AVG vs 27% in the control when apples were stored at 70°F for 26 days. AVG is not known to inhibit fruit rot organisms, but the rot inhibition may be a result of AVG maintenance of fruit firmness and condition. Dipping peach and nectarine fruit (Byers, 1997) with ReTain maintained fruit firmness when held at 70°F for 12 days. In addition, ethylene production was completely inhibited by dipping fruit in AVG for 30 seconds or less.

1-Methylcyclopropene (MCP) is an inhibitor of ethylene action that has been found to block ethylene responses in plants (Fan et al. 1999; Sisler and M. Serek, 1997). MCP is a gas which has been formulated as a powder with the trade name EthylBloc. EthylBloc releases the MCP gas when mixed with a base. MCP is currently being used commercially in the cut flower industry, and has potential for use in apple cold storages to prolong the post-harvest quality of apples and peaches (Fan et al., 1999). On September 24 1999, we gassed 'Golden Delicious' trees in the field with MCP using 300 cubic foot bags. At this time the control fruit averaged 18.5 lbs. firmness. Fruit drop was not controlled by MCP, but 30 days after gassing whole trees, fruit were still 18.3 lbs on Oct 24 1999 (control was 14.0 lbs). In addition, we also were partially successful in making a sprayable formulation. The MCP spray was not as effective as the gas, but fruit from sprayed trees were 15.9 lbs. firmness compared to the control at 14.0 lbs.

The objectives of these experiments were to investigate 1) sprays of ReTain, NAA, dicamba, 2,4-DP, tryclopyr, fluroxypyr, their combinations, and adjuvants for maximum control of pre-harvest fruit drop and maintenance of "on tree" fruit quality, 2) fruit dips to provide short-term room temperature storage of apples, 3) fruit dips for long term regular storage, and 4) dips to promote shelf life of fruit after removal to room temperature from cold storage.

Materials and Methods

Trees were selected for uniformity and blocked according to row and terrain into six or more blocks for the number of treatments listed in each table. Specific information about spray application dates, tree size, chemical rates, maturity at harvests, and storage temperatures are reported in each table when appropriate. Experimental procedures will follow previous work on fruit drop and fruit quality (Byers, 1997abc; Marini et al., 1988ab; Marini et al.,1989).

Five to 10 limbs/tree (with a minimum of approximately 50 fruit/tree) were selected and tagged to monitor fruit drop . At 7-day intervals, fruit remaining on these limbs were counted and the percentage of fruit drop was calculated. Fruit samples were taken at intervals for testing.

In several experiments, a 10 fruit sample was collected near fruit maturity from each tree for quality evaluations (flesh firmness, soluble solids concentration, starch staining, percentage red color, fruit scaring and/or russet, and incidence of water core). Flesh firmness of was measured on two sides of each fruit with an Effegi penetrometer (Model FT327: McCormick Fruit Tech, Yakima, Wash.) fitted with an 11.1-mm tip. Soluble solids concentration (SSC) was estimated with an Atago hand-held refractometer (Model N1, McCormick Fruit Tech, Yakima, Wash.), utilizing a composite sample of juice resulting from penetrometer testing of all replicates of each treatment. Each apple fruit was cut in half transversely, and severity of water core was rated on a scale of 0 to 5 (0= none, 5 = severe). Flesh starch was evaluated by dipping half of each apple in iodine solution for approximately 15 s. The degree of staining was rated on a scale of 0 to 8 where 0 = staining of the entire cut surface and 8 = absence of starch (Poapst et al., 1959). Stem-end and side russet were rated as 0=no russet to 5= severe russet.

Unfortunately a sample of 2,4-DP was not available for testing. Past results indicated this compound will inhibit fruit drop without promoting fruit ripening (Marini and Byers 1988a).

Expt. 1. In 2000, thirty 5-year-old 'Arlet'/M.7 trees (5 blocks) were used for 6 treatments (Tables 1A, 1B, and 1C.). EthylBloc was applied either as a gas or spray alone or in combination with ReTain + Silwet-L-77. Treatments were applied on July 18 at an estimated 4 weeks before the optimum harvest date (August 15).

When EthylBloc was applied as a gas to individual trees in the field, trees were covered with a 10 mil silage bag 12 ft in diameter and 20 ft in height, gassed over night 6PM to 8AM, and the bag taken off in the morning to prevent sunlight heating. The bag fitted snugly on the ground the bag cylinder was tied at the top during gassing. The approximate bag volume was 314 ft^3.

Expt. 2. In 2000, seventy-seven 12-year-old 'Ace Delicious'/MM.111 trees (7 blocks) were used for 11 treatments (Tables 2A, 2B, 2C). Treatments were applied on 25 Aug at an estimated 10 days before the optimum harvest date (5 Sep).

Expt. 3. In 2000, eighty-four 23-year-old ' Redspur Delicious'/MM.111 trees (7 blocks) were used for 12 treatments (Tables 3A, 3B, 3C). Treatments were applied on 4 Sep at an estimated 1 week before the optimum harvest date (12 Sep).

Expt. 4. In 2000, fifty-six 25-year-old 'Golden Delicious'/MM.111 trees (7 blocks) were used for 8 treatments (Tables 4A, 4B, 4C, 4D). Treatments were applied on 1 Sep at an estimated 1 week before the optimum harvest date (8 Sep).

Expt. 5. In 2000, sixty-four 25-year-old 'York'/MM.111 trees (8 blocks) were used for 8 treatments (Tables 5A, 5B, 5C). Treatments were applied on 2 Sep at an estimated 5 weeks before the optimum harvest date (6 Oct).

Expt. 6. In 2000, ninety-six 25-year-old 'Law Rome'/MM.111 trees (8 blocks) were used for 12 treatments (Tables 6A, 6B, 6C). Treatments were applied on 5 Sep at an estimated 4 weeks before the optimum harvest date (2 Oct).

Expt. 7. In 2001, forty 5-year-old 'Golden Supreme'/MM.111 trees (5 blocks) were used for 8 treatments (Tables 7A, 7B, 7C). Treatments were applied on 25 July at an estimated 4 weeks before the optimum harvest date (24 Aug.).

Expt. 8. In 2001, forty nine 5-year-old 'Gala'/M.9 trees (7 blocks) were used for 7 treatments (Tables 8A, 8B). Treatments were applied on 8 August at an estimated 3 weeks before the optimum harvest date (29 Aug.), except for ethephon which was applied on 22 Aug. Fruit drop and maturity data were taken at various intervals of time.

Expt. 9. In 2001, forty nine 13-year-old 'Law Rome'/MM.111 trees (6 blocks) were used for 9 treatments (Tables 9A, 9B). Treatments were applied on 27 September at an estimated 2 weeks before the optimum harvest date (11 Oct.). Fruit drop and maturity data at various intervals of time.

Expt. 10. In 2000, 10 bushels NuRed Rome fruit of uniform diameter were harvested from 5 trees. Twenty fruit were dipped for 1 minute or gassed for 12 hours on Sept 26, dried, and 4 groups of 20 each were placed in a film liner in a tray-pack box (Table 10A, 10B, 10C, 10D) and stored at 70°F. A second box of 4 groups of 20 each treatment were stored at 35°F.

Expt. 11. In 2001, 4 bushels 'Sunrise' apples of uniform diameter were harvested from 2 trees. Forty fruit were dipped for 1 minute for each treatment on August 13 when firmness was 16.4 lbs; fruit were divided into 2 groups of 20 each and were placed in a film liner in a tray-pack box and stored at 70°F (Table 11A, 11B). Twenty fruit were evaluated on Aug 23 and Sept. 2 for maturity.

Expt. 12. In 2001, Three limbs were selected on 6 'Cresthaven' trees each for application of Kinetin on either 9 Aug or 16 Aug or none on each tree. Ten fruits were evaluated from each limb for fruit firmness, soluble solids, red color and background color on Aug. 23 and Aug. 29.

Expt. 13. In 2001, approximately 15 bushels of 'Cresthaven' fruit of uniform maturity and diameter were harvested from 20 trees. Forty fruit were dipped for 1 minute for each treatment on August 20 when firmness was 18.2 lbs; fruit were divided into 2 groups of 20 each and were placed in a film liner in a tray-pack box and stored at 70°F or 40°F (Table 13A, 13B). Twenty fruit were evaluated on Aug 25, Aug. 30 and Sept. 4 for fruit firmness, soluble solids, red color and percent rots.

Results and Discussion

Expt. 1. EthylBloc applied as a gas or spray did not affect fruit drop (Table 1A) or pull force (trt 2,3) (Table 1B). ReTain (trt 4) inhibited fruit drop (Table 1A), loss of fruit firmness (Table 1B), starch degradation (Table 1B), inhibited red color (Table 1C), maintained green background color (Table 1C), and increased pull force (Table 1B) when compared to the control. The tank mix spray of EthylBloc (gas or spray) + ReTain further inhibited fruit drop (Table 1A, trt 5,6) and promoted increased soluble solids (Table 1C), inhibited red color, maintained green background color when compared to ReTain alone. The combination or ReTain + EthylBloc spray (trt 6) provided the best control of fruit drop, loss of fruit firmness, starch degradation, and increased pull force. EthylBloc alone did not inhibit loss of starch or increase pull (Table 1ABC) .

As the season progressed, fruit treated with ReTain (trt 4,5,6) continued to increase in diameter until to Oct 10 (Table 1B). However, fruit of the control and EthylBloc treatments increased in diameter only until Aug 31 and then decreased in diameter. Untreated fruit that remained on the tree were shriveled on Oct.10 and most stems were in various stages of turning brown and dying, but ReTain treated fruit were not shriveled and stems were green.

Assuming that August 15 was the optimum harvest date based on fruit firmness, trees sprayed with ReTain + EthylBloc (trt 6) maintained fruit firmness above 16 lbs (Table 1B) and increased in fruit diameter (Table 1B) for 35 days past the optimum harvest date (until at least Sept 19).

Expt 2. NAA, dicamba, tryclopyr salt, tryclopyr ester, and ReTain inhibited 'Ace Delicious' fruit drop (Table 2A) and increased pull force (Table 2B). The application of ReTain with any of the auxins inhibited the loss of firmness (Table 2B), starch (Table 2B), but ReTain depressed soluble solids (Table 2B). The combination of dicamba + ReTain (trt 9) provided the best control of fruit drop (Table 2A). Firmness of fruit from trees sprayed with ReTain + EthylBloc (trt 6) was maintained above 14 lbs pressure (Table 2B) for 30 days (Oct 3) past the optimum harvest date (Sept 5).

Fruit stored for 117 days at 32°F in regular cold storage had lost considerable fruit firmness (Table 2C). Fruit from trees sprayed with ReTain were approximately 2 lbs more firm than the control (Table 2C). The auxin treated trees did not affect fruit firmness during cold storage (Table 2C)

Expt 3. NAA, dicamba, and ReTain inhibited 'Redspur Delicious' fruit drop (Table 3A), but neither cyclanilide, or EthylBloc affected fruit drop or pull force (Table 3B). The use of ReTain with any of the auxins inhibited the loss of firmness, starch (Table 3B), and water core (Table 3B), but ReTain depressed soluble solids (Table 3B). The combination spray of dicamba + ReTain + EthylBloc (trt 9) provided the best control of fruit drop (Table 3A) and the strongest pull force (Table 3B). NAA caused fruit stem-end cracking (Table 3B), but ReTain in combination with NAA inhibited this cracking.

Fruit stored for 117 days at 32°F in regular cold storage had lost considerable fruit firmness (Table 3C). Fruit from trees sprayed with ReTain were approximately 1 lbs more firm than the control (Table 3C). The auxin treated trees did not affect fruit firmness during cold storage (Table 3C)

Expt 4. Dicamba, floroxypyr, tryclopyr, and ReTain inhibited 'Golden Delicious' fruit drop and increased pull force (Table 4A), but cyclanilide or EthylBloc did not. The combination spray of dicamba + ReTain + EthylBloc (trt 8) provided the best control of fruit drop and the strongest pull force (Table 4A). ReTain or ReTain + dicamba + EthylBloc inhibited the loss of firmness, starch, fruit shriveling, and ethylene evolution (Table 4A, 4B, 4C). Fruit diameter increased from Oct. 6 to Oct. 16 but decreased from Oct 16 to Nov. 15. Fruit stored for 120 days (Feb. 5) was out of condition, but ReTain maintained firmness better than other treatments.

Expt. 5. ReTain or cyclanilide did not control 'York' fruit drop and did not influence fruit flesh firmness, starch, water core (Table 5B).

Expt. 6. NAA, dicamba, floroxypyr, cyclanilide, and ReTain inhibited fruit drop of 'Law Rome', but EthylBloc did not (Table 6A). The combination spray of dicamba + ReTain + EthylBloc (trt 12) provided the best control of fruit drop. Several of the treatments containing ReTain inhibited the loss of firmness), starch degradation, and % of fruit with red flesh bleeding (Table 6B).

Expt. 7. ReTain and/or NAA inhibited fruit drop, 5-year-old 'Golden Supreme'/MM.111. EthylBloc did not affect fruit drop alone or when combined with ReTain. Cyclanilide increase the rate of fruit drop and when combined with ReTain. Cyclanilide inhibited the influence ReTain on fruit drop (Tables 7A, 7B, 7C). The combination of ReTain + NAA + EthylBloc provided superior control of fruit drop (Table 7A).

A delay in harvest date allowed ReTain fruit to increase in fruit diameter without loss of fruit quality until at least Sept 29 (Table 7B). ReTain delayed fruit softening, NAA hastened softening, and EthylBloc had no effect. ReTain maintained starch but NAA, EthylBloc, and Cyclanilide did not. ReTain delayed the starch:sugar conversion as indicated by lower soluble solids and higher starch levels. ReTain delayed the development of background color, fruit shriveling, and fruit cracking (Table 7C).

Expt. 8. Ethephon nor its combination with ReTain or NAA+ReTain affected the rate of fruit drop of 'Gala'/M.9 trees (Table 8A); however, little drop occurred by Sept 18. A delay in harvest from 22 Aug to 5 Sept allowed fruit to increase in diameter without loss of fruit quality (Table 8B). Ethephon caused fruit to have about the same firmness, less starch, and more color than control fruit. ReTain delayed fruit maturity, soluble solids, red color development, loss of starch, and loss of firmness. Ethephon+ ReTain sprayed trees had higher firmness and more starch than the control on 5 Sept and better red color than ReTain alone on 5 Sept and 19 Sept (Table 8B).

Expt. 9. ReTain and/or NAA inhibited fruit drop, 10-year-old 'Law Rome'/MM.111 trees. On 18 Oct NAA, EthylBloc, Kinetin, or Cycilinalid did not affect fruit drop, firmness, starch, soluble solids, or red color alone. ReTain delayed fruit drop loss of fruit firmness, and starch (Tables 9A 9B). The combination of ReTain + NAA + EthylBloc provided superior control of fruit drop (Table 7A).

Expt. 10. When 'NuRed Rome 262' fruit were picked, dipped in Mertect and stored at 70°F, Mertect had no influence on fruit firmness, starch, % rots, but Mertect increased soluble solids when compared to untreated fruit (Table 7A). EthylBloc (gas or dip), EthylBloc (gas or dip)+ Mertect, or ReTain + Mertect inhibited loss of fruit firmness and starch and reduced fruit rots, but cyclanilide + Mertect did not. Approximately 56 days after harvest (Nov. 22), fruit dipped in ReTain + EthylBloc + Mertect (trt 9) on Sept 26, were still showing 20.1 lbs pressure; whereas, untreated fruit were only 12 lbs. firmness (Table 10A).

Fruit dipped in ReTain + EthylBloc (gas or dip) and stored at 35°F maintained 20.7 lbs. fruit firmness for 8 weeks (Table 10B) compared to the control of 14.4 lbs. However, after 16 weeks, ReTain + EthylBloc (gas or dip) softened to 15.3 lbs. compared to the control at 12.1 lbs (Table 10C). Fruit rots were substantially inhibited by EthylBloc and/or ReTain in combination with Mertect fungicide. These data suggest fruit firmness retention helped inhibit fungus disease development in cold storage.

Expt. 11. In 2001, ReTain and/or EthylBloc dipped 'Sunrise' apples stored at 70°F delayed the loss of fruit firmness in tests on Aug 23 and Sept. 2 (Table11).

Expt. 12. In 2001, Kinetin applied to 'Cresthaven' tree limbs on either 9 Aug or 16 Aug did not affect firmness, soluble solids, red color and background color on Aug. 23 or Aug. 29 testing dates (Table 12).

Expt. 13. In 2001, 'Cresthaven' fruit dipped in ReTain on August 20 and stored at 70°F greatly slowed the loss of firmness when evaluated on Aug 25, Aug. 30. and Sept. 4(Table 13A). ReTain and/or EthylBloc was as effective as Scholar for control of fruit rots. At 40°F EthylBloc was more effective than ReTain for slowing the loss of fruit firmness (Table 13B), but not at 70°F.

Expected Significance to the Virginia Apple Industry

These experiments demonstrate that one spray of dicamba, NAA, or tryclopyr + ReTain can delay maturity, preharvest fruit drop, and increase fruit size making a wider window of harvest possible without the loss of fruit firmness.

Fruit dipped in ReTain + EthylBloc (gas or dip) at harvest and stored at 70°F for 6 to 8 weeks maintained 20. 2 lbs. firmness without the expense of cold storage (Table 7A). Fruit rots were a major problem for fruit held at 70°F for extended periods. Fruit dips inhibited fruit rots by maintaining fruit firmness. Delayed maturity by dipping fruit after harvest has the potential to reduce or replace the need for short-term refrigerated storage, extend shelf-life, reduce the need to rapidly cool large quantities of fruit to 35°F, and reduce losses related to loss of firmness, starch, and fruit rots.

Fruit dipped in ReTain + EthylBloc (gas or dip) and stored at 35°F maintained 20.7 lbs. fruit firmness for 8 weeks (Table 7C) compared to the control of 14.4 lbs. However, after 16 weeks, ReTain + EthylBloc (gas or dip) softened to 15.3 lbs. compared to the control at 12.1 lbs (Table 7C). This data suggests that an additional treatment of EthylBloc and /or ReTain may be needed to further delay loss of fruit firmness. Fruit rots were substantially inhibited by EthylBloc and/or ReTain in combination with Mertect fungicide. These data suggest fruit firmness retention helped inhibit fungus disease development in cold storage.

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Additional reference available on request.

Table 1A. Influence of EthylBloc and ReTain “on-tree treatment” 'Arlet'/M.7 apple fruit drop and fruit maturity (2000).

No.	Color	Treatment^{zy}	Rate/ Gallon or /tree	Application method	Cumulative % of fruit dropped/ tree								Shriveled fruit (%)	Brown stem (%)
					Aug 8	Aug 15	Aug 22	Aug 29	Sept 5	Sept 12	Sept 19	Oct 10	10 Oct	10 Oct
1.	W	Control			0.6 a^{x}	15 a	40 a	55 a	70 a	75 a	80 a	85 a	60 abc	67.5 ab
2.	R	EthylBloc + Buffer	3 g 60 ml	(gas)	0.6 a	10 ab	35 a	52 a	61 a	68 a	71 a	77 a	88 a	74.0 a
3.	B	EthylBloc + Silwet L-77	3 g 2.36 ml	(spray)	0.6 a	5 bc	36 a	55 a	66 a	71 a	73 a	80 a	68 ab	56.2 abc
4.	FO	ReTain (50 ppm) + Silwet L-77	1.61g 2.36 ml	(spray)	0.2 a	1 c	2 b	4 b	9 b	24 b	40 b	54 b	20 cd	25.0 cd
5.	HP	EthylBloc + Buffer ReTain (50 ppm) + Silwet L-77	3 g 60 ml 1.61g 2.36 ml	(gas) (spray)	0.2 a	0.6 c	3 b	5 b	10 b	19 c	28 c	41 c	32 bcd	34.0 bcd
6.	OBKD	ReTain (50 ppm) + EthylBloc + Silwet L-77	1.61g 3 g 2.36 ml	(spray)	0.4 a	0.6 c	1 b	3 b	6 b	14 bc	17 c	28 d	0 d	6.0 d

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	EthylBloc gas vs none	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
1 vs 3	EthylBloc spray vs none	ns	**	ns	ns	ns	ns	ns	ns	ns	ns
1 vs 4	ReTain vs none	ns	***	***	***	***	***	***	***	*	*
1 vs 5	EthylBloc spray + ReTain vs none	ns	***	***	***	***	***	***	***	ns	ns
1 vs 6	EthylBloc gas + vs none	ns	***	***	***	***	***	***	***	**	**
2 vs 3	EthylBloc gas vs EthylBloc spray	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
2 vs 4	EthylBloc gas vs ReTain	ns	**	***	***	***	***	***	***	***	**
3 vs 4	EthylBloc spray vs ReTain	ns	ns	***	***	***	***	***	***	*	ns
4 vs 5	ReTain vs EthylBloc spray + ReTain	ns	ns	ns	ns	ns	ns	ns	*	ns	ns
4 vs 6	ReTain vs EthylBloc gas + ReTain	ns	ns	ns	ns	ns	*	***	***	ns	ns
5 vs 6	EthylBloc spray + ReTain vs EthylBloc gas + ReTain	ns	ns	ns	ns	ns	ns	ns	**	ns	ns
1,2,3 vs 4,5,6	ReTain vs none	ns	***	***	***	***	***	***	***	***	***

[zy] Spray treatments were applied with a high pressure hand-gun sprayer. EthylBloc was applied on 17 July (gas) and18 July (spray) when fruit firmness was 25.7 lbs.

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

Table 1B. Influence of EthylBloc and ReTain "on-tree treatment" 'Arlet'/M.7 apple fruit drop and fruit maturity (2000).

No.	Color	Treatment[zy]	Rate/ Gallon or /tree	Application method	Fruit diameter (cm)					Fruit firmness (lb.)					Starch (1-8 rating)					Pull force (lb.)		
					Aug 8	Aug 22	Aug 31	Sept 19	Oct 10	Aug 8	Aug 22	Aug 31	Sept 19	Oct 10	Aug 8	Aug 22	Aug 31	Sept 19	Oct 10	Aug 31	Sept 19	Oct 10
1.	W	Control			7.30 a[x]	7.54 a	7.46 bc	7.25 b	7.12 b	20.0 d	17.7 c	17.0 c	13.8 b	11.5 b	5.84 a	6.88 b	7.88 a	8.00 a	8.00 a	2.15 c	2.13 b	1.39 d
2.	R	EthylBloc + Buffer	3 g 60 ml	(gas)	7.28 a	7.48 a	7.27 c	7.36 b	7.15 b	20.4 cd	19.5 ab	18.2 b	15.0 b	13.4 ab	6.36 a	6.94 b	7.96 a	7.96 ab	8.00 a	1.89 c	2.46 b	2.60 bc
3.	B	EthylBloc + Silwet L-77	3 g 2.36 ml	(spray)	7.25 ab	7.47 a	7.54 abc	7.37 b	7.25 b	20.1 d	19.0 b	16.6 c	14.4 b	12.8 ab	5.80 a	7.64 a	7.88 a	8.00 a	8.00 a	2.09 c	2.11 b	2.02 cd
4.	FO	ReTain (50 ppm) + Silwet L-77	1.61g 2.36 ml	(spray)	7.26 ab	7.66 a	7.81 a	7.89 a	8.06 a	21.8 a	20.1 a	19.0 a	15.0 b	13.9 a	4.00 b	5.44 c	7.40 b	7.96 ab	8.00 a	3.08 b	2.59 b	3.40 a
5.	HP	EthylBloc + Buffer ReTain (50 ppm) + Silwet L-77	3 g 60 ml 1.61g 2.36 ml	(gas) (spray)	7.29 a	7.62 a	7.77 ab	8.03 a	8.17 a	20.9 bc	18.0 b	19.3 a	16.5 a	13.4 ab	3.48 b	5.22 c	7.04 b	7.92 ab	8.00a	3.43 b	2.67 b	2.91 ab
6.	OBKD	ReTain (50 ppm) + EthylBloc + Silwet L-77	1.61g 3 g 2.36 ml	(spray)	7.10 b	7.53 a	7.77 ab	8.03 a	8.18 a	21.3 ab	19.6 ab	19.1 a	16.7 a	14.5 a	4.08 b	5.30 c	7.00 b	7.76 b	8.00 a	4.17 a	3.39 a	2.68 abc
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		EthylBloc gas vs none			ns	ns	ns	ns	ns	ns	***	**	ns	ns	ns	ns	ns	ns	ns	ns	ns	**
1 vs 3		EthylBloc spray vs none			ns	ns	ns	ns	ns	ns	***	ns	ns	ns	ns	**	ns	ns	ns	ns	ns	ns
1 vs 4		ReTain vs none			ns	ns	*	**	***	***	***	***	ns	*	***	***	*	ns	ns	**	ns	***
1 vs 5		EthylBloc spray + ReTain vs none			*	ns	*	**	***	**	***	***	***	ns	***	***	***	*	ns	***	***	***
1 vs 6		EthylBloc gas + vs none			ns	ns	*	**	***	*	***	***	***	**	***	***	***	ns	ns	***	ns	**
2 vs 3		EthylBloc gas vs spray			ns	ns	ns	ns	ns	ns	ns	***	ns	ns	ns	*	ns	ns	ns	ns	ns	ns
2 vs 4		EthylBloc gas vs ReTain			ns	*	**	ns	***	***	*	*	ns	ns	***	***	ns	ns	ns	**	ns	*
3 vs 4		EthylBloc spray vs ReTain			ns	*	ns	*	***	***	**	***	ns	ns	***	***	*	ns	ns	**	ns	***
4 vs 5		ReTain vs EthylBloc spray + ReTain			*	ns	ns	ns	ns	ns	ns	ns	*	ns	ns	ns	ns	*	ns	**	*	ns
4 vs 6		ReTain vs EthylBloc gas + ReTain			ns	ns	ns	ns	ns	*	**	ns	*	ns	ns	ns	ns	ns	ns	ns	ns	ns
5 vs 6		EthylBloc spray + ReTain vs EthylBloc gas + ReTain			*	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	*	ns
1,2,3 vs 4,5,6		ReTain vs none			ns	*	***	***	***	***	***	***	***	*	***	***	***	ns	ns	***	**	***

[zy] Spray treatments were applied with a high pressure hand-gun sprayer. EthylBloc was applied on 17 July (gas), and 18 July (spray), when fruit firmness was 25.7 lbs.

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

Table 1C. Influence of EthylBloc and ReTain "on-tree treatment" 'Arlet'/M.7 apple fruit drop and fruit maturity (2000-01).

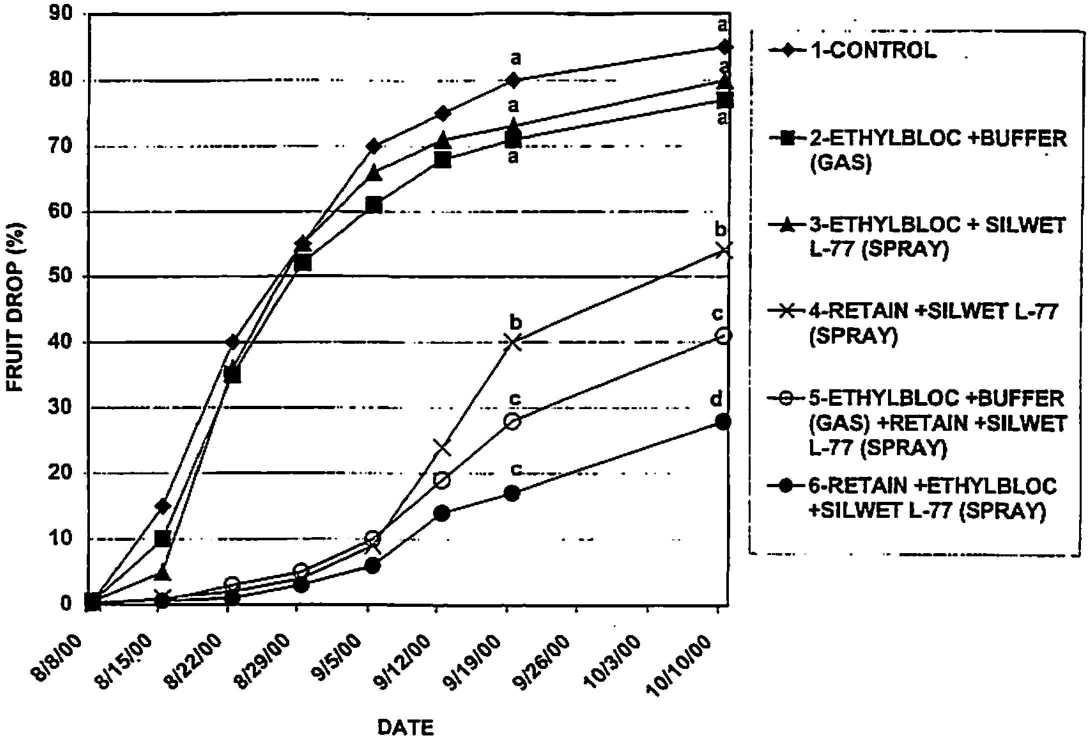
No.	Color	Treatment^{zy}	Rate/ Gallon or /tree	Application method	Soluble solids (%)					Color (red side) (%)					Color (green side) (0-5)					Visual % of spurs flowerin (0-100%) (16 Apr 01)
					Aug 8	Aug 22	Aug 31	Sept 19	Oct 10	Aug 8	Aug 22	Aug 31	Sept 19	Oct 10	Aug 8	Aug 22	Aug 31	Sept 19	Oct 10	
1.	W	Control			13.6 a^x	15.0 ab	15.5 a	15.4 b	14.9 c	36 ab	83 a	88 a	86 a	85 b	2.0 b	2.8 a	3.0 ab	3.4 a	3.6 ab	98.0 a
2.	R	EthylBloc + Buffer	3 g 60 ml	(gas)	14.2 a	15.6 a	16.0 a	15.9 ab	15.9 abc	42 a	80 a	82 abc	88 a	87 ab	2.3 a	2.6 ab	3.3 a	3.3 a	3.5 ab	99.5 a
3.	B	EthylBloc + Silwet L-77	3 g 2.36 ml	(spray)	13.9 a	15.0 ab	15.4 a	15.7 ab	15.1 bc	38 ab	79 a	84 ab	85 a	90 a	2.2 a	2.5 bc	2.9 b	3.2 a	3.7 a	97.5
4.	FO	ReTain (50 ppm) + Silwet L-77	1.61g 2.36 ml	(spray)	13.9 a	14.9 ab	15.5 a	15.6 ab	16.1 ab	36 ab	68 b	81 bc	86 a	89 ab	2.1 ab	2.1 d	2.3 c	3.4 a	3.6 ab	99.0 a
5.	HP	EthylBloc + Buffer ReTain (50 ppm) + Silwet L-77	3 g 60 ml 1.61g 2.36 ml	(gas) (spray)	13.9 a	14.9 ab	15.5 a	15.6 ab	16.3 a	37 ab	60 bc	77 cd	83 a	89 ab	2.1 ab	2.2 cd	2.0 c	3.3 a	3.4 ab	99.0 a
6.	OBKD	ReTain (50 ppm) + EthylBloc + Silwet L-77	1.61g 3 g 2.36 ml	(spray)	14,1 a	14.7 b	15.7 a	16.2 a	16.0 ab	33 b	55 c	75 d	85 a	87 ab	2.0 b	2.0 d	2.3 c	3.1 a	3.3 b	98.0 a
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
1 vs 2		EthylBloc gas vs none			ns	ns	ns	ns	ns	ns	ns	*	ns	ns	*	ns	ns	ns	ns	ns
1 vs 3		EthylBloc spray vs none			ns	ns	ns	ns	ns	ns	ns	ns	ns	*	*	*	ns	ns	ns	ns
1 vs 4		ReTain vs none			ns	ns	ns	ns	*	ns	**	*	ns	ns	ns	***	***	ns	ns	ns
1 vs 5		EthylBloc spray + ReTain vs none			ns	ns	ns	*	**	ns	***	***	ns	ns	ns	***	***	ns	ns	ns
1 vs 6		EthylBloc gas + vs none			ns	ns	ns	ns	*	ns	***	***	ns	ns	ns	***	***	ns	ns	ns
2 vs 3		EthylBloc gas vs EthylBloc spray			ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	*	ns	ns	ns
2 vs 4		EthylBloc gas vs ReTain			ns	ns	ns	ns	ns	ns	*	ns	ns	ns	*	**	***	ns	ns	ns
3 vs 4		EthylBloc spray vs ReTain			ns	ns	ns	ns	*	ns	*	ns	ns	ns	ns	**	**	ns	ns	ns
4 vs 5		ReTain vs EthylBloc spray + ReTain			ns	ns	ns	ns	ns	ns	**	*	ns	ns	ns	ns	ns	ns	ns	ns
4 vs 6		ReTain vs EthylBloc gas + ReTain			ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
5 vs 6		EthylBloc spray + ReTain vs EthylBloc gas + ReTain			ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
1,2,3 vs 4,5,6		ReTain vs none			ns	ns	ns	ns	**	ns	***	***	ns	ns	ns	***	***	ns	ns	ns

zySpray treatments were applied with a high pressure hand-gun sprayer. EthylBloc was applied on 17 July (gas), and 18 July (spray), when fruit firmness was 25.7 lbs.

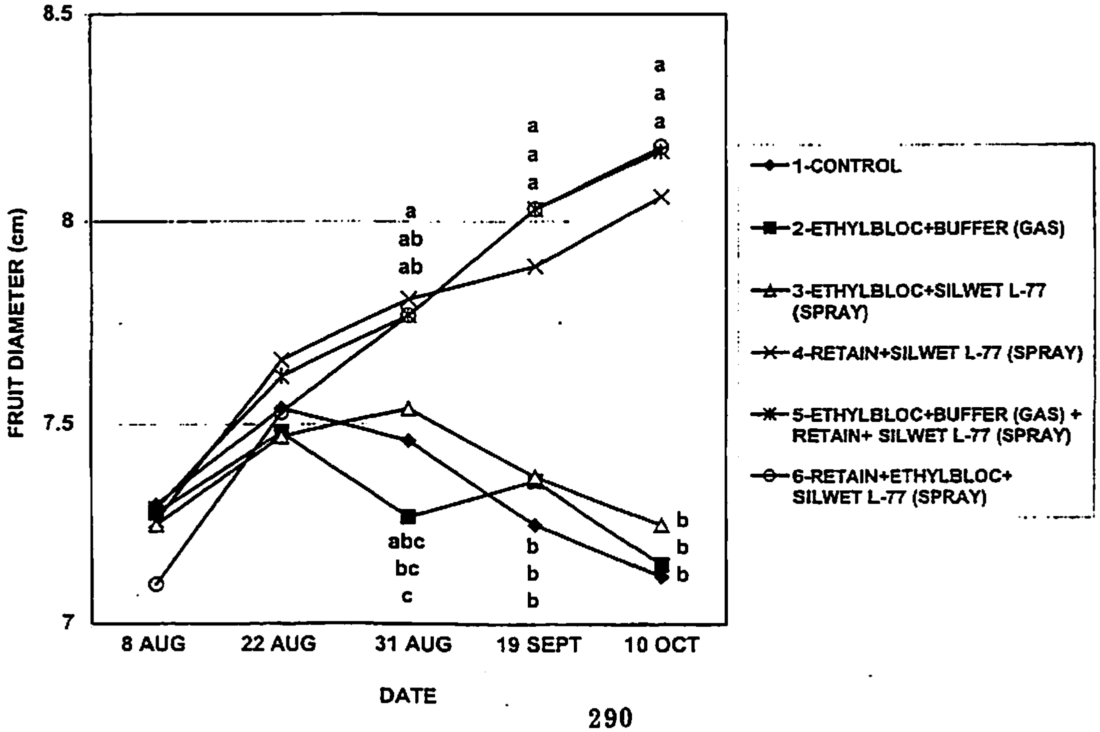
xMean separation within columns by Duncan's New Multiple Range Test;($P \leq 0.05$).

Byers

INFLUENCE OF ETHYLBLOC AND RETAIN ON FRUIT DROP OF ARLET APPLES

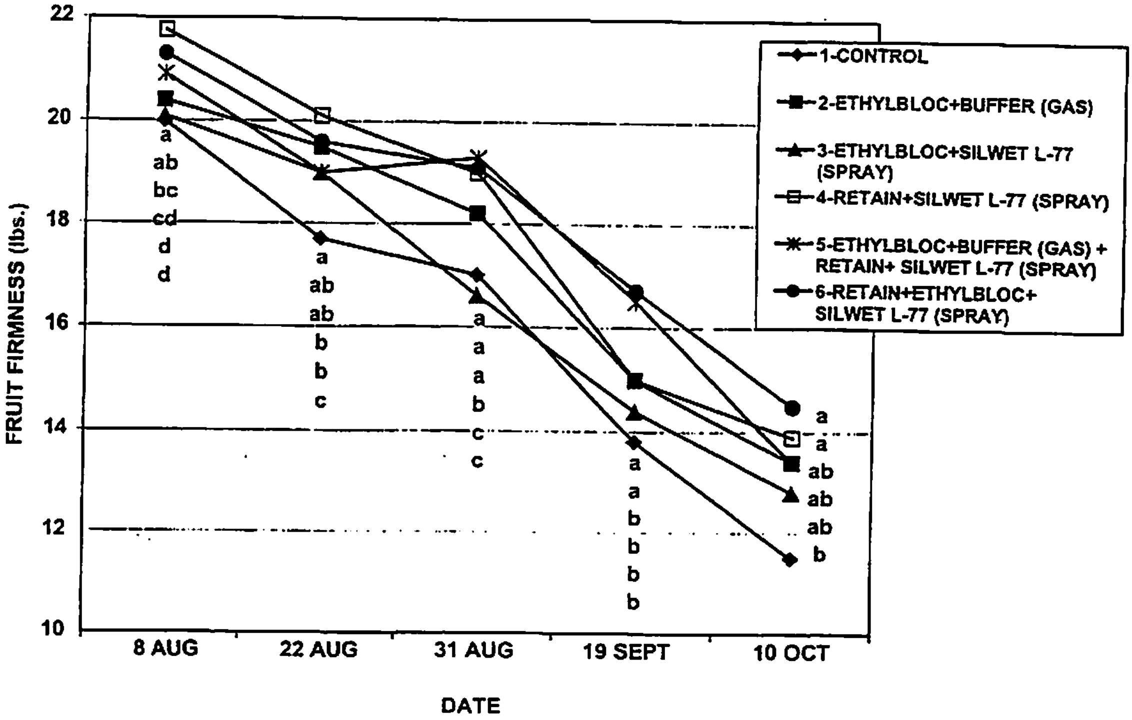


INFLUENCE OF ETHYLBLOC AND RETAIN ON FRUIT SIZE IN ARLET APPLES TREATED JULY 17; FRUIT DIAMETER = 6.42 CM



INFLUENCE OF ETHYLBLOC AND RETAIN
ON FIRMNESS IN ARLET APPLES
TREATED JULY 17; FRUIT FIRMNESS = 25.7 LBS.

Byers



INFLUENCE OF ETHYLBLOC AND RETAIN ON
STARCH IN ARLET APPLES
TREATED JULY 17, 2000
(TESTED AUG. 8, 2000)

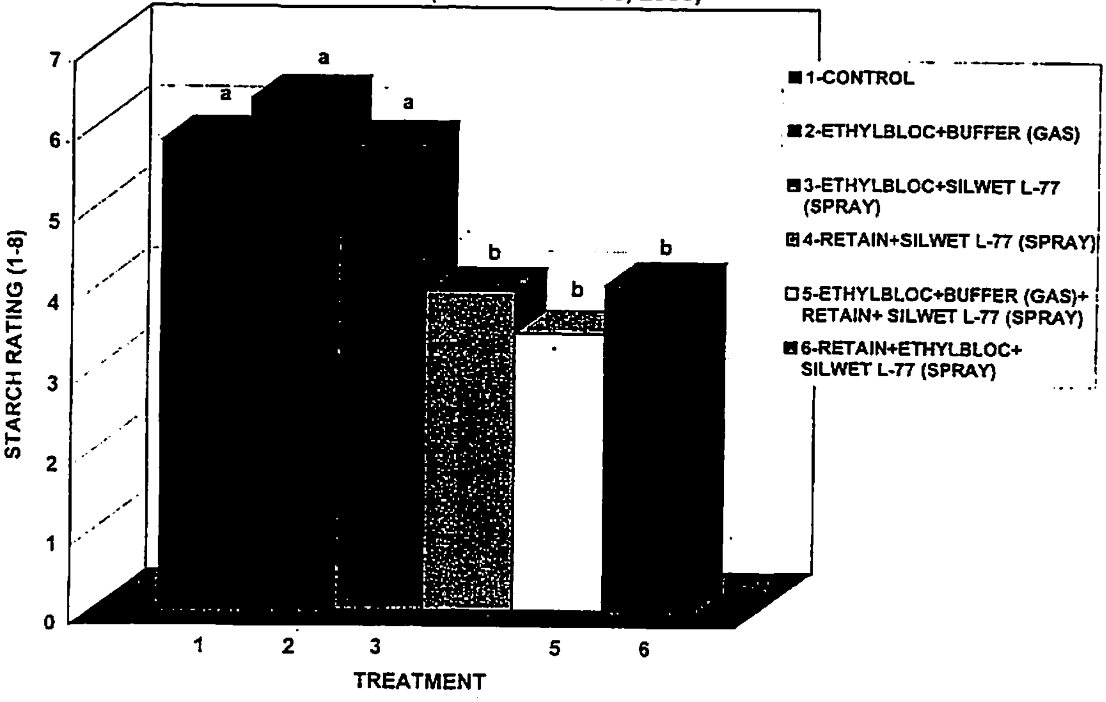


Table 2A. Effect of plant growth regulators on fruit drop of 'Ace Delicious'/MM.111 (2000).

No.	Color	Treatment^{zy}	Rate (g/100gal) (100 gallons water / acre)	% Fruit Drop									
				Sept 8	Sept 15	Sept 22	Sept 29	Oct 6	Oct 13	Oct 20	Oct 27	Nov 3	Nov 10
1.	W	Control		0.5 a^{x}	5.1 a	11.5 a	21.9 a	48 2 a	57.2 a	73.5 a	77.5 a	88.9 a	90.7 a
2.	R	NAA (10ppm) Fruitone N + Silwet L-77 (0.1%)	366g/100 189.5 ml	0.6 a	4.9 ab	6.1 bc	10.4 bc	18.0 cd	22.3 cd	47.6 bc	60.2 bc	72.7 abc	83.3 a
3.	B	Dicamba (Clarity) + Silwet L-77 (0.1%)	30 ml 189.5 ml	0.0 a	3.3 ab	4.1 bc	5.2 cd	11.8 def	20.8 cd	35.3 cde	44.2 cde	56.8 c	67.8 b
4.	Y	Fluroxypyr + Silwet L-77 (0.1%)	80 ml 189.5 ml	0.0 a	2.4 ab	4.5 bc	14.3 b	30.6 b	38.7 b	58.2 b	67.7 ab	77.5 ab	85.0 a
5.	LG	Tryclopyr (salt, Garlon 3A) (3 lb/gal) + Silwet L-77 (0.1%)	40 ml 189.5 ml	0.0 a	3.7 ab	8.7 ab	11.7 bc	27.4 bc	28.7 bc	47.7 bc	54.9 bcd	75.2 abc	83.3 a
6.	LP/HPS	Tryclopyr (ester, Garlon 4) (4 lb/gal) + Silwet L-77 (0.1%)	30 ml 189.5 ml	0.5 a	2.7 ab	4.3 bc	7.3 bcd	16.5 de	20.6 cd	39.4 cd	52.6 bcd	68.5 bc	83.0 a
7.	PBKS	ReTain (15%) + Silwet L-77 (0.1%)	333g/100 189.5 ml	0.9 a	3.3 ab	4.1 bc	8.7 bcd	13.4 def	18.0 cde	30.2 de	43.4 cde	63.1 bc	80.0 ab
8.	OBKS	ReTain (15%) + NAA (10ppm) Fruitone N + Silwet L-77 (0.1%)	333g/100 366g/100 189.5 ml	1.5 a	2.5 ab	3.5 bc	4.8 cd	5.7 ef	7.8 ef	15.2 fg	35.3 e	56.1 c	81.6 ab
9.	RBKD	ReTain (15%) + Dicamba (Clarity) + Silwet L-77 (0.1%)	333g/100 30 ml 189.5 ml	0.0 a	1.2 b	2.1 c	2.8 d	4.0 f	4.9 f	9.6 g	15.5 f	29.5 d	51.0 c
10.	OBKD	ReTain (15%) + Fluroxypyr + Silwet L-77 (0.1%)	333g/100 80 ml 189.5 ml	1.3 a	3.2 ab	4.5 bc	6.2 cd	15.9 de	19.4 cd	28.7 def	46.1 cde	59.9 bc	77.6 ab
11.	RYS	ReTain (15%) + Tryclopyr (salt, Garlon 3A) (3 lb/gal) + Silwet L-77 (0.1%)	333g/100 40 ml 189.5 ml	0.0 a	3.7 ab	5.3 bc	7.2 bcd	10.5 def	13.7 def	23.4 efg	40.8 de	61.3 bc	80.8 ab

Table 2A cont.

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	NAA vs none	ns	ns	*	***	***	***	***	*	*	ns
1 vs 3	Dicamba vs none	ns	ns	**	***	***	***	***	***	***	***
1 vs 4	Fluroxypyr vs none	ns	ns	**	*	***	***	*	ns	ns	ns
1 vs 5	Garlon 3A vs none	ns	ns	ns	**	***	***	***	**	ns	ns
1 vs 6	Garlon 4 vs none	ns	ns	**	***	***	***	***	**	*	ns
1 vs 7	ReTain vs none	ns	ns	**	***	***	***	***	***	**	ns
2 vs 3	NAA vs Dicamba	ns	ns	ns	ns	ns	ns	ns	ns	ns	*
2 vs 4	NAA vs Fluroxypyr	ns	ns	ns	ns	*	**	ns	ns	ns	ns
2 vs 5	NAA vs Garlon 3A	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
2 vs 6	NAA vs Garlon 4	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
2 vs 7	NAA vs ReTain	ns	ns	ns	ns	ns	ns	*	ns	ns	ns
2 vs 8	NAA vs ReTain+NAA	ns	ns	ns	ns	ns	**	**	ns	ns	ns
3 vs 9	Dicamba vs Dicamba +ReTain	ns	ns	ns	ns	ns	**	***	***	**	***
4 vs 10	Fluroxypyr vs Fluroxypyr+ReTain	ns	ns	ns	ns	**	***	***	**	*	ns
5 vs 11	Garlon 3A vs Garlon 3A+ReTain	ns	ns	ns	*	**	**	**	ns	ns	ns
5 vs 6	Garlon 3A vs Garlon 4	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
7 vs 8	ReTain vs ReTain+NAA	ns	ns	ns	ns	ns	ns	*	ns	ns	ns
7 vs 9	ReTain vs ReTain+ Dicamba	ns	ns	ns	ns	ns	*	**	***	***	***
7 vs 10	ReTain vs ReTain+Fluroxypyr	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
7 vs 11	ReTain vs ReTain+Garlon 3A	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
1,2,3,4,5 vs 7,8,9,10,11	ReTain vs none (all materials)	ns	ns	**	***	***	***	***	***	***	**

[Z] All treatments were applied with an airblast machine at 100 gals/acre. Tree size was considered to be 50% TRV. Treatments were applied on 25 Aug., when fruit maturity was : fruit diameter 7.78 cm, fruit firmness 17.7 lbs., starch 2.5, soluble solids 10.2, and color 96% .

[Y] Estimated optimum harvest date: Sept 20, 2000.

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

Table 2B. Effect of plant growth regulators on fruit drop of 'Ace Delicious'/MM.111 (2000-01).

No.	Color	Treatment^{zy}	Rate (g/100gal) (100 gallons water / acre)	Fruit diameter (cm) (3 Oct 00)	Fruit firmness (lb) (3 Oct 00)	Soluble Solids (3 Oct 00)	Starch (0-8) (3 Oct 00)	Fruit color (%) (3 Oct 00)	Pull force (lb) (3 Oct 00)	Water core (0-5) (3 Oct 00)	Visual spurs flowering (0-100%) (23 Apr 01)	Flowering clusters /cm^2 limb cross sectional area (23 Apr 01)
1.	W	Control		8.64 a^x	13.0 cd	13.7 a	7.13 a	99.2 ab	1.75 b	0.00 a	81 ab	7.48 a
2.	R	NAA (10ppm) Fruitone N + Silwet L-77 (0.1%)	366g/100 189.5 ml	8.45 abc	13.1 cd	13.2 abc	6.88 ab	99.1 ab	2.79 a	0.33 a	90 a	8.00 a
3.	B	Dicamba (Clarity) + Silwet L-77 (0.1%)	30 ml 189.5 ml	8.27 c	13.4 bcd	12.9 bcd	6.97 ab	98.9 ab	2.54 a	0.57 a	71 ab	6.16 a
4.	Y	Fluroxypyr + Silwet L-77 (0.1%)	80 ml 189.5 ml	8.38 abc	12.6 d	13.0 abcd	7.12 a	99.1 ab	2.98 a	0.33 a	73 ab	7.00 a
5.	LG	Tryclopyr (salt, Garlon 3A) (3 lb/gal) + Silwet L-77 (0.1%)	40 ml 189.5 ml	8.57 ab	12.6 d	13.0 abcd	7.33 a	99.4 a	2.86 a	0.17 a	91 a	7.35 a
6.	LP/HPS	Tryclopyr (ester, Garlon 4) (4 lb/gal) + Silwet L-77 (0.1%)	30 ml 189.5 ml	8.34 bc	12.7 cd	13.4 ab	7.30 a	99.3 ab	3.12 a	0.29 a	86 a	6.44 a
7.	PBKS	ReTain (15%) + Silwet L-77 (0.1%)	333g/100 189.5 ml	8.48 abc	13.8 abc	12.6 cde	6.27 c	98.3 b	3.30 a	0.00 a	73 ab	6.98 a
8.	OBKS	ReTain (15%) + NAA (10ppm) Fruitone N + Silwet L-77 (0.1%)	333g/100 366g/100 189.5 ml	8.28 c	14.8 a	12.1 e	6.22 c	99.3 ab	2.98 a	0.00 a	58 b	5.23 a
9.	RBKD	ReTain (15%) + Dicamba (Clarity) + Silwet L-77 (0.1%)	333g/100 30 ml 189.5 ml	8.35 bc	14.3 ab	12.4 de	6.22 c	98.9 ab	3.00 a	0.00 a	69 ab	6.33 a
10.	OBKD	ReTain (15%) + Fluroxypyr + Silwet L-77 (0.1%)	333g/100 80 ml 189.5 ml	8.42 abc	14.3 ab	13.1 abc	6.20 c	98.6 ab	2.95 a	0.00 a	81 ab	7.65 a
11.	RYS	ReTain (15%) + Tryclopyr (salt, Garlon 3A) (3 lb/gal) + Silwet L-77 (0.1%)	333g/100 40 ml 189.5 ml	8.39 abc	14.3 ab	12.8 bcd	6.53 bc	98.7 ab	2.91 a	0.14 a	89 a	7.15 a

Table 2B cont.

Contrasts	Comparisons	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F
1 vs 2	NAA vs none	ns	ns	ns	ns	ns	**	ns	ns	ns
1 vs 3	Dicamba vs none	**	ns	*	ns	ns	*	*	ns	ns
1 vs 4	Fluroxypyr vs none	*	ns	*	ns	ns	**	ns	ns	ns
1 vs 5	Garlon 3A vs none	ns	ns	*	ns	ns	**	ns	ns	ns
1 vs 6	Garlon 4 vs none	**	ns	ns	ns	ns	***	ns	ns	ns
1 vs 7	ReTain vs none	ns	ns	***	**	*	***	ns	ns	ns
2 vs 3	NAA vs Dicamba	ns	ns	ns	ns	ns	ns	ns	ns	ns
2 vs 4	NAA vs Fluroxypyr	ns	ns	ns	ns	ns	ns	ns	ns	ns
2 vs 5	NAA vs Garlon 3A	ns	ns	ns	ns	ns	ns	ns	ns	ns
2 vs 6	NAA vs Garlon 4	ns	ns	ns	ns	ns	ns	ns	ns	ns
2 vs 7	NAA vs ReTain	ns	ns	ns	*	ns	ns	ns	ns	ns
2 vs 8	NAA vs ReTain+NAA	ns	*	**	**	ns	ns	*	**	*
3 vs 9	Dicamba vs Dicamba +ReTain	ns	ns	ns	**	ns	ns	*	ns	ns
4 vs 10	Fluroxypyr vs Fluroxypyr+ReTain	ns	**	ns	**	ns	ns	ns	ns	ns
5 vs 11	Garlon 3A vs Garlon 3A+ReTain	ns	**	ns	**	ns	ns	ns	ns	ns
5 vs 6	Garlon 3A vs Garlon 4	ns	ns	ns	ns	ns	ns	ns	ns	ns
7 vs 8	ReTain vs ReTain+NAA	ns	ns	ns	ns	*	ns	ns	ns	ns
7 vs 9	ReTain vs ReTain+ Dicamba	ns	ns	ns	ns	ns	ns	ns	ns	ns
7 vs 10	ReTain vs ReTain+Fluroxypyr	ns	ns	ns	ns	ns	ns	ns	ns	ns
7 vs 11	ReTain vs ReTain+Garlon 3A	ns	ns	ns	ns	ns	ns	ns	ns	ns
1,2,3,4,5 vs 7,8,9,10,11	ReTain vs none (all materials)	ns	***	***	***	ns	ns	*	ns	ns

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[Z]All treatments were applied with an airblast machine at 100 gals/acre. Tree size was considered to be 50% TRV. Treatments were applied on 25 Aug., when fruit maturity was : fruit diameter 7.78 cm, fruit firmness 17.7 lbs., starch 2.5, soluble solids 10.2, and color 96% .

[Y]Estimated optimum harvest date: Sept 20, 2000.

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

Table 2C. Effect of plant growth regulators on fruit drop of 'Ace Delicious'/MM.111 (in storage 117 days) (2000).

No.	Color	Treatment[zy]	Rate (g/100gal) (100 gallons water / acre)	Fruit diameter (cm) (1 Jan 01)	Fruit firmness (lb) (1 Jan 01)	Soluble solids (1 Jan 01)	Fruit color (%) (1 Jan 01)
1.	W	Control		8.46 ab[x]	7.93 e	13.4 a	97.4 ab
2.	R	NAA (10ppm) Fruitone N	366g/100	8.50 ab	8.10 de	13.3 ab	97.3 ab
		+ Silwet L-77 (0.1%)	189.5 ml				
3.	B	Dicamba (Clarity)	30 ml	8.40 ab	9.03 cd	13.1 abc	97.3 ab
		+ Silwet L-77 (0.1%)	189.5 ml				
4.	Y	Fluroxypyr	80 ml	8.38 ab	7.90 e	13.2 abc	97.3 ab
		+ Silwet L-77 (0.1%)	189.5 ml				
5.	LG	Tryclopyr (salt, Garlon 3A) (3 lb/gal)	40 ml	8.50 ab	7.93 e	13.1 abc	96.7 b
		+ Silwet L-77 (0.1%)	189.5 ml				
6.	LP/HPS	Tryclopyr (ester, Garlon 4) (4 lb/gal)	30 ml	8.38 ab	7.76 e	13.1 abc	96.6 b
		+ Silwet L-77 (0.1%)	189.5 ml				
7.	PBKS	ReTain (15%)	333g/100	8.36 ab	10.7 a	12.6 cd	96.0 b
		+ Silwet L-77 (0.1%)	189.5 ml				
8.	OBKS	ReTain (15%)	333g/100	8.28 b	10.2 ab	12.7 bcd	97.3 ab
		+ NAA (10ppm) Fruitone N	366g/100				
		+ Silwet L-77 (0.1%)	189.5 ml				
9.	RBKD	ReTain (15%)	333g/100	8.40 ab	10.2 ab	12.4 d	99.0 a
		+ Dicamba (Clarity)	30 ml				
		+ Silwet L-77 (0.1%)	189.5 ml				
10.	OBKD	ReTain (15%)	333g/100	8.52 ab	9.87 abc	13.1 abc	95.2 b
		+ Fluroxypyr	80 ml				
		+ Silwet L-77 (0.1%)	189.5 ml				
11.	RYS	ReTain (15%)	333g/100	8.64 a	9.60 bc	12.9 abcd	95.6 b
		+ Tryclopyr (salt, Garlon 3A) (3 lb/gal)	40 ml				
		+ Silwet L-77 (0.1%)	189.5 ml				

Table 2C cont.

Contrasts	Comparisons	Pr>F	Pr>F	Pr>F	Pr>F
1 vs 2	NAA vs none	ns	ns	ns	ns
1 vs 3	Dicamba vs none	ns	*	ns	ns
1 vs 4	Fluroxypyr vs none	ns	ns	ns	ns
1 vs 5	Garlon 3A vs none	ns	ns	ns	ns
1 vs 6	Garlon 4 vs none	ns	ns	ns	ns
1 vs 7	ReTain vs none	ns	***	**	ns
2 vs 3	NAA vs Dicamba	ns	ns	ns	ns
2 vs 4	NAA vs Fluroxypyr	ns	ns	ns	ns
2 vs 5	NAA vs Garlon 3A	ns	ns	ns	ns
2 vs 6	NAA vs Garlon 4	ns	ns	ns	ns
2 vs 7	NAA vs ReTain	ns	***	*	ns
2 vs 8	NAA vs ReTain+NAA	ns	*	ns	ns
3 vs 9	Dicamba vs Dicamba +ReTain	ns	*	*	ns
4 vs 10	Fluroxypyr vs Fluroxypyr+ReTain	*	***	ns	*
5 vs 11	Garlon 3A vs Garlon 3A+ReTain	ns	***	ns	ns
5 vs 6	Garlon 3A vs Garlon 4	ns	ns	ns	ns
7 vs 8	ReTain vs ReTain+NAA	ns	ns	ns	ns
7 vs 9	ReTain vs ReTain+ Dicamba	ns	ns	ns	**
7 vs 10	ReTain vs ReTain+Fluroxypyr	**	ns	ns	ns
7 vs 11	ReTain vs ReTain+Garlon 3A	ns	*	ns	ns
1,2,3,4,5 vs 7,8,9,10,11	ReTain vs none (all materials)	ns	***	***	ns

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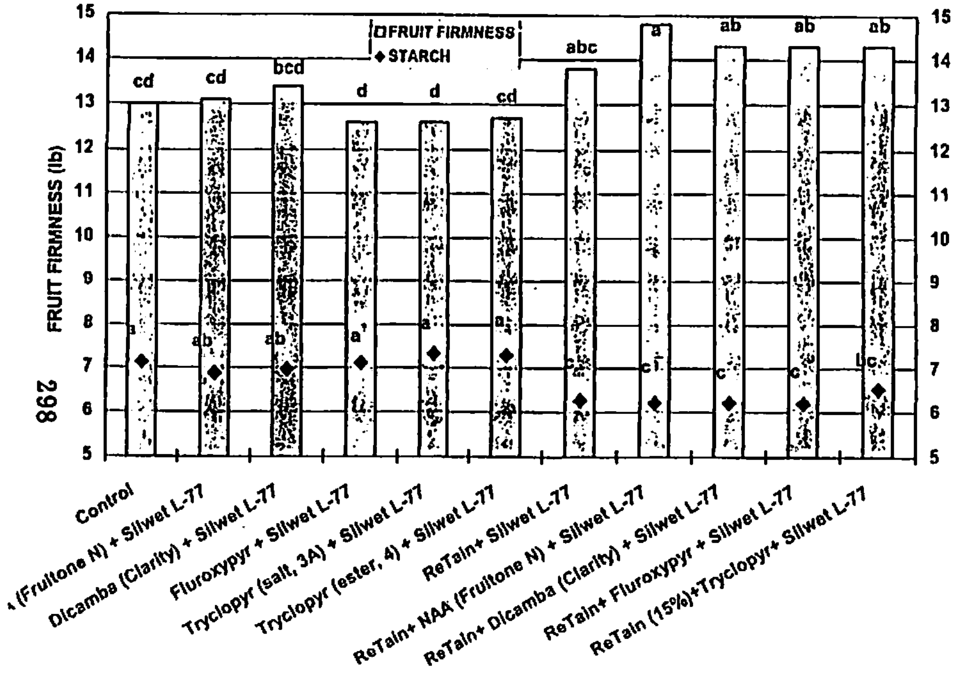
[Z] All treatments were applied with an airblast machine at 100 gals/acre. Tree size was considered to be 50% TRV. Treatments were applied on 25 Aug., when fruit maturity was : fruit diameter 7.78 cm, fruit firmness 17.7 lbs., starch 2.5, soluble solids 10.2, and color 96% .

[Y] Estimated optimum harvest date: Sept 20, 2000.

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

EFFECT OF PLANT GROWTH REGULATORS ON MATURITY OF "ACE DELICIOUS'/MM.111 (2000)



EFFECT OF PLANT GROWTH REGULATORS ON FRUIT DROP OF 'ACE DELICIOUS'/MM.111 (2000)

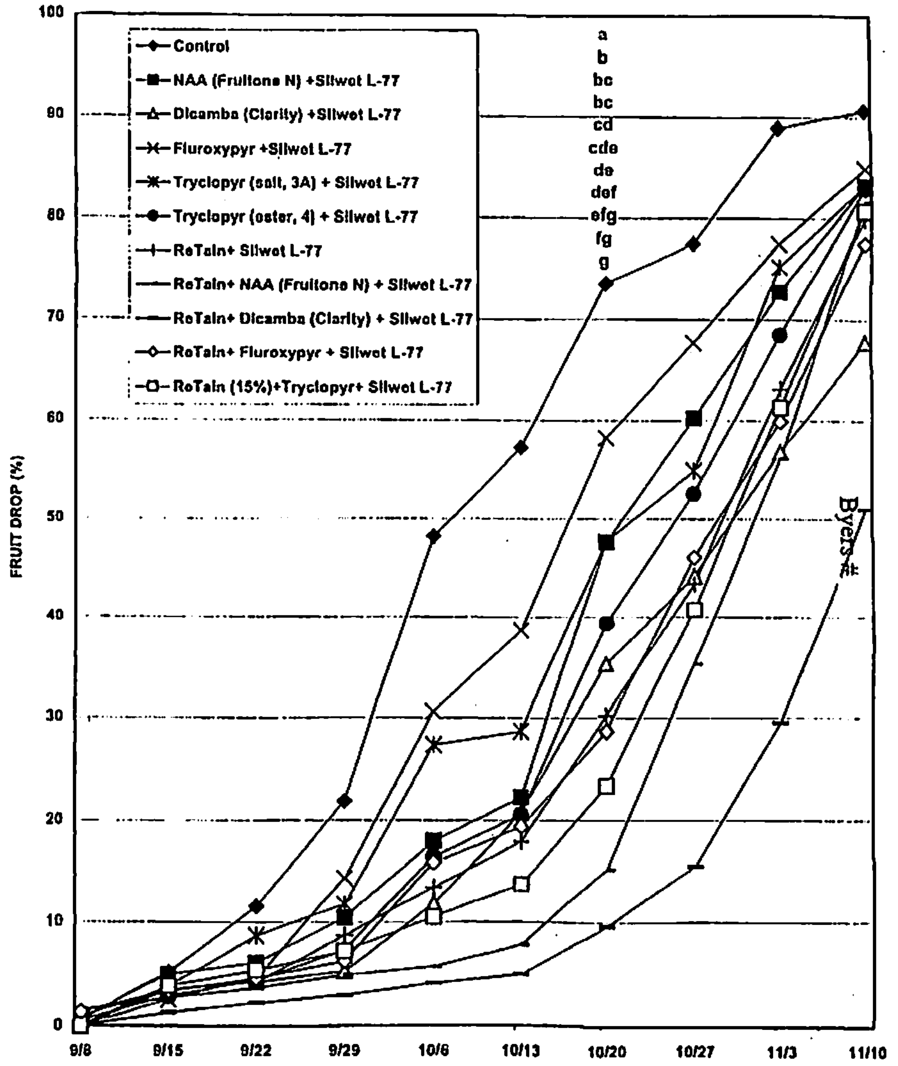


Table 3A. Effect of plant growth regulators on fruit drop of 'Redspur Delicious'/MM.111 (2000-01).

No.	Treatment^{ZY}	Rate (g/100gal)	% Fruit Drop									Visual spurs flowering (0-100%)	Flowering clusters /cm^{2} limb cross sectional area
		(100 gallons water / acre)	Sept 11	Sept 18	Sept 25	Oct 2	Oct 9	Oct 16	Oct 23	Oct 30	Nov 6	(19 Apr 01)	(19 Apr 01)
1.	Control		3.0 a^{X}	5.2 ab	9.2 ab	11.6 abc	20.9 ab	35.0 a	49.2 a	64.2 a	69.1 a	72 abc	6.77 ab
2.	NAA (10ppm) Fruitone N + Silwet L-77 (0.1%)	366g/100 189.5 ml	5.6 a	5.9 ab	9.8 ab	11.2 abc	15.6 abcd	19.2 bcd	31.4 bc	44.8 bcd	48.7 bc	86 abc	7.08 ab
3.	Dicamba (Clarity) + Silwet L-77 (0.1%)	30 ml 189.5 ml	3.5 a	5.0 ab	8.5 ab	10.4 abc	11.5 abcd	12.1 cde	12.4 de	16.1 ef	19.8 d	52 c	7.84 ab
4.	Cyclanilide + Silwet L-77 (0.1%)	101 ml 189.5 ml	4.0 a	5.2 ab	11.1 ab	14.5 ab	20.2 abc	34.4 a	48.6 a	61.9 ab	67.6 a	56 bc	4.23 b
5.	ReTain (15%) + Silwet L-77 (0.1%)	333g/100 189.5 ml	4.9 a	8.7 ab	10.7 ab	13.0 ab	17.0 abc	22.6 abcd	29.8 c	41.3 cd	49.7 bc	80 abc	6.11 b
6.	NAA Fruitone N + ReTain (15%) + Silwet L-77 (0.1%)	366g 333 g 189.5 ml	4.3 a	4.6 ab	5.8 ab	6.4 bc	8.2 cd	10.6 de	16.9 cde	29.3 de	38.5 c	72 abc	4.81 b
7.	Dicamba (Clarity) + ReTain (15%) + Silwet L-77 (0.1%)	30 ml 333 g 189.5 ml	4.2 a	4.9 ab	5.9 ab	7.9 bc	10.0 bcd	10.4 de	12.6 de	14.8 ef	18.8 d	87 abc	8.19 ab
8.	Cyclanilide + ReTain (15%) + Silwet L-77 (0.1%)	101 ml 333g 189.5 ml	4.4 a	11.0 a	12.5 a	15.4 ab	19.0 abc	25.5 abc	32.8 bc	51.5 abc	57.8 ab	95 a	8.01 ab
9.	EthylBloc + Silwet L-77 (0.1%)	300 g 189.5 ml	5.6 a	10.5 a	14.0 a	19.1 a	22.6 a	32.3 ab	45.9 ab	62.7 a	65.8 ab	82 abc	7.16 ab
10.	EthylBloc + ReTain (15%) + Silwet L-77 (0.1%)	300 g 333 g 189.5 ml	4.0 a	5.2 ab	6.6 ab	7.6 bc	10.6 abcd	15.2 cde	25.2 cd	48.5 abc	59.4 ab	84 abc	6.02 b
11.	EthylBloc + Dicamba (Clarity) + ReTain (15%) + Silwet L-77 (0.1%)	300 g 30 ml 333 g 189.5 ml	1.2 a	1.8 b	2.2 b	2.2 c	3.8 d	3.8 e	4.5 e	8.7 f	9.1 d	77 abc	10.8 a
12.	Silwet L-77 (0.1%)	189.5 ml	4.9 a	7.6 ab	8.9 ab	12.6 ab	20.4 abc	32.8 ab	50.0 a	61.4 ab	64.3 ab	89 ab	6.52 b

Table 3A cont.

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	NAA vs none	ns	ns	ns	ns	ns	**	*	*	*	ns	ns
1 vs 3	Dicamba vs none	ns	ns	ns	ns	ns	***	***	***	***	ns	ns
1 vs 4	Cyclanilide vs none	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
1 vs 5	ReTain vs none	ns	ns	ns	ns	ns	*	**	**	*	ns	ns
1 vs 9	EthylBloc vs none	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
1 vs 12	Silwet L-77 vs none	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
2 vs 3	NAA vs Dicamba	ns	ns	ns	ns	ns	ns	*	***	***	*	ns
2 vs 4	NAA vs Cyclanilide	ns	ns	ns	ns	ns	*	*	*	*	*	ns
2 vs 5	NAA vs ReTain	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
2 vs 6	NAA vs NAA + ReTain	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
3 vs 7	Dicamba vs Dicamba + ReTain	ns	ns	ns	ns	ns	ns	ns	ns	ns	*	ns
4 vs 8	ReTain vs none (Cyclanilide)	ns	ns	ns	ns	ns	ns	*	ns	ns	*	*
9 vs 10	ReTain vs none (EthylBloc)	ns	ns	ns	*	*	*	**	ns	ns	ns	ns
11 vs 10	Dicamba vs none (EthylBloc + ReTain)	ns	ns	ns	ns	ns	ns	**	***	***	ns	*
11 vs 7	EthylBloc vs none (Dicamba + ReTain)	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
11 vs 5	EthylBloc + Dicamba vs none (ReTain)	ns	ns	ns	*	*	**	***	***	***	ns	*
1,2,3,4,9 vs 5,6,7,8,10	ReTain vs none (all treatments)	ns	ns	ns	ns	*	**	***	***	*	*	ns

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[Z] All treatments were applied with an airblast machine at 100 gals/acre. Tree size was considered to be 75% TRV. Treatments were applied on 5 Sept., when fruit maturity was : fruit diameter 7.80 cm, fruit firmness 17.5 lbs., starch 4.4, soluble solids 9.8, and color 90% .

[Y] Estimated optimum harvest date: Sept 25, 2000.

[X] Mean separation within columns by Duncan's New Multiple Range Test;(P≤ 0.05).

Table 3B. Effect of plant growth regulators on fruit drop and maturity of 'Redspur Delicious'/MM.111 harvested Oct. 24, 2000.

No.	Treatment^{ZY}	Rate (g/100gal) (100 gallons water / acre)	Fruit diameter (cm) (Oct 24)	Fruit firmness (lb) (Oct 24)	Starch (0-8) (Oct 24)	Pull force (lb) (Oct 24)	Soluble Solids (Oct 24)	Water core rating (0-5) (Oct 24)	Water core (% fruit) (Oct 24)	Stem end cracking (%) (Oct 24)
1.	Control		8.31 b^X	7.99 c	7.97 a	1.47 bc	12.38 ab	0.83 abc	57 a	0.0 b
2.	NAA (10ppm) Fruitone N + Silwet L-77 (0.1%)	366g/100 189.5 ml	8.34 ab	8.33 bc	7.82 abcd	1.78 abc	12.42 a	1.00 ab	60 a	11.7 a
3.	Dicamba (Clarity) + Silwet L-77 (0.1%)	30 ml 189.5 ml	8.33 ab	8.13 bc	7.90 ab	2.39 ab	12.23 ab	1.00 ab	63 a	1.7 b
4.	Cyclanilide + Silwet L-77 (0.1%)	101 ml 189.5 ml	8.27 b	11.11 ab	7.73 abcde	1.92 abc	11.83 ab	1.05 a	63 a	3.3 b
5.	ReTain (15%) + Silwet L-77 (0.1%)	333g/100 189.5 ml	8.38 ab	10.75 abc	7.58 de	1.54 bc	12.03 ab	0.50 bc	40 a	0.0 b
6.	NAA Fruitone N + ReTain (15%) + Silwet L-77 (0.1%)	366g 333 g 189.5 ml	8.36 ab	12.28 a	7.57 de	1.93 abc	11.32 b	0.57 abc	45 a	1.7 b
7.	Dicamba (Clarity) + ReTain (15%) + Silwet L-77 (0.1%)	30 ml 333 g 189.5 ml	8.18 b	9.97 abc	7.64 bcde	1.88 abc	12.27 ab	0.79 abc	59 a	7.1 ab
8.	Cyclanilide + ReTain (15%) + Silwet L-77 (0.1%)	101 ml 333g 189.5 ml	8.41 ab	9.30 bc	7.53 e	1.74 abc	12.80 a	0.95 ab	60 a	3.3 b
9.	EthylBloc + Silwet L-77 (0.1%)	300 g 189.5 ml	8.48 ab	8.35 bc	7.87 abc	1.27 c	11.85 ab	0.58 abc	42 ab	3.3 b
10.	EthylBloc + ReTain (15%) + Silwet L-77 (0.1%)	300 g 333 g 189.5 ml	8.42 ab	10.43 abc	7.77 abcde	1.91 abc	12.48 a	0.35 c	22 b	0.0 b
11.	EthylBloc + Dicamba (Clarity) + ReTain (15%) + Silwet L-77 (0.1%)	300 g 30 ml 333 g 189.5 ml	8.66 a	9.27 bc	7.62 cde	2.52 a	12.38 ab	0.80 abc	53 a	0.0 b
12.	Silwet L-77 (0.1%)	189.5 ml	8.40 ab	8.05 c	7.92 a	1.17 c	12.18 ab	1.00 ab	62 a	1.7 b

Contrasts	Comparisons	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F
1 vs 2	NAA vs none	ns	ns	ns	ns	ns	ns	ns	**
1 vs 3	Dicamba vs none	ns	ns	ns	*	ns	ns	ns	ns
1 vs 4	Cyclanilide vs none	ns	*	*	ns	ns	ns	ns	ns
1 vs 5	ReTain vs none	ns	*	**	ns	ns	ns	ns	ns
1 vs 9	EthylBloc vs none	ns	ns	ns	ns	ns	ns	ns	ns
1 vs 12	Silwet L-77 vs none	ns	ns	ns	ns	ns	ns	ns	ns
2 vs 3	NAA vs Dicamba	ns	ns	ns	ns	ns	ns	ns	**
2 vs 4	NAA vs Cyclanilide	ns	*	ns	ns	ns	ns	ns	*
2 vs 5	NAA vs ReTain	ns	ns	ns	ns	ns	*	ns	**
2 vs 6	NAA vs NAA + ReTain	ns	**	*	ns	*	ns	ns	**
3 vs 7	ReTain vs none (Dicamba)	ns	ns	*	ns	ns	ns	ns	ns
4 vs 8	ReTain vs none (Cyclanilide)	ns	ns	ns	ns	*	ns	ns	ns
9 vs 10	ReTain vs none (EthylBloc)	ns	ns	ns	ns	ns	ns	ns	ns
11 vs 10	Dicamba vs none (EthylBloc + ReTain)	ns	ns	ns	ns	ns	ns	*	ns
11 vs 7	EthylBloc vs none (Dicamba + ReTain)	**	ns	ns	ns	ns	ns	ns	*
11 vs 5	EthylBloc + Dicamba vs none (ReTain)	ns	ns	ns	*	ns	ns	ns	ns
1,2,3,4,9 vs 5,6,7,8,10	ReTain vs none (all treatments)	ns	**	***	ns	ns	*	*	ns

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^{Z}All treatments were applied with an airblast machine at 100 gals/acre. Tree size was considered to be 75% TRV. Treatments were applied on 5 Sept., when fruit maturity was : fruit diameter 7.80 cm, fruit firmness 17.5 lbs., starch 4.4, soluble solids 9.8, and color 90 %.

^{Y}Estimated optimum harvest date: Sept 25, 2000.

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

Table 3C. Effect of plant growth regulators on fruit drop and maturity of 'Redspur Delicious'/MM.111 harvested Oct. 5, 2000 and placed in storage 117 days.

No.	Treatment[Z][Y]	Rate (g/100gal) (100 gallons water / acre)	Fruit diameter (cm) (30 Jan 01)	Fruit firmness (lb) (30 Jan 01)	Soluble Solids (30 Jan 01)	Fruit color (%) (30 Jan 01)	Rots (%) (30 Jan 01)
1.	Control		8.29 a[X]	9.09 ab	12.19 ab	96.7 a	0 b
2.	NAA (10ppm) Fruitone N + Silwet L-77 (0.1%)	366g/100 189.5 ml	7.96 ab	9.05 ab	11.87 ab	97.0 a	3 ab
3.	Dicamba (Clarity) + Silwet L-77 (0.1%)	30 ml 189.5 ml	7.76 b	9.23 ab	11.55 ab	95.7 a	5 a
4.	Cyclanilide + Silwet L-77 (0.1%)	101 ml 189.5 ml	8.31 a	10.85 ab	11.17 ab	95.0 a	0 b
5.	ReTain (15%) + Silwet L-77 (0.1%)	333g/100 189.5 ml	7.89 ab	10.67 ab	11.67 ab	95.2 a	2 ab
6.	NAA Fruitone N + ReTain (15%) + Silwet L-77 (0.1%)	366g 333 g 189.5 ml	8.15 ab	11.13 a	11.07 b	95.2 a	0 b
7.	Dicamba (Clarity) + ReTain (15%) + Silwet L-77 (0.1%)	30 ml 333 g 189.5 ml	8.12 ab	9.19 ab	12.00 ab	96.4 a	1 ab
8.	Cyclanilide + ReTain (15%) + Silwet L-77 (0.1%)	101 ml 333g 189.5 ml	7.97 ab	9.40 ab	12.38 a	94.2 a	3 ab
9.	EthylBloc + Silwet L-77 (0.1%)	300 g 189.5 ml	8.40 a	9.02 ab	11.55 ab	95.8 a	0 b
10.	EthylBloc + ReTain (15%) + Silwet L-77 (0.1%)	300 g 333 g 189.5 ml	8.08 ab	10.48 ab	12.05 ab	95.5 a	0 b
11.	EthylBloc + Dicamba (Clarity) + ReTain (15%) + Silwet L-77 (0.1%)	300 g 30 ml 333 g 189.5 ml	8.27 a	9.32 ab	12.17 ab	96.2 a	0 b
12.	Silwet L-77 (0.1%)	189.5 ml	8.13 ab	8.72 b	12.12 ab	81.8 b	2 ab

Contrasts	Comparisons	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F
1 vs 2	NAA vs none	ns	ns	ns	ns	ns
1 vs 3	Dicamba vs none	*	ns	ns	ns	*
1 vs 4	Cyclanilide vs none	ns	*	ns	ns	ns
1 vs 5	ReTain vs none	ns	*	ns	ns	ns
1 vs 9	EthylBloc vs none	ns	ns	ns	ns	ns
1 vs 12	Silwet L-77 vs none	ns	ns	ns	*	ns
2 vs 3	NAA vs Dicamba	ns	ns	ns	ns	ns
2 vs 4	NAA vs Cyclanilide	ns	ns	ns	ns	ns
2 vs 5	NAA vs ReTain	ns	ns	ns	ns	ns
2 vs 6	NAA vs NAA + ReTain	ns	*	ns	ns	ns
3 vs 7	ReTain vs none (Dicamba)	ns	ns	ns	ns	ns
4 vs 8	ReTain vs none (Cyclanilide)	ns	ns	*	ns	ns
9 vs 10	ReTain vs none (EthylBloc)	ns	ns	ns	ns	ns
11 vs 10	Dicamba vs none (EthylBloc + ReTain)	ns	ns	ns	ns	ns
11 vs 7	EthylBloc vs none (Dicamba + ReTain)	ns	ns	ns	ns	ns
11 vs 5	EthylBloc + Dicamba vs none (ReTain)	ns	ns	ns	ns	ns
1,2,3,4,9 vs 5,6,7,8,10	ReTain vs none (all treatments)	ns	ns	ns	ns	ns

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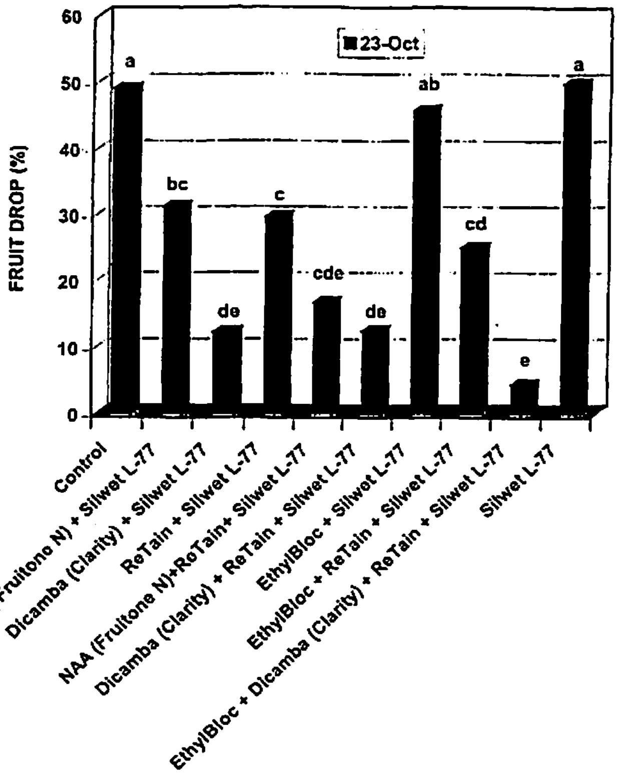
[Z] All treatments were applied with an airblast machine at 100 gals/acre. Tree size was considered to be 75% TRV. Treatments were applied on 5 Sept., when fruit maturity was : fruit diameter 7.80 cm, fruit firmness 17.5 lbs., starch 4.4, soluble solids 9.8, and color 90 %.

[Y] Estimated optimum harvest date: Sept 25, 2000.

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

Byers # 28

EFFECT OF PLANT GROWTH REGULATORS ON
FRUIT DROP OF 'REDSPUR DELICIOUS'/MM.111 (2000)



EFFECT OF PLANT GROWTH REGULATORS ON FRUIT
MATURITY OF 'REDSPUR DELICIOUS'/MM.111 (2000)

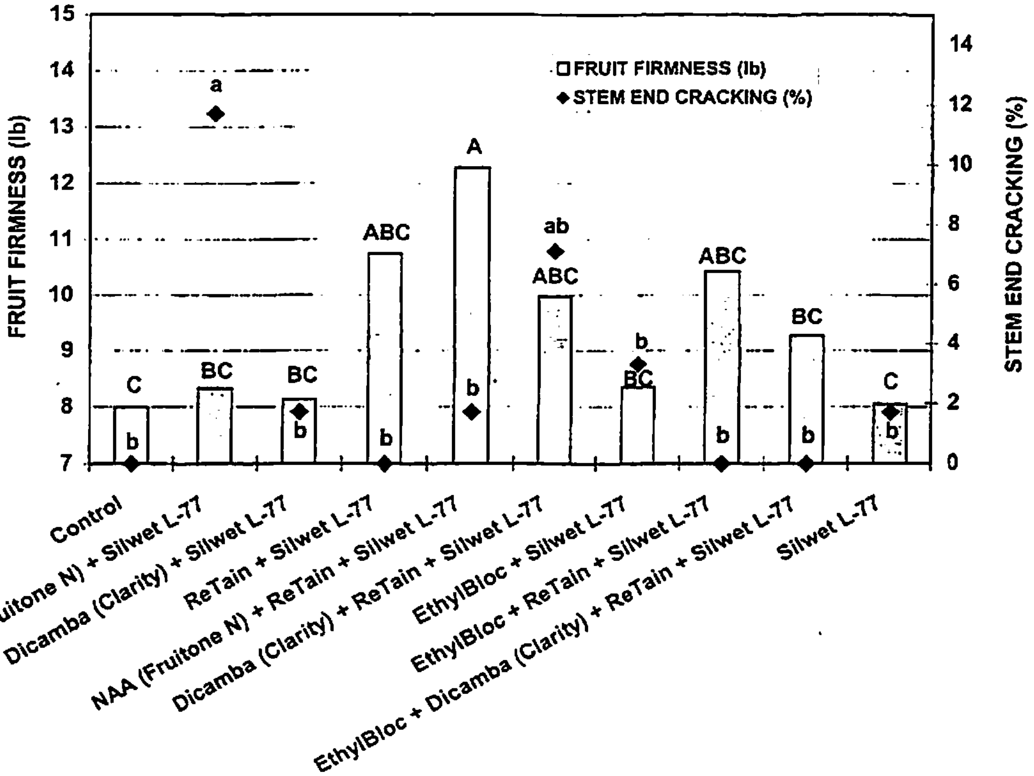


Table 4A. Effect of plant growth regulators on fruit drop, ethylene, and shriveling of 'Golden Delicious'/MM.111 (2000).

No.	Color	Treatment[ZY]	Rate (g/100gal) (100 gallons water /acre)	% Fruit Drop										Pull force (lbs.)		Ethylene (ul/kg/hr)	Shriveled Fruit (%)
				Sept 8	Sept 15	Sept 22	Sept 29	Oct 6	Oct 13	Oct 20	Oct 27	Nov 3	Nov 10	Oct 16	Nov 6	17 Oct 00	6 Nov 00
1.	W	Control		0.8 ab[x]	7.5 a	11.6 a	17.3 a	30.6 a	44.6 a	62.0 a	71.3 a	79.7 a	86.4 a	1.14 d	1.27 d	1.44 b	55 a
2.	B	Dicamba (Clarity) + Silwet L-77 (0.1%)	30 ml 189.5 ml	1.1 ab	1.9 bc	3.0 b	6.0 c	16.8 bc	24.9 cd	31.5 bc	40.0 c	44.9 c	64.2 c	2.24 bc	1.70 bcd	1.23 b	57 a
3.	LG	Floroxypyr + Silwet L-77 (0.1%)	80ml 189.5 ml	2.0 a	3.8 bc	4.3 b	6.9 c	10.8 cd	20.1 cd	40.2 bc	51.1 bc	58.7 bc	66.6 bc	2.34 bc	1.44 d	1.25 b	60 a
4.	FO	ReTain (15%) + Silwet L-77 (0.1%)	333g/100 189.5 ml	0.3 b	3.1 bc	4.9 b	9.4 bc	12.7 cd	16.9 de	29.1 c	44.5 c	50.4 c	52.2 c	3.37 a	2.25 ab	0.08 c	0 c
5.	YBKD	Garlon 3 + Silwet L-77 (0.1%)	40 ml 189.5 ml	0.8 ab	2.5 bc	4.7 b	8.4 bc	13.0 cd	16.0 de	29.5 c	34.8 c	43.1 c	52.8 c	2.66 b	2.15 abc	0.94 b	29 b
6.	PBKD	Cyclanilide + Silwet L-77 (0.1%)	101 ml 189.5 ml	0.4 ab	5.8 ab	10.3 a	14.7 ab	23.2 ab	29.3 bc	64.8 a	75.1 a	81.6 a	85.0 a	1.16 d	1.59 cd	1.39 b	44 ab
7.	RYS	EthylBloc + Silwet L-77 (0.1%)	300 g 189.5 ml	1.5 ab	3.8 bc	8.1 ab	13.6 ab	26.3 a	35.8 ab	48.7 ab	64.9 ab	73.2 ab	77.8 ab	1.82 c	1.46 d	2.27 a	63 a
8.	GD	EthylBloc + Dicamba (Clarity) + ReTain (15%) + Silwet L-77 (0.1%)	300 g 30 ml 333 g 189.5 ml	0.5 ab	1.8 c	2.7 b	3.7 c	6.1 d	7.7 e	10.6 d	13.3 d	15.7 d	21.1 d	3.28 a	2.61 a	0.11 c	1 c

[Z] All treatments were applied with an airblast machine at 100 gals/acre. Tree size was considered to be 50% TRV. Treatments were applied 1 Sept. when fruit were; fruit diameter = 7.31 cm, fruit firmness = 20.7 lbs., starch = 3.2, soluble solids = 12.2, and color = 3.2.

[Y] Estimated optimum harvest date: Sept 20, 2000.

[X] Mean separation within columns by Duncan's New Multiple Range Test: (P≤ 0.05).

Table 4B. Influence of EthylBloc and ReTain 'Golden Delicious'/MM.111 apple fruit maturity (2000-01).

No.	Color	Treatment[ZY]	Rate/ Gallon or /tree	Fruit diameter (cm)			Fruit firmness (lb.)			Starch (1-8 rating)			Estimated cropload per tree (0-4)[X] Oct 10, 2000	Visual spurs flowering (0-100%) (23 Apr 01)
				Oct 6	Oct 16	Nov 6	Oct 6	Oct 16	Nov 6	Oct 6	Oct 16	Nov 6		
1.	W	Control		7.82 a[W]	8.00 a	7.84 ab	14.4 bc	11.8 bc	9.23 b	7.09 abc	7.94 a	8.00 a	2.57 a	60 b
2.	B	Dicamba (Clarity) + Silwet L-77 (0.1%)	30 ml 189.5 ml	7.65 a	7.95 a	7.62 b	12.8 b	10.9 bc	8.30 b	7.27 abc	7.90 ab	8.00 a	2.43 a	70 ab
3.	LG	Floroxypyr + Silwet L-77 (0.1%)	80ml 189.5 ml	7.70 a	7.87 a	7.73 ab	13.5 cd	10.5 c	8.41 b	7.49 a	7.94 a	7.94 ab	2.43 a	75 ab
4.	FO	ReTain (15%) + Silwet L-77 (0.1%)	333g/100 189.5 ml	7.75 a	8.02 a	7.81 ab	16.5 a	15.3 a	11.60 a	6.47 d	7.27 c	7.77 c	2.14 ab	79 ab
5.	YBKD	Garlon 3 + Silwet L-77 (0.1%)	40 ml 189.5 ml	7.76 a	7.93 a	7.81 ab	13.8 bcd	11.6 bc	8.97 b	7.43 ab	8.00 a	7.96 ab	1.43 ab	94 a
6.	PBKD	Cyclanilide + Silwet L-77 (0.1%)	101 ml 189.5 ml	7.76 a	7.84 a	7.62 b	15.0 b	11.9 b	9.65 b	7.04 bc	7.90 ab	8.00 a	2.57 a	70 ab
7.	RYS	EthylBloc + Silwet L-77 (0.1%)	300 g 189.5 ml	7.83 a	8.05 a	7.72 ab	13.8 bcd	11.0 bc	9.31 b	6.89 c	7.90 ab	7.96 ab	1.14 b	96 a
8.	GD	+ EthylBloc + Dicamba (Clarity) + ReTain (15%) + Silwet L-77 (0.1%)	300 g 30 ml 333 g 189.5 ml	7.85 a	7.96 a	7.90 a	16.5 a	15.3 a	12.26 a	6.24 d	7.64 b	7.84 bc	2.57 a	78 ab

[Z] All treatments were applied with an airblast machine at 100 gals/acre. Tree size was considered to be 50% TRV. Treatments were applied 1 Sept. when fruit were; fruit diameter = 7.31 cm, fruit firmness = 20.7 lbs., starch = 3.2, soluble solids = 12.2, and color = 3.2.

[Y] Estimated optimum harvest date: Sept 20, 2000.

[X] Cropload was rated; 0 = no cropload, 4 = heavy cropload.

[W] Mean separation within columns by Duncan's New Multiple Range Test; (P≤ 0.05).

Table 4C. Influence of EthylBloc and ReTain 'Golden Delicious'/MM.111 apple fruit maturity (2000).

No.	Color	Treatment[ZY]	Rate/ Gallon or /tree	Side cracking (%)			Stem end cracking (%)			Soluble solids (%)			Color (green side) (0-5)		
				Oct 6	Oct 16	Nov 6	Oct 6	Oct 16	Nov 6	Oct 6	Oct 16	Nov 6	Oct 6	Oct 16	Nov 6
1.	W	Control		5.7 a[x]	1.4 a	5.0 a	5.7 b	2.9 b	13.3 ab	14.7 ab	15.3 ab	14.9 bc	2.9 abc	2.8 a	4.0 a
2.	B	Dicamba (Clarity)	30 ml	2.9 a	1.4 a	0.0 a	14.3 ab	5.7 ab	11.4 ab	14.9 ab	15.2 ab	15.2 abc	3.2 a	2.9 a	3.7 abc
		+ Silwet L-77 (0.1%)	189.5 ml												
3.	LG	Floroxypyr	80ml	0.0 a	0.0 a	5.7 a	17.1 ab	8.6 ab	5.7 ab	14.3 b	15.3 ab	15.8 a	3.1 ab	3.0 a	3.6 abc
		+ Silwet L-77 (0.1%)	189.5 ml												
4.	FO	ReTain (15%)	333g/100	0.0 a	0.0 a	4.2 a	5.7 b	2.9 b	14.3 ab	14.9 ab	15.1 abc	15.7 a	2.6 d	2.1 b	3.6 bc
		+ Silwet L-77 (0.1%)	189.5 ml												
5.	YBKD	Garlon 3	40 ml	2.9 a	1.4 a	4.3 a	28.6 a	14.3 a	15.7 a	14.7 ab	15.0 abc	15.4 ab	3.1 a	2.8 a	3.9 ab
		+ Silwet L-77 (0.1%)	189.5 ml												
6.	PBKD	Cyclanilide	101 ml	0.0 a	0.0 a	7.1 a	11.4 ab	7.1 ab	4.3 b	14.6 ab	14.4 c	15.0 bc	2.8 bcd	2.9 a	3.8 ab
		+ Silwet L-77 (0.1%)	189.5 ml												
7.	RYS	EthylBloc	300 g	2.9 a	1.4 a	5.7 a	20.0 ab	10.0 ab	4.3 b	15.1 a	15.7 a	15.7 a	3.0 ab	3.0 a	3.8 ab
		+ Silwet L-77 (0.1%)	189.5 ml												
8.	GD	+ EthylBloc	300 g	0.0 a	0.0 a	1.4 a	2.9 b	0.0 b	8.6 ab	14.1 b	14.6 bc	14.6 c	2.7 cd	2.3 b	3.4 c
		+ Dicamba (Clarity)	30 ml												
		+ ReTain (15%)	333 g												
		+ Silwet L-77 (0.1%)	189.5 ml												

[Z] All treatments were applied with an airblast machine at 100 gals/acre. Tree size was considered to be 50% TRV. Treatments were applied 1 Sept. when fruit were fruit diameter = 7.31 cm, fruit firmness = 20.7 lbs., starch = 3.2, soluble solids = 12.2, and color = 3.2.

[Y] Estimated optimum harvest date: Sept 20, 2000.

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

Table 4D. Influence of EthylBloc and ReTain on 'Golden Delicious'/MM.111 apple fruit drop and fruit maturity harvested Oct. 6, 2000 and placed in storage 120 days (2000).

		Treatment^{ZY}	Rate/ Gallon or /tree	Fruit diameter (cm) (5 Feb 01)	Fruit firmness (lb.) (5 Feb 01)	Soluble solids (%) (5 Feb 01)	Color (green side) (0-5) (5 Feb 01)	Rots (%) (5 Feb 01)
1.	W	Control		7.68 ab^{X}	8.8 c	14.7 a	3.9 ab	3 b
2.	B	Dicamba (Clarity)	30 ml	7.11 bc	9.0 c	14.9 a	4.0 a	7 ab
		+ Silwet L-77 (0.1%)	189.5 ml					
3.	LG	Floroxypyr	80ml	7.50 abc	9.3 bc	14.9 a	3.9 ab	1 b
		+ Silwet L-77 (0.1%)	189.5 ml					
4.	FO	ReTain (15%)	333g/100	7.82 a	11.0 a	14.6 a	3.6 bc	1 b
		+ Silwet L-77 (0.1%)	189.5 ml					
5.	YBKD	Garlon 3	40 ml	7.21 abc	9.7 b	15.0 a	4.0 a	9 ab
		+ Silwet L-77 (0.1%)	189.5 ml					
6.	PBKD	Cyclanilide	101 ml	7.38 abc	9.7 b	14.4 a	3.8 ab	6 ab
		+ Silwet L-77 (0.1%)	189.5 ml					
7.	RYS	EthylBloc	300 g	6.91 c	9.6 b	15.0 a	3.9 a	11 a
		+ Silwet L-77 (0.1%)	189.5 ml					
8.	GD	+ EthylBloc	300 g	7.41 abc	11.2 a	14.3 a	3.6 c	6 ab
		+ Dicamba (Clarity)	30 ml					
		+ ReTain (15%)	333 g					
		+ Silwet L-77 (0.1%)	189.5 ml					

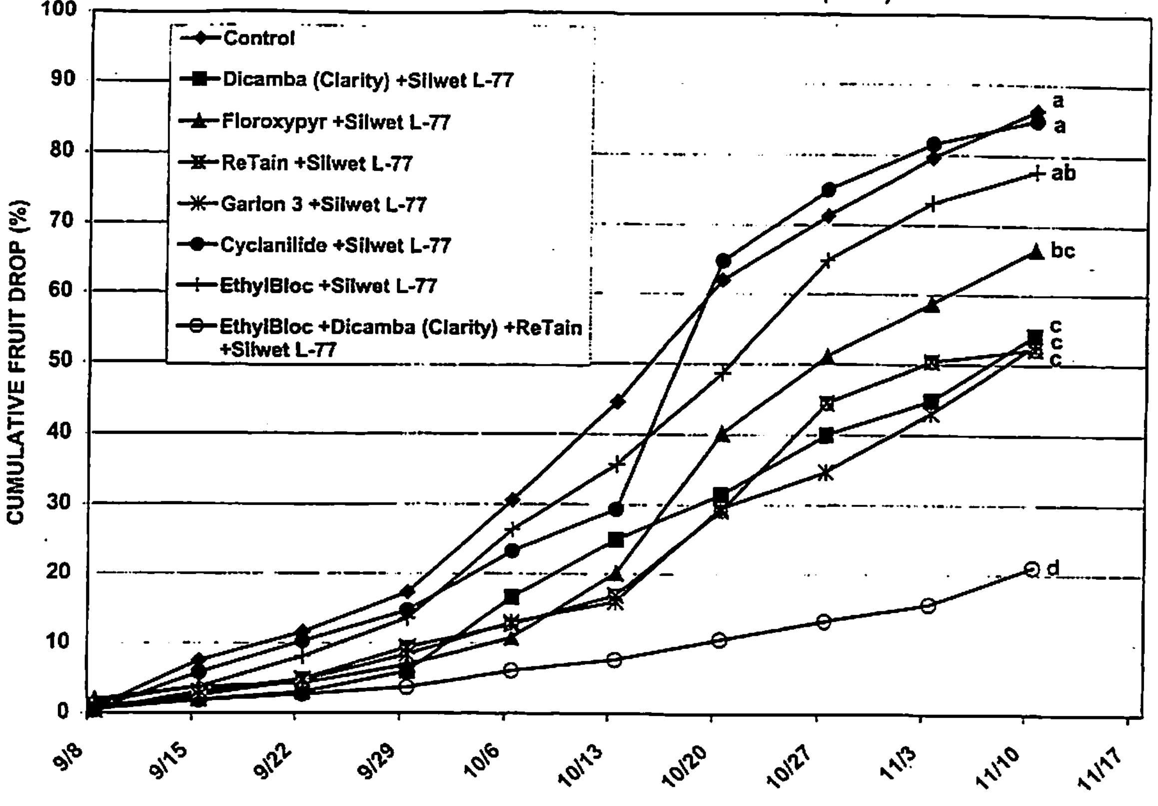
[Z] All treatments were applied with an airblast machine at 100 gals/acre. Tree size was considered to be 50% TRV. Treatments were applied 1 Sept. when fruit were; fruit diameter = 7.31 cm, fruit firmness = 20.7 lbs., starch = 3.2, soluble solids = 12.2, and color = 3.2.

[Y] Estimated optimum harvest date: Sept 20, 2000.

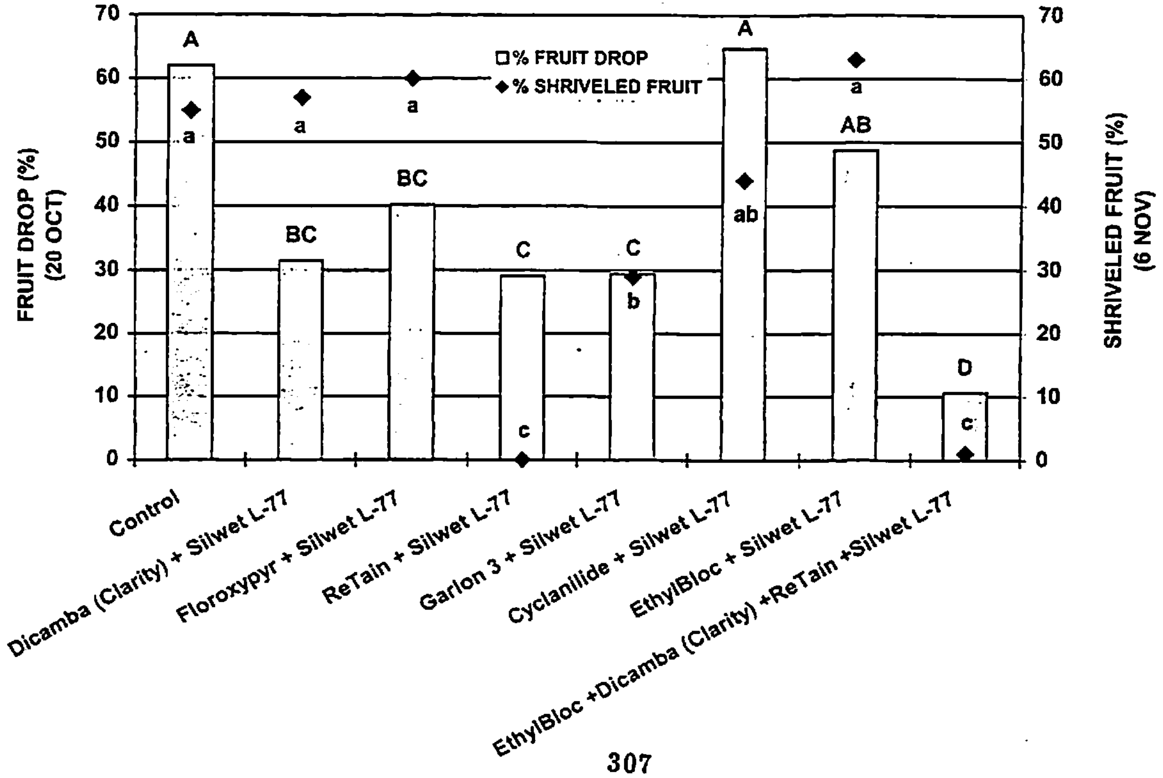
[X] Mean separation within columns by Duncan's New Multiple Range Test; ($P \leq 0.05$)

Byers # 32

INFLUENCE OF PLANT GROWTH REGULATORS ON 'GOLDEN DELICIOUS'/MM.111 FRUIT DROP (2000)

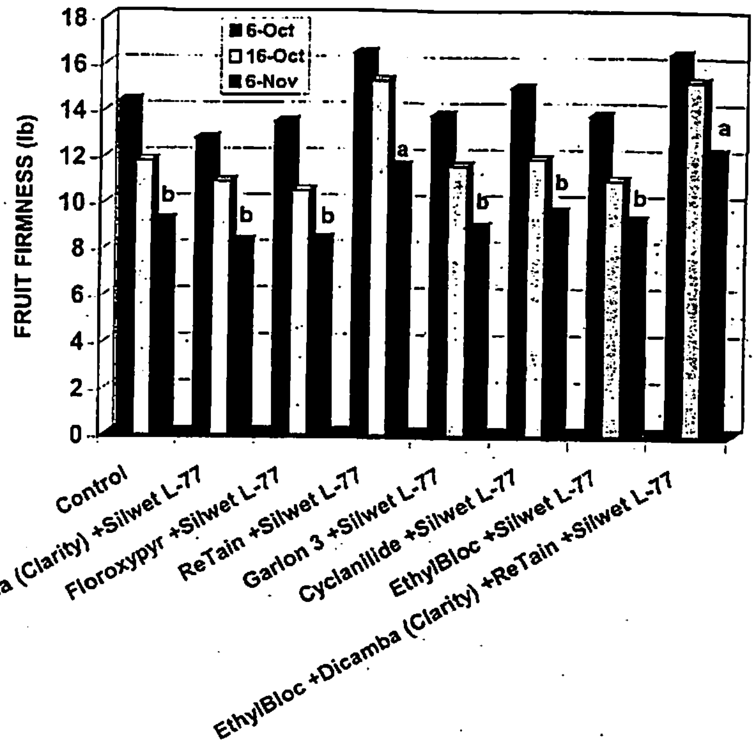


EFFECT OF PLANT GROWTH REGULATORS ON FRUIT DROP AND MATURITY OF 'GOLDEN DELICIOUS'/MM.111 (2000)

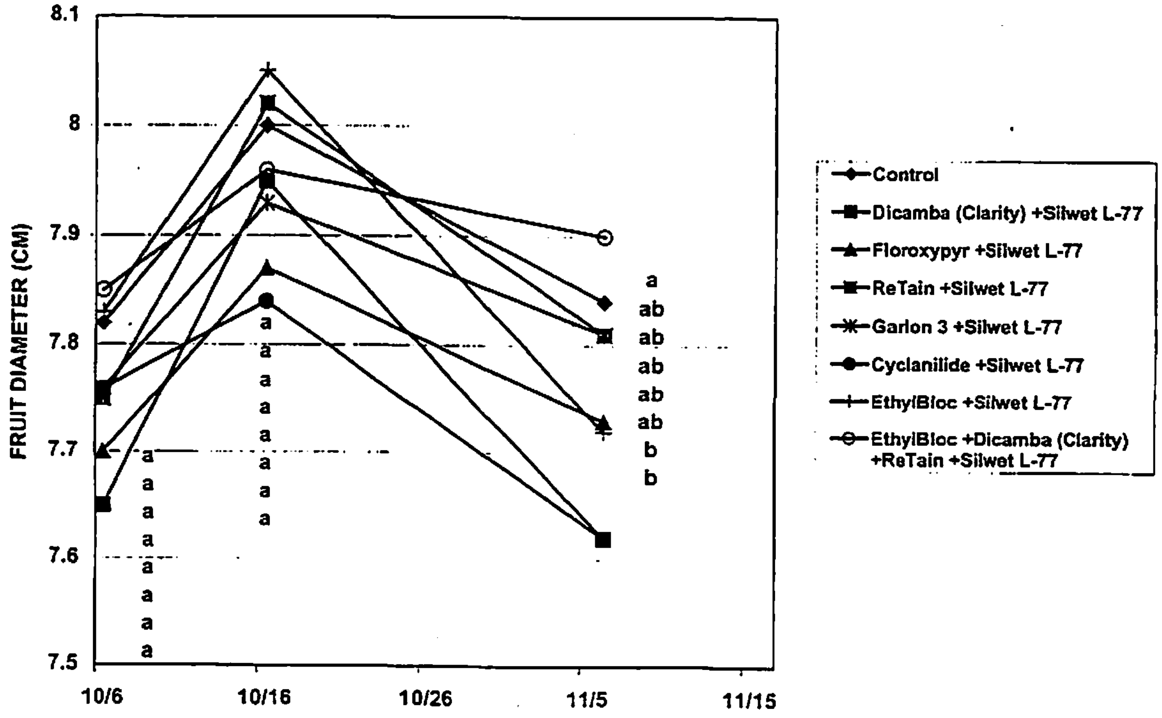


Byers # 32

INFLUENCE OF ETHYLBLOC AND RETAIN ON "GOLDEN DELICIOUS'/MM.111 (2000)



INFLUENCE OF PLANT GROWTH REGULATORS ON 'GOLDEN DELICIOUS'/MM.111 FRUIT DIAMETER (2000)



Firmness of 'Golden Delicious'/MM.111 Fruit Harvested on October 6, 2000 and stored at 35F Degrees for 120 Days

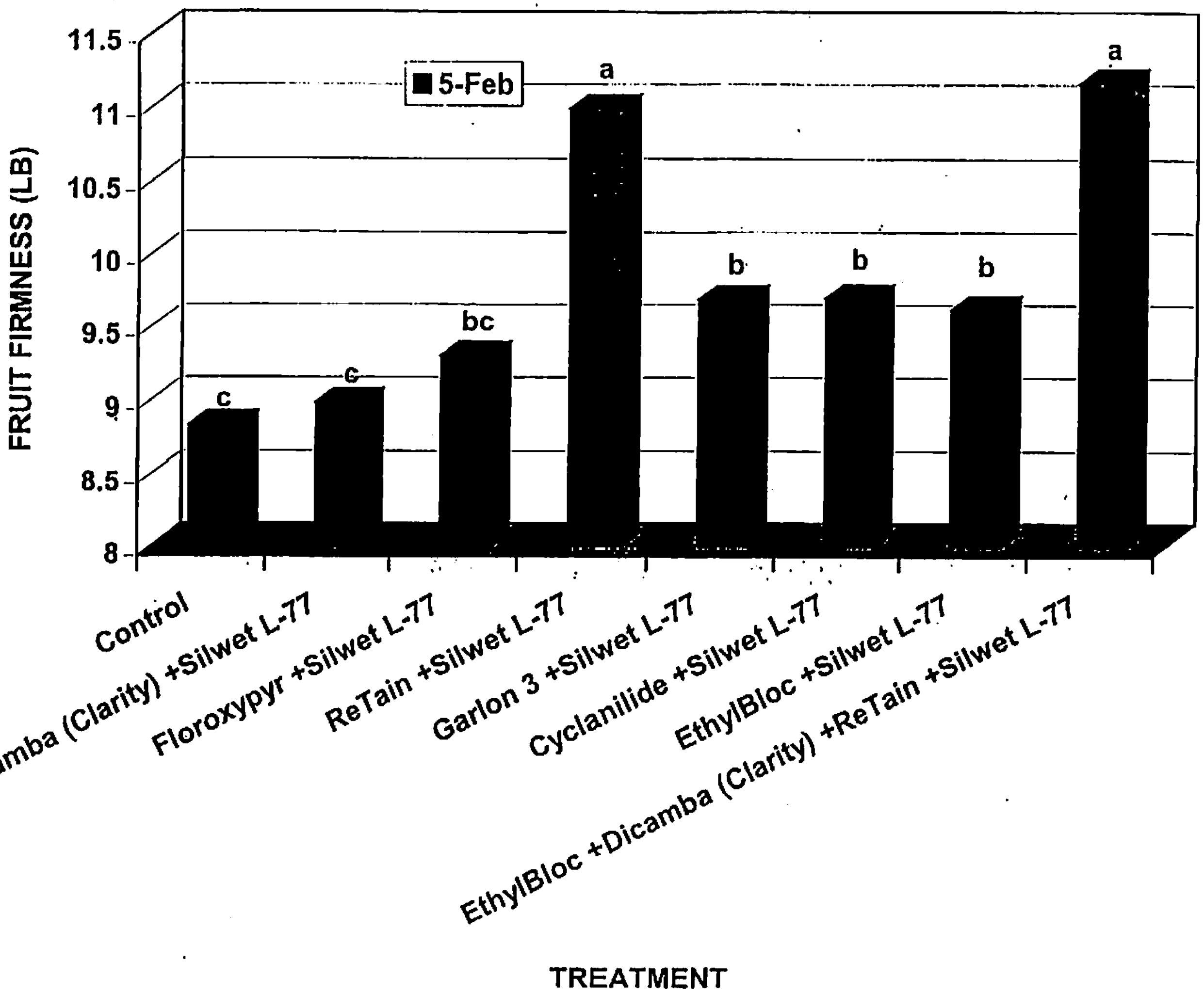


Table 5A. Effect of plant growth regulators on fruit drop of 'York'/MM.111 (2000).

No.	Treatment[Z,Y]	Rate (g/100gal) (100 gallons water / acre)	% Fruit Drop							
			Sept 20	Sept 28	Oct 4	Oct 11	Oct 18	Oct 25	Nov 1	Nov 8
1.	Control		2.3 a[X]	8.8 a	15.5 a	23.3 a	38.3 a	48.3 bcd	62.1 abc	69.9 bc
2.	ReTain (15%) + Silwet L-77 (0.1%)	333g/100 189.5 ml	4.1 a	7.9 a	11.7 a	14.9 a	27.0 a	35.4 d	48.5 c	55.6 d
3.	ReTain (15%) + Silwet L-77 (0.1%) + NH4SO4	333g/100 189.5 ml 908 g	3.5 a	8.2 a	14.5 a	19.4 a	27.0 a	39.2 cd	52.3 bc	61.1 cd
4.	ReTain (15%) + Silwet L-77 (0.1%) + NH4SO4 + Oil	333g/100 189.5 ml 908 g 946 ml	2.5 a	7.1 a	11.5 a	14.8 a	28.9 a	40.1 cd	52.0 bc	59.6 cd
5.	Cyclanilide	101ml/100	2.7 a	8.2 a	16.6 a	20.8 a	32.8 a	56.0 ab	68.3 a	80.5 ab
6.	Cyclanilide + Silwet L-77 (0.1%)	101ml 189.5 ml	4.4 a	9.6 a	14.2 a	19.8 a	33.8 a	51.7 abc	70.8 a	83.6 a
7.	Cyclanilide + Silwet L-77 (0.1%) + NH4SO4	101ml/100 189.5 ml 908 g	1.6 a	6.2 a	11.7 a	17.1 a	30.5 a	48.6 bcd	64.9 ab	76.5 ab
8.	Cyclanilide + Silwet L-77 (0.1%) + NH4SO4 + Oil	101ml/100 189.5 ml 908 g 946 ml	2.7 a	7.8 a	16.5 a	22.5 a	38.7 a	65.1 a	75.4 a	83.2 a

Contrasts	Comparisons	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F
1 vs 2	ReTain + L-77 vs none	ns	ns	ns	ns	ns	ns	*	*
1 vs 3	ReTain + L-77 + NH4SO4 vs none	ns	ns	ns	ns	ns	ns	ns	ns
1 vs 4	ReTain + L-77 + NH4SO4 + Oil vs none	ns	ns	ns	ns	ns	ns	ns	ns
1 vs 5	Cyclanilide vs none	ns	ns	ns	ns	ns	ns	ns	ns
1 vs 6	Cyclanilide + L-77 vs none	ns	ns	ns	ns	ns	ns	ns	**
1 vs 7	Cyclanilide + L-77 + NH4SO4 vs none	ns	ns	ns	ns	ns	ns	ns	ns
1 vs 8	Cyclanilide + L-77 + NH4SO4 + Oil vs none	ns	ns	ns	ns	ns	*	*	*
2 vs 3	NH4SO4 vs none (ReTain + L-77)	ns	ns	ns	ns	ns	ns	ns	ns
2 vs 4	NH4SO4 + Oil vs none (ReTain + L-77)	ns	ns	ns	ns	ns	ns	ns	ns
2 vs 5	Cyclanilide vs ReTain (L-77)	ns	ns	ns	ns	ns	**	**	***
3 vs 4	Oil vs none (ReTain + L-77 + NH4SO4)	ns	ns	ns	ns	ns	ns	ns	ns
5 vs 6	L-77 vs none (Cyclanilide)	ns	ns	ns	ns	ns	ns	ns	ns
5 vs 7	L-77 + NH4SO4 vs none (Cyclanilide)	ns	ns	ns	ns	ns	ns	ns	ns
5 vs 8	L-77 + NH4SO4 + Oil vs none (Cyclanilide)	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 50% TRV. Treatments were applied on 7 Sept. , when fruit were : fruit diameter=7.60 cm, fruit firmness=24.7 lbs., starch=1.7, soluble solids=10.0, and color=70 % .

[Y] Estimated optimum harvest date: Sept 20, 2000.

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

Table 5B. Effect of plant growth regulators on fruit drop of 'York'/MM.111 (2000).

No.	Treatment[ZY]	Rate (g/100gal) (100 gallons water /acre)	Fruit diameter (cm) (2 Nov)	Fruit firmness (lb) (2 Nov)	Starch (0-8) (2 Nov)	Pull force (lb) (2 Nov)	Soluble Solids (2 Nov)	Water core rating (0-5) (2 Nov)	Water core (% fruit) (2 Nov)
1.	Control		7.99 a[X]	18.2 a	5.09 a	1.07 b	14.6 a	0.71 a	41 a
2.	ReTain (15%) + Silwet L-77 (0.1%)	333g/100 189.5 ml	7.88 a	19.4 a	4.76 a	1.92 a	13.1 b	0.31 ab	21 ab
3.	ReTain (15%) + Silwet L-77 (0.1%) + NH4SO4	333g/100 189.5 ml 908 g	8.05 a	19.4 a	4.99 a	1.55 ab	13.0 b	0.36 ab	24 ab
4.	ReTain (15%) + Silwet L-77 (0.1%) + NH4SO4 + Oil	333g/100 189.5 ml 908 g 946 ml	7.96 a	18.8 a	4.76 a	1.68 ab	13.0 b	0.07 b	7 b
5.	Cyclanilide	101ml/100	7.99 a	18.9 a	4.84 a	1.36 ab	13.8 ab	0.26 b	23 ab
6.	Cyclanilide + Silwet L-77 (0.1%)	101ml 189.5 ml	7.87 a	18.8 a	4.58 a	1.51 ab	13.1 b	0.43 ab	28 ab
7.	Cyclanilide + Silwet L-77 (0.1%) + NH4SO4	101ml/100 189.5 ml 908 g	7.86 a	19.5 a	4.83 a	1.17 ab	13.8 ab	0.43 ab	30 ab
8.	Cyclanilide + Silwet L-77 (0.1%) + NH4SO4 + Oil	101ml/100 189.5 ml 908 g 946 ml	7.86 a	19.2 a	4.70 a	1.12 b	13.3 b	0.23 b	20 ab
Contrasts	Comparisons		Pr>F	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F
1 vs 2	ReTain + L-77 vs none		ns	*	ns	*	***	*	ns
1 vs 3	ReTain + L-77 + NH4SO4 vs none		ns	*	ns	ns	***	ns	ns
1 vs 4	ReTain + L-77 + NH4SO4 + Oil vs none		ns	ns	ns	ns	***	**	**
1 vs 5	Cyclanilide vs none		ns	ns	ns	ns	ns	*	ns
1 vs 6	Cyclanilide + L-77 vs none		ns	ns	ns	ns	***	ns	ns
1 vs 7	Cyclanilide + L-77 + NH4SO4 vs none		ns	*	ns	ns	ns	ns	ns
1 vs 8	Cyclanilide + L-77 + NH4SO4 + Oil vs none		ns	ns	ns	ns	**	*	ns
2 vs 3	NH4SO4 vs none (ReTain + L-77)		ns	ns	ns	ns	ns	ns	ns
2 vs 4	NH4SO4 + Oil vs none (ReTain + L-77)		ns	ns	ns	ns	ns	ns	ns
2 vs 5	Cyclanilide vs ReTain (L-77)		ns	ns	ns	ns	ns	ns	ns
3 vs 4	Oil vs none (ReTain + L-77 + NH4SO4)		ns	ns	ns	ns	ns	ns	ns
5 vs 6	L-77 vs none (Cyclanilide)		ns	ns	ns	ns	*	ns	ns
5 vs 7	L-77 + NH4SO4 vs none (Cyclanilide)		ns	ns	ns	ns	ns	ns	ns
5 vs 8	L-77 + NH4SO4 + Oil vs none (Cyclanilide)		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 50% TRV. Treatments were applied on 7 Sept., when fruit were : fruit diameter=7.60 cm, fruit firmness=24.7 lbs., starch=1.7, soluble solids=10.0, and color=70 %.

[Y] Estimated optimum harvest date: Sept 20, 2000.

[X] Mean separation within columns by Duncan's New Multiple Range Test;(P≤ 0.05).

Table 5C. Effect of plant growth regulators on fruit drop and fruit maturity of 'York'/MM.111 harvested November 2, 2000 and placed in storage for 103 days.

No.	Treatment[Z,Y]	Rate (g/100gal) (100 gallons water /acre)	Fruit diameter (cm) (13 Feb 01)	Fruit firmness (lb) (13 Feb 01)	Soluble Solids (13 Feb 01)	Color (%) (13 Feb 01)	Visual spurs flowering (0-100%) (23 Apr 01)
1.	Control		8.22 ab[X]	14.9 bc	14.1 ab	87 a	76 a
2.	ReTain (15%) + Silwet L-77 (0.1%)	333g/100 189.5 ml	8.15 ab	15.9 ab	13.8 b	85 a	40 ab
3.	ReTain (15%) + Silwet L-77 (0.1%) + NH4SO4	333g/100 189.5 ml 908 g	8.16 ab	16.4 a	13.9 ab	86 a	65 ab
4.	ReTain (15%) + Silwet L-77 (0.1%) + NH4SO4 + Oil	333g/100 189.5 ml 908 g 946 ml	8.37 a	15.8 ab	13.7 b	87 a	35 b
5.	Cyclanilide	101ml/100	8.25 ab	14.8 bc	13.9 ab	87 a	64 ab
6.	Cyclanilide + Silwet L-77 (0.1%)	101ml 189.5 ml	8.10 b	14.6 c	14.1 ab	86 a	48 ab
7.	Cyclanilide + Silwet L-77 (0.1%) + NH4SO4	101ml/100 189.5 ml 908 g	8.16 ab	15.7 ab	14.5 a	88 a	46 ab
8.	Cyclanilide + Silwet L-77 (0.1%) + NH4SO4 + Oil	101ml/100 189.5 ml 908 g 946 ml	8.13 ab	15.3 abc	14.2 ab	85 a	40 ab

Contrasts	Comparisons	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F
1 vs 2	ReTain + L-77 vs none	ns	*	ns	ns	*
1 vs 3	ReTain + L-77 + NH4SO4 vs none	ns	**	ns	ns	ns
1 vs 4	ReTain + L-77 + NH4SO4 + Oil vs none	ns	ns	ns	ns	*
1 vs 5	Cyclanilide vs none	ns	ns	ns	ns	ns
1 vs 6	Cyclanilide + L-77 vs none	ns	ns	ns	ns	*
1 vs 7	Cyclanilide + L-77 + NH4SO4 vs none	ns	ns	ns	ns	ns
1 vs 8	Cyclanilide + L-77 + NH4SO4 + Oil vs none	ns	ns	ns	ns	*
2 vs 3	NH4SO4 vs none (ReTain + L-77)	ns	ns	ns	ns	ns
2 vs 4	NH4SO4 + Oil vs none (ReTain + L-77)	ns	ns	ns	ns	ns
2 vs 5	Cyclanilide vs ReTain (L-77)	ns	*	ns	ns	ns
3 vs 4	Oil vs none (ReTain + L-77 + NH4SO4)	ns	ns	ns	ns	ns
5 vs 6	L-77 vs none (Cyclanilide)	ns	ns	ns	ns	ns
5 vs 7	L-77 + NH4SO4 vs none (Cyclanilide)	ns	ns	ns	ns	ns
5 vs 8	L-77 + NH4SO4 + Oil vs none (Cyclanilide)	ns	ns	ns	ns	ns

[Z] All treatments were applied with an airblast machine at 100 gals/acre. Tree size was considered to be 50% TRV. Treatments were applied on 7 Sept., when fruit were : fruit diameter=7.60 cm, fruit firmness=24.7 lbs., starch=1.7, soluble solids=10.0, and color=70 %.

[Y] Estimated optimum harvest date: Sept 20, 2000.

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

Table 6A. Effect of plant growth regulators on fruit drop of 'Law Rome'/MM.111 (2000).

No.	Treatment^{ZY}	Rate (g/100gal) (100 gallons water / acre)	% Fruit Drop (cumulative)							
			Sept 20	Sept 28	Oct 4	Oct 11	Oct 18	Oct 25	Nov 1	Nov 8
1.	Control		13.3 a^x	17.1 a	26.8 a	36.6 a	56.2 a	75.5 a	85.3 a	86.4 a
2.	NAA (10ppm) Fruitone N + Silwet L-77 (0.1%)	732g/100 189.5 ml	6.4 abc	10.1 abc	12.9 bc	16.0 bc	30.7 bc	39.1 bc	45.5 bc	50.6 bc
3.	Dicamba (Clarity) + Silwet L-77 (0.1%)	30 ml 189.5 ml	8.3 abc	11.9 abc	16.2 abc	19.5 bc	22.8 cd	30.4 cd	33.5 cde	35.4 cde
4.	ReTain (15%) + Silwet L-77 (0.1%)	333g /100 189.5 ml	4.7 bc	8.9 abc	13.7 bc	16.0 bc	18.4 cd	22.9 cd	28.7 de	33.2 de
5.	Cyclanilide + Silwet L-77 (0.1%)	101 ml 189.5 ml	6.3 abc	11.8 abc	17.5 abc	25.7 ab	41.1 b	67.8 a	81.4 a	83.9 a
6.	Fluroxypyr + Silwet L-77 (0.1%)	80ml 189.5 ml	4.9 bc	8.8 abc	12.0 bc	15.4 bc	32.9 bc	47.9 b	55.9 b	58.6 b
7.	NAA Fruitone N + ReTain (15%) + Silwet L-77 (0.1%)	366g 333g 189.5 ml	3.6 bc	8.2 abc	9.4 bc	10.4 c	14.7 d	20.2 d	23.7 de	30.6 de
8.	Dicamba (Clarity) + ReTain (15%) + Silwet L-77 (0.1%)	30 ml 333g 189.5 ml	5.5 bc	6.6 abc	10.4 bc	10.9 c	13.9 d	16.3 d	17.3 e	21.8 de
9.	Cyclanilide + ReTain (15%) + Silwet L-77 (0.1%)	101 ml 333g 189.5 ml	7.6 abc	12.2 abc	15.0 abc	19.4 bc	24.3 cd	29.4 cd	36.1 cd	38.8 cd
10.	EthylBloc + Silwet L-77 (0.1%)	300 g 189.5 ml	11.0 ab	16.8 ab	19.9 ab	25.1 ab	39.8 b	69.3 a	79.9 a	83.8 a
11.	EthylBloc + Cyclanilide + ReTain + Silwet L-77 (0.1%)	300 g 101ml 333g 189.5 ml	3.2 c	6.1 bc	7.4 bc	8.6 c	11.4 d	15.7 d	20.6 de	26.3 de
12.	EthylBloc + Dicamba (Clarity) + ReTain + Silwet L-77 (0.1%)	300 g 30 ml 333 g 189.5 ml	3.8 bc	5.3 c	6.4 c	7.5 c	10.4 d	13.8 d	18.6 e	20.3 e

Table 6A (cont.)

Contrasts	Comparisons	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F
1 vs 2	NAA vs none	ns	ns	*	**	***	***	***	***
1 vs 3	Dicamba vs none	**	ns	ns	**	***	***	***	***
1 vs 4	ReTain vs none	*	ns	*	**	***	***	***	***
1 vs 5	Cyclanilide vs none	**	ns	ns	ns	*	ns	ns	ns
1 vs 6	Fluroxypyr vs none	ns	ns	**	***	***	***	***	***
2 vs 3	NAA vs Dicamba	ns	ns	ns	ns	ns	ns	ns	ns
2 vs 4	NAA vs ReTain	ns	ns	ns	ns	ns	ns	*	*
2 vs 5	NAA vs Cyclanilide	ns	ns	ns	ns	ns	***	***	***
2 vs 6	NAA vs Fluroxypyr	ns	ns	ns	ns	ns	ns	ns	ns
2 vs 7	NAA vs NAA+ReTain	ns	ns	ns	ns	*	*	**	*
3 vs 8	Dicamba vs Dicamba+ReTain	ns	ns	ns	ns	ns	ns	*	ns
4 vs 3	ReTain vs Dicamba	ns	ns	ns	ns	ns	ns	ns	ns
4 vs 5	ReTain vs Cyclanilide	ns	ns	ns	ns	**	***	***	***
4 vs 6	ReTain vs Fluroxypyr	ns	ns	ns	ns	ns	**	**	**
4 vs 7	ReTain vs NAA+ReTain	ns	ns	ns	ns	ns	ns	ns	ns
4 vs 8	ReTain vs Dicamba+ReTain	ns	ns	ns	ns	ns	ns	ns	ns
4 vs 9	ReTain vs Cyclanilide+ReTain	ns	ns	ns	ns	ns	ns	ns	ns
4 vs 11	ReTain vs EthylBloc+Cyclanilide+ReTain	ns	ns	ns	ns	ns	ns	ns	ns
4 vs 12	ReTain vs EthylBloc+ Dicamba+ReTain	ns	ns	ns	ns	ns	ns	ns	ns
5 vs 9	Cyclanilide vs Cyclanilide+ReTain	ns	ns	ns	ns	**	***	***	***
9 vs 11	EthylBloc vs none (Cyclanilide+ReTain)	ns	ns	ns	ns	ns	ns	ns	ns
10 vs 11	Cyclanilide+ReTain vs none (EthylBloc)	*	**	*	**	***	***	***	***
10 vs 12	Dicamba vs ReTain (EthylBloc)	ns	**	*	**	***	***	***	***
11 vs 12	Dicamba vs Cyclanilide (EthylBloc+ ReTain)	ns	ns	ns	ns	ns	ns	ns	ns
1,2,3,5 vs 4,7,8,9	ReTain vs EthylBloc	ns	ns	*	***	***	***	***	***

[Z] All treatments were applied with an airblast machine at 100 gals/acre. Tree size was considered to be 50% TRV. Treatments were applied on Sept. 5, when fruit were : fruit diameter=7.80 cm, fruit firmness =2.9 lbs., starch=2.5, soluble solids=11.0, and color=78 % .

[Y] Estimated optimum harvest date: Oct 10, 2000.

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

Table 6B. Effect of plant growth regulators on fruit drop of 'Law Rome'/MM.111 (2000).

No.	Treatment[ZY]	Rate (g/100gal) (100 gallons water /acre)	Fruit diameter (cm) (23 Oct 00)	Fruit firmness (lb) (23 Oct 00)	Starch (0-8) (23 Oct 00)	Pull force (lb) (23 Oct 00)	Soluble Solids (23 Oct 00)	Bleeding (0-10) (23 Oct 00)	Fruit with bleeding (%) (23 Oct 00)
1.	Control		8.33 a[X]	14.7 c	7.59 a	1.13 f	12.9 b	0.50 bc	54 abc
2.	NAA (10ppm) Fruitone N + Silwet L-77 (0.1%)	732g/100 189.5 ml	8.61 a	15.8 bc	7.42 a	1.98 cde	13.7 ab	0.39 bcd	55 abc
3.	Dicamba (Clarity) + Silwet L-77 (0.1%)	30 ml 189.5 ml	8.43 a	13.1 d	7.60 a	2.32 bcd	13.6 ab	0.96 a	77 a
4.	ReTain (15%) + Silwet L-77 (0.1%)	333g /100 189.5 ml	8.54 a	19.2 a	6.06 d	2.85 ab	13.6 ab	0.25 cde	40 bcd
5.	Cyclanilide + Silwet L-77 (0.1%)	101 ml 189.5 ml	8.87 a	16.3 b	7.24 ab	1.70 def	13.4 ab	0.24 cde	43 bcd
6.	Fluroxypyr + Silwet L-77 (0.1%)	80ml 189.5 ml	8.44 a	16.2 b	7.43 a	2.28 bcd	13.7 ab	0.32 bcde	46 bcd
7.	NAA Fruitone N + ReTain (15%) + Silwet L-77 (0.1%)	366g 333g 189.5 ml	8.35 a	18.9 a	6.73 bc	3.29 a	13.3 ab	0.43 bcd	44 bcd
8.	Dicamba (Clarity) + ReTain (15%) + Silwet L-77 (0.1%)	30 ml 333g 189.5 ml	8.32 a	18.5 a	7.30 ab	2.53 abc	13.8 ab	0.13 de	30 cde
9.	Cyclanilide + ReTain (15%) + Silwet L-77 (0.1%)	101 ml 333g 189.5 ml	8.50 a	19.4 a	6.31 cd	2.82 ab	14.1 a	0.16 de	19 de
10.	EthylBloc + Silwet L-77 (0.1%)	300 g 189.5 ml	8.70 a	16.8 b	7.12 ab	1.47 ef	14.2 a	0.58 b	67 ab
11.	EthylBloc + Cyclanilide + ReTain + Silwet L-77 (0.1%)	300 g 101ml 333g 189.5 ml	8.39 a	20.0 a	6.25 cd	2.77 abc	13.8 ab	0.18 de	30 cde
12.	EthylBloc + Dicamba (Clarity) + ReTain + Silwet L-77 (0.1%)	300 g 30 ml 333 g 189.5 ml	8.37 a	18.9 a	7.06 ab	2.82 ab	13.5 ab	0.03 e	6 e

Table 6B (cont.)

Contrasts	Comparisons	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F
1 vs 2	NAA vs none	ns	ns	ns	ns	ns	ns	ns
1 vs 3	Dicamba vs none	ns	*	ns	**	ns	**	ns
1 vs 4	ReTain vs none	ns	***	***	***	ns	ns	ns
1 vs 5	Cyclanilide vs none	ns	*	ns	ns	ns	ns	ns
1 vs 6	Fluroxypyr vs none	ns	*	ns	**	ns	ns	ns
2 vs 3	NAA vs Dicamba	ns	***	ns	ns	ns	***	ns
2 vs 4	NAA vs ReTain	ns	***	***	*	ns	ns	ns
2 vs 5	NAA vs Cyclanilide	ns	ns	ns	ns	ns	ns	ns
2 vs 6	NAA vs Fluroxypyr	ns	ns	ns	ns	ns	ns	ns
2 vs 7	NAA vs NAA+ReTain	ns	***	ns	***	ns	ns	ns
3 vs 8	Dicamba vs Dicamba+ReTain	ns	***	ns	ns	ns	***	***
4 vs 3	ReTain vs Dicamba	ns	***	***	ns	ns	***	**
4 vs 5	ReTain vs Cyclanilide	ns	***	***	**	ns	ns	ns
4 vs 6	ReTain vs Fluroxypyr	ns	***	***	ns	ns	ns	ns
4 vs 7	ReTain vs NAA+ReTain	ns	ns	*	ns	ns	ns	ns
4 vs 8	ReTain vs Dicamba+ReTain	ns	ns	***	ns	ns	ns	ns
4 vs 9	ReTain vs Cyclanilide+ReTain	ns	ns	ns	ns	ns	ns	ns
4 vs 11	ReTain vs EthylBloc+Cyclanilide+ReTain	ns	ns	ns	ns	ns	ns	ns
4 vs 12	ReTain vs EthylBloc+ Dicamba+ReTain	ns	ns	***	ns	ns	ns	**
5 vs 9	Cyclanilide vs Cyclanilide+ReTain	ns	***	***	**	ns	ns	*
9 vs 11	EthylBloc vs none (Cyclanilide+ReTain)	ns	ns	ns	ns	ns	ns	ns
10 vs 11	Cyclanilide+ReTain vs none (EthylBloc)	ns	***	**	**	ns	**	**
10 vs 12	Dicamba vs ReTain (EthylBloc)	ns	**	ns	***	ns	***	***
11 vs 12	Dicamba vs Cyclanilide (EthylBloc+ ReTain)	ns	ns	*	ns	ns	ns	*
1,2,3,5 vs 4,7,8,9	ReTain vs EthylBloc	ns	***	***	***	ns	***	***

[Z]All treatments were applied with an airblast machine at 100 gals/acre. Tree size was considered to be 50% TRV. Treatments were applied on Sept. 5, when fruit were : fruit diameter=7.80 cm, fruit firmness =2.9 lbs., starch=2.5, soluble solids=11.0, and color=78 % .

[Y]Estimated optimum harvest date: Oct 10, 2000.

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

Table 6C. Effect of plant growth regulators on fruit drop and fruit maturity of 'Law Rome'/MM.111 harvested October 24, 2000 and placed in storage 105 days (2000-01).

No.	Treatment[ZY]	Rate (g/100gal) (100 gallons water /acre)	Fruit diameter (cm) (6 Feb 01)	Fruit firmness (lb) (6 Feb 01)	Soluble Solids (6 Feb 01)	Color (%) (6 Feb 01)	Rots (%) (6 Feb 01)	Visual spurs flowering (0-100%) (27 Apr 01)
1.	Control		8.25 a[x]	10.0 cd	12.0 b	98 ab	0 a	81 ab
2.	NAA (10ppm) Fruitone N + Silwet L-77 (0.1%)	732g/100 189.5 ml	8.55 a	9.7 cd	13.3 a	98 abc	0 a	94 a
3.	Dicamba (Clarity) + Silwet L-77 (0.1%)	30 ml 189.5 ml	8.35 a	9.4 d	12.9 a	98 abc	0 a	84 ab
4.	ReTain (15%) + Silwet L-77 (0.1%)	333g /100 189.5 ml	8.78 a	12.5 a	13.3 a	95 bcd	0 a	97 a
5.	Cyclanilide + Silwet L-77 (0.1%)	101 ml 189.5 ml	8.49 a	9.9 cd	12.8 a	97 abc	0 a	97 a
6.	Fluroxypyr + Silwet L-77 (0.1%)	80ml 189.5 ml	8.62 a	9.7 cd	13.3 a	98 abc	0 a	84 ab
7.	NAA Fruitone N + ReTain (15%) + Silwet L-77 (0.1%)	366g 333g 189.5 ml	8.38 a	12.1 a	12.9 a	97 abc	0 a	95 a
8.	Dicamba (Clarity) + ReTain (15%) + Silwet L-77 (0.1%)	30 ml 333g 189.5 ml	8.56 a	11.7 ab	12.8 a	95 cd	0 a	69 ab
9.	Cyclanilide + ReTain (15%) + Silwet L-77 (0.1%)	101 ml 333g 189.5 ml	8.65 a	12.3 a	13.2 a	94 d	0 a	97 a
10.	EthylBloc + Silwet L-77 (0.1%)	300 g 189.5 ml	8.93 a	10.7 bc	13.3 a	99 a	0 a	95 a
11.	EthylBloc + Cyclanilide + ReTain + Silwet L-77 (0.1%)	300 g 101ml 333g 189.5 ml	8.57 a	12.7 a	13.4 a	98 abc	0 a	96 a
12.	EthylBloc + Dicamba (Clarity) + ReTain + Silwet L-77 (0.1%)	300 g 30 ml 333 g 189.5 ml	8.43 a	11.5 ab	13.2 a	97 abc	0 a	57 b

Table 6C (cont.)

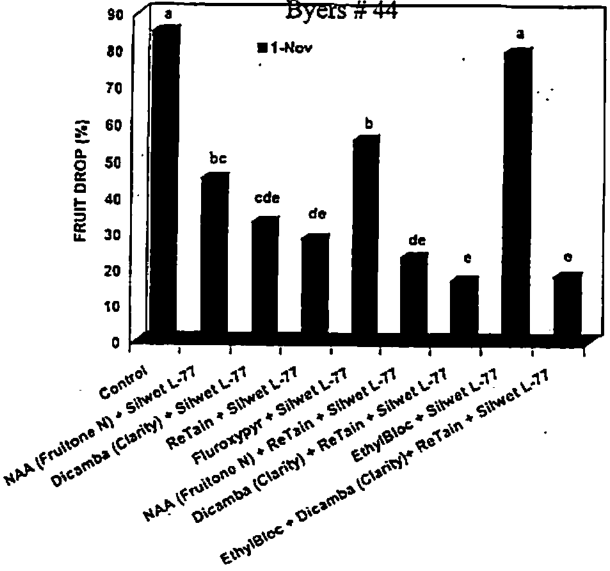
Contrasts	Comparisons	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F
1 vs 2	NAA vs none	ns	ns	**	ns	ns	ns
1 vs 3	Dicamba vs none	ns	ns	*	ns	ns	ns
1 vs 4	ReTain vs none	ns	***	***	*	ns	ns
1 vs 5	Cyclanilide vs none	ns	ns	*	ns	ns	ns
1 vs 6	Fluroxypyr vs none	ns	ns	***	ns	ns	ns
2 vs 3	NAA vs Dicamba	ns	ns	ns	ns	ns	ns
2 vs 4	NAA vs ReTain	ns	***	ns	*	ns	ns
2 vs 5	NAA vs Cyclanilide	ns	ns	ns	ns	ns	ns
2 vs 6	NAA vs Fluroxypyr	ns	ns	ns	ns	ns	ns
2 vs 7	NAA vs NAA+ReTain	ns	***	ns	ns	ns	ns
3 vs 8	Dicamba vs Dicamba+ReTain	ns	***	ns	*	ns	ns
4 vs 3	ReTain vs Dicamba	ns	***	ns	*	ns	ns
4 vs 5	ReTain vs Cyclanilide	ns	***	ns	ns	ns	ns
4 vs 6	ReTain vs Fluroxypyr	ns	***	ns	*	ns	ns
4 vs 7	ReTain vs NAA+ReTain	ns	ns	ns	ns	ns	ns
4 vs 8	ReTain vs Dicamba+ReTain	ns	ns	ns	ns	ns	ns
4 vs 9	ReTain vs Cyclanilide+ReTain	ns	ns	ns	ns	ns	ns
4 vs 11	ReTain vs EthylBloc+Cyclanilide+ReTain	ns	ns	ns	ns	ns	ns
4 vs 12	ReTain vs EthylBloc+ Dicamba+ReTain	ns	ns	ns	ns	ns	**
5 vs 9	Cyclanilide vs Cyclanilide+ReTain	ns	***	ns	*	ns	ns
9 vs 11	EthylBloc vs none (Cyclanilide+ReTain)	ns	ns	ns	**	ns	ns
10 vs 11	Cyclanilide+ReTain vs none (EthylBloc)	ns	***	ns	ns	ns	ns
10 vs 12	Dicamba vs ReTain (EthylBloc)	ns	ns	ns	ns	ns	*
11 vs 12	Dicamba vs Cyclanilide (EthylBloc+ ReTain)	ns	*	ns	ns	ns	*
1,2,3,5 vs 4,7,8,9	ReTain vs EthylBloc	ns	***	ns	***	ns	ns

[Z] All treatments were applied with an airblast machine at 100 gals/acre. Tree size was considered to be 50% TRV. Treatments were applied on Sept. 5, when fruit were : fruit diameter=7.80 cm, fruit firmness =2.9 lbs., starch=2.5, soluble solids=11.0, and color=78 % . [Y] Estimated optimum harvest date: Oct 10, 2000.

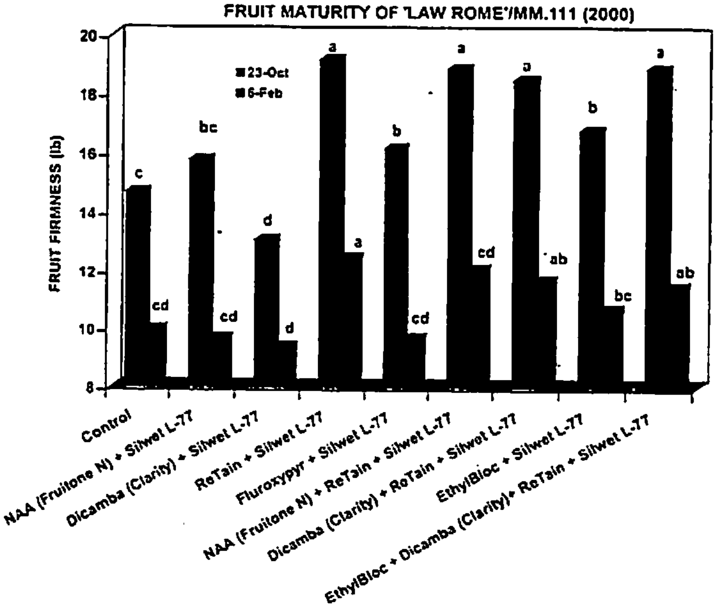
[X] Mean separation within columns by Duncan's New Multiple Range Test;($P \leq 0.05$).

EFFECT OF PLANT GROWTH REGULATORS
ON FRUIT DROP OF "LAW ROME'/MM.111 (2000)

Byers # 44



EFFECT OF PLANT GROWTH REGULATORS ON
FRUIT MATURITY OF 'LAW ROME'/MM.111 (2000)



EFFECT OF PLANT GROWTH REGULATORS
ON FRUIT MATURITY OF 'LAW ROME'/MM/111 (2000)

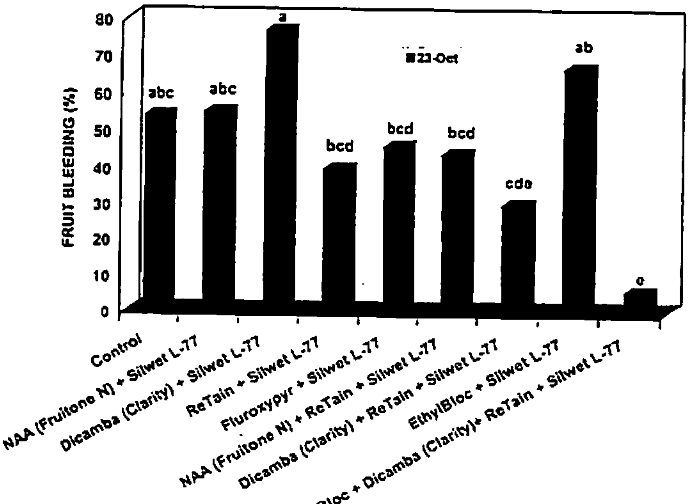


Table 7A. Influence of plant growth regulator sprays on 'Golden Supreme'/MM.111 apple fruit drop and fruit maturity (2001).

No.	Color	Treatment[zy]	Rate/ Gallon	Cumulative (%) fruit dropped			
				Aug 14	Aug 28	Sept 11	Sept 25
1.	W	Control		14 c[x]	88 a	100 a	100 a
2.	R	Cyclanilide (2500 ppm) + Silwet L-77	47.28ml 2.36 ml	64 a	100 a	100 a	100 a
3.	B	Retain (50 ppm) + Silwet L-77	1.61g 2.36 ml	1 d	20 bc	66 bc	93 a
4.	FO	Fruit Tone N NAA (10 ppm) + Silwet L-77	1.22g 2.36 ml	1 d	29 b	56 c	81 b
5.	PUR	+ EthylBloc (0.795 ppm) + Silwet L-77	3 g 2.36 ml	5 cd	89 a	100 a	100 a
6.	HP	Retain (50 ppm) + EthylBloc (0.795 ppm) + Silwet L-77	1.61g 3 g 2.36 ml	2 d	25 bc	71 b	94 a
7.	OBKD	Retain (50 ppm) + EthylBloc (0.795 ppm) + Silwet L-77 + NAA (10 ppm)	1.61g 3 g 2.36 1.22g ml	0.4 d	14 c	43 d	78 b
8.	YRD	Retain (50 ppm) + Cyclanilide (2500 ppm) + Silwet 77	1.61g 47.28ml 2.36 ml	26 b	100 a	100 a	100 a
Contrasts		**Comparisons**		**Pr>F**	**Pr>F**	**Pr>F**	**Pr>F**
1 vs 2		Cyclanilide vs none		***	ns	ns	ns
1 vs 3		ReTain vs none		**	***	***	*
1 vs 4		NAA vs none		**	***	***	***
1 vs 5		EthylBloc vs none		*	ns	ns	ns
1 vs 6		ReTain + Ethylbloc vs none		**	***	***	ns
1 vs 7		ReTain + Ethylbloc + NAA vs none		**	***	***	***
1 vs 8		ReTain + Cyclanilide vs none		**	ns	ns	ns
2 vs 8		Cyclanilide + ReTain vs Cyclanilide		***	ns	ns	ns
3 vs 5		ReTain vs NAA		ns	***	***	*
3 vs 4		ReTain vs EthylBloc		ns	ns	ns	**
3 vs 6		ReTain vs ReTain + Ethylbloc		ns	ns	ns	ns
3 vs 7		ReTain vs ReTain + Ethylbloc + NAA		ns	ns	***	***
3 vs 8		ReTain vs ReTain + Cyclanilide		***	***	***	*
4 vs 7		NAA vs ReTain + Ethylbloc + NAA		ns	*	*	ns
5 vs 6		EthylBloc vs ReTain + Ethylbloc		ns	***	***	ns
5 vs 7		EthylBloc vs ReTain + Ethylbloc + NAA		ns	***	***	***
6 vs 7		ReTain + Ethylbloc vs ReTain + Ethylbloc + NAA		ns	ns	***	***

[zy] Spray treatments were applied with a high pressure hand-gun sprayer on 25 July when fruit firmness was 26.0 lbs. Anticipated optimum harvest date was 24 Aug.

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

Table 7B. Influence of plant growth regulator sprays on 'Golden Supreme'/MM.111 apple fruit drop and fruit maturity (2001).

No.	Color	Treatment^{ZY}	Rate/ Gallon	Fruit diameter (cm)				Fruit firmness (lb.)				Starch (1-8 rating)				Soluble solids			
				Aug 15	Aug 29	Sept 12	Sept 25	Aug 15	Aug 29	Sept 12	Sept 25	Aug 15	Aug 29	Sept 12	Sept 25	Aug 15	Aug 29	Sept 12	Sept 25
1.	W	Control		7.51 a[x]	8.04 a	8.09 c	--	22.2 b	17.6 b	15.6 a	--	4.6 ab	7.3 ab	7.6 ab	--	12.5 ab	14.5 a	16.2 a	--
2.	R	Cyclanilide (2500 ppm) + Silwet L-77	47.28ml 2.36 ml	7.44 a	--	--	--	22.4 ab	--	--	--	5.5 a	--	--	--	12.6 a	--	--	--
3.	B	Retain (50 ppm) + Silwet L-77	1.61g 2.36 ml	7.54 a	8.30 a	8.68 a	8.00 a	23.2 a	18.8 a	15.0 ab	16.8 a	1.7 d	3.7 d	7.2 b	7.7 ab	11.5 d	12.6 b	15.4 a	14.8 a
4.	FO	Fruit Tone N NAA (10 ppm) + Silwet L-77	1.22g 2.36 ml	7.57 a	8.15 a	8.28 bc	7.74 a	22.6 ab	16.6 c	14.2 b	15.2 ab	4.1 ab	7.9 a	8.0 a	8.0 a	12.0 bc	14.7 a	16.1 a	15.0 a
5.	PUR	+ EthylBloc (0.795 ppm) + Silwet L-77	3 g 2.36 ml	7.72 a	8.34 a	7.62 d	--	22.1 b	17.5 b	14.5 ab	--	4.4 ab	7.0 bc	8.0 a	--	12.4 ab	14.5 a	16.1 a	--
6.	HP	Retain (50 ppm) + EthylBloc (0.795 ppm) + Silwet L-77	1.61g 3 g 2.36 ml	7.60 a	8.24 a	8.58 ab	7.72 a	23.3 a	18.7 a	15.4 ab	15.9 ab	2.6 cd	3.8 d	6.8 b	7.1 b	11.7 cd	12.8 b	15.0 a	15.2 a
7.	OBKD	Retain (50 ppm) + EthylBloc (0.795 ppm) + Silwet L-77 + NAA (10 ppm)	1.61g 3 g 2.36 1.22g ml	7.49 a	8.13 a	8.37 abc	8.08 a	22.5 ab	18.0 ab	14.9 ab	13.5 b	3.6 bc	6.3 c	7.1 b	8.0 a	11.5 d	13.1 b	15.5 a	14.6 a
8.	YRD	Retain (50 ppm) + Cyclanilide (2500 ppm) + Silwet 77	1.61g 47.28ml 2.36 ml	7.49 a	--	--	--	23.3 a	--	--	--	5.4 a	--	--	--	12.3 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
1 vs 2		Cyclanilide vs none		ns	--	--	--	ns	--	--	--	ns	--	--	--	ns	--	--	--
1 vs 3		ReTain vs none		ns	ns	••	--	•	••	ns	--	•••	•••	ns	--	•••	•••	ns	--
1 vs 4		NAA vs none		ns	ns	ns	--	ns	•	ns	--	ns	ns	ns	--	•	ns	ns	--
1 vs 5		EthylBloc vs none		ns	•	•	--	ns	ns	ns	--	ns	ns	ns	--	ns	ns	ns	--
1 vs 6		ReTain + Ethylbloc vs none		ns	ns	•	--	•	••	ns	--	••	•••	ns	--	•••	•••	•	--
1 vs 7		ReTain + Ethylbloc + NAA vs none		ns	ns	ns	--	ns	ns	ns	--	ns	•	ns	--	•••	•••	--	--
1 vs 8		ReTain + Cyclanilide vs none		ns	--	--	--	•	--	--	--	ns	--	--	--	ns	--	--	--
2 vs 8		Cyclanilide + ReTain vs Cyclanilide		ns	--	--	--	•	--	--	--	ns	--	--	--	ns	--	--	--
3 vs 5		ReTain vs NAA		ns	ns	•••	--	•	••	ns	--	•••	•••	•	--	•••	•••	ns	--
3 vs 4		ReTain vs EthylBloc		ns	ns	•	ns	ns	•••	ns	ns	••	•••	•	ns	•	•••	ns	ns
3 vs 6		ReTain vs ReTain + Ethylbloc		ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
3 vs 7		ReTain vs ReTain + Ethylbloc + NAA		ns	ns	ns	ns	ns	ns	ns	•	•	•••	ns	ns	ns	ns	ns	ns
3 vs 8		ReTain vs ReTain + Cyclanilide		ns	--	--	--	ns	--	--	--	•••	--	--	--	••	--	--	--
4 vs 7		NAA vs ReTain + Ethylbloc + NAA		ns	ns	ns	ns	ns	••	ns	ns	ns	••	•	ns	•	•••	•	ns
5 vs 6		EthylBloc vs ReTain + Ethylbloc		ns	ns	•••	--	••	••	ns	--	•	•••	••	--	••	•••	••	--
5 vs 7		EthylBloc vs ReTain + Ethylbloc + NAA		ns	ns	•••	--	ns	ns	ns	--	ns	ns	•	--	•••	•••	•	--
6 vs 7		ReTain + Ethylbloc vs ReTain + Ethylbloc + NAA		ns	ns	ns	ns	ns	ns	ns	ns	ns	•••	ns	•	ns	ns	ns	ns

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[ZY] Spray treatments were applied with a high pressure hand-gun sprayer on 25 July when fruit firmness was 26.0 lbs. Anticipated optimum harvest date was 24 Aug.

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

Table 7C. Influence of plant growth regulator sprays on 'Golden Supreme'/MM.111 apple fruit drop and fruit maturity (2001).

No.	Color	Treatment^{zy}	Rate/ Gallon	Background color				Shriveled fruit (%)				Cracked fruit (%)			
				Aug 15	Aug 29	Sept 12	Sept 25	Aug 15	Aug 29	Sept 12	Sept 25	Aug 15	Aug 29	Sept 12	Sept 25
1.	W	Control		2.3 ab^{x}	3.9 a	3.8 ab	--			53 a	--			7 b	--
2.	R	Cyclanilide (2500 ppm) + Silwet L-77	47.28ml 2.36 ml	2.5 a	--	--	--			--	--			--	--
3.	B	Retain (50 ppm) + Silwet L-77	1.61g 2.36 ml	2.1 b	2.4 c	3.6 ab	3.7 bc			4 b	13 a			0 b	0 a
4.	FO	Fruit Tone N NAA (10 ppm) + Silwet L-77	1.22g 2.36 ml	2.4 ab	4.0 a	4.0 a	3.9 ab			8 b	32 a			36 ab	0 a
5.	PUR	+ EthylBloc (0.795 ppm) + Silwet L-77	3 g 2.36 ml	2.4 ab	4.0 a	4.0 a	--			67 a	--			58 a	--
6.	HP	Retain (50 ppm) + EthylBloc (0.795 ppm) + Silwet L-77	1.61g 3 g 2.36 ml	2.2 b	2.6 c	3.4 b	3.6 c			0 b	5 a			8 b	0 a
7.	OBKD	Retain (50 ppm) + EthylBloc (0.795 ppm) + Silwet L-77 + NAA (10 ppm)	1.61g 3 g 2.36 1.22g ml	2.2 ab	3.5 b	3.5 ab	4.0 a			0 b	16 a			20 b	0 a
8.	YRD	Retain (50 ppm) + Cyclanilide (2500 ppm) + Silwet 77	1.61g 47.28ml 2.36 ml	2.4 ab	--	--	--			--	--			--	--
<u>Contrasts</u>		<u>Comparisons</u>		<u>Pr>F</u>	<u>Pr>F</u>	<u>Pr>F</u>	<u>Pr>F</u>	<u>Pr>F</u>	<u>Pr>F</u>	<u>Pr>F</u>	<u>Pr>F</u>	<u>Pr>F</u>	<u>Pr>F</u>	<u>Pr>F</u>	<u>Pr>F</u>
1 vs 2		Cyclanilide vs none		ns	--	--	--			--	--			--	--
1 vs 3		ReTain vs none		ns	***	**	--			**	--			ns	--
1 vs 4		NAA vs none		ns	ns	**	--			**	--			ns	--
1 vs 5		EthylBloc vs none		ns	ns	ns	--			ns	--			*	--
1 vs 6		ReTain + Ethylbloc vs none		ns	***	**	--			**	--			ns	--
1 vs 7		ReTain + Ethylbloc + NAA vs none		ns	**	**	--			**	--			ns	--
1 vs 8		ReTain + Cyclanilide vs none		ns	--	--	--			--	--			--	--
2 vs 8		Cyclanilide + ReTain vs Cyclanilide		ns	--	--	--			--	--			--	--
3 vs 5		ReTain vs NAA		*	***	***	--			***	--			**	--
3 vs 4		ReTain vs EthylBloc		ns	***	ns	ns			ns	ns			*	ns
3 vs 6		ReTain vs ReTain + Ethylbloc		ns	ns	ns	ns			ns	ns			ns	ns
3 vs 7		ReTain vs ReTain + Ethylbloc + NAA		ns	***	ns	ns			ns	ns			ns	ns
3 vs 8		ReTain vs ReTain + Cyclanilide		ns	--	--	--			--	--			--	--
4 vs 7		NAA vs ReTain + Ethylbloc + NAA		ns	**	ns	ns			ns	ns			ns	ns
5 vs 6		EthylBloc vs ReTain + Ethylbloc		ns	***	***	--			***	--			*	--
5 vs 7		EthylBloc vs ReTain + Ethylbloc + NAA		ns	**	***	--			***	--			*	--
6 vs 7		ReTain + Ethylbloc vs ReTain + Ethylbloc + NAA		ns	***	ns	**			ns	ns			ns	ns

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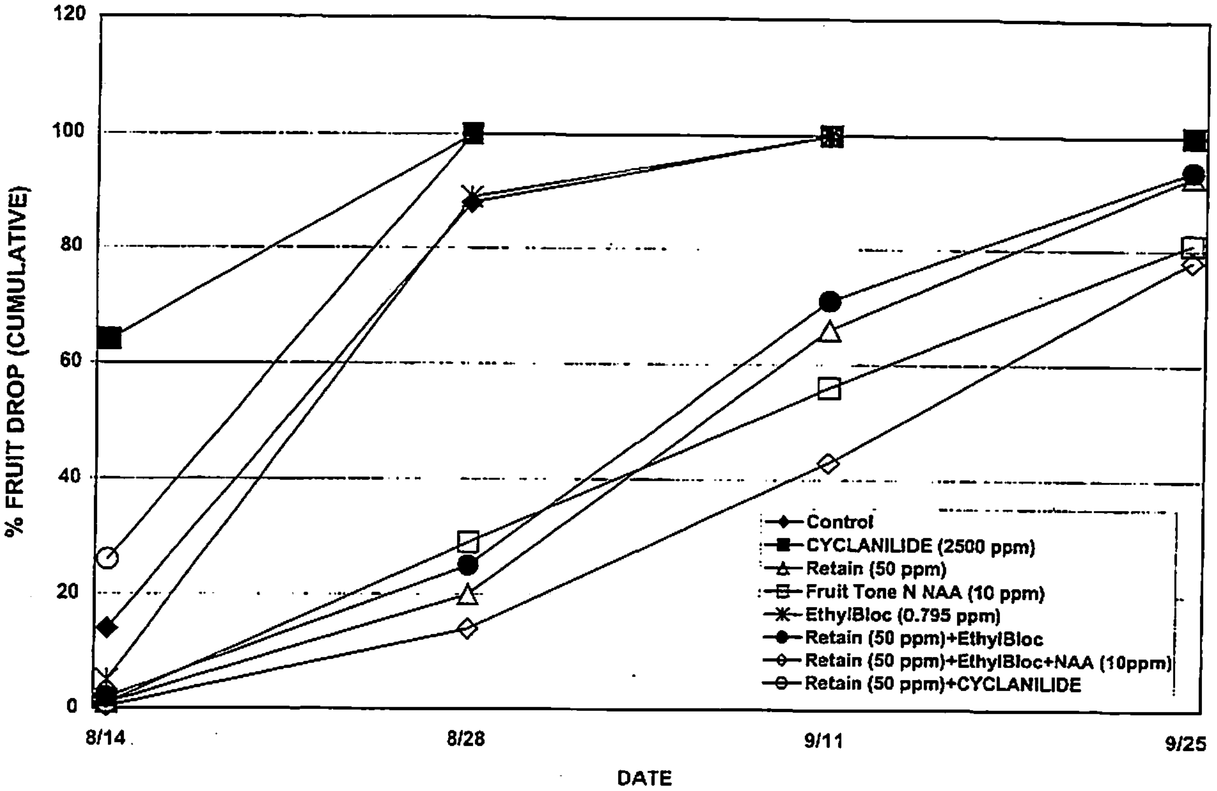
[zy] Spray treatments were applied with a high pressure hand-gun sprayer on 25 July when fruit firmness was 26.0 lbs. Anticipated optimum harvest date was 24 Aug.

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

INFLUENCE OF PLANT GROWTH REGULATOR SPRAYS ON 'GOLDEN SUPREME'/MM.111 APPLE FRUIT DROP AND MATURITY (2001)



INFLUENCE OF PLANT GROWTH REGULATOR SPRAYS ON 'GOLDEN SUPREME'/MM.111 APPLE FRUIT DROP AND MATURITY (2001)

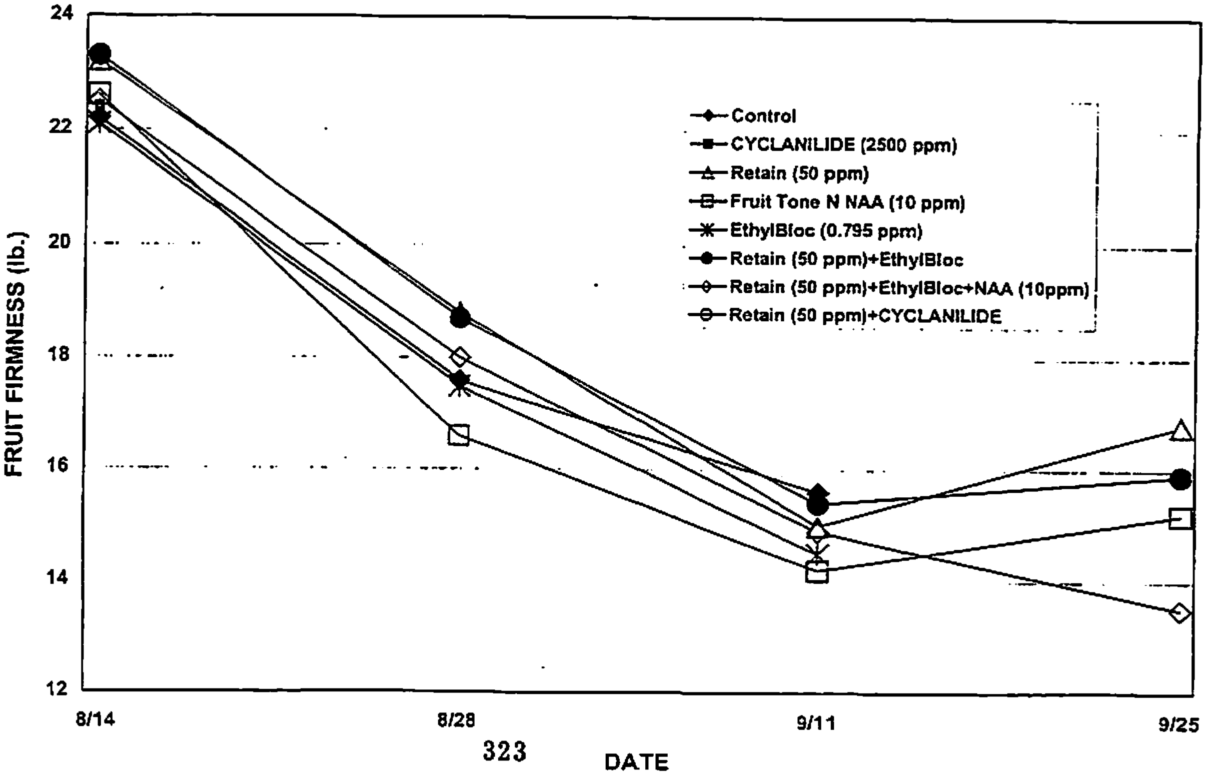


Table 8A. Influence of plant growth regulator sprays on 'Gala'/M.9 apple fruit drop and maturity (2001).

No.	Color	Treatment^{zy}	Rate/ Gallon 100 gal/Acre	Cumulative (%) of fruit dropped		
				Aug 22	Sept 5	Sept 18
1.	W	Control		0 a^{x}	0 a	13 a
2.	R	ReTain (30 g)	2.0 g	0 a	0 a	5 ab
		+ Silwet L-77	3.78 ml			
3.	B	ReTain (50 g)	3.33 g	0 a	0 a	1 b
		+ Silwet L-77	3.78 ml			
4.	FO	ReTain (30 g)	2.0 g	0 a	0 a	3 b
		+Ethephon 135ppm	2.37 ml			
		+ Silwet L-77	3.78ml			
5.	HP	ReTain (50 g)	3.33g	0 a	0 a	4 ab
		+ Ethephon 135ppm	2.37 ml			
		+ Silwet L-77	3.78 ml			
6.	OBKS	ReTain (50 g)	3.33g	0 a	0 a	5 ab
		+ Ethephon 135ppm	2.37 ml			
		+ NAA NuTone N (10 ppm)	1.22 g			
		+ Silwet L-77	3.78 ml			
7.	PBKS	Ethephon (135ppm	2.37 ml	0 a	0 a	7 ab
		+ Silwet L-77	3.78 ml			

Contrasts	Comparisons	Pr>F	Pr>F	Pr>F
2,3 vs 4,5	Ethephon vs none (ReTain 30g and 50g)	ns	ns	ns
2,4 vs 3,5	ReTain 30g and 50g (Ethephon)	ns	ns	ns
1 vs 7	Ethephon vs none	ns	ns	ns
2 vs 7	30g ReTain vs Ethephon	ns	ns	ns
3 vs 7	50g ReTain vs Ethephon	ns	ns	ns
2 vs 3	30g ReTain vs 50g ReTain	ns	ns	ns
4 vs 5	30g vs 50g ReTain (Ethephon)	ns	ns	ns
6 vs 7	ReTain+NAA+Ethephon vs Ethephon	ns	ns	ns
5 vs 6	ReTain+NAA+Ethephon vs ReTain+Ethephon	ns	ns	ns

[zy] Spray treatments were applied with a high pressure hand-gun sprayer. ReTain was applied on 8 Aug and Ethephon was applied 22 Aug.

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

Table 8B. Influence of plant growth regulator sprays on 'Gala'/M.9 apple fruit drop and fruit maturity (2001).

No.	Color	Treatment[zy]	Rate/ Gallon or 100 gal /acre	Fruit diameter (cm)			Fruit firmness (lb.)			Starch (1-8 rating)			Soluble solids			Color (0-100%)			Cracked fruit (%) (19 Sept 01)
				Aug 22	Sept 5	Sept 19	Aug 22	Sept 5	Sept 19	Aug 22	Sept 5	Sept 19	Aug 22	Sept 5	Sept 19	Aug 22	Sept 5	Sept 19	
1.	W	Control		6.40 a[x]	6.91 a	7.06 a	21.8 bc	17.1 bc	14.8 b	2.5 a	6.7 ab	7.9 a	10.6 a	12.4 a	13.4 a	60 a	82 b	89 a	1.4 a
2.	R	ReTain (30 g) + Silwet L-77	2.0 g 3.78 ml	6.47 a	6.89 a	7.03 a	22.8 a	18.8 a	17.1 a	1.6 b	3.7 d	7.5 b	10.8 a	12.0 abc	13.0 ab	49 ab	71 c	86 b	1.4 a
3.	B	ReTain (50 g) + Silwet L-77	3.33 g 3.78 ml	6.40 a	6.91 a	6.99 a	22.5 ab	18.3 a	18.4 a	1.5 b	3.7 d	6.6 c	10.5 ab	11.5 c	12.9 ab	42 b	62 d	83 c	5.7 a
4.	FO	ReTain (30 g) +Ethephon 135ppm + Silwet L-77	2.0 g 2.37 ml 3.78ml	6.50 a	6.95 a	7.06 a	22.2 abc	18.4 a	17.5 a	1.9 b	6.3 bc	7.6 b	10.8 a	12.3 a	13.1 ab	38 b	76 bc	86 b	4.3 a
5.	HP	ReTain (50 g) + Ethephon 135ppm + Silwet L-77	3.33g 2.37 ml 3.78 ml	6.47 a	6.96 a	6.98 a	21.6 bc	17.8 ab	18.2 a	2.0 b	6.0 bc	7.5 b	10.2 b	11.6 bc	12.6 b	47 ab	78 b	85 b	7.1 a
6.	OBKS	ReTain (50 g) + Ethephon 135ppm + NAA NuTone N (10 ppm) + Silwet L-77	3.33g 2.37 ml 61 g 3.78 ml	6.46 a	6.90 a	7.00 a	22.5 ab	18.5 a	18.2 a	1.6 b	5.6 c	7.4 b	10.5 ab	12.1 ab	13.3 ab	43 b	79 b	87 b	5.7 a
7.	PBKS	Ethephon (135ppm + Silwet L-77	2.37 ml 3.78 ml	6.40 a	6.94 a	6.94 a	21.4 c	16.6 c	15.0 b	1.9 b	7.6 a	7.9 a	10.7 a	12.3 a	13.3 ab	52 ab	88 a	91 a	0.0 a
<u>Contrasts</u>		<u>Comparisons</u>		<u>Pr>F</u>	<u>Pr>F</u>	<u>Pr>F</u>	<u>Pr>F</u>	<u>Pr>F</u>	<u>Pr>F</u>	<u>Pr>F</u>	<u>Pr>F</u>	<u>Pr>F</u>	<u>Pr>F</u>	<u>Pr>F</u>	<u>Pr>F</u>	<u>Pr>F</u>	<u>Pr>F</u>	<u>Pr>F</u>	<u>Pr>F</u>
2,3 vs 4,5		Ethephon vs none (ReTain 30g and 50g)		ns	ns		*	ns	ns	ns	***	***	ns	ns	ns	ns	***	ns	ns
2,4 vs 3,5		ReTain 30g and 50g (Ethephon)		ns	ns	ns	ns	ns	*	ns	ns	***	**	**	ns	ns	ns	*	ns
1 vs 7		Ethephon vs none		ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	*	ns	ns
2 vs 7		30g ReTain vs Ethephon		ns	ns	ns	**	***	**	ns	***	**	ns	ns	ns	ns	***	***	ns
3 vs 7		50g ReTain vs Ethephon		ns	ns	ns	*	***	***	ns	***	***	ns	**	ns	ns	***	***	ns
2 vs 3		30g ReTain vs 50g ReTain		ns	ns	ns	ns	ns	*	ns	ns	***	ns	ns	ns	ns	**	*	ns
4 vs 5		30g vs 50g ReTain (Ethephon)		ns	ns	ns	ns	ns	ns	ns	ns	ns	**	ns	ns	ns	ns	ns	ns
6 vs 7		ReTain+NAA+Ethephon vs Ethephon		ns	ns	ns	**	***	***	ns	***	**	ns	ns	ns	ns	**	**	ns
5 vs 6		ReTain+NAA+Ethephon vs ReTain+Ethephon		ns	ns	ns	*	ns	ns	ns	ns	ns	ns	ns	*	ns	ns	ns	ns

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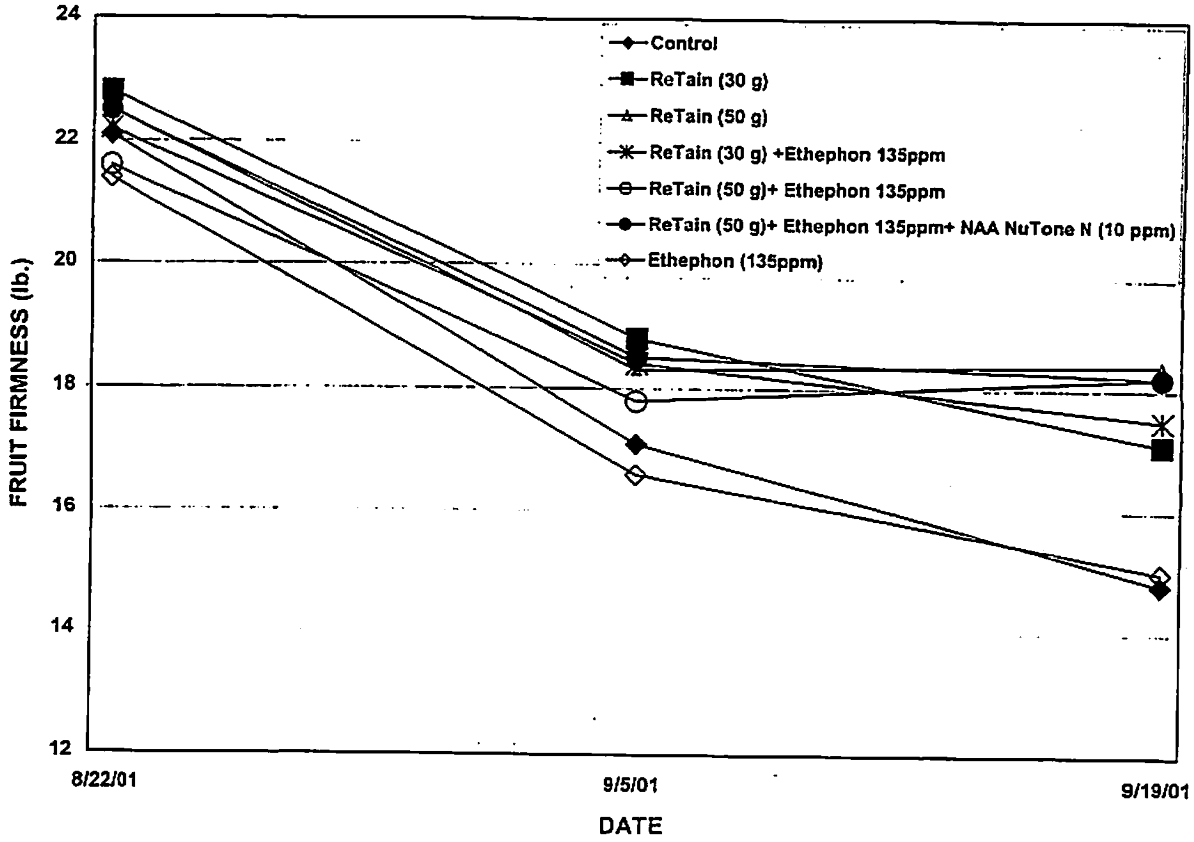
[zy] Spray treatments were applied with a high pressure hand-gun sprayer. ReTain was applied on 8 Aug and Ethephon was applied 22 Aug.

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

EFFECT OF PLANT GROWTH REGULATORS ON FRUIT FIRMNESS OF 'GALA'/M.9

Byers # 91



EFFECT OF PLANT GROWTH REGULATORS ON STARCH OF 'GALA'/M.9

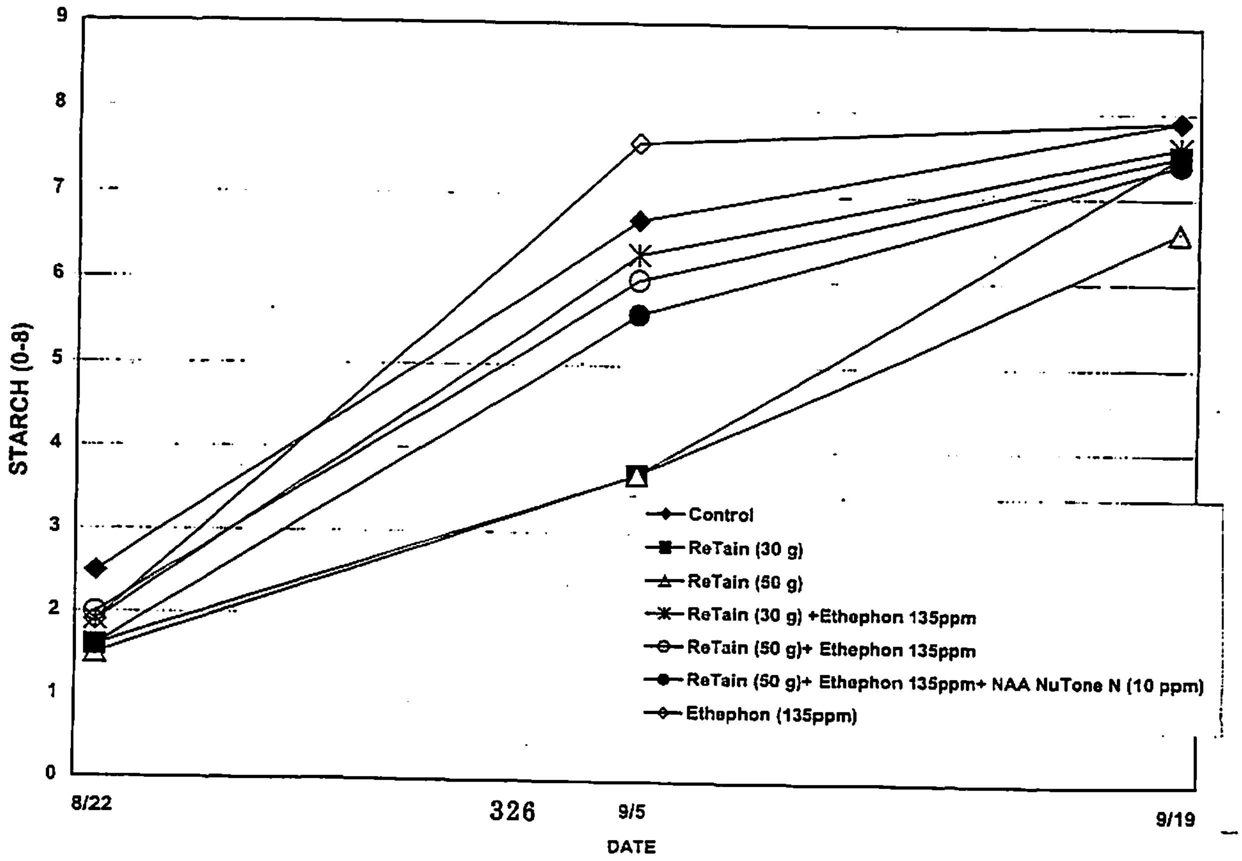


Table 9A. Influence of plant growth regulator sprays on 'Law Rome'/MM.111 apple fruit drop and fruit maturity (2001).

No.	Color	Treatment^{zy}	Rate/ Gallon	Cumulative number of fruit / tree dropped			
				Oct 11	Oct 18	Oct 25	Nov 1
1.	W	Control		35.8 a^{x}	172.0 ab	212.7 a	215.3 ab
2.	B	Retain	3.33g	25.7 ab	46.0 c	134.2 bc	165.8 bc
		+ Silwet L-77	1.90 ml				
3.	R	Fruit Tone N NAA (10 ppm)	7.32g	13.8 c	123.8 b	172.8 ab	181.7 ab
		+ Silwet L-77	1.90 ml				
4.	PUR	EthylBloc	9 g	31.3 ab	182.8 a	240.7 a	245.7 a
		+ Silwet L-77	1.90 ml				
5.	HP	Kinetin	25.0 ml	28.7 ab	176.5 ab	221.8 a	229.3 ab
		+ Silwet -77	1.18 ml				
6.	FO	Cyclanilide (2500 ppm)	141.84ml	28.0 ab	153.2 ab	192.5 ab	196.3 ab
		+ Silwet –77	1.90 ml				
7.	OBKD	Retain (50 ppm)	3.33g	26.0 ab	42.3 c	81.3 cd	99.0 cd
		+ EthylBloc	9 g				
		+ Silwet L-77	1.90 ml				
8.	YRD	Retain (50 ppm)	3.33g	13.2 c	29.8 c	49.0 d	65.8 d
		+ EthylBloc	9 g				
		+ Silwet L-77	1.90				
		+ NAA (10 ppm)	7.32g ml				
9.	PBKD	Retain (50 ppm)	3.33g	22.3 bc	41.0 c	72.0 cd	88.7 d
		+ EthylBloc	9 g				
		+ Silwet L-77	1.90 ml				
		+ Kinetin	25.0 ml				

Contrasts	Comparisons	Pr>F	Pr>F	Pr>F	Pr>F
1 vs 2	Retain vs none	ns	***	*	ns
1 vs 3	Fruit Tone N NAA vs none	***	ns	ns	ns
1 vs 4	EthylBloc vs none	ns	ns	ns	ns
1 vs 5	Kinetin vs none	ns	ns	ns	ns
1 vs 6	Cyclanilide vs none	ns	ns	ns	ns
2 vs 3	Retain vs Fruit Tone N NAA	*	**	ns	ns
2 vs 4	Retain vs EthylBloc	ns	***	**	*
2 vs 5	Retain vs Kinetin	ns	***	**	ns
2 vs 6	Retain vs Cyclanilide	ns	***	ns	ns
2 vs 7	Retain vs Retain + EthylBloc	ns	ns	ns	ns
2 vs 8	Retain vs Retain + EthylBloc + Fruit Tone N NAA	*	ns	*	**
2 vs 9	Retain vs Retain + EthylBloc + Kinetin	ns	ns	ns	*
3 vs 8	Fruit Tone N NAA vs Retain + EthylBloc + Fruit Tone N NAA	ns	***	***	**

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^{zy}Spray treatments were applied with a high pressure hand-gun sprayer. EthylBloc was applied on 27 Sept. when fruit firmness = 22.2 lbs.; starch = 4.4; soluble solids = 12.5.

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

Table 9B. Influence of plant growth regulator sprays on 'Law Rome'/MM.111 apple fruit drop and fruit maturity (2001).

No.	Color	Treatment[zY]	Rate/ Gallon or 100 gal /acre	Fruit diameter (cm)		Fruit firmness (lb.)		Starch (1-8 rating)		Soluble solids		Color (0-100%)		Water core (0-5)		Bleeding (0-5)	
				Oct 18	Nov 1	Oct 18	Nov 1	Oct 18	Nov 1	Oct 18	Nov 1	Oct 18	Nov 1	Oct 18	Nov 1	Oct 18	Nov 1
1.	W	Control		9.11 a[x]	--	15.9 b	--	7.3 a	--	12.7 abc	--	100 a	--	0.10 a	--	0.53 a	--
2.	B	Retain + Silwet L-77	3.33g 1.90 ml	9.09 ab	9.27 a	20.1 a	18.7 a	6.7 b	7.8 a	12.9 ab	13.2 a	98 ab	99 a	0.07 a	0.23 a	0.00 b	0.10 a
3.	R	Fruit Tone N NAA (10 ppm) + Silwet L-77	7.32g 1.90 ml	9.23 ab	9.47 a	15.0 b	10.8 b	7.6 a	8.0 a	12.4 abc	12.9 a	98 ab	99 a	0.20 a	0.36 a	0.17 b	0.24 a
4.	PUR	EthylBloc + Silwet L-77	9 g 1.90 ml	9.17 ab	--	16.6 b	--	7.5 a	--	12.7 abc	--	98 ab	--	0.04 a	--	0.00 b	--
5.	HP	Kinetin + Silwet -77	25.0 ml 1.18 ml	9.28 a	--	15.5 b	--	7.5 a	--	12.0 c	--	98 ab	--	0.07 a	--	0.00 b	--
6.	FO	Cyclanilide (2500 ppm) + Silwet –77	141.84ml 1.90 ml	9.12 ab	9.14 a	15.1 b	10.6 b	7.4 a	8.0 a	12.5 abc	--	99 ab	99 a	0.03 a	0.07 a	0.07 b	0.00 a
7.	OBKD	Retain (50 ppm) + EthylBloc + Silwet L-77	3.33g 9 g 1.90 ml	8.86 b	9.18 a	20.6 a	20.2 a	6.3 b	7.7 a	12.8 abc	12.6 a	99 ab	99 a	0.03 a	0.13 a	0.07 b	0.07 a
8.	YRD	Retain (50 ppm) + EthylBloc + Silwet L-77 + NAA (10 ppm)	3.33g 9 g 1.90 7.32g ml	9.02 ab	9.16 a	18.9 a	19.9 a	6.5 b	7.8 a	13.1 a	12.8 a	98 ab	100 a	0.17 a	0.23 a	0.03 b	0.40 a
9.	PBKD	Retain (50 ppm) + EthylBloc + Silwet L-77 + Kinetin	3.33g 9 g 1.90 ml 25.0 ml	9.14 ab	9.20 a	20.4 a	19.8 a	6.5 b	7.8 a	12.2 bc	12.4 a	97 b	99 a	0.10 a	0.33 a	0.03 b	0.20 a

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	Retain vs none	ns	--		***	--		*	--		ns	--		ns	--	ns	--	***	--
1 vs 3	Fruit Tone N NAA vs none	ns	--		ns	--		ns	--		ns	--		ns	--	ns	--	**	--
1 vs 4	EthylBloc vs none	ns	--		ns	--		ns	--		ns	--		ns	--	ns	--	***	--
1 vs 5	Kinetin vs none	ns	--		ns	--		ns	--		ns	--		ns	--	ns	--	***	--
1 vs 6	Cyclanilide vs none	ns	--		ns	--		ns	--		ns	--		ns	--	ns	--	***	--
2 vs 3	Retain vs Fruit Tone N NAA	ns	--		***	--		***	--		ns	--		ns	--	ns	--	ns	--
2 vs 4	Retain vs EthylBloc	ns	--		***	--		**	--		ns	--		ns	--	ns	--	ns	--
2 vs 5	Retain vs Kinetin	ns	--		***	--		**	--		*	--		ns	--	ns	--	ns	--
2 vs 6	Retain vs Cyclanilide	ns	--		***	--		**	--		ns	--		ns	--	ns	--	ns	--
2 vs 7	Retain vs Retain + EthylBloc	ns	ns		ns	ns		ns	ns		ns	ns		ns	ns	ns	ns	ns	ns
2 vs 8	Retain vs Retain + EthylBloc + Fruit Tone N NAA	ns	ns		ns	ns		ns	ns		ns	ns		ns	ns	ns	ns	ns	ns
2 vs 9	Retain vs Retain + EthylBloc + Kinetin	ns	ns		ns	ns		ns	ns		ns	ns		ns	ns	ns	ns	ns	ns
3 vs 8	Fruit Tone N NAA vs Retain + EthylBloc + Fruit Tone N NAA	ns	--		***	--		***	--		*	--		ns	--	ns	--	ns	--

[zY] Spray treatments were applied with a high pressure hand-gun sprayer. EthylBloc was applied on 27 Sept. when fruit firmness = 22.2 lbs.; starch = 4.4; soluble solids = 12.5.

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

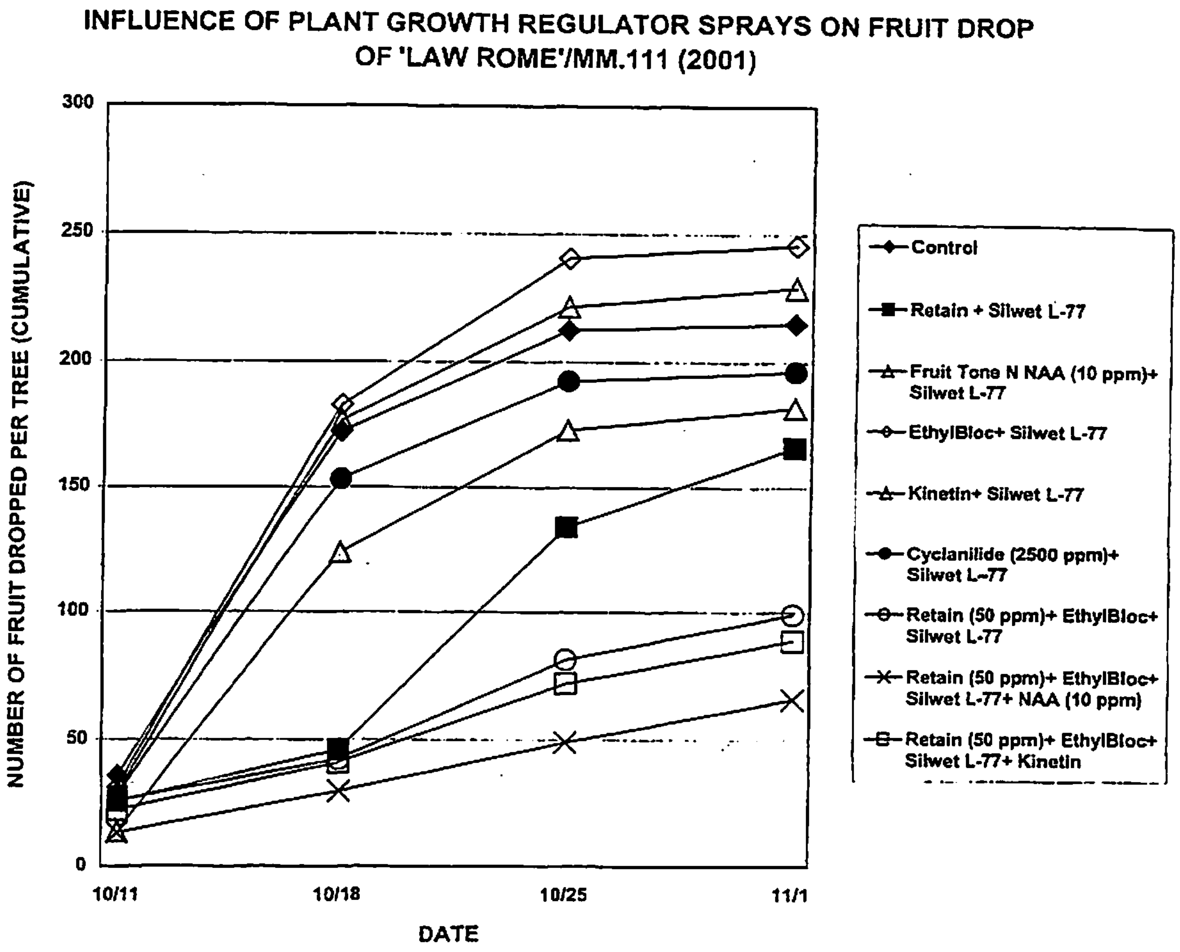

INFLUENCE OF PLANT GROWTH REGULATOR SPRAYS ON FRUIT DROP OF 'LAW ROME'/MM.111 (2001)
NUMBER OF FRUIT DROPPED PER TREE (CUMULATIVE)
300
250
200
150
100
50
0
10/11
10/18
10/25
11/1
DATE
Control
Retain + Silwet L-77
Fruit Tone N NAA (10 ppm)+ Silwet L-77
EthylBloc+ Silwet L-77
Kinetin+ Silwet L-77
Cyclanilide (2500 ppm)+ Silwet L-77
Retain (50 ppm)+ EthylBloc+ Silwet L-77
Retain (50 ppm)+ EthylBloc+ Silwet L-77+ NAA (10 ppm)
Retain (50 ppm)+ EthylBloc+ Silwet L-77+ Kinetin

Table 10A. Influence of EthylBloc and ReTain dips and gasses on 'NuRed Rome 262'/MM.111 apple fruit stored at 70° (2000).

No.	Treatment[zy]	Application method	Rate/3 gallons or g or ml/dm^3	Fruit diameter (cm)				Fruit firmness (lb.)				Starch (1-8 rating)				Rots (%)			
				Oct 11	Oct 25	Nov 8	Nov 22	Oct 11	Oct 25	Nov 8	Nov 22	Oct 11	Oct 25	Nov 8	Nov 22	Oct 11	Oct 25	Nov 8	Nov 22
1.	Control (no trt)	none		7.75 a[x]	7.32 b	7.39 a	7.80 a	15.2 c	12.6 d	12.0 e	12.0 d	7.20 a	8.00 a	8.00 a	8.00 a	0 b	15 cd	50 bc	75 ab
2.	Mertect	dip	14.2ml	7.76 a	7.50 ab	7.35 a	7.99 a	14.2 d	12.8 d	13.0 de	9.2 e	7.25 a	8.00 a	8.00 a	8.00 a	0 b	25 bc	40 cd	65 b
3.	EthylBloc + Buffer	(gas)	0.1g/35dm^3 7 ml/35dm^3	7.50 a	7.81 ab	7.62 a	7.50 a	21.8 ab	17.0 c	14.4 cd	11.9 d	6.20 c	7.95 ab	8.00 a	8.00 a	5 ab	0 d	15 d	70 ab
4.	EthylBloc + Buffer + Mertect	(gas) (dip)	1g/35dm^3 7 ml/35dm^3 14.2ml	7.40 a	7.79 ab	7.73 a	7.51 a	22.5 a	19.9 ab	14.7 cd	13.5 c	6.35 c	7.75 bcd	8.00 a	8.00 a	0 b	0 d	30 cd	45 bcd
5.	EthylBloc	(dip)	9 g	7.57 a	7.69 ab	7.58 a	7.79 a	22.0 a	21.0 a	14.8 cd	13.5 c	6.15 c	7.70 cd	8.00 a	8.00 a	0 b	0 d	15 d	30 cd
6.	EthylBloc + Mertect	(dip)	9 g 14.2ml	7.69 a	7.58 ab	7.49 a	8.14 a	22.0 a	21.4 a	16.3 c	14.4 c	6.10 c	7.68 cd	8.00 a	8.00 a	0 b	5 d	30 cd	20 d
7.	ReTain	(dip)	189.25 g	7.70 a	7.84 ab	7.56 a	7.77 a	20.9 b	18.3 bc	16.5 c	20.3 a	6.53 bc	7.90 abc	8.00 a	8.00 a	5 ab	10 cd	55 bc	50 bcd
8.	ReTain +Mertect	(dip)	189.25 g 14.2ml	7.69 a	7.93 a	7.67 a	7.84 a	21.0 b	19.8 ab	18.5 b	19.0 b	6.85 ab	7.63 d	8.00 a	8.00 a	0 b	5 d	15 d	25 cd
9.	ReTain +Mertect + EthylBloc	(dip)	189.25 g 14.2ml 9 g	7.84 a	7.73 ab	7.99 a	7.71 a	22.0 a	20.6 ab	20.6 a	20.1 ab	6.10 c	7.38 e	8.00 a	8.00 a	0 b	5 d	30 cd	55 bc
10.	Cyclanilide	(dip)	142 ml	7.81 a	7.68 ab	7.61 a	---	14.0 d	11.2 d	12.7 de	---	7.18 a	7.95 ab	8.00 a	---	15 a	35 ab	85 a	100 a
11.	Cyclanilide + Mertect	(dip)	142ml 14.2ml	7.75 a	7.78 ab	7.94 a	7.32 a	15.5 c	11.6 d	13.2 de	12.1 d	7.29 a	8.00 a	8.00 a	8.00 a	10 ab	45 a	75 ab	70 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
1 vs 2	Control vs Mertect			ns	ns	ns	ns	*	ns	ns	***	ns	ns	ns	ns	ns	ns	ns	ns
1 vs 3	EthylBloc gas vs none			ns	ns	ns	ns	***	***	*	ns	***	ns	ns	ns	ns	*	**	ns
1 vs 4	EthylBloc gas+Mertect dip vs none			ns	ns	ns	ns	***	***	**	*	***	*	ns	ns	ns	*	ns	*
1 vs 5	EthylBloc dip vs none			ns	ns	ns	ns	***	***	**	*	***	**	ns	ns	ns	*	**	**
1 vs 6	EthylBloc dip+Mertect dip vs none			ns	ns	ns	ns	***	***	***	***	***	**	ns	ns	ns	ns	ns	***
1 vs 7	ReTain vs none			ns	*	ns	ns	***	***	***	***	**	ns	ns	ns	ns	ns	ns	ns
1 vs 8	ReTain+Mertect vs none			ns	*	ns	ns	***	***	***	***	ns	**	ns	ns	ns	ns	**	**
1 vs 9	ReTain+Mertect+ EthylBloc dip vs none			ns	ns	*	ns	***	***	***	***	***	***	ns	ns	ns	ns	ns	ns
1 vs 10	Cyclanilide vs none			ns	ns	ns	---	**	ns	ns	---	ns	ns	ns	---	*	**	**	ns
1 vs 11	Cyclanilide+Mertect vs none			ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	***	*	ns
2 vs 4	EthylBloc gas vs none (Mertect)			ns	ns	ns	ns	***	***	ns	***	***	*	ns	ns	ns	**	ns	ns
2 vs 6	EthylBloc dip vs none (Mertect)			ns	ns	ns	ns	***	***	**	***	***	**	ns	ns	ns	**	ns	**
2 vs 8	ReTain vs none (Mertect)			ns	ns	ns	ns	***	***	***	***	ns	**	ns	ns	ns	**	*	**
2 vs 9	ReTain+EthylBloc vs none (Mertect)			ns	ns	*	ns	***	***	***	***	***	***	ns	ns	ns	**	ns	ns
2 vs 11	Cyclanilide vs none (Mertect)			ns	ns	*	ns	**	ns	ns	***	ns	ns	ns	ns	ns	**	**	ns
3,4 vs 5,6	EthylBloc gas vs EthylBloc dip			ns	ns	ns	ns	ns	***	ns	**	ns	*	ns	ns	ns	ns	ns	**
3 vs 5	EthylBloc gas vs EthylBloc dip			ns	ns	ns	ns	ns	***	ns	*	ns	*	ns	ns	ns	ns	ns	**
4 vs 6	EthylBloc gas vs EthylBloc dip (Mertect)			ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
6 vs 9	EthylBloc+Mertect dip vs ReTain+Mertect +EthylBloc dip			ns	ns	ns	ns	ns	ns	***	***	ns	**	ns	ns	ns	ns	ns	*
7 vs 9	ReTain dip vs ReTain+Mertect+EthylBloc dip			ns	ns	ns	ns	*	ns	***	ns	*	***	ns	ns	ns	ns	*	ns
8 vs 9	ReTain+Mertect dip vs ReTain+Mertect+EthylBloc dip			ns	ns	ns	ns	*	ns	*	ns	***	*	ns	ns	ns	ns	ns	*
2,4,6,8,11 vs 1,3,5,7,10	Mertect vs none			ns	ns	ns	ns	ns	*	*	ns	ns	ns	ns	ns	ns	ns	ns	**

[zy] EthylBloc was applied on Sept 26, 2000, when fruit firmness was 22.5 lbs, starch 3.35, soluble solids 12.9, and background color 2.6.

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

Table 10B. Influence of EthylBloc and ReTain dips and gasses on 'NuRed Rome 262'/MM.111 apple fruit stored at 70° (2000).

No.	Treatment[zy]	Application method	Rate/3 gallons or g or ml/dm³	Soluble solids (%)				Background color (0-5)				Bleeding (0-5)			
				Oct 11	Oct 25	Nov 8	Nov 22	Oct 11	Oct 25	Nov 8	Nov 22	Oct 11	Oct 25	Nov 8	Nov 22
1.	Control (no trt)	none		13.5 a[x]	12.8 b	12.3 d	13.0 c	2.60 b	2.90 ab	3.50 a	4.00 a	--	0.0 b	--	--
2.	Mertect	dip	14.2ml	13.5 a	13.3 ab	13.0 c	13.2 bc	2.45 bc	2.70 abc	3.13 ab	4.00 a	--	0.0 b	--	--
3.	EthylBloc + Buffer	(gas)	0.1 g / 35dm³ 7 ml / 35dm³	13.1 a	13.6 a	13.2 bc	13.4 abc	1.78 e	2.60 abcd	3.15 ab	4.00 a	--	0.0 b	--	--
4.	EthylBloc + Buffer + Mertect	(gas) (dip)	1g / 35dm³ 7 ml / 35dm³ 14.2ml	13.3 a	13.3 ab	14.0 a	13.4 abc	1.95 de	1.70 f	2.63 cd	3.70 ab	--	0.0 b	--	--
5.	EthylBloc	(dip)	9 g	13.3 a	13.6 a	13.6 ab	13.1 c	2.25 bcd	2.00 ef	2.48 d	3.78 ab	--	0.0 b	--	--
6.	EthylBloc + Mertect	(dip)	9 g 14.2ml	13.2 a	13.0 ab	14.0 a	13.2 bc	2.00 de	2.03 ef	2.33 d	4.00 a	--	0.0 b	--	--
7.	ReTain	(dip)	189.25 g	13.4 a	13.0 ab	13.3 bc	13.8 a	2.20 cd	2.45 bcde	2.35 d	3.50 bc	--	0.0 b	--	--
8.	ReTain +Mertect	(dip)	189.25 g 14.2ml	13.2 a	13.3 ab	13.3 bc	13.5 ab	2.05 de	2.25 cde	2.35 d	3.13 c	--	0.0 b	--	--
9.	ReTain +Mertect + EthylBloc	(dip)	189.25 g 14.2ml 9 g	13.4 a	13.4 ab	13.6 ab	13.7 a	2.15 cde	2.15 def	1.83 e	3.13 c	--	0.0 b	--	--
10.	Cyclanilide	(dip)	142 ml	13.7 a	13.6 a	13.1 bc	---	3.09 a	2.73 abc	3.00 bc	---	--	0.9 a	--	--
11.	Cyclanilide + Mertect	(dip)	142ml 14.2ml	13.5 a	13.3 ab	13.1 bc	13.1 c	3.08 a	3.03 a	3.00 bc	4.00 a	--	0.0 b	--	--
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
1 vs 2	Control vs Mertect			ns	ns	**	ns	ns	ns	ns	ns	--	ns	--	--
1 vs 3	EthylBloc gas vs none			ns	*	***	*	***	ns	ns	ns	--	ns	--	--
1 vs 4	EthylBloc gas+Mertect dip vs none			ns	ns	***	ns	***	***	***	ns	--	ns	--	--
1 vs 5	EthylBloc dip vs none			ns	**	***	ns	ns	***	***	ns	--	ns	--	--
1 vs 6	EthylBloc dip+Mertect dip vs none			ns	ns	***	ns	**	***	***	ns	--	ns	--	--
1 vs 7	ReTain vs none			ns	ns	***	***	*	ns	***	*	--	ns	--	--
1 vs 8	ReTain+Mertect vs none			ns	ns	***	*	**	*	***	***	--	ns	--	--
1 vs 9	ReTain+Mertect+ EthylBloc dip vs none			ns	*	***	**	*	**	***	***	--	ns	--	--
1 vs 10	Cyclanilide vs none			ns	**	***	---	**	ns	*	---	--	**	--	--
1 vs 11	Cyclanilide+Mertect vs none			ns	ns	***	ns	*	ns	*	ns	--	ns	--	--
2 vs 4	EthylBloc gas vs none (Mertect)			ns	ns	***	ns	**	***	*	ns	--	ns	--	--
2 vs 6	EthylBloc dip vs none (Mertect)			ns	ns	***	ns	*	**	***	ns	--	ns	--	--
2 vs 8	ReTain vs none (Mertect)			ns	ns	ns	ns	*	ns	***	***	--	ns	--	--
2 vs 9	ReTain+EthylBloc vs none (Mertect)			ns	ns	*	*	ns	*	***	***	--	ns	--	--
2 vs 11	Cyclanilide vs none (Mertect)			ns	ns	ns	ns	**	ns	ns	ns	--	ns	--	--
3,4 vs 5,6	EthylBloc gas vs EthylBloc dip			ns	ns	ns	ns	*	ns	**	ns	--	ns	--	--
3 vs 5	EthylBloc gas vs EthylBloc dip			ns	ns	ns	ns	*	*	**	ns	--	ns	--	--
4 vs 6	EthylBloc gas vs EthylBloc dip (Mertect)			ns	ns	ns	ns	ns	ns	ns	ns	--	ns	--	--
6 vs 9	EthylBloc+Mertect dip vs ReTain+Mertect+EthylBloc dip			ns	ns	ns	**	ns	ns	*	***	--	ns	--	--
7 vs 9	ReTain dip vs ReTain+Mertect+EthylBloc dip			ns	ns	ns	ns	ns	ns	*	ns	--	ns	--	--
8 vs 9	ReTain+Mertect dip vs ReTain+Mertect+EthylBloc dip			ns	ns	ns	ns	ns	ns	*	ns	--	ns	--	--
2,4,6,8,11 vs 1,3,5,7,10	Mertect vs none			ns	ns	***	ns	ns	ns	*	ns	--	ns	--	--

[zy] EthylBloc was applied on Sept 26, 2000, when fruit firmness was 22.5 lbs, starch 3.35, soluble solids 12.9, and background color 2.6.

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

Table 10C. Influence of EthylBloc and ReTain dips and gasses on" 'NuRed Rome 262'/MM.111 apple fruit maturity stored at 35°(2000-01).

No.	Treatment^{zy}	Application method	Rate/3 gallons or g or ml/dm^3	Fruit diameter (cm)				Fruit firmness (lb.)				Starch (1-8 rating)				Rots (%)			
				Nov 27	Jan 27	Mar 27	May 27	Nov 27	Jan 27	Mar 27	May 27	Nov 27	Jan 27	Mar 27	May 27	Nov 27	Jan 27	Mar 27	May 27
1.	Control (no trt)	none		7.77 a^{x}	7.70 abcd	7.74 ab	7.88 a	14.4 e	12.1 e	12.1 d	12.3 cd	7.80 a	8.0 a	--	--	--	--	--	--
2.	Mertect	dip	14.2ml	7.82 a	7.94 ab	7.80 ab	7.80 a	14.1 e	12.1 e	12.4 d	12.4 cd	7.75 a	8.0 a	--	--	--	--	--	--
3.	EthylBloc + Buffer	(gas)	0.1 g / 35dm^3 7 ml / 35dm^3	7.82 a	7.77 abcd	7.68 ab	7.68 a	17.3 c	15.0 a	13.7 bc	13.8 a	7.70 a	8.0 a	--	--	--	--	--	--
4.	EthylBloc + Buffer + Mertect	(gas) (dip)	1g / 35dm^3 7 ml / 35dm^3 14.2ml	7.85 a	7.62 bcd	7.87 ab	7.66 a	18.3 b	15.0 a	14.1 ab	13.4 ab	7.85 a	8.0 a	--	--	--	--	--	--
5.	EthylBloc	(dip)	9 g	7.68 a	7.49 cd	7.60 b	7.89 a	18.9 b	15.2 a	14.4 ab	13.6 a	7.75 a	8.0 a	--	--	--	--	--	--
6.	EthylBloc + Mertect	(dip)	9 g 14.2ml	7.73 a	7.71 abcd	7.89 ab	7.88 a	18.8 b	15.6 a	14.9 a	13.4 ab	7.80 a	8.0 a	--	--	--	--	--	--
7.	ReTain	(dip)	189.25 g	7.86 a	7.42 d	7.80 ab	7.93 a	16.6 d	13.3 bc	12.9 cd	12.4 cd	7.75 a	8.0 a	--	--	--	--	--	--
8.	ReTain +Mertect	(dip)	189.25 g 14.2ml	7.74 a	7.89 ab	7.98 a	7.73 a	15.8 d	13.9 b	13.6 bc	12.9 bc	7.85 a	8.0 a	--	--	--	--	--	--
9.	ReTain +Mertect + EthylBloc	(dip)	189.25 g 14.2ml 9 g	7.69 a	7.82 abc	7.84 ab	7.86 a	20.7 a	15.3 a	14.4 ab	13.8 a	7.75 a	8.0 a	--	--	--	--	--	--
10.	Cyclanilide	(dip)	142 ml	7.91 a	8.03 a	7.94 ab	7.78 a	14.4 e	12.4 de	12.8 cd	11.9 d	7.80 a	8.0 a	--	--	--	--	--	--
11.	Cyclanilide + Mertect	(dip)	142ml 14.2ml	7.86 a	7.73 abcd	7.70 ab	7.82 a	14.5 e	13.0 cd	12.7 cd	11.9 d	8.00 a	8.0 a	--	--	--	--	--	--
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
1 vs 2	Control vs Mertect			ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	--	--	--	--	--	--
1 vs 3	EthylBloc gas vs none			ns	ns	ns	ns	***	***	***	***	ns	ns	--	--	--	--	--	--
1 vs 4	EthylBloc gas+Mertect dip vs none			ns	ns	ns	ns	***	***	***	***	ns	ns	--	--	--	--	--	--
1 vs 5	EthylBloc dip vs none			ns	ns	ns	ns	***	***	***	***	ns	ns	--	--	--	--	--	--
1 vs 6	EthylBloc dip+Mertect dip vs none			ns	ns	ns	ns	***	***	***	***	ns	ns	--	--	--	--	--	--
1 vs 7	ReTain vs none			ns	ns	ns	ns	**	**	ns	ns	ns	ns	--	--	--	--	--	--
1 vs 8	ReTain+Mertect vs none			ns	ns	ns	ns	**	***	**	ns	ns	ns	--	--	--	--	--	--
1 vs 9	ReTain+Mertect+ EthylBloc dip vs none			ns	ns	ns	ns	***	***	***	***	ns	ns	--	--	--	--	--	--
1 vs 10	Cyclanilide vs none			ns	*	ns	ns	ns	ns	ns	ns	ns	ns	--	--	--	--	--	--
1 vs 11	Cyclanilide+Mertect vs none			ns	ns	ns	ns	ns	**	ns	ns	ns	ns	--	--	--	--	--	--
2 vs 4	EthylBloc gas vs none (Mertect)			ns	ns	ns	ns	***	***	***	**	ns	ns	--	--	--	--	--	--
2 vs 6	EthylBloc dip vs none (Mertect)			ns	ns	ns	ns	***	***	***	**	ns	ns	--	--	--	--	--	--
2 vs 8	ReTain vs none (Mertect)			ns	ns	ns	ns	***	***	*	ns	ns	ns	--	--	--	--	--	--
2 vs 9	ReTain+EthylBloc vs none (Mertect)			ns	ns	ns	ns	***	***	***	***	ns	ns	--	--	--	--	--	--
2 vs 11	Cyclanilide vs none (Mertect)			ns	ns	ns	ns	ns	*	ns	ns	ns	ns	--	--	--	--	--	--
3,4 vs 5,6	EthylBloc gas vs EthylBloc dip			ns	ns	ns	ns	***	ns	*	ns	ns	ns	--	--	--	--	--	--
3 vs 5	EthylBloc gas vs EthylBloc dip (no Mertect)			ns	ns	ns	ns	***	ns	ns	ns	ns	ns	--	--	--	--	--	--
4 vs 6	EthylBloc gas vs EthylBloc dip (Mertect)			ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	--	--	--	--	--	--
6 vs 9	EthylBloc+Mertect dip vs ReTain+Mertect+EthylBloc dip			ns	ns	ns	ns	***	ns	ns	ns	ns	ns	--	--	--	--	--	--
7 vs 9	ReTain dip vs ReTain+Mertect+EthylBloc dip			ns	*	ns	ns	***	***	**	***	ns	ns	--	--	--	--	--	--
8 vs 9	ReTain+Mertect dip vs ReTain+Mertect+EthylBloc dip			ns	ns	ns	ns	***	***	ns	**	ns	ns	--	--	--	--	--	--
2,4,6,8,11 vs 1,3,5,7,10	Mertect vs none			ns	ns	ns	ns	ns	*	ns	ns	ns	ns	--	--	--	--	--	--

^{zy}EthylBloc was applied on Sept 26, 2000, when fruit firmness was 22.5 lbs, starch 3.35, soluble solids 12.9, and background color 2.6.
^{x}Mean separation within columns by Duncan's New Multiple Range Test; (P≤ 0.05).

Table 10D. Influence of EthylBloc and ReTain dips and gasses on 'NuRed Rome 262'/MM.111 apple fruit maturity stored at 35°(2000-01).

No.	Treatment^{zy}	Application method	Rate/3 gallons or g or ml/dm^3	Soluble solids (%) Nov 27	Soluble solids (%) Jan 27	Soluble solids (%) Mar 27	Soluble solids (%) May 27	Color (0-5) Nov 27	Color (0-5) Jan 27	Color (0-5) Mar 27	Color (0-5) May 27
1.	Control (no trt)	none		13.9 a^x	12.6 b	12.7 b	12.0 f	2.70 a	2.90 bc	2.95 bc	3.30 ab
2.	Mertect	dip	14.2ml	13.7 a	13.3 a	13.4 a	13.4 ab	2.25 b	2.75 cd	2.95 bc	2.95 c
3.	EthylBloc + Buffer	(gas)	0.1 g / 35dm^3 7 ml / 35dm^3	13.4 a	13.5 a	13.6 a	13.6 a	2.55 a	2.55 d	2.55 d	2.55 d
4.	EthylBloc + Buffer + Mertect	(gas) (dip)	1g / 35dm^3 7 ml / 35dm^3 14.2ml	13.3 a	13.2 ab	13.4 a	12.8 e	2.75 a	2.85 bc	2.75 cd	3.00 bc
5.	EthylBloc	(dip)	9 g	13.5 a	13.3 a	13.2 a	13.0 de	2.80 a	2.80 cd	2.65 cd	3.15 abc
6.	EthylBloc + Mertect	(dip)	9 g 14.2ml	13.4 a	13.4 a	13.4 a	13.1 cde	2.70 a	2.90 bc	2.85 bcd	3.15 abc
7.	ReTain	(dip)	189.25 g	13.5 a	13.2 ab	13.2 a	13.0 de	2.50 ab	2.90 bc	2.70 cd	3.15 abc
8.	ReTain +Mertect	(dip)	189.25 g 14.2ml	13.3 a	13.3 a	13.4 a	13.2 bcd	2.50 ab	2.85 bc	2.80 bcd	3.40 a
9.	ReTain +Mertect + EthylBloc	(dip)	189.25 g 14.2ml 9 g	13.3 a	13.1 ab	13.3 a	13.1 cde	2.70 a	3.35 a	3.40 a	3.25 abc
10.	Cyclanilide	(dip)	142 ml	13.5 a	13.2 ab	13.4 a	13.4 abc	2.60 a	3.25 a	3.30 a	3.35 a
11.	Cyclanilide + Mertect	(dip)	142ml 14.2ml	13.4 a	13.3 a	13.3 a	13.2 bcd	2.70 a	3.15 ab	3.10 ab	3.00 bc

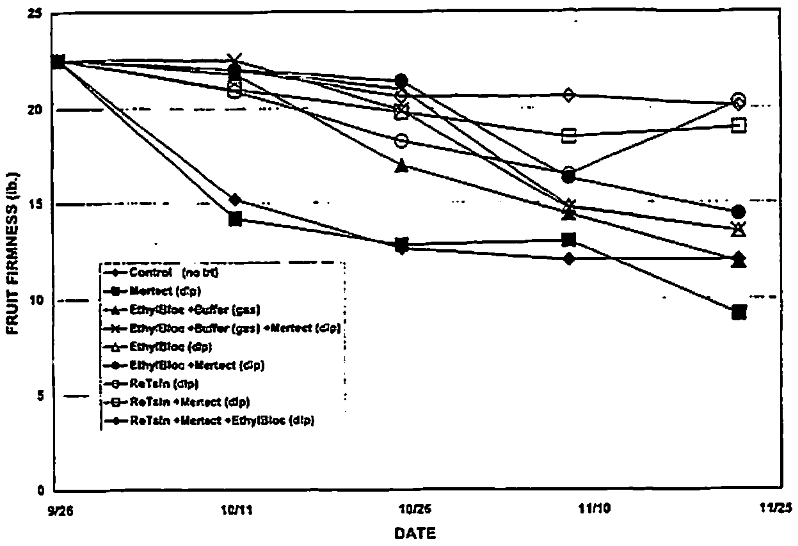
Contrasts	Comparisons	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F
1 vs 2	Control vs Mertect	ns	*	***	***	**	ns	ns	*
1 vs 3	EthylBloc gas vs none	ns	**	***	***	ns	*	**	***
1 vs 4	EthylBloc gas+Mertect dip vs none	*	*	**	***	ns	ns	ns	*
1 vs 5	EthylBloc dip vs none	ns	*	*	***	ns	ns	*	ns
1 vs 6	EthylBloc dip+Mertect dip vs none	ns	**	***	***	ns	ns	ns	ns
1 vs 7	ReTain vs none	ns	*	*	***	ns	ns	ns	ns
1 vs 8	ReTain+Mertect vs none	*	*	**	***	ns	ns	ns	ns
1 vs 9	ReTain+Mertect+ EthylBloc dip vs none	*		**	***	ns	**	**	ns
1 vs 10	Cyclanilide vs none	ns	ns	**	***	ns	*	*	ns
1 vs 11	Cyclanilide+Mertect vs none	ns	ns	**	***	ns	ns	ns	*
2 vs 4	EthylBloc gas vs none (Mertect)	ns	*	ns	***	***	ns	ns	ns
2 vs 6	EthylBloc dip vs none (Mertect)	ns	ns	ns	*	**	ns	ns	ns
2 vs 8	ReTain vs none (Mertect)	ns	ns	ns	ns	ns	ns	ns	**
2 vs 9	ReTain+EthylBloc vs none (Mertect)	ns	ns	ns	*	**	***	**	*
2 vs 11	Cyclanilide vs nono (Mertect)	ns	ns	ns	ns	**	**	ns	ns
3,4 vs 5,6	EthylBloc gas vs EthylBloc dip	ns	ns	ns	ns	ns	ns	ns	***
3 vs 5	EthylBloc gas vs EthylBloc dip	ns	ns	*	***	ns	ns	ns	***
4 vs 6	EthylBloc gas vs EthylBloc dip (Mertect)	ns	ns	ns	ns	ns	ns	ns	ns
6 vs 9	EthylBloc+Mertect dip vs ReTain+Mertect +EthylBloc dip	ns	ns	ns	ns	ns	**	***	ns
7 vs 9	ReTain dip vs ReTain+Mertect+EthylBloc dip	ns	ns	ns	ns	ns	**	***	ns
8 vs 9	ReTain+Mertect dip vs ReTain+Mertect+EthylBloc dip	ns	ns	ns	ns	ns	***	***	ns
2,4,6,8,11 vs 1,3,5,7,10	Mertect vs none	ns	ns	ns	*	ns	ns	ns	ns

ZYSept 26, 2000, when fruit firmness was 22.5 lbs, starch 3.35, soluble solids 12.9, and background color 2.6.

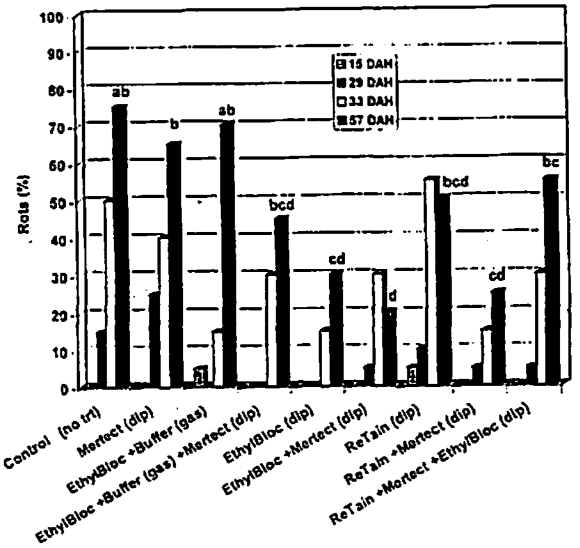
XMean separation within columns by Duncan's New Multiple Range Test; ($P \leq 0.05$).

Byers # 59

Firmness of 'NuRed Rome 262' Apple Fruit Harvested, Dipped, and Stored on Sept 26 at 70F Degrees



'NuRed Rome 262' Apples Harvested, Dipped, and Stored on Sept 26 at 70F Degrees



Firmness of 'NuRed Rome 262' Apple Fruit Harvested, Dipped, and Stored on Sept 26 at 35F Degrees

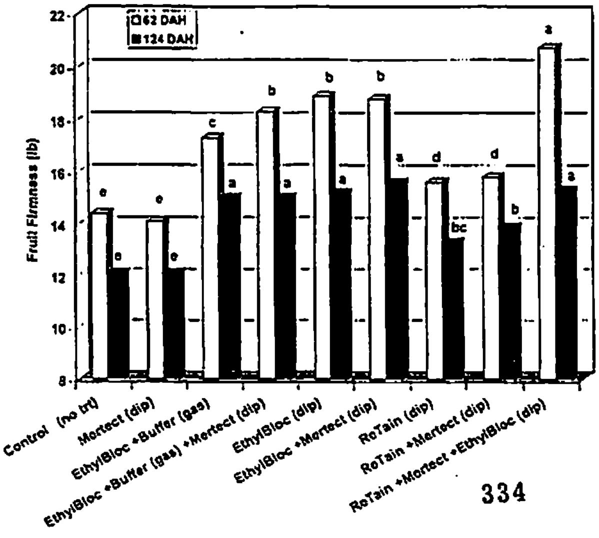


Table 11. Influence of EthylBloc and ReTain dips on 'Sunrise'/MM.111 apple fruit stored at 70° (2001).

No.		Treatment[zy]	Application method	Rate/3 gallons or g or ml/dm^3	Fruit diameter (cm)		Fruit firmness (lb.)		Soluble solids		Starch (1-8 rating)		Color (0-100%)		Rots (%)		Splits (%)		Internal breakdown (%)	
					Aug 23	Sep 2	Aug 23	Sep 2	Aug 23	Sep 2	Aug 23	Sep 2	Aug 23	Sep 2	Aug 23	Sep 2	Aug 23	Sep 2	Aug 23	Sep 2
1.	W	Control (no trt)	none		7.18 a[x]	7.15 a	6.2 c	2.0 c	–	–	8.0 a	8.0 a	78 a	78 a	–	55 a	25 a	95 a	–	100 a
2.	R	Mertect + Captan	dip	14.2ml 13.6 g	7.04 ab	7.29 a	5.8 c	2.3 c	–	–	8.0 a	8.0 a	86 a	75 a	–	40 a	20 a	100 a	–	100 a
3.	FO	EthylBloc + Mertect + Captan	(dip)	9 g 14.2ml 13.6 g	6.92 b	7.06 a	16.0 a	10.9 a	13.2 a	13.6 a	7.9 a	8.0 a	76 a	72 a	–	0 b	0 b	0 b	–	10 c
4.	B	ReTain + Mertect + Captan	(dip)	189.25 g 14.2ml 13.6 g	7.19 a	7.19 a	10.0 b	4.5 b	12.9 a	13.3 a	8.0 a	8.0 a	81 a	75 a	–	0 b	0 b	0 b	–	75 b
5.	BK	ReTain + Mertect + Captan + EthylBloc	(dip)	189.25 g 14.2ml 13.6 g 9 g	7.01 ab	7.06 a	14.9 a	11.9 a	13.1 a	13.5 a	8.0 a	8.0 a	81 a	73 a	–	0 b	0 b	0 b	–	0 c

[zy]Fruit were dipped on Aug 13, 2001, when fruit firmness = 16.4 lbs, starch= 3.4, soluble solids = 12.8, and color = 60%.

[x]Mean separation within columns by Duncan's New Multiple Range Test; ($P \leq 0.05$). 20 fruit sample tested for each date evaluated.

INFLUENCE OF ETHYLBLOC AND RETAIN DIPS ON FRUIT FIRMNESS OF 'SUNRISE'/MM.111 STORED AT 70F (2001)

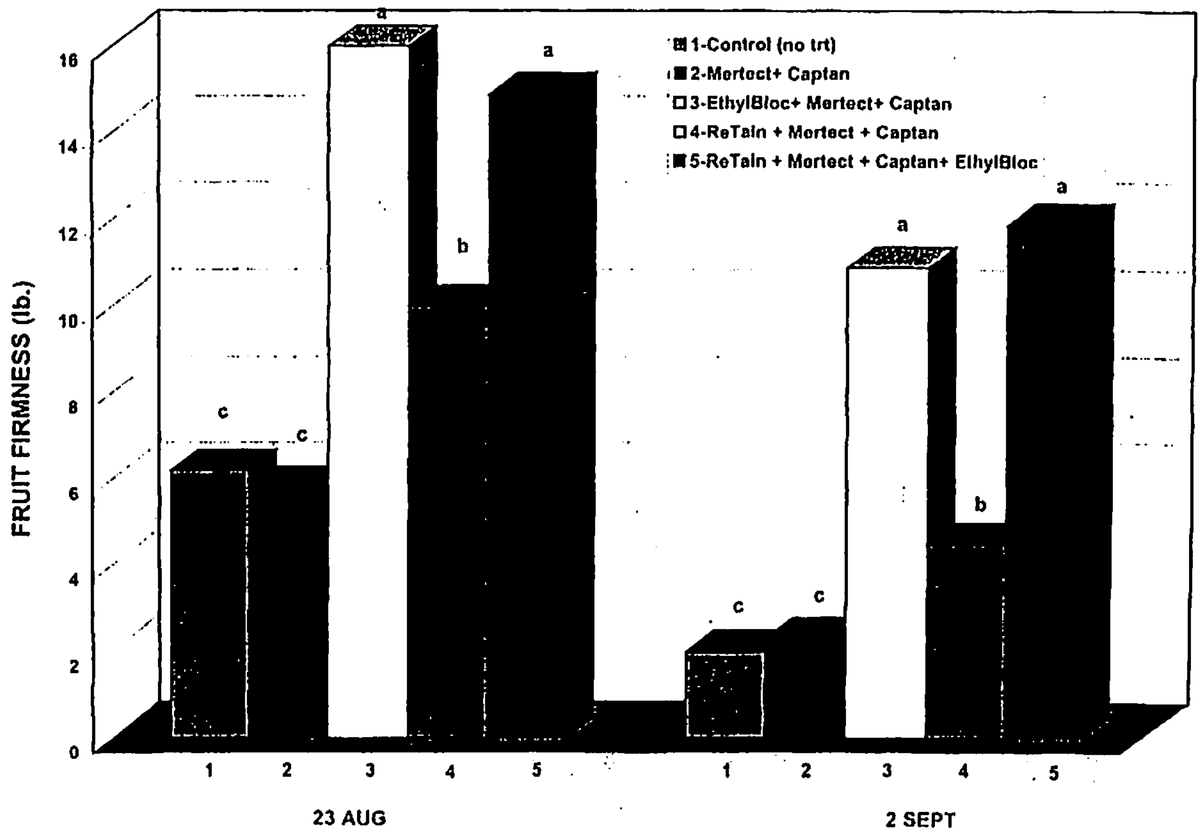


Table 12. Influence of Kinetin sprays on maturtly of 'Cresthaven' peach fruit at harvest (2001).

No.	Color	Treatment[zy]	Rate/ Gallon	Time	Fruit firmness (lb)		Soluble solids		Red color (%)		Background color (0-5)	
					Aug 23	Aug 29	Aug 23	Aug 29	Aug 23	Aug 29	Aug 23	Aug 29
1.	W	Control			14.4 a[x]	6.0 a	9.55 a	10.9 a	78 a	91 a	4.8 a	4.7 a
2.	R	Kinetin +Silwet -77	8.0 ml 1.18 ml	9 August	14.2 a	7.5 a	9.95 a	11.2 a	75 a	87 b	4.8 a	4.3 b
3.	B	Kinetin +Silwet -77	8.0 ml 1.18 ml	16 August	11.2 a	7.0 a	9.80 a	11.0 a	75 a	90 ab	4.9 a	4.5 ab

[zy] Spray treatments were applied with a low pressure hand-gun sprayer.

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

Table 13A. Influence of EthylBloc, ReTain, and Scholar dips on 'Cresthaven' peach fruit stored at 70° (2001).

		Treatment[zy]	Application method	Rate/3 gallons or g or ml/dm^3	Fruit diameter (Inches)			Fruit firmness (lb.)			Soluble solids			Color (%)			Rots (%)		
					Aug 25	Aug 30	Sep 4	Aug 25	Aug 30	Sep 4	Aug 25	Aug 30	Sep 4	Aug 25	Aug 30	Sep 4	Aug 25	Aug 30	Sep 4
1.	W	Control (no trt)	none		2.77 b[x]	2.76 c	2.61 c	3.58 de	1.92 d	1.50 c	10.3 a	9.9 a	9.7 ab	69 b	71 b	77 c	--	--	72 a
2.	R	Scholar	dip	7.1 ml	2.83 ab	2.84 ab	2.81 ab	3.04 e	2.18 d	1.84 c	10.2 a	10.2 a	9.7 ab	74 ab	71 b	80 bc	--	--	0 b
3.	B	EthylBloc + Scholar	(dip)	9 g 7.1 ml	2.85 ab	2.83 ab	2.83 ab	5.08 d	2.18 d	1.70 c	10.0 a	10.0 a	10.1 ab	77 a	81 a	81 abc	--	--	0 b
4.	FO	ReTain + Scholar	(dip)	189.25 g 7.1 ml	2.82 ab	2.82 abc	2.85 a	9.44 c	6.96 c	4.68 b	9.9 a	10.1 a	10.4 a	73 ab	77 ab	82 ab	--	--	0 b
5.	HP	ReTain + Scholar + EthylBloc	(dip)	189.25 g 7.1 ml 9 g	2.81 ab	2.77 bc	2.80 ab	11.30 b	10.68 a	7.32 a	9.5 a	9.8 a	10.1 a	74 ab	77 ab	84 ab	--	--	0 b
6.	OBKS	EthylBloc	(dip)	9 g	2.78 b	2.78 bc	2.77 b	4.02 de	2.50 d	1.92 c	10.1 a	9.8 a	9.3 b	80 a	82 a	85 a	--	--	4 b
7.	PBKS	ReTain	(dip)	189.25 g	2.87 a	2.85 a	2.84 ab	16.12 a	8.36 b	5.26 b	9.6 a	9.7 a	10.2 a	67 b	71 b	84 ab	--	--	0 b

[zy] Fruit were diped on Aug 20, 2001, when fruit diameter = 2.82 in., fruit firmness = 18.2 lbs, soluble solids = 9.9 %, and red color = 35 %.

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

Table 13B. Influence of EthylBloc, ReTain, and Scholar dips on 'Cresthaven' peach fruit stored at 40° (2001).

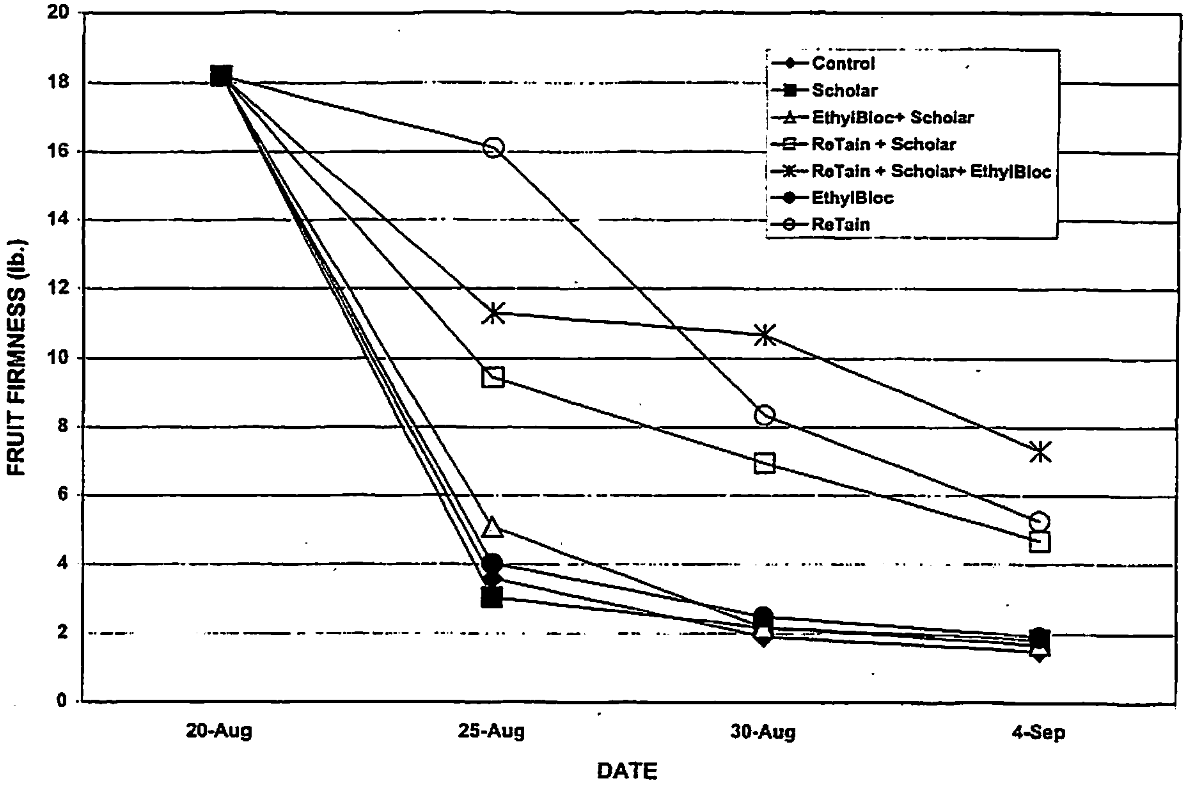
No.		Treatment[zy]	Application method	Rate/3 gallons or g or ml/dm^3	Fruit diameter (Inches)			Fruit firmness (lb.)			Soluble solids			Color (%)			Rots (%)		
					Aug 25	Aug 30	Sep 4	Aug 25	Aug 30	Sep 4	Aug 25	Aug 30	Sep 4	Aug 25	Aug 30	Sep 4	Aug 25	Aug 30	Sep 4
1.	W	Control (no trt)	none		2.83 a[x]	2.84 ab	2.80 a	12.1 b	5.0 c	2.7 c	9.8 a	10.2 a	10.2 ab	71 a	66 a	69 a	--	--	--
2.	R	Scholar	dip	7.1 ml	2.79 a	2.92 a	2.87 a	10.6 bc	5.3 c	3.3 c	9.7 a	10.2 a	10.2 ab	62 ab	60 ab	58 abc	--	--	--
3.	B	EthylBloc + Scholar	(dip)	9 g 7.1 ml	2.80 a	2.85 ab	2.86 a	14.4 a	11.4 a	7.0 a	9.9 a	9.4 b	9.3 b	58 b	66 a	53 c	--	--	--
4.	FO	ReTain + Scholar	(dip)	189.25 g 7.1 ml	2.86 a	2.86 ab	2.83 a	8.7 c	6.1 c	3.3 c	10.1 a	9.9 ab	10.0 ab	62 ab	50 b	57 abc	--	--	--
5.	HP	ReTain + Scholar + EthylBloc	(dip)	189.25 g 7.1 ml 9 g	2.82 a	2.84 ab	2.85 a	11.9 b	8.0 b	4.0 bc	9.6 a	10.0 a	10.4 a	65 ab	66 a	66 ab	--	--	--
6.	OBKS	EthylBloc	(dip)	9 g	2.83 a	2.81 b	2.80 a	15.7 a	12.1 a	5.3 b	10.0 a	9.7 ab	10.1 ab	62 ab	71 a	68 a	--	--	--
7.	PBKS	ReTain	(dip)	189.25 g	2.89 a	2.85 ab	2.86 a	10.7 bc	5.4 c	3.8 bc	9.8 a	9.9 ab	9.8 ab	61 ab	64 a	56 bc	--	--	--

[zy] Fruit were diped on Aug 20, 2001, when fruit diameter = 2.82 in., fruit firmness = 18.2 lbs, soluble solids = 9.9 %, and red color = 35 %.

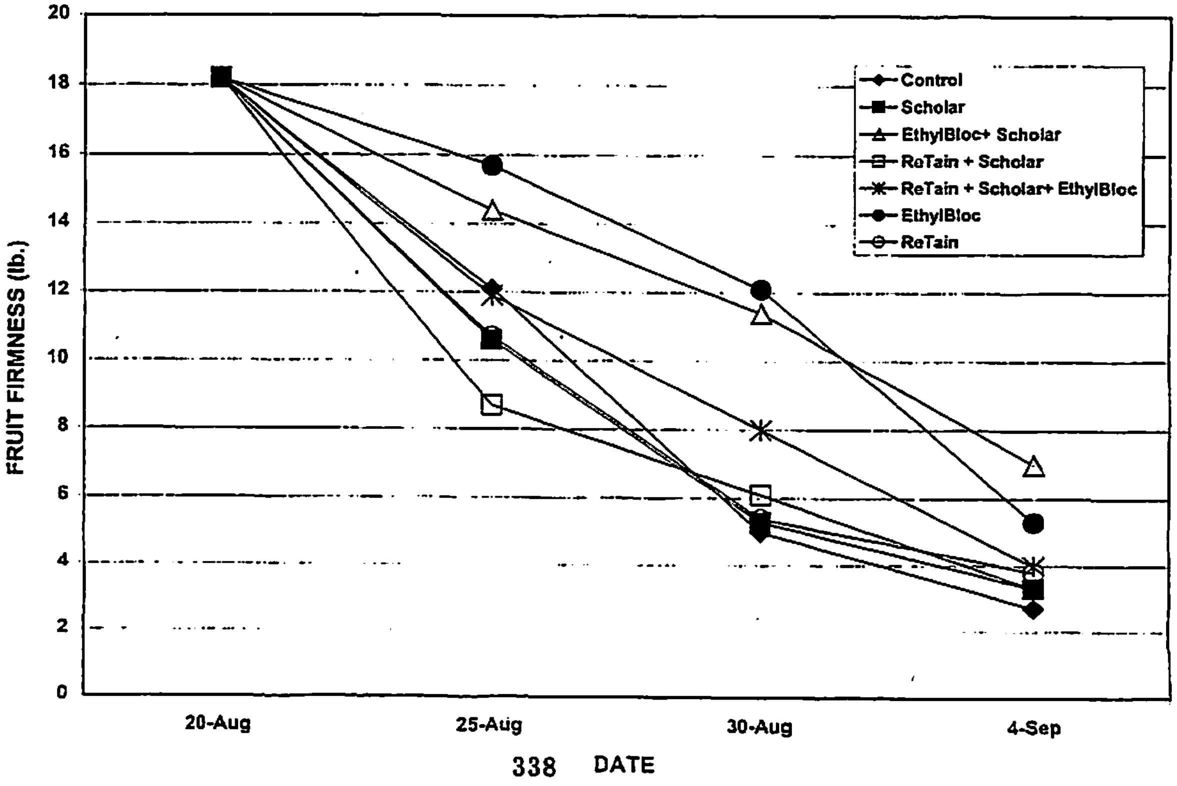
[x] Mean separation within columns by Duncan's New Multiple Range Test; ($P \leq 0.05$).

Byers # 63

INFLUENCE OF ETHYLBLOC, RETAIN, AND SCHOLAR DIPS ON FRUIT FIRMNESS OF 'CRESTHAVEN' PEACHES STORED AT 70F (2001)



INFLUENCE OF ETHYLBLOC, RETAIN, AND SCHOLAR DIPS ON FRUIT FIRMNESS OF 'CRESTHAVEN' PEACHES STORED AT 40F (2001)



(Not for publication or distribution, CSFWC 2001)

Influence of Chemicals, Adjuvants, and Temperature on Apple Fruit Thinning, Fruit Size, Shape, Color, Injuries, and Appearance and Peach Thinning Results in 2001.

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Abstract. When applied to 'Starkrimson Delicious'/MM.106 & MM.111, NAA alone or in combination with 6-BA or Accel caused an undesirable increase in the numbers of small fruit < 25mm on 6 June and decreased the numbers of large fruit > 25 mm when compared to the untreated controls. At harvest on 11 Sept., NAA alone or in combinations with 6-BA (45g/acre) or Accel (45g/acre) increase the numbers of fruit below 2.25 inches and decreased the fruit numbers above 2.50 and 2.75 inches. NAA+Accel+Li-700 increase the total number of fruit/cm^2 limb cross sectional area and NAA+6-BA+Li-700 numerically was greater but was not significantly.

Thinning sprays applied to 'Ace Delicious'/MM.111 trees of 6-BA (90g/acre) + Li-700 or 6-BA (90g/acre) + Oil provided more thinning than Accel (90g/acre) + Li-700 or Accel (90g/acre) + Oil. Oil was a superior adjuvant for thinning with 6-BA and Accel based on single degree of freedom contrasts.

Thinning sprays of ethephon applied at 5 pt/acre to 'Rome'/MM.106 trees when fruit were 13 mm in diameter caused more fruit thinning than at 2.5 pt/acre regardless of water volume. While keeping the chemical rate/acre constant, the water rates of 100 gal/acre or 400gal/acre were equally effective. With the greater fruit thinning of ethephon, the greater was the fruit length and diameter at harvest; however, greater thinning did not affect the L/D ratio.

Thinning sprays of ethephon applied at 8 to 16 pt/acre to 'Fuji'/M.27 and/or its combinations with Sevin, Accel, Oil or Silwet L-77 when fruit were 21.5 mm in diameter did not cause fruit thinning. Apparently 'Fuji' become very resistant to late thinning.

None of the spray treatments caused significant fruit thinning of 'Starkrimson Delicious'/Mark (young) when applied with a hand-wand sprayer to trees on 22 May at 23.5 mm fruit diameter. Over all combinations, Sevin XLR caused more fruit injury than Sevin 50WP, but this difference was small. Sevin XLR caused slightly more fruit injury in lenticles than Sevin 50WP. The addition of Accel or Accel+Oil caused more injury than Sevin alone. Oil did not increase injury to fruit. Sevin + Accel + Oil or Sevin + 6-BA + Oil caused more injury than no treatment. Pigmy fruit development <32 mm on 26 June was increased by Accel more than by 6-BA even when combined with Sevin+Oil. Sevin XLR, Sevin 50WP, or

ethephon did not influence pigmy fruit development. Fruit larger than 32mm was not affected by treatment.

'Starkrimson Delicious'/MM.106 and MM.111 trees having a high percentage of pigmy fruit were sprayed with ethephon + Sevin + Oil to determine if small fruit could be preferentially removed. More small fruit were removed than large fruit. There was a greater percentage of fruit above 2.25 and 2.75 in the sprayed trees.

Accel (90g/acre)+ Silwet L-77 and/or 6-BA (90g/acre)+ Oil applied to 26-year-old 'Golden Delicious'/MM.111 trees caused more pigmy fruit than on the untreated control trees. Accel + Silwet L-77 caused more thinning than the other treatments.

All 6-BA (90g/acre) and Accel (90g/acre) treatments caused fruit thinning of 'York'/MM.111 trees and increased fruit diameter but did not affect the L/D ratio. No pigmy fruit were observed.

None of the Accel treatments caused fruit thinning of 26-year-old 'Empire'/MM.111. trees; but did increase the % of pigmy fruit when compared to the untreated control.

After spraying 3-year-old 'Golden Delicious'/M.27 trees with various chemical thinners (Carbaryl; NAA + Regulaid; Carbaryl + NAA + Regulaid; Accel; 6-BA; or Carbaryl + Accel + Oil) trees exposed to continuous post-treatment darkness for a period of 68 hours at 40°F retained their large (>19mm) fruit better than if held at 70°F. Ethephon treated trees were equally susceptible to post-thinning temperatures of 40°F or 70°F. Trees held at 70°F darkness for 68 hours or outside after digging produced few pigmy fruit; but trees at 40°F for 68 hours in darkness had 5 times more pigmy fruit. Accel and 6-BA also produced a significant number of pigmy fruit at 40°F but at 70°F 6-BA produced fewer pigmy fruit compared to Accel.

'Golden Delicious'/M.27 trees exposed in a growth chamber to continuous darkness for periods of 68 to 140 hours at 40°F retained their large (>24mm) fruit better than if held at 70°F and also retained more pigmy fruit (<24mm); however, trees held for 44 hours at either 40°F or 70°F did not affect the numbers of large and small fruit. Trees held at 70°F darkness for 68 hours or outside after digging produced few pigmy fruit; but trees at 40°F for 68 hours in darkness had 5 times more pigmy fruit. Trees given 21 hours darkness in a growth chamber and 3 hours sun light each 24 hours for a period of 140 hours at either 40°F or 70°F, responded differently. Trees at 40°F retained more large and small fruit than those at 70°F similar to the 140 hours of continuous 40°F and 70°F.

Accel + Sevin + Oil applied to 'Gala'/M.26 or 'Golden Delicious'/M.26 trees with a commercial airblast sprayer caused more fruit thinning than NAA + Sevin + Oil when fruit were about 12 mm in diameter.

At a 9X registration rate, Nova 40 W (45 oz/acre) reduced fruit length, fruit weight and length diameter ratio, but fruit diameter was not affected. No differences were found between the treatments regarding firmness, soluble solids, starch, or red color. When the whole 'Gala' tree's fruit sample was sized and placed into 0.25-inch fruit diameter categories, the highest Nova 40 W rate (45 oz/acre) fruit were smaller than the control as indicated by the percentage of fruit <and> 2.5 inches, <and> 2.75 inches, % fruit 2.00 to 2.25 inches, and % fruit 2.75 to 3.00 inches. No difference in fruit numbers/tree were noticed.

In peaches, two applications of ATS caused over thinning of 'Bisco' trees when sprayed on successive days. A freeze occurred in this area which lowered fruit numbers on both control and ATS sprayed trees. Fruit diameter was increased by 0.8 inches.

In peaches, two applications of ATS caused over thinning of 'Redhaven' trees when sprayed on successive days. Fruit diameter was increased by 0.52 inches.

In peaches, two applications of ATS caused over thinning of 'Cresthaven' trees when sprayed on successive days. Fruit diameter was increased by 0.52 inches.

Chemicals used: Sodium salt of napthalene acetic acid (NAA, Fruitone-N; 901; Pace); 2-chloroethylphosphonic acid (ethephon, Ethrel); 1-naphthy N-methylcarbamate (carbaryl, Sevin 50WP, Sevin XLR); 6-BA (6-benzyladinine); mixture of 6-benzyladinine and gibberellin A_{4+7}(Accel); ATS (60% ammonium thiosulfate; 55% -- ATS Thinset). Procure, Nova

Introduction

The objectives of the experiments reported here were to: 1) investigate hormone-type chemical combinations for apple fruit thinning, 2) observe injuries to fruit and foliage caused by chemical thinners, 3) compare the effectiveness of chemical thinner and adjuvant combinations, 4) determine the influence of temperatures (40°F and 70°F) alone or after chemical thinner application on fruit retention and low light stress, and 5) determine the influence of multiple applications of a pollination/fertilization inhibitor (ATS) on peach flower thinning, fruit set, foliage, and twig injury.

Materials and Methods

Chemicals were applied to whole trees with a Swanson 3-point-hitch airblast sprayer (Durand Wayland, Inc., LaGrange, Georgia; both fans adjusted to one side to double air output) or with a hand wand sprayer, or a low-pressure hand-wand sprayer. Specific information about tree size, spray application dates, chemical and water rates, stage of development, and temperatures are reported in each table. All apple tests were randomized complete block experiments. Trees were selected for uniform flowering at bloom and were blocked according to row and terrain into replicate blocks for the number of treatments listed in each table.

Apple crop density (fruit/cm^2 limb cross sectional area, CD) was determined by counting fruit on 3 pre-selected limbs per tree; or on whole trees (fruit/cm^2 trunk cross sectional area, CD). Three limbs per tree were tagged during the late pink stage; at the point where limbs were tagged, limb circumferences were measured. The number of fruit on each limb were counted 50 to 55 days (following bloom and after unfertilized fruit had dropped). Crop density (CD) on sample limbs was expressed as fruit•cm^2 limb cross-sectional area (LCSA). In the event that all the fruit on a tree were counted, crop density (CD) was expressed as fruit•cm^2 trunk cross-sectional area (TCSA). Past experience has indicated that when using these techniques the desirable crop load is approximately 4 to 6 fruit•cm^2 limb (or trunk) cross-sectional area after thinning (Byers and Lyons 1984, 1985; Byers, et. al. 1985; Byers; Byers and Carbaugh, 1991; Byers, 1997).

In several experiments, a 10 fruit sample was collected from each tree near harvest. Fruit diameter and length, percentage red color, fruit scarring, and/or russet was determined for each sample. Fruit diameter and length was determined by alignment of all 10 fruit on a right angle board for measurement. Percentage red color was visually rated from 0 to 100%. Stem-end and side russet were rated as 0=no russet to 5= severe russet.

Data for apple and peach crop density, fruit diameter, and vegetative injury were analyzed with SAS (SAS Institute, Cary, N. C.), general linear model (GLM procedures) to evaluate the linear and quadratic effects, pre-planned single-degree of freedom contrasts of interest, and/or Duncan's New Multiple Range Test depending upon the experimental design. The experimental designs for all apple experiments were randomized complete block designs (RCBD) and were blocked by location within rows.

Expt. 1. Thirty-six 14-year-old 'Starkrimson Delicious'/MM.106 & MM.111 trees (6 blocks) were selected for 6 treatments (Table 1). Treatments were applied with Swanson 3-point-hitch airblast sprayer at 100 gal/acre on May 8 when fruit were 11 mm in diameter.

Expt. 2. Forty-five 13-year-old 'Ace Delicious'/MM.111 (9 blocks) were selected for 5 treatments (Table 2). Accel or 6-BA were applied in combination with either Oil or Li-700 and compared with an untreated control.). Treatments were applied with Swanson 3-point-hitch airblast sprayer at 100 gal/acre on May 8 when fruit were 11.3 mm in diameter.

Expt. 3 Forty-five 18-year-old 'Law Rome'/MM.106 trees (9 blocks) were used for 5 treatments (Table 3). Ethephon was applied at two chemical rates of 2.5 or 5.0 pt./acre at 100 or 400 gal/acre. Treatments were applied with a Swanson 3-point-hitch airblast sprayer on May 16 when fruit were 13 mm in diameter.

Expt. 4 One hundred 'Fuji'/M.27 trees (10 blocks) were used for 10 treatments (Table 4). Ethephon was applied alone at 8pt/100 gal or 16 pt with either Oil or Silwet L-77, or a combination of Oil + Silwet L-77, and two additional treatments, ethephon + Accel + Sevin + Oil and Sevin + Accel + Oil, were compared for late thinning of Fuji/M.27. Sprays were applied dilute with a low pressure hand-wand sprayer on 24 May when fruit were 21.5 mm.

Expt. 5. One-hundred-twelve 10-year-old 'Starkrimson Delicious'/Mark trees (8 blocks) were selected for 14 treatments (Table 5). Sevin XLR Plus or Sevin 50WP and were compared alone or in combination with Accel, 6-BA, Oil, Silwet L-77 in selected combinations to ethephon and untreated controls. Sprays were applied dilute with a low pressure hand-wand sprayer on May 22 when fruit were 23.5 mm in diameter.

Expt. 6. Sixteen 14-year-old 'Starkrimson Delicious'/MM.106 & MM.111 trees (8 blocks) were selected for 2 treatments (Table 6) after Expt. 1. Since certain treatments in Expt. 1 caused a high percentage of pigmy fruit, trees having pigmy fruit were randomized and replicated and sprayed with ethephon + Sevin + Oil to determine if small fruit could be preferentially removed. Treatments were applied with Swanson 3-point-hitch airblast sprayer at 100 gal/acre on 6 June when fruit were 26 mm in diameter. Catch frames were placed under heavy limbs to determine the numbers of large and small fruit that dropped.

Expt. 7. Forty-five 26-year-old 'Golden Delicious'/MM.111. trees (9 blocks) were used for 5 treatments (Table 7). 6-BA was applied alone or with Li-700 or Oil and were compared with Accel +Silwet L-77 or an untreated control. Sprays were applied with a Swanson 3-point-hitch airblast sprayer at 100 gal/acre on 11 May when fruit were 11.3 mm in diameter.

Expt. 8. Thirty 26-year-old 'York'/MM.111. trees (6 blocks) were used for 5 treatments (Table 8). 6-BA was applied alone or with Li-700 or Oil and were compared with Accel + Silwet L-77 or an untreated control. Sprays were applied with a Swanson 3-point-hitch airblast sprayer at 100 gal/acre on 11 May when fruit were 11.7 mm in diameter.

Expt. 9. Forty-five 26-year-old 'Empire'/MM.111. trees (6 blocks) were used for 4 treatments (Table 9). Accel was applied alone or with Oil, Li-700 , or Silwet L-77 and were compared with an untreated control. Sprays were applied with a Swanson 3-point-hitch airblast sprayer at 100 gal/acre on 11 May when fruit were 11.3 mm in diameter.

Expt. 10. In 1999, one-hundred-eight 3-year-old 'Golden Delicious'/M.27 trees were dug from the field and placed in 25 cm diameter root bags (Root Control , Inc. Oklahoma City, OK) in the dormant season. Tree were planted in root bags to reduce transplanting shock in future experiments. In 2001, when the larger fruit were about 12.4 mm fruit diameter (three days prior to moving trees into growth chambers) trees were dug and placed in 19-L plastic buckets (Table 10). Trees were blocked by crop load into six groups of 18 trees. The 18 trees within in each block were assigned to the following treatments:1) Control—trees were undisturbed and remained in the field in root bags, 2) Control—trees were dug and remained in buckets and placed outside during normal light and dark periods, 3-16) trees were moved into growth chambers held in the darkness for 68 hours at either 40°F or 70°F (from 1 pm to 8 am 3 days later); in addition, trees were sprayed at 10 am on 11 May (12.4 mm fruit diameter) with: 3-4) No spray treatment; 5-6) Carbaryl; 7-8) NAA (10mg/L) + Regulaid (0.125%); 9-10); Carbaryl + NAA (10mg/L) + Regulaid (0.125%); 11-12) Ethrel; 13-14) Accel; 15-16) 6-BA; 17-18) Carbaryl + Accel + Oil. Fruit numbers/tree were not counted before spraying and placement into the growth chambers, May 11. Immediately after 40°F or 70°F treatment, trees were returned to the field on May 14, where they were placed in their original holes and watered. After fruit abscission, all fruit were counted and sized on each tree on May 31.

Expt. 11. In 1999, seventy 3-year-old 'Golden Delicious'/M.27 trees were dug from the field and placed in 25 cm diameter root bags (Root Control , Inc. Oklahoma City, OK) in the dormant season. Tree were planted in root bags to reduce transplanting shock in future experiments. In 2001, when the larger fruit were about 15 mm fruit diameter (three days prior to moving trees into growth chambers) trees were dug and placed in 19-L plastic buckets (Table 11). Trees were blocked by crop load into five groups of 14 trees. The 14 trees within each block were assigned to the following treatments: 1) Control—trees were undisturbed and remained in the field in root bags, 2) Control—trees were dug and remained in buckets and placed outside during normal light and dark periods, 3-13) trees were moved into growth chambers held in the darkness for 44, 68, 92, 116, or 140 hours at either 40°F or 70°F (from 1 pm to 8 am); in addition, 5 trees each were moved from either a 40°F or and 70°F room into 21 hours darkness to 3 hours sun light each 24 hours for a period of 140 hours (which was a total of 125 hours dark and 15 hours sun light) . Fruit numbers/tree were counted before placement into the growth chambers, May 18. Immediately after 40°F or 70°F treatment, trees were returned to the field on May 18 to May 22, where they were placed in their original holes and watered. After fruit abscission, all fruit were counted and sized on each tree on 6 June.

Expt. 12. In 2001, NAA + Sevin + Oil or Accel + Sevin + Oil was applied to 'Golden Delicious'/M.26 trees in adjacent rows with a commercial airblast sprayer with border rows sprayed between treatments about 20 days AFB when fruit were about 12 mm in diameter (Table 12). Fruit were counted on 29 May after a severe hail storm. Trees were defruited with a chemical thinner shortly thereafter due to the reduced fruit quality.

Expt. 13. In 2001, NAA + Sevin + Oil or Accel + Sevin + Oil was applied to 'Gala'/M.26 trees in adjacent rows with a commercial airblast sprayer with border rows sprayed between treatments about 20 days AFB when fruit were about 12 mm in diameter (Table 13). Fruit were counted on 29 May after a severe hail storm. Trees were defruited shortly thereafter due to the reduced fruit quality.

Expt. 14. In 2001, the sterol inhibiting fungicides, Procure 50 W or Nova 40 W, were applied to 'Gala'/M.27 trees at the 0, 1X, 3X, and 9X the registered chemical rates (Table 14). A 10 fruit maturity sample was obtained on 28 Aug from each tree. Fruit length, diameter, firmness, soluble solids, starch, red color and fruit weight were obtained. The remaining fruit on each tree were counted, fruit diameter and length obtained, rated for red color, and placed into 0.25-inch fruit diameter categories.

Expt. 15. In 2001, a block of 9-year-old 'Bisco' peach trees, 3 rows wide and 32 trees long, were used for 2 treatments (Table15). (This experiment was not a RCBD). Three interior trees per treatment were monitored for fruit set. The 96 trees were divided into 4-8 tree sections 3 rows wide. The spray treatments consisted of ATS (Table 12) applied in two applications on 12 April and 13 April after approximately 30% and 85% of the flowers had opened and a non-sprayed control. The number of fruit on each tree was counted on 29 May and expressed as fruit/cm2 limb cross sectional area. Ten fruit were harvested from each tree on 20 Aug and fruit diameter was recorded.

Expt. 16. In 2001, a block of 9-year-old 'Redhaven' peach trees, 3 rows wide and 32 trees long, were used for 4 treatments (Table16). (This experiment was not a RCBD). Three interior trees per treatment were monitored for fruit set. The 96 trees were divided into 4-8 tree sections 3 rows wide. The spray treatments consisted of ATS (Table 12) applied two applications on 12 April and 13 April after approximately 30% and 85% of the flowers had opened and a non-sprayed control. The number of fruit on each tree was counted on 29 May and expressed as fruit/cm^2 limb cross sectional area. Ten fruit were harvested from each tree on 20 Aug and fruit diameter was recorded.

Expt. 17. In 2001, a block of 9-year-old 'Cresthaven' peach trees, 3 rows wide and 32 trees long, were used for 4 treatments (Table17). (This experiment was not a RCBD). Three interior trees per treatment were monitored for fruit set. The 96 trees were divided into 4-8 tree sections 3 rows wide. The spray treatments consisted of ATS (Table 12) applied two applications on 12 April and 13 April after approximately 30% and 85% of the flowers had opened and a non-sprayed control. The number of fruit on each tree was counted on 29 May and expressed as fruit/cm^2 limb cross sectional area. Ten fruit were harvested from each tree on 20 Aug and fruit diameter was recorded.

Results and Discussion

Expt. 1. In 2001, sprays on 13-year-old 'Starkrimson Delicious'/MM.106 & MM.111 of NAA alone or in combination with 6-BA or Accel caused an increase in the numbers of small fruit < 25mm on 6 June and decreased the numbers of large fruit > 25 mm on 6 June when compared to the untreated control, 6-BA (90g/acre) + Li-700, or Accel (90g/acre) + Li-700 (Table 1). At harvest on 11 Sept., NAA alone or in combinations with 6-BA (45g/acre) or Accel (45g/acre) increase the numbers of fruit below 2.25 inches and decreased the fruit numbers above 2.50 and 2.75 inches. NAA+Accel+Li-700 increase the total number of fruit/cm^2 limb cross sectional area and NAA+6-BA+Li-700 numerically was greater but was not significantly..

Expt. 2. In 2001, sprays on 14-year-old .'Ace Delicious'/MM.111 trees 6-BA (90g/acre) + Li-700 or Oil provided more thinning than Accel (90g/acre) + Li-700 or Oil (Table 2). Oil was a superior adjuvant for thinning with 6-BA and Accel based on single degree of freedom contrasts.

Expt. 3. In 2001, ethephon applied at 5 pt/acre to 'Rome'/MM.106 when fruit were 13 mm in diameter caused more fruit thinning than at 2.5 pt/acre regardless of water volume (Table 3). While keeping the chemical rate/acre constant, the water rates of 100 gal/acre or 400gal/acre were equally effective. The greater fruit thinning with ethephon the greater was the fruit length and diameter at harvest; however, greater thinning did not affect the L/D ratio.

Expt. 4. In 2001, ethephon and/or its combinations with Sevin, Accel, Oil or Silwet L-77 were applied to 'Fuji'/M.27 at 16 pt/acre when fruit were 21.5 mm in diameter did not cause fruit thinning (Table 4). Apparently 'Fuji' are very resistant to late thinning.

Expt. 5. In 2001, None of the treatments caused significant fruit thinning of 'Starkrimson Delicious'/Mark (young) when applied with a hand-wand sprayer to trees on 22 May at 23.5 mm fruit diameter (Table 5). Over all combinations, Sevin XLR caused more fruit injury than Sevin 50WP, but this difference was small. Sevin XLR caused slightly more fruit injury in lenticles than Sevin 50WP. The addition of Accel or Accel+Oil caused more injury than Sevin alone. Oil did not increase injury to fruit. Sevin + Accel + Oil or Sevin + 6-BA + Oil caused more injury than no treatment (trt#1). Pigmy fruit development <32 mm on 26 June was increased by Accel more than by 6-BA even when combined with Sevin+Oil. Sevin XLR, Sevin 50WP, or ethephon did not influence pigmy fruit development. Fruit larger than 32 mm was not affected by treatment.

Expt. 6. In 2001 certain treatments in Expt. 1 caused a high percentage of pigmy fruit, trees having pigmy fruit were randomized and replicated and sprayed with ethephon + Sevin + Oil to determine if small fruit could be preferentially removed. Treatments were applied airblast sprayer at 100 gal/acre on 6 June when fruit were 26 mm in diameter. More small fruit were removed than large fruit. However, proportion of large and small fruit at the beginning of the experiment were not known. There was a greater percentage of fruit above 2.25 and 2.75 in the sprayed trees.

Expt. 7. Accel (90g/acre)+ Silwet L-77 and/or 6-BA (90g/acre)+ Oil applied to 26-year-old 'Golden Delicious'/MM.111 trees caused more pigmy fruit than on the untreated control. Accel + Silwet L-77 caused more thinning than the other treatments.

Expt. 8. All 6-BA (90g/acre) and Accel (90g/acre) treatments caused fruit thinning of 'York'/MM.111 trees and increased fruit diameter but did not affect the L/D ratio. No pigmy fruit were observed.

Expt. 9. None of the Accel treatments caused fruit thinning of 26-year-old 'Empire'/MM.111 trees; but did increase the % of pigmy fruit when compared to the untreated control.

Expt. 10. After spraying 3-year-old 'Golden Delicious'/M.27 trees with various chemical thinners (Carbaryl; NAA + Regulaid; Carbaryl + NAA + Regulaid; Accel; 6-BA; or Carbaryl + Accel + Oil) trees exposed to continuous post-treatment darkness for a period of 68 hours at 40°F retained their large (>19mm) fruit better than if held at 70°F. Ethephon treated trees were equally susceptible to post-thinning temperatures of 40°F or 70°F.

Trees held at 70°F darkness (trt#4) for 68 hours or outside (trt#2) after digging produced few pigmy fruit; but trees at 40°F for 68 hours in darkness (trt#3) had 5 times more pigmy fruit. Accel and 6-BA also produced a significant number of pigmy fruit at 40°F but at 70°F 6-BA produced fewer pigmy fruit compared to Accel.

Expt. 11.'Golden Delicious'/M.27 trees exposed in a growth chamber to continuous darkness for periods of 68 to 140 hours at 40°F retained their large (>24mm) fruit better than if held at 70°F and also retained more pigmy fruit (<24mm); however, trees held for 44 hours at either 40°F or 70°F did not affect the numbers of large and small fruit.

Trees held at 70°F darkness (trt#6) for 68 hours or outside (trt#2) after digging produced few pigmy fruit; but trees at 40°F for 68 hours in darkness (trt#5) had 5 times more pigmy fruit. Trees given 21 hours darkness in a growth chamber and 3 hours sun light each 24 hours for a period of 140 hours at either 40°F or 70°F, responded differently. Trees at 40°F retained more large and small fruit than those at 70°F similar to the 140 hours of continuous 40°F and 70°F.

Expt. 12. Accel + Sevin + Oil applied to 'Golden Delicious'/M.26 trees with a commercial airblast sprayer caused more fruit thinning than NAA + Sevin + Oil when fruit were about 12 mm in diameter.

Expt. 13. Accel + Sevin + Oil applied to 'Gala'/M.26 trees with a commercial airblast sprayer caused more fruit thinning than NAA + Sevin + Oil when fruit were about 12 mm in diameter.

Expt. 14. In a 10 fruit sample from each tree the highest Nova 40 W rate (45 oz/acre) reduced the fruit length and weight (Table 14A, trt#7), but did not influence fruit diameter (Table 14A). At all chemical rates (1X, 3X, and 9X), Nova reduce the L/D ratio (Table 14A).

No differences were found between the treatments regarding firmness, soluble solids, starch, or red color in the 10 fruit maturity sample.

When the whole tree's fruit sample (which included the 10 fruit sample) was sized and placed into 0.25-inch fruit diameter categories, the highest Nova 40 W rate (45 oz/acre)fruit were smaller than the control as indicated by the percentage of fruit <and> 2.5 inches, <and> 2.75 inches, % fruit 2.00 to 2.25 inches, and % fruit 2.75 to 3.00 inches (Table 14 B). No difference in fruit numbers/tree were noticed.

In the whole tree's fruit sample, fruit length, fruit weight and length diameter ratio was reduced by the highest Nova 40 W rate (45 oz/acre), but fruit diameter was not affected (Table 14 C).

Expt. 15. Two applications of ATS caused over thinning of 'Bisco' trees when sprayed on successive days. A freeze occurred in this area which lowered fruit numbers on both control and ATS sprayed trees. Fruit diameter was increased by 0.8 inches.

Expt. 16. Two applications of ATS caused over thinning of 'Redhaven' trees when sprayed on successive days. Fruit diameter was increased by 0.52 inches.

Expt. 17. Two applications of ATS caused over thinning of 'Cresthaven' trees when sprayed on successive days. Fruit diameter was increased by 0.52 inches.

Expected Significance to the Apple Industry

When applied to 'Starkrimson Delicious'/MM.106 & MM.111, NAA alone or in combination with 6-BA or Accel caused an undesirable increase in the numbers of small fruit < 25 mm on 6 June and decreased the numbers of large fruit > 25 mm when compared to the untreated controls. At harvest on 11 Sept., NAA alone or in combinations with 6-BA (45g/acre) or Accel (45g/acre) increase the numbers of fruit below 2.25 inches and decreased the fruit numbers above 2.50 and 2.75 inches. NAA+Accel+Li-700 increase the total number of fruit/cm^2 limb cross sectional area and NAA+6-BA+Li-700 numerically was greater but was not significantly. Obviously, these combinations of materials should be commercially avoided.

'Starkrimson Delicious'/MM.106 and MM.111 trees having a high percentage of pigmy fruit were sprayed with ethephon + Sevin + Oil to determine if small fruit could be preferentially removed. More small fruit were removed than large fruit. There was a greater percentage of fruit above 2.25 and 2.75 in the sprayed trees.

Thinning sprays applied to 14-year-old 'Ace Delicious'/MM.111 trees of 6-BA (90g/acre) + Li-700 or 6-BA (90g/acre) + Oil provided more thinning than Accel (90g/acre) + Li-700 or Accel (90g/acre) + Oil. Oil was a superior adjuvant for thinning with 6-BA and/or Accel based on single degree of freedom contrasts.

Accel (90g/acre)+ Silwet L-77 and/or 6-BA (90g/acre)+ Oil applied to 26-year-old 'Golden Delicious'/MM.111 trees caused more pigmy fruit than on the untreated control trees. Accel + Silwet L-77 caused more thinning than the other treatments.

Thinning sprays of ethephon applied at 5 pt/acre to 'Rome'/MM.106 trees when fruit were 13 mm in diameter caused more fruit thinning than at 2.5 pt/acre regardless of water volume. While keeping the chemical rate/acre constant, the water rates of 100 gal/acre or 400gal/acre were equally effective. With the greater fruit thinning of ethephon, the greater was the fruit length and diameter at harvest; however, greater thinning did not affect the L/D ratio.

Thinning sprays of ethephon applied at 8 to 16 pt/acre to 'Fuji'/M.9 and/or its combinations with Sevin, Accel, Oil or Silwet L-77 when fruit were 21.5 mm in diameter did not cause fruit thinning. Apparently 'Fuji' become very resistant to late thinning.

None of the spray treatments caused significant fruit thinning of 'Starkrimson Delicious'/Mark (young) when applied with a hand-wand sprayer to trees on 22 May at 23.5 mm fruit diameter. Over all combinations, Sevin XLR caused more fruit injury than Sevin 50WP, but this difference was small. Sevin XLR caused slightly more fruit injury in lenticles than Sevin 50WP. The addition of Accel or Accel+Oil caused more injury than Sevin alone. Oil did not increase injury to fruit. Sevin + Accel + Oil or Sevin + 6-BA + Oil caused more injury than no treatment. Pigmy fruit development <32 mm on 26 June was increased by Accel more than by 6-BA even when combined with Sevin+Oil. Sevin XLR, Sevin 50WP, or ethephon did not influence pigmy fruit development. Fruit larger than 32 mm was not affected by treatment.

All 6-BA (90g/acre) and Accel (90g/acre) treatments caused fruit thinning of 'York'/M111 trees and increased fruit diameter but did not affect the L/D ratio. No pigmy fruit were observed.

None of the Accel treatments caused fruit thinning of 26-year-old 'Empire'/MM.111. trees; but did increase the % of pigmy fruit when compared to the untreated control.

After spraying 3-year-old 'Golden Delicious'/M.27 trees with various chemical thinners (Carbaryl; NAA + Regulaid; Carbaryl + NAA + Regulaid; Accel; 6-BA; or Carbaryl + Accel + Oil) trees exposed to continuous post-treatment darkness for a period of 68 hours at 40°F retained their large (>19mm) fruit better than if held at 70°F. Ethephon treated trees were equally susceptible to post-thinning temperatures of 40°F or 70°F. Trees held at 70°F darkness for 68 hours or outside after digging produced few pigmy fruit; but trees at 40°F for 68 hours in darkness had 5 times more pigmy fruit. Accel and 6-BA also produced a significant number of pigmy fruit at 40°F but at 70°F 6-BA produced fewer pigmy fruit compared to Accel.

'Golden Delicious'/M.27 trees exposed in a growth chamber to continuous darkness for periods of 68 to 140 hours at 40°F retained their large (>24mm) fruit better than if held at 70°F and also retained more pigmy fruit (<24mm); however, trees held for 44 hours at either 40°F or 70°F did not affect the numbers of large and small fruit. Trees held at 70°F darkness for 68 hours or outside after digging produced few pigmy fruit; but trees at 40°F for 68 hours in darkness had 5 times more pigmy fruit. Trees given 21 hours darkness in a growth chamber and 3 hours sun light each 24 hours for a period of 140 hours at either 40°F or 70°F, responded differently. Trees at 40°F retained more large and small fruit than those at 70°F similar to the 140 hours of continuous 40°F and 70°F.

Accel + Sevin + Oil applied to 'Gala'/M.26 or 'Golden Delicious'/M.26 trees with a commercial airblast sprayer caused more fruit thinning than NAA + Sevin + Oil when fruit were about 12 mm in diameter.

At a 9X registration rate, Nova 40 W (45 oz/acre) reduced fruit length, fruit weight and length diameter ratio, but fruit diameter was not affected. No differences were found between the treatments regarding firmness, soluble solids, starch, or red color. When the whole 'Gala' tree's fruit sample was sized and placed into 0.25-inch fruit diameter categories, the highest Nova 40 W rate (45.oz/acre) fruit were smaller than the control as indicated by the percentage of fruit <and> 2.5 inches, <and> 2.75 inches, % fruit 2.00 to 2.25 inches, and % fruit 2.75 to 3.00 inches. No difference in fruit numbers/tree were noticed.

In peaches, two applications of ATS caused over thinning of 'Bisco' trees when sprayed on successive days. A freeze occurred in this area which lowered fruit numbers on both control and ATS sprayed trees. Fruit diameter was increased by 0.8 inches.

In peaches, two applications of ATS caused over thinning of 'Redhaven' trees when sprayed on successive days. Fruit diameter was increased by 0.52 inches.

In peaches, two applications of ATS caused over thinning of 'Cresthaven' trees when sprayed on successive days. Fruit diameter was increased by 0.52 inches.

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Table 1. Influence of plant growth regulators on fruit thinning of 'Starkrimson Delicious'/MM.106 & MM.111 (2001).

No.	Color	Treatment[zy]	Rate/acre /100 gal	Rate/ gal	Fruit/cm^2 limb cross sectional area (4 Jun 01)	Fruit size (mm) (40 fruit sample) (6 Jun 01)	Fruit weight (g) (40 fruit sample) (6 Jun 01)	Pigmy fruit (%) (40 fruit sample) (< 25mm) (6 Jun 01)	Large fruit (%) (40 fruit sample) (> 25mm) (6 Jun 01)	Cropload visual estimate (%) (15 Aug 01)	Fruit diameter (cm) (11 Sep 01)	Fruit length (cm) (11 Sep 01)	Length/ diameter ratio (11 Sep 01)	Categories by fruit diameter (%) (11 Sep 01)		
														<2.25 in.	>2.25 in.	>2.75 in.
1.	W	Control			5.61 bc[x]	32.0 a	17.0 a	0.0 b	100.0 a	159 bc	6.99 ab	6.50 ab	0.930 a	6 c	94 a	32 ab
2.	R	NAA (Fruitone-N)	549.6g		6.87 abc	25.3 c	10.3 b	48.8 a	51.2 b	193 ab	7.01 ab	6.71 ab	0.958 a	53 b	47 b	14 bcd
		(7.5ppm, 3X=22.5 ppm)														
		+ LI-700	473 ml													
3.	B	6-BA 90g/acre	4732 ml		4.30 c	31.7 a	16.7 a	10.8 b	89.2 a	101 c	7.23 a	6.78 a	0.938 a	13 c	87 a	47 a
		+ LI-700	1 pt (473 ml)													
4.	FO	Accel 90g/acre	4732 ml		6.68 bc	29.0 b	14.0 a	18.3 b	81.7 a	175 b	7.05 ab	6.67 ab	0.947 a	16 c	84 a	24 bc
		+ LI-700	1 pt (473 ml)													
5.	HP	NAA (Fruitone-N)	549.6g		8.44 ab	24.2 c	9.0 b	64,2 a	35.8 b	206 ab	6.87 b	6.51 ab	0.948 a	77 a	23 c	8 cd
		(7.5ppm, 3X=22.5 ppm)														
		6-BA 45g/acre	2,366ml													
		+ LI-700	1 pt (473 ml)													
6.	PUR	NAA (Fruitone-N)	549.6g		9.78 a	24.5 c	9.1 b	54.6 a	45.4 b	250 a	6.84 b	6.45 b	0.943 a	75 a	25 c	2 d
		(7.5ppm, 3X=22.5 ppm)														
		Accel 45g/acre	2,366ml													
		+ LI-700	1 pt (473 ml)													
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
2 vs 6		Accel vs none (NAA+LI-700)			*	ns	ns	ns	ns	ns	ns	ns	ns	*	*	ns
2 vs 5		6-BA vs none (NAA+LI-700)			ns	ns	ns	ns	ns	ns	ns	ns	ns	**	**	ns
5 vs 6		6-BA vs Accel			ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
3 vs 4		6-BA vs Accel			ns	*	ns	ns	ns	*	ns	ns	ns	ns	ns	ns
3,5 vs 4,6		6-BA vs Accel (NAA+LI-700 and none)			ns	ns	ns	ns	ns	*	ns	ns	ns	ns	ns	ns

[z] Full bloom occurred April 22, (90% open); petal fall (April 30,).

[y] Treatments were applied May 8 (10.85mm). On June 6 fruit 20.4mm in diameter were turning red and dropping. Those may have been related to both the chemical treatment and cloudy weather. The average daytime high temperatures for the 2 day period after application was 72°F, 78°F, and the night time low was 60°F, 59°F. Treatments were applied with an airblast sprayer at 100 gal water/A. Airblast sprayer was calibrated for trees spaced 20 ft between rows, 13 ft tree width, and 15 ft tree height which was equivalent to 75% TRV.

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

INFLUENCE OF PLANT GROWTH REGULATORS ON FRUIT THINNING OF 'STARKRIMSON DELICIOUS'/MM.106 & MM.111

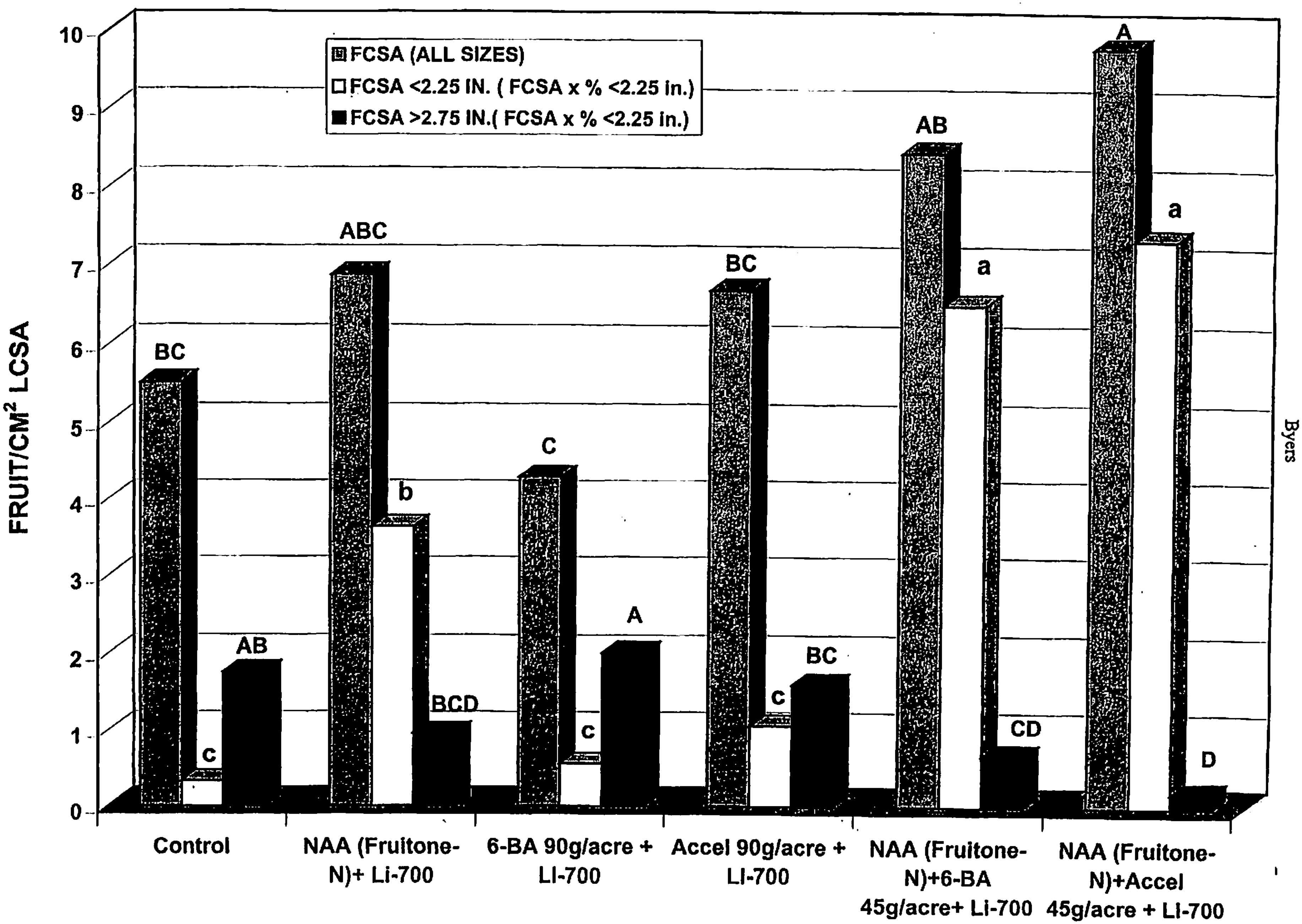

Table 2. Influence of plant growth regulators on fruit thinning of 'Ace Delicious'/MM.111 (2001).

No.	Color	Treatment[z,y]	Rate/acre /100 gal	Rate/ gal	Spray Timing PF to 12 mm	Visual spurs flowering (0-100%) (23 Apr 01)	Fruit/cm2 limb cross sectional area (7 Jun 01)	Estimated visual cropload (%) (Aug 15)	Fruit diameter (cm) (Aug 30)	Fruit length (cm) (Aug 30)	Length/ diameter ratio (Aug 30)
1.	W	Control			--	90 a[x]	6.15 b	176 a	7.43 ab	7.06 b	0.950 b
2.	OBKS	6-BA 90g/acre + LI-700	4732 ml 1 pt (473)			89 a	5.12 b	150 ab	7.60 a	7.38 a	0.971 ab
3.	PBKS	Accel 90g/acre + LI-700	4732 ml 1 pt (473)			87 a	7.72 a	177 a	7.39 b	7.21 ab	0.976 a
4.	OD	6-BA 90g/acre + Oil	4732 ml 1 pt (473)			91 a	4.53 b	134 b	7.45 ab	7.22 ab	0.969 ab
5.	BD	Accel 90g/acre + Oil	4732 ml 1 pt (473)			81 a	5.51 b	161 ab	7.40 ab	7.29 a	0.986 a
Contrasts		Comparisons				Pr>F	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F
1 vs 2,3,4,5		Control vs All treatments				ns	ns	ns	ns	*	**
2,3 vs 4,5		LI-700 vs Oil				ns	*	ns	ns	ns	ns
2,4 vs 3,5		6-BA (Oil or LI-700) vs Accel (Oil or LI-700)				ns	**	*	*	ns	ns

[z] Full bloom occurred Apr 23, 2001 (90% open); petal fall (May 1, 2001).

[y] Treatments were applied May 8, 2001 (11.3 mm) with an airblast sprayer that was calibrated for trees spaced 20 ft between rows, 10 ft tree wideth, and 14 ft tree height which was equivalent to 50% TRV. The average daytime high temperatures for the 2 day period after application was 72°F, 78°F and the night time low was 60°F, 58°F. Treatments were applied at 100 gal water/A.

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

Table 3. Effect of ethephon on fruit thinning of 'Rome' /MM.106 (Early Application) (2001).

No.	Color	Treatment[z,y]	Water volume /acre	Chemical Rate/ acre	Rate/ 100 gal	Bloom rating (0-100%) (27 April)	Fruit/cm2 cross sectional area limb (5 June)	Visual crop load estimate (%) (29 June)	Fruit diameter (cm) (24 Sept)	Fruit length (cm) (24 Sept)	Length/ diameter ratio (cm) (24 Sept)
1.	W					99.4 a[x]	12.9 a	151 a	6.59 d	5.66 d	0.858 a
2.	R	ethephon	100	2.5 pt	1182.5	99.6 a	2.7 bc	50 c	7.77 b	6.61 b	0.850 a
3.	B	ethephon	400	2.5 pt	296	99.4 a	3.6 b	66 b	7.26 c	6.24 c	0.860 a
4.	FO	ethephon	100	5 pt	2365	99.8 a	1.6 c	11 d	8.35 a	7.21 a	0.864 a
5.	RYS	ethephon	400	5 pt	591.25	99.8 a	1.6 c	14 d	8.32 a	7.17 a	0.862 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
2,4 vs 3,5		Water rate (100 gal vs 400 gal/acre)				ns	ns	ns	*	*	ns

[z] Full bloom occurred 4 May 2001 .

[y] Treatments were applied May 16, 2001 when fruit diameter was 12.98 mm. Trees were 24 feet between rows, tree width was 13 feet, and tree height was 18 ft (75% TRV).

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

Table 4. Effect of ethephon applied at 21.5 mm on 'Fuji'/M.27 (2001).

No.	Color	Treatment[zy]	Rate /gallon	Chemical rate /acre 400gal /acre dilute	Fruit/cm^2 limb cross sectional area (11 June 01)
1.	W	Control	–		16.77 a[x]
2.	R	Ethephon	9.46ml	8pt	14.91 a
3.	B	Ethephon	18.92ml	16pt	14.15 a
4.	FO	Ethephon	9.46ml	8pt.	14.69 a
		+Silwet L-77	2.37 ml	2pt	
5.	HP	Ethephon	18.92ml	16pt	15.63 a
		+Silwet L-77	2.37 ml	2pt	
6.	Y	Ethephon	9.46ml	8pt	14.40 a
		+Oil	18.9ml	16pt	
7.	RS	Ethephon	18.92ml	16pt	15.85 a
		+Oil	18.92ml	16pt	
8.	BS	Ethephon	9.46 ml	8pt	16.80 a
		+Oil	18.92 ml	16pt	
		+Silwet L-77	2.37 ml	2pt	
9.	GS	Ethephon	9.46 ml	8pt	16.97 a
		+Oil	18.9 ml	16pt	
		+Accel	15.8 ml	13.6pt	
		+Sevin XLR	4.73 ml	4pt	
10.	OS	+Sevin XLR	4.73 ml	4pt	15.42 a
		+Oil	18.9 ml	16pt	
		+Accel	15.8 ml	13.6pt	

Contrasts:	Comparisons:	Pr>F
2,3 vs 4,5	Ethephon (Silwet L-77 vs none)	ns
2,3 vs 6,7	Ethephon (Oil vs none)	ns
3 vs 8	Ethephon (Silwet L-77+Oil vs none)	ns
3 vs 9	Ethephon (Oil+Accel+Sevin XLR Plus vs none)	ns
3 vs 10	Ethephon vs Oil+Accel+Sevin XLR Plus	ns
9 vs 10	Ethephon (Oil+Accel+Sevin XLR Plus vs Oil+Accel+Sevin XLR Plus	ns

[z] Full bloom occurred 22 April 2001; petal fall 1 May 2001.

[y] Treatments were applied at 21.5mm (24 May) with a low pressure hand wand sprayer dilute. The average daytime high temperatures for the 2 day period after application was 79°F,69°F, and the night time low was 63°F,57°F. Treatments were applied

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

Table 5. Effect of carbaryl formulations and combinations on fruit injury and fruit set of 'Starkrimson Delicious'/Mark (Young)(2001).

No.	Color	Treatment^{zy}	Rate /gallon	Spray Timing (22 May)	Fruit/cm² limb cross sectional area (4 June)	Fruit injury /cm² trunk cross sectional area ^{x} (7 June)	% of total fruit with injury (7 June)	Injury Rating(%) (cm² trunk cross sectional area) light	moderate	heavy	Pigmy fruit (< 32mm) /cm² limb cross sectional area (26 June)	Large fruit (> 32mm) /cm² limb cross sectional area (26 June)	Percent of pigmy fruit (26 June)
1.	W	Control	--	--	8.68 ab^{w}	0.33 efg	4 ef	1.0 cde	0.03 d	0.000 a	0.06 e	8.63 a	0.6 e
2.	R	Sevin XLR Plus + Oil	4.73 ml 18.9 ml		8.24 ab	0.74 def	8 def	1.8 abcd	0.29 cd	0.000 a	0.16 e	8.08 a	2.1 e
3.	B	Sevin 50WP + Oil	4.54 g 18.9 ml		7.64 ab	0.53 efg	7 def	1.4 bcde	0.17 cd	0.046 a	0.19 e	7.44 a	2.7 e
4.	FO	Sevin XLR Plus + Accel	4.73 ml 10.51 ml		8.38 ab	0.87 cde	12 bcd	2.2 abc	0.55 cd	0.000 a	0.76 bc	7.62 a	10.2 bc
5.	HP	Sevin 50WP + Accel	4.54 g 10.51 ml		7.56 ab	0.67 def	10 cde	1.8 abcd	0.47 cd	0.000 a	0.67 bcd	6.89 a	9.0 bcd
6.	Y	Sevin XLR Plus + Accel + Oil	4.73 ml 10.51 ml 18.9 ml		8.50 ab	1.66 a	22 a	2.5 ab	2.06 a	0.168 a	1.05 b	7.44 a	13.8 ab
7.	RS	Sevin 50WP + Accel + Oil	4.54 g 10.51 ml 18.2 ml		8.65 ab	1.39 abc	16 abc	2.3 ab	0.95 cd	0.000 a	1.09 b	7.56 a	12.3 b
8.	BS	Sevin XLR Plus + 6-BA + Oil	4.73 ml 10.51 ml 18.9 ml		7.73 ab	1.63 ab	21 a	2.8 a	1.96 ab	0.068 a	0.41 cde	7.31 a	5.4 cde
9.	GS	Sevin 50WP + 6-BA + Oil	4.54 g 10.51 ml 18.9 ml		6.73 b	1.09 bcd	19 ab	2.8 a	1.11 bc	0.050 a	0.25 de	6.49 a	4.4 de
10.	OS	Sevin XLR Plus + Accel + Oil + L-77	4.54 g 10.51 ml 18.9 ml 2.37 ml		8.08 ab	1.35 abc	20 a	2.2 abc	2.27 a	0.055 a	1.04 b	7.04 a	12.9 b
11.	RD	Accel high rate + Oil	42.04 ml 18.9 ml		9.81 a	0.61 defg	7 def	1.5 bcde	0.04 d	0.000 a	1.66 a	8.15 a	18.5 a
12.	BD	6-BA high rate +Oil	42.04 ml 18.9 ml		8.75 ab	0.52 efg	6 def	1.0 cde	0.33 cd	0.000 a	0.97 b	7.78 a	12.6 b
13.	GD	Ethephon	7.10 ml		6.85 b	0.27 fg	4 ef	0.8 de	0.04 d	0.000 a	0.05 e	6.79 a	0.9 e
14.	OD	Ethephon	14.20 ml		7.75 ab	0.09 g	1 f	0.3 e	0.00 d	0.000 a	0.18 e	7.57 a	2.5 e

Contrasts:	Comparisons:	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F
2,4,6,8,10 vs 3,5,7,9	Sevin XLR Plus vs Sevin 50WP	ns	*	*	ns	***	ns	ns	ns	ns
2,3 vs 4,5	Oil vs Accel	ns	ns	ns	ns	ns	ns	***	ns	***
4,5 vs 6,7	Accel vs Accel+Oil	ns	***	***	ns	**	ns	*	ns	ns
6,7 vs 8,9	Accel+Oil vs 6-BA+Oil	ns	ns	ns	ns	ns	ns	***	ns	***
6 vs 10	L-77 vs none (Sevin XLR Plus and Sevin 50WP+Accel+Oil+L-77)	ns	ns	ns	ns	ns	ns	ns	ns	ns
8 vs 10	6-BA+Oil vs Accel+Oil+L-77	ns	ns	ns	ns	ns	ns	**	ns	**
11 vs 12	Accel(high rate) vs 6-BA (high rate)	ns	ns	ns	ns	ns	ns	***	ns	*
13 vs 14	Ethephon (high rate vs low rate)	ns	ns	ns	ns	ns	ns	ns	ns	ns
1 vs 2,3	Sevin XLR Plus and Sevin 50WP+Oil vs none	ns	ns	ns	ns	ns	ns	ns	ns	ns
1 vs 4,5	Sevin XLR Plus and Sevin 50WP+Accel vs none	ns	*	*	*	ns	ns	**	ns	***
1 vs 6,7	Sevin XLR Plus and Sevin 50WP+Accel+Oil vs none	ns	***	***	**	***	ns	***	ns	***
1 vs 8,9	Sevin XLR Plus and Sevin 50WP+6-BA+Oil vs none	ns	***	***	***	***	ns	ns	ns	*
1 vs 10	Sevin XLR Plus and Sevin 50WP+Accel+Oil+L-77 vs none	ns	***	***	*	***	ns	***	ns	***
1 vs 11	Accel (high rate)+Oil vs none	ns	ns	ns	ns	ns	ns	***	ns	***
1 vs 12	6-BA (high rate)+Oil vs none	ns	ns	ns	ns	ns	ns	***	ns	***
1 vs 13	Ethephon (low rate) vs none	ns	ns	ns	ns	ns	ns	ns	ns	ns
1 vs 14	Ethephon (high rate) vs none	ns	ns	ns	ns	ns	ns	ns	ns	ns

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[z] Full bloom occurred 17 April 2001; petal fall 27 April 2001.

[y] Treatments were applied with a low-pressure hand-wand sprayer at 23.5mm (22 May). 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 74°F, 77° F, and the night time low was 59°F, 58°F. Treatments were applied with a low pressure hand wand sprayer.

[x] Fruit with caylx-end injury (typical of Sevin injury) .

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

EFFECT OF CARBARYL FORMULATIONS AND COMBINATIONS ON FRUIT INJURY AND FRUIT SET OF 'STARKRIMSON DELICIOUS'/MARK (YOUNG)(2001).

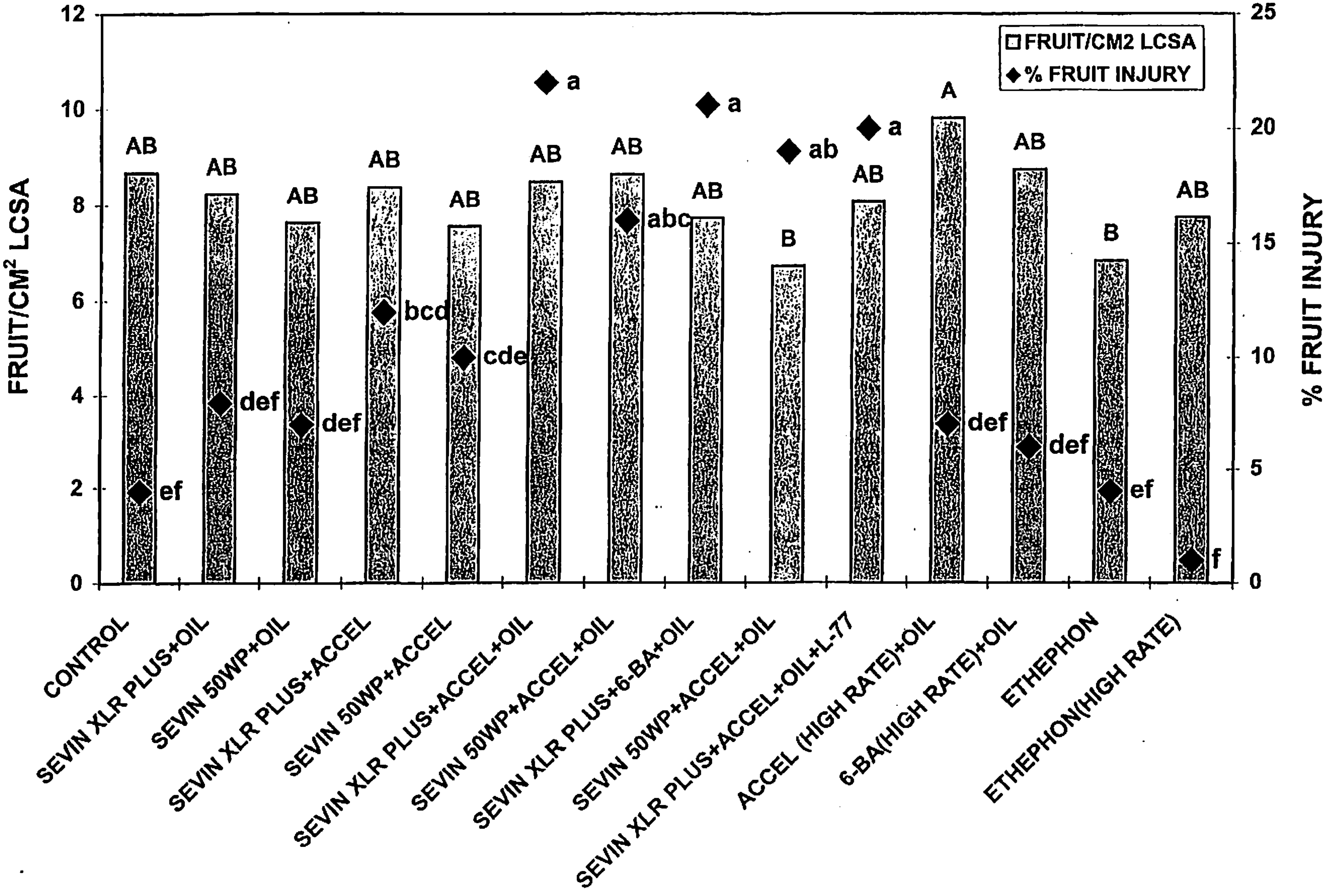


Table 6. Influence of late application of thinners on fruit thinning of 'Starkrimson Delicious'/MM.106 & MM.111 (2001).

No.	Color	Treatment^{zy}	Rate/acre /100 gal	Small fruit /cm^2 limb cross sectional area (12 Jun)	Small fruit /cm^2 limb cross sectional area (27 Jun)	Small fruit (<25mm) /m^2 in catch frames^x (27 Jun)	Large fruit (>25mm) /m^2 in catch frames^x (27 Jun)	Average fruit size of fruit dropped (<25mm)^x (27 Jun)	Average fruit size of fruit dropped (>25mm)^x (27 Jun)	Estimate visual cropload (0-100%) (15 Aug)	Fruit diameter (cm) (11 Sep)	Fruit length (cm) (11 Sep)	Length/ diameter ratio (11 Sep)	Catagories by fruit diameter (%) <2.25 in.	>2.25 in.	>2.75 in.
1.	W	Control		5.38 a^w	5.15 a	3.95 b	0.00 b	14.7 b	0.0 b	238 a	6.90 a	6.53 a	0.947 a	73 a	27 b	5 b
2.	R	Ethephon + Sevin XLR Plus + Oil	5 pt 1 pt 1 qt	3.79 a	0.41 b	43.61 a	22.08 a	18.7 a	30.1 a	118 b	7.04 a	6.50 a	0.922 b	28 b	72 a	15 a

^{z}Full bloom occurred April 22, (90% open); petal fall (April 30,).

^{y}Treatments were applied 6 June (26.75 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}Catch frames were 1.07m x 1.07m and were placed on the ground under heavy limbs on trees.

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

Table 7. Chemical thinning of 'Golden Delicious'/MM.111 (2001).

No.	Color	Treatment^{zy}	Rate/acre /100 gal	Visual spurs flowering (0-100%) (23 Apr)	Fruit/cm^2 limb cross sectional area (31 May)	Pigmy fruit /cm^2 limb cross sectional area (3 Aug)	% Pigmy fruit (3 Aug)	Estimated visual cropload (%) (3 Aug)	Fruit diameter (cm) (3 Oct)	Fruit length (cm) (3 Oct)	Length/ diameter ratio (3 Oct)
1.	W	Control		94 a^x	12.5 a	0.02 c	0.2 c	225 a	6.83 a	6.40 b	0.937 b
2.	R	6-BA 90g/acre	4732 ml	95 a	9.7 ab	0.10 c	1.1 bc	206 a	6.97 a	6.58 ab	0.944 ab
3.	B	6-BA 90g/acre + Oil	4732 ml 2 qt (1872 ml)	95 a	10.5 ab	0.36 b	3.9 b	200 a	7.03 a	6.75 a	0.961 a
4.	FO	6-BA 90g/acre + LI-700	4732 ml 1 pt (473 ml)	96 a	9.6 ab	0.05 c	0.6 c	208 a	7.01 a	6.55 ab	0.935 b
5.	HP	Accel 90g/acre + Silwet L-77	4732 ml 1 pt (473 ml)	95 a	8.1 b	0.72 a	10.2 a	197 a	7.00a	6.71 a	0.959 a

^{z}Full bloom occurred 24 April (90% open); petal fall (3 May).

^{y}Treatments were applied May 11, 2001 (11.27mm).
The average daytime high temperatures for the 2 day period after application was 87°F , 75°F and the night time low was 67°F, 55°F . 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}Mean separation within columns by Duncan's New Multiple Range Test($P \leq 0.05$).

Table 8. Chemical thinning of 'York'/MM.111 (2001).

No.	Color	Treatment[zy]	Rate/acre /100 gal	Visual spurs flowering (0-100%) (Apr 26)	Fruit/cm^2 limb cross sectional area (May 30)	Estimated visual cropload (%) (Aug 3)	Fruit diameter (cm) (Oct 4)	Fruit length (cm) (Oct 4)	Length/ diameter ratio (Oct 4)
1.	W	Control		91 a[x]	10.2 a	217 a	7.17 c	5.41 b	0.754 a
2.	R	6-BA 90g/acre	4732 ml	93 a	6.1 b	163 b	7.36 b	5.60 ab	0.761 a
3.	B	6-BA 90g/acre + Oil	4732 ml 2 qt (1872 ml)	91 a	4.7 b	165 b	7.42 ab	5.56 b	0.749 a
4.	FO	6-BA 90g/acre + LI-700	4732 ml 1 pt (473 ml)	93 a	6.8 b	161 b	7.45 ab	5.59 ab	0.750 a
5.	HP	Accel 90g/acre + Silwet L-77	4732 ml 1 pt (473 ml)	91 a	4.7 b	133 b	7.54 a	5.78 a	0.766 a

[z] Full bloom occurred 27 April (90% open); petal fall (5 May).

[y] Treatments were applied May 11, 2001 (11.67mm). The average daytime high temperatures for the 2 day period after application was 87°F , 75°F and the night time low was 67°F, 55°F . 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] Mean separation within columns by Duncan's New Multiple Range Test($P \leq 0.05$).

Table 9. Chemical thinning of 'Empire'/MM.111 (2001).

No.	Color	Treatment[zy]	Rate/acre /100 gal	Visual spurs flowering (0-100%) (19 Apr 01)	Fruit/cm^2 limb cross sectional area (7 Jun 01)	Pigmy fruit /cm^2 limb cross sectional area (3 Aug 01)	% Pigmy fruit (3 Aug 01)	Estimated visual cropload (%) (3 Aug 01)	Fruit diameter (cm) (3 Oct 01)	Fruit length (cm) (3 Oct 01)	Length/ diameter ratio (3 Oct 01)
1.	W	Control		97 ab[x]	10.8 a	0.15 b	1.3 c	204 a	7.55 a	6.45 ab	0.855 a
2.	FO	Accel 90g/acre + Oil	4732 ml 2 qt (1872)	96 ab	11.5 a	0.79 a	7.4 a	208 a	7.55 a	6.35 b	0.841 a
3.	HP	Accel 90g/acre + LI-700	4732 ml 1 pt (473)	95 b	13.4 a	0.47 ab	3.8 bc	208 a	7.67 a	6.63 a	0.864 a
4.	LG	Accel 90g/acre + Silwet L-77	4732 ml 1 pt (473)	98 a	12.2 a	0.81 a	6.4 ab	208 a	7.59 a	6.49 ab	0.855 a

[z] Full bloom occurred Apr 20, 2001 (90% open); petal fall (May 1, 2001).

[y] Treatments were applied May 14, 2001 (14.9 mm). The average daytime high temperatures for the 2 day period after application was 62°F, 60°F and the night time low was 48°F, 50°F. 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] Mean separation within columns by Duncan's New Multiple Range Test($P \leq 0.05$).

Table 10. Effect of 68 hours of post-spray dark temperatures on chemical thinning of 'Golden Delicious'/M.27 trees with various plant growth regulators (2001).

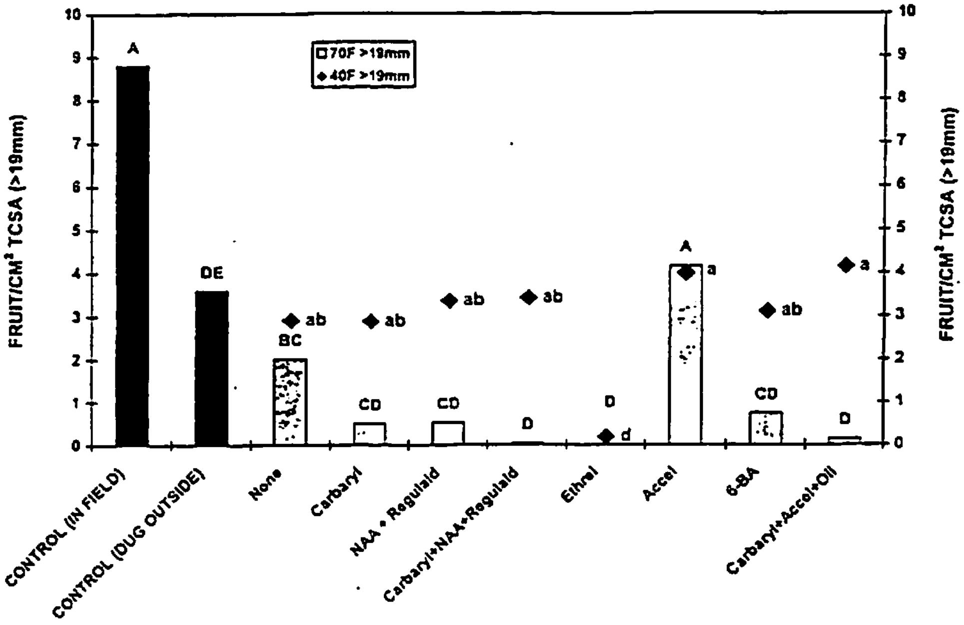
No.	Color	Treatment[zy] dark temp (°F)	Chemical spray (11 May)	Rate/ gallon (11 May)	Into darkness (in lab) (11 May)	Out of Darkness into Sunlight (outside) (14 May)	Tree removed from the soil (23 Apr)	Fruit/cm² trunk cross sectional area (all sizes) (31 May)	Small fruit (<19mm) /cm² trunk cross sectional area (31 May)	Large fruit (>19mm) /cm² trunk cross sectional area (31 May)	Average single fruit weight (g) (7 June)
2.	W	Control					dug (outside)	3.95 bcd[x]	0.35 de	3.60 ab	11.1 ab
3.	R	40°F	None		1 pm	8 am	dug	4.68 bcd	1.77 abc	2.90 ab	11.6 ab
4.	RS	70°F	None		1 pm	8 am	dug	2.30 def	0.29 de	2.01 bc	12.4 ab
5.	B	40°F	Carbaryl	9.08 ml	1 pm	8 am	dug	3.89 bcd	1.00 bcde	2.88 ab	11.1 ab
6.	BS	70°F	Carbaryl	9.08 ml	1 pm	8 am	dug	0.83 ef	0.33 de	0.50 cd	11.6 ab
7.	Y	40°F	NAA + Regulaid	1.22 g 4.73 ml	1 pm	8 am	dug	4.88 bc	1.52 abcd	3.36 ab	9.4 abcd
8.	YS	70°F	NAA + Regulaid	1.22 g 4.73 ml	1 pm	8 am	dug	1.41 ef	0.89 cde	0.53 cd	5.2 de
9.	G	40°F	Carbaryl + NAA + Regulaid	9.08ml 1.22 g 4.73 ml	1 pm	8 am	dug	5.76 b	2.35 ab	3.42 ab	8.2 bcd
10.	GS	70°F	Carbaryl + NAA + Regulaid	9.08 ml 1.22 g 4.73 ml	1 pm	8 am	dug	2.77 cde	2.72 a	0.04 d	3.6 e
11.	BK	40°F	Ethrel	9.46 ml	1 pm	8 am	dug	0.22 f	0.03 e	0.19 d	6.4 cde
12.	BKS	70°F	Ethrel	9.46 ml	1 pm	8 am	dug	0.07 f	0.07 e	0.00 d	11.5 ab
13.	O	40°F	Accel	38.5 ml	1 pm	8 am	dug	5.92 b	1.93 abc	3.99 a	9.1 abcd
14.	OS	70°F	Accel	38.5 ml	1 pm	8 am	dug	6.00 b	1.86 abc	4.15 a	9.8 abc
15.	HP	40°F	6-BA	38.5 ml	1 pm	8 am	dug	4.69 bcd	1.56 abcd	3.12 ab	9.9 abc
16.	HPS	70°F	6-BA	38.5 ml	1 pm	8 am	dug	0.88 ef	0.13 e	0.75 cd	9.6 abcd
17.	RCK	40°F	Carbaryl + Accel + Oil	9.08 ml 9.625 ml 18.16 ml	1 pm	8 am	dug	5.17 bc	1.02 bcde	4.15 a	13.1 a
18.	OCK	70°F	Carbaryl + Accel + Oil	9.08 ml 9.625 ml 18.16 ml	1 pm	8 am	dug	0.23 f	0.08 e	0.15 d	11.3 ab
1.	W	Control				(in field)	(outside)	10.9 a	2.12 abc	8.81 a	14.1 a

Contrasts	Comparisons	Pr>F	Pr>F	Pr>F	Pr>F
3,5,7,9,11,13,15,17 vs 4,6,8,10,12,14,16,18	40°F vs 70°F	***	**	***	ns
3 vs 4	40°F vs 70°F none	*	*	ns	ns
5 vs 6	40°F vs 70°F Carbaryl	**	ns	**	ns
7 vs 8	40°F vs 70°F NAA + Regulaid	***	ns	***	*
9 vs 10	40°F vs 70°F Carbaryl + NAA + Regulaid	**	ns	***	*
11 vs 12	40°F vs 70°F Ethrel	ns	ns	ns	ns
13 vs 14	40°F vs 70°F Accel	ns	ns	ns	ns
15 vs 16	40°F vs 70°F 6-BA	***	*	**	ns
17 vs 18	40°F vs 70°F Carbaryl + Accel + Oil	***	ns	***	ns
3,4 vs 5,6	Carbaryl vs none	ns	ns	ns	ns
3,4 vs 7,8	NAA + Regulaid vs none	ns	ns	ns	***
3,4 vs 9,10	Carbaryl + NAA + Regulaid vs none	ns	***	ns	***
3,4 vs 11,12	Ethrel vs none	***	*	***	ns
3,4 vs 13,14	Accel vs none	***	*	**	ns
3,4 vs 15,16	6-BA vs none	ns	ns	ns	ns
3,4 vs 17,18	Carbaryl + Accel + Oil vs none	ns	ns	ns	ns
2 vs 3,5,7,9,11,13,15,17	Outside control vs 40°F (all thinners)	ns	*	ns	ns
2 vs 4,6,8,10,12,14,16,18	Outside control vs 70°F (all thinners)	**	ns	***	ns
2 vs 3	Outside control vs 40°F (no thinners)	ns	*	ns	ns
2 vs 4	Outside control vs 70°F (no thinners)	ns	ns	ns	ns

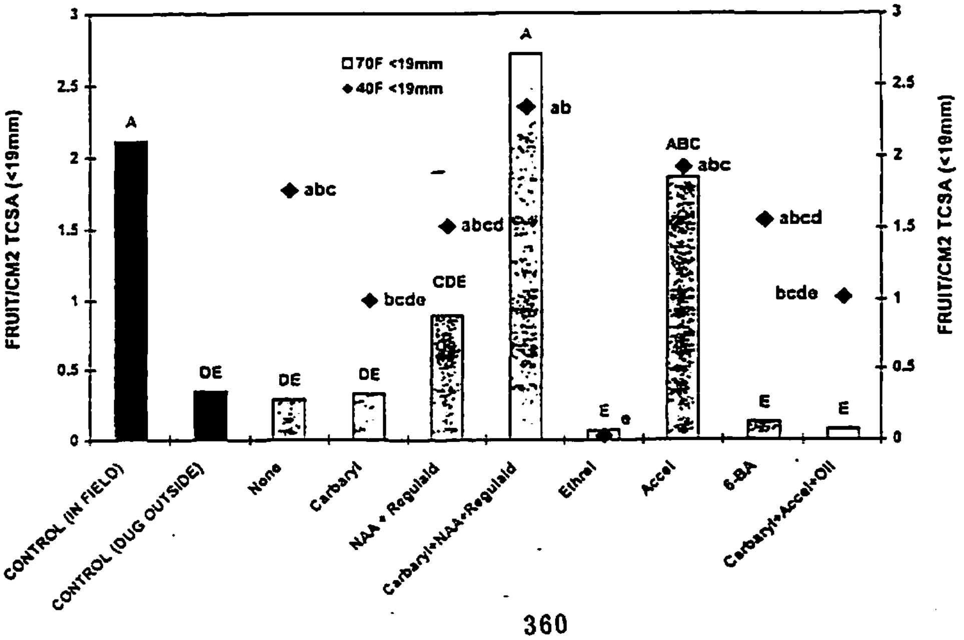
[z] Spray treatments were applied 11 May with a low pressure hand-wand sprayer when fruit diameter was 12.4mm.

[y] Trees were moved 4 hours after spraying from outside lighting to growth chamber darkness at 40°F or 70°F for a period of 68 hours.

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



EFFECT OF 68 HOURS OF POST-SPRAY DARK TEMPERATURES ON CHEMICAL THINNING OF 'GOLDEN DELICIOUS'/M.27 TREES WITH VARIOUS PLANT GROWTH REGULATORS (2001).



EFFECT OF 68 HOURS OF POST-SPRAY DARK TEMPERATURES ON CHEMICAL THINNING OF 'GOLDEN DELICIOUS'/M.27 TREES WITH VARIOUS PLANT GROWTH REGULATORS (2001).

Table 11. Effect temperatures on fruit retention of 'Golden Delicious'/M.27 trees (2001).

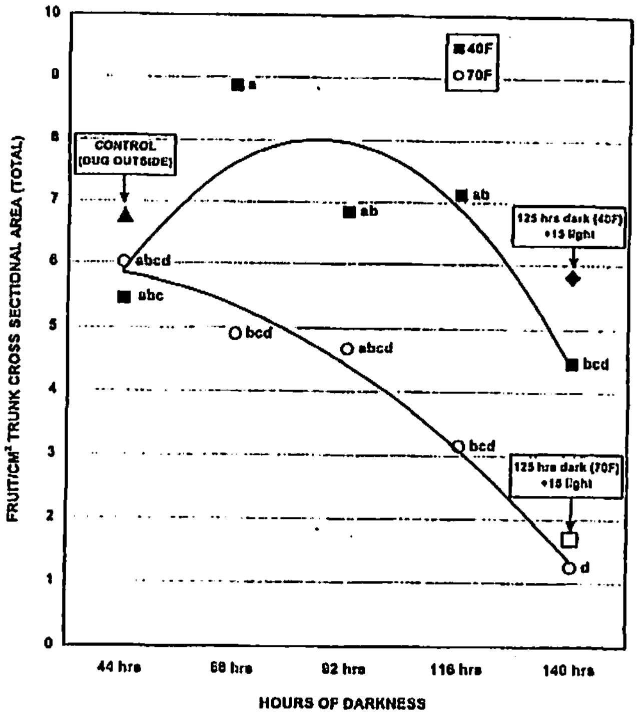
No.	Color	Treatment^{ZY} (°F)	Chemical spray	Hours darkness	Into darkness 16 May	Out of darkness into sunlight (outside)		Tree removed from the soil	Fruit/cm² trunk cross sectional area (4 Jun)	Average single fruit weight (g) (6 Jun)	Fruit/cm² trunk cross sectional area >24mm in diameter (6 Jun)	Fruit/cm² trunk cross sectional area <24mm in diameter (6 Jun)	% Fruit >24mm in diameter (6 Jun)	% Fruit <24mm in diameter (6 Jun)
2.	PUR/W	Control	None					dug (outside)	6.77 ab^{X}	13.3 ab	5.61 a	1.16 b	85 ab	15 ab
3.	RYD	40°F	None	44 hrs	noon	9 am	18 May	dug	5.45 abcd	13.7 a	5.15 a	0.30 b	95 a	5 b
4.	WOD	70°F	None	44 hrs	noon	9 am	18 May	dug	6.01 abc	12.6 abc	5.60 a	0.41 b	92 a	8 b
5.	OBKD	40°F	None	68 hrs	noon	9 am	19 May	dug	8.87 a	8.4 e	5.57 a	3.30 a	64 b	36 a
6.	WBKD	70°F	None	68 hrs	noon	9 am	19 May	dug	4.91 abcd	12.2 abcd	4.07 ab	0.84 b	90 a	10 b
7.	WRD	40°F	None	92 hrs	noon	9 am	20 May	dug	6.85 ab	9.4 cde	5.05 a	1.80 ab	74 ab	26 ab
8.	WGD	70°F	None	92 hrs	noon	9 am	20 May	dug	4.69 abcd	12.2 abcd	4.34 ab	0.36 b	90 a	10 b
9.	YBKD	40°F	None	116 hrs	noon	9 am	21 May	dug	7.13 ab	10.0 bcde	5.67 a	1.46 ab	83 ab	17 ab
10.	RBKD	70°F	None	116 hrs	noon	9 am	21 May	dug	3.15 bcd	9.3 cde	2.56 ab	0.59 b	70 ab	30 ab
11.	RBKCK	40°F	None	140 hrs	noon	9 am	22 May	dug	4.47 abcd	8.8 de	3.64 ab	0.83 b	72 ab	28 ab
12.	YCK	70°F	None	140 hrs	noon	9 am	22 May	dug	1.25 d	9.4 cde	0.90 b	0.35 b	80 ab	20 ab
13.	WCK	40°F	None	125 hrs +15hrs light	noon	9-12 am	18-22 May Each day 3 hrs light	dug	5.81 abc	7.6 e	3.50 ab	2.31 ab	62 b	38 a
14.	GCK	70°F	None	125 hrs +15hrs light	noon	9-12 am	18-22 May Each day 3 hrs light	dug	1.70 cd	10.4 abcde	1.38 b	0.32 b	85 ab	15 ab
1.	PUR	Control	None		(In field)			In soil in bag	12.2 a	15.3 a	11.6 a	0.62 b	95 a	5 b

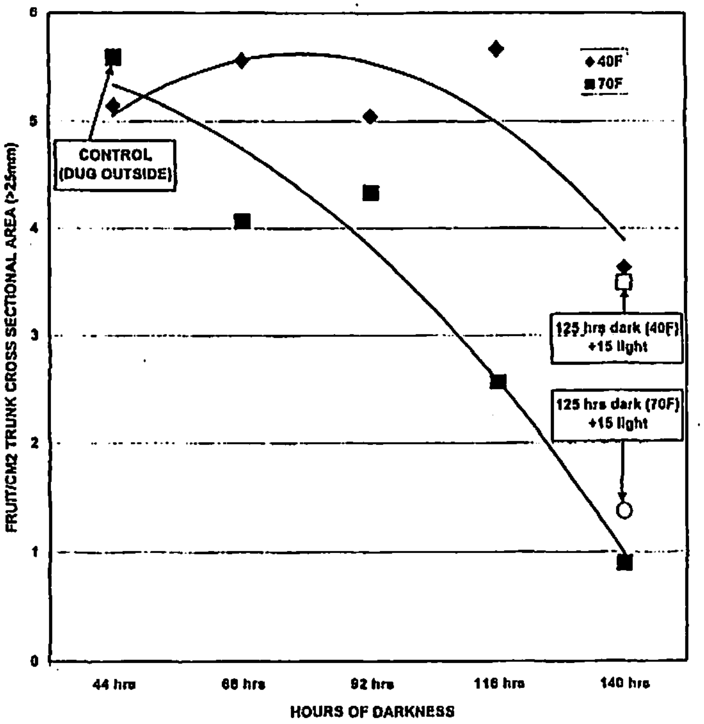
Contrasts	Comparisons	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F
3,5,7,9,11,13 vs 4,6,8,10,12,14	40°F vs 70°F	***	*	*	**	ns	ns
3 vs 5	44 hrs vs 68 hrs (40°F)	ns	**	ns	**	**	**
3 vs 7	44 hrs vs 92 hrs (40°F)	ns	*	ns	ns	ns	ns
3 vs 9	44 hrs vs 116 hrs (40°F)	ns	**	ns	ns	*	*
3 vs 11	44 hrs vs 140 hrs (40°F)	ns	**	ns	ns	*	*
4 vs 6	44 hrs vs 68 hrs (70°F)	ns	ns	ns	ns	ns	ns
4 vs 8	44 hrs vs 92 hrs (70°F)	ns	ns	ns	ns	ns	ns
4 vs 10	44 hrs vs 116 hrs (70°F)	*	ns	ns	*	ns	ns
4 vs 12	44 hrs vs 140 hrs (70°F)	***	ns	**	**	ns	ns
4 vs 14	44 hrs vs 140 hrs+15 hrs light (70°F)	***	ns	*	**	ns	ns
11 vs 12	40°F vs 70°F (140 hrs)	ns	ns	ns	ns	ns	ns
11 vs 13	140 hrs vs 125 hrs+15 hrs light (40°F)	ns	ns	ns	ns	ns	ns
12 vs 14	140 hrs vs 125 hrs+15 hrs light (70°F)	ns	ns	ns	ns	ns	ns
13 vs 14	40°F vs 70°F (125 hrs+15 hrs light)	ns	ns	ns	*	*	*

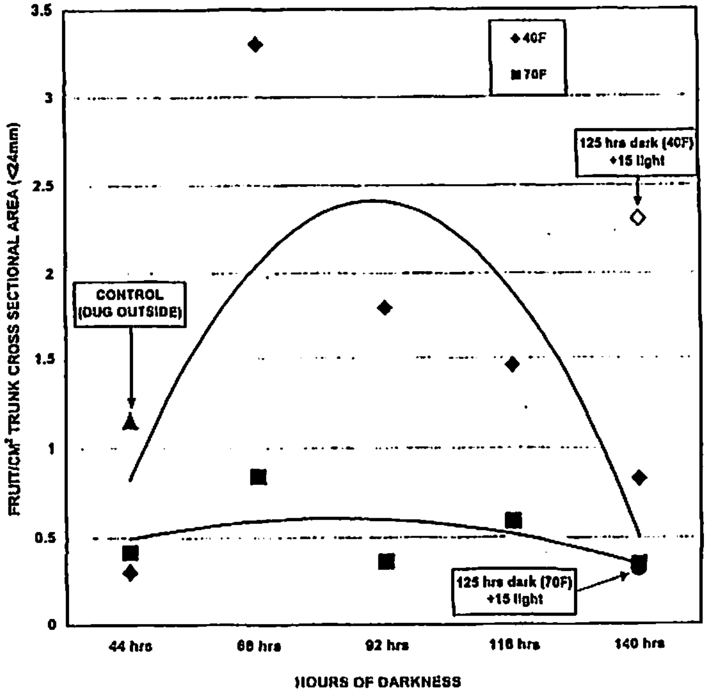
[Z] Treatments were started 16 May when fruit diameter was 15 mm.

[Y] Trees were moved from darkness at 40°F or 70°F to outside daylight for a 3 hour period each day for duration of experiment.

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







Influence of continuous 44 to 140 hours of darkness, or 125 hours of 21 hours darkness + 3 hours sunlight each 24 hours on total fruit retention of 'Golden Delicious'/M.27 trees held in controlled environment rooms at 4.4C or 21.1C. Trees held in the dark from 68 to 140 hours at 4.4C maintained more fruit on the trees than those held at 21.1C. Trees held for 68 or more hours at 21.1C lost more fruit than trees held at 4.4C. (Byers 2001, unpublished results).

Table 12. Effect of Accel and NAA on fruit thinning of 'Golden Delicious'/M.26 planted in 1997 (2001).

No.	Color	Treatment[zy]	Water volume /acre	Fruit/cm^2 limb cross sectional area (29 May 01)
1.	FO	Accel + Sevin + Oil	40	4.47 b[x]
2.	RYD	NAA + Sevin + Oil	40	6.31 a

[z] Full bloom occurred 25 April 2001 . Small fruit were removed by hand thinning in July.

[y] Treatments were applied May 10 . Trees were 18 feet between rows, tree width was 9 feet, and tree height was 8 ft (30% TRV). Chemicals/100 gal were:
Accel 35.6 oz; Sevin=3pt.; NAA= 4 oz; + Oil= 1pt.

[x] Mean separation within columns by t-test, $P \leq 0.05$.

Table 13. Effect of Accel and NAA on fruit thinning of 'Gala'/M.26 planted in 1997 (2001).

No.	Color	Treatment[zy]	Water volume /acre	Fruit/cm^2 limb cross sectional area (29 May 01)
1.	FO	NAA + Sevin + Oil	40	9.57 a[x]
2.	RYD	Accel + Sevin + Oil	40	4.47 b

[z] Full bloom occurred 20 April 2001 . Small fruit were removed by hand thinning in July.

[y] Treatments were applied May 10 . Trees were 18 feet between rows, tree width was 9 feet, and tree height was 8 ft (30% TRV). Chemicals/100 gal were:
Accel 35.6 oz; Sevin=3pt.; NAA= 4 oz; + Oil= 1pt.

[x] Mean separation within columns by t-test, $P \leq 0.05$.

Table 14A. Influence of two sterol inhibitors on 10 fruit maturity sample/tree of 2.50-2.75 diameter fruit on 'Gala'/M.27 (2001).

No.	Color	Treatment[z,y]	Equivalent 400 gal /acre (oz)	Rate/ oz 100 gal/A (3875 L/A) dilute	Rate g/gal. dilute	Application date/timing					Fruit length (cm)	Fruit diameter (cm)	Length diameter ratio (cm)	Fruit firmness (lb)	Soluble solids	Starch (0-8)	Red color (0-100%)	Single fruit weight (g)
						Late Pink Apr 10	FB Apr 19	PF Apr 24	5mm May 1	10.4mm May 8	(28 Aug)	(28 Aug)	(28 Aug)	(28 Aug)	(28 Aug)	(28 Aug)	(28 Aug)	(28 Aug)
1.	W	Control									6.01 a[x]	6.96 a	0.863 a	17.4 a	15.3 a	6.69 a	82 a	151.4 a
2.	R	Procure 50 W	10	2.5 oz	0.709g	X	X	X	X	X	5.80 a	6.88 a	0.844 ab	17.0 a	14.7 a	7.03 a	85 a	141.4 ab
3.	B	Procure 50 W	30	7.5 oz	2.12g	X	X	X	X	X	5.96 a	6.91 a	0.862 a	17.4 a	14.7 a	6.93 a	83 a	145.8 ab
4.	FO	Procure 50 W	90	22.5 oz	6.379g	X	X	X	X	X	5.81 a	6.90 a	0.843 ab	17.6 a	15.2 a	7.24 a	84 a	142.1 ab
5.	HP	Nova 40 W	5	1.25 oz	0.354g	X	X	X	X	X	5.79 a	6.94 a	0.834 b	17.6 a	14.9 a	6.93 a	83 a	145.6 ab
6.	Y	Nova 40 W	15	3.75 oz	1.063g	X	X	X	X	X	5.82 a	7.00 a	0.831 b	17.8 a	14.8 a	7.09 a	84 a	147.4 ab
7.	DG	Nova 40 W	45	11.25 oz	3.189g	X	X	X	X	X	5.47 b	6.81 a	0.804 c	17.5 a	14.9 a	7.06 a	85 a	134.6 b

[z] Seasonal fungicide program: = chemicals applied; Dithane, Topsin M., Ziram, Agrimycin, Imidam, Provado, Lannate. Dates applied: 14, 22 Apr; 1, 10, 25 May; 2,16 Jun; 3, 13, 30 Jul; 17 Aug.
Full bloom: Apr. 17, 2001.
All treatments were sprayed with Sevin XLR Plus and Oil on 10 May, 2001 for thinning when fruit size was approximately 12mm.
All treatments hand thinned 31 May, 1 June, 2001 to singles at 27mm.

[y] Treatments (X) were applied with a low-pressure hand-wand sprayer except for the control and cover sprays which were applied airblast at 100gal/A.

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

Table 14B. Influence of two sterol inhibitors on fruit size (whole tree) on 'Gala'/M.27 (2001).

No.	Color	Treatment[z,y]	Equivalent 400 gal/acre (oz)	Rate/ oz 100 gal/A (3875 L/A) dilute	Rate g/gal. dilute	Fruit/cm^2 trunk cross sectional area (28 Aug 01)	Total number of fruit harvested per tree (28 Aug 01)	Catagories by fruit diameter(%) (inches) (28 Aug 01)						Catagories by fruit diameter(%) (inches)		Catagories by fruit diameter(%) (inches)	
								< 2.00	2.00 to 2.25	2.25 to 2.50	2.50 to 2.75	2.75 to 3.00	> 3.00	< 2.50	> 2.50	< 2.75	> 2.75
1.	W	Control				5.92 a	74.6 a	0.4 a[x]	2.1 b	19.2 c	53.6 a	21.7 a	2.9 a	22 c	78 a	75 c	25 a
2.	R	Procure 50 W	10	2.5 oz	0.709g	6.02 a	84.0 a	0.3 a	8.2 ab	36.0 ab	47.9 a	7.7 bc	0.0 a	44 ab	56 bc	92 ab	8 bc
3.	B	Procure 50 W	30	7.5 oz	2.12g	6.75 a	97.3 a	0.7 a	6.2 ab	33.0 abc	44.9 a	15.1 ab	0.0 a	40 abc	60 abc	85 bc	15 ab
4.	FO	Procure 50 W	90	22.5 oz	6.379g	5.98 a	85.1 a	1.5 a	8.3 ab	31.3 abc	50.0 a	8.9 bc	0.0 a	41 abc	59 abc	91 ab	9 bc
5.	HP	Nova 40 W	5	1.25 oz	0.354g	5.77 a	74.3 a	0.0 a	8.6 ab	27.2 bc	53.4 a	9.9 bc	0.0 a	36 abc	64 abc	90 ab	10 bc
6.	Y	Nova 40 W	15	3.75 oz	1.063g	5.99 a	75.6 a	0.6 a	5.0 ab	24.8 bc	60.5 a	9.1 bc	0.0 a	30 bc	70 ab	91 ab	9 bc
7.	DG	Nova 40 W	45	11.25 oz	3.189g	5.48 a	84.3 a	0.7 a	9.7 a	43.8 a	44.6 a	1.4 c	0.0 a	54 a	46 c	99 a	1 c

[z] Seasonal fungicide program: = chemicals applied; Dithane, Topsin M., Ziram, Agrimycin, Imidam, Provado, Lannate.
Dates applied: 14, 22 Apr; 1, 10, 25 May; 2,16 Jun; 3, 13, 30 Jul; 17 Aug. Full bloom: Apr. 17, 2001.
All treatments were sprayed with Sevin XLR Plus and Oil on 10 May, 2001 for thinning when fruit size was approximately 12mm.
All treatments hand thinned 31 May, 1 June, 2001 to singles at 27mm.

[y] Treatments were applied with a low-pressure hand-wand sprayer except for the control and cover sprays which were applied airblast at 100gal/A.

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

Table 14C. Influence of two sterol inhibitors on fruit size and yield (whole tree) of on 'Gala'/M.27 (2001).

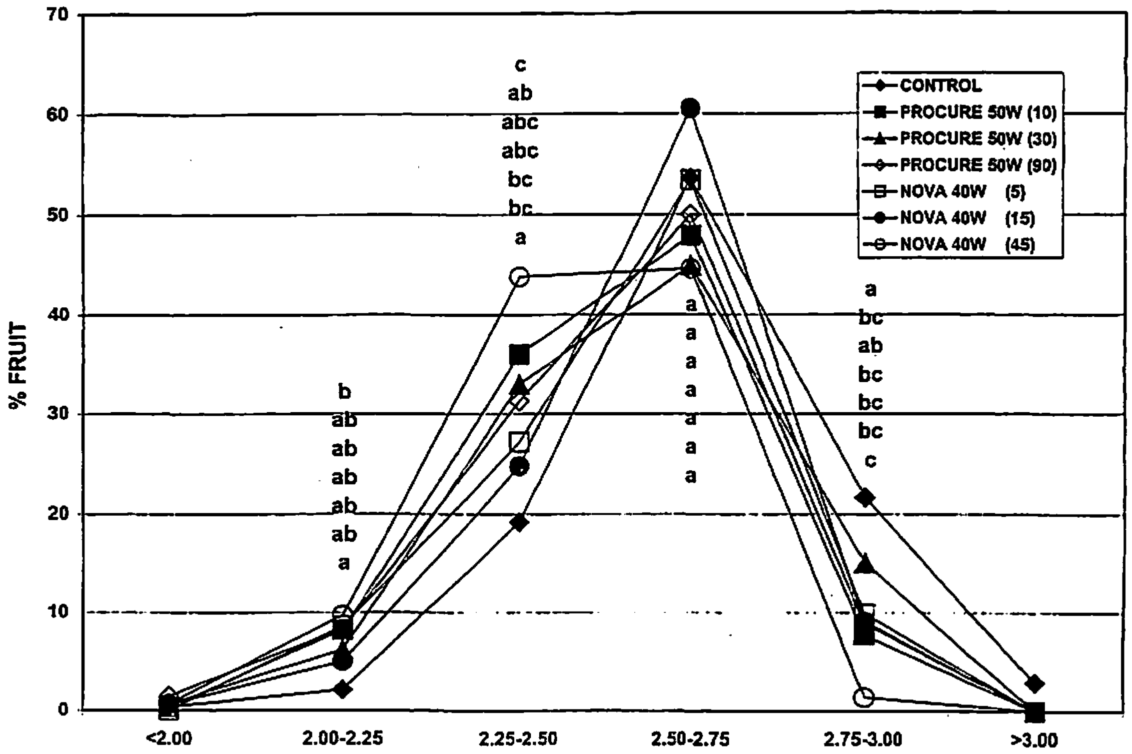
No.	Color	Treatment^{zy}	Equivalent 400 gal /acre (oz)	Rate/ oz 100 gal/A (3875 L/A) dilute	Rate g/gal. dilute	Application date/timing					Fruit/cm^2 trunk cross sectional area (28 Aug)	Total number of fruit harvested per tree (28 Aug)	Fruit length (cm) (28 Aug)	Fruit diameter (cm) (28 Aug)	Length diameter ratio (cm) (28 Aug)	Single fruit weight (g) (28 Aug)
						Late Pink Apr 10	FB Apr 19	PF Apr 24	5mm May 1	10.4mm May 8						
1.	W	Control									5.92 a	74.6 a	5.39 a^x	6.13 a	0.881 a	132.4 a
2.	R	Procure 50 W	10	2.5 oz	0.709g	X	X	X	X	X	6.02 a	84.0 a	5.26 a	6.14 a	0.856 abc	115.4 ab
3.	B	Procure 50 W	30	7.5 oz	2.12g	X	X	X	X	X	6.75 a	97.3 a	5.42 a	6.26 a	0.870 ab	116.1 ab
4.	FO	Procure 50 W	90	22.5 oz	6.379g	X	X	X	X	X	5.98 a	85.1 a	5.06 ab	5.97 a	0.851 abcd	117.4 ab
5.	HP	Nova 40 W	5	1.25 oz	0.354g	X	X	X	X	X	5.77 a	74.3 a	5.07 ab	6.01 a	0.843 bcd	119.4 ab
6.	Y	Nova 40 W	15	3.75 oz	1.063g	X	X	X	X	X	5.99 a	75.6 a	4.90 ab	5.89 a	0.834 cd	117.8 ab
7.	DG	Nova 40 W	45	11.25 oz	3.189g	X	X	X	X	X	5.48 a	84.3 a	4.72 b	5.73 a	0.822 d	101.7 b

[z] Seasonal fungicide program: = chemicals applied; Dithane, Topsin M., Ziram, Agrimycin, Imidam, Provado, Lannate.
Dates applied: 14, 22 Apr; 1, 10, 25 May; 2,16 Jun; 3, 13, 30 Jul; 17 Aug.
Full bloom: Apr. 17, 2001.
All treatments were sprayed with Sevin XLR Plus and Oil on 10 May, 2001 for thinning when fruit size was approximately 12mm.
All treatments hand thinned 31 May, 1 June, 2001 to singles at 27mm.

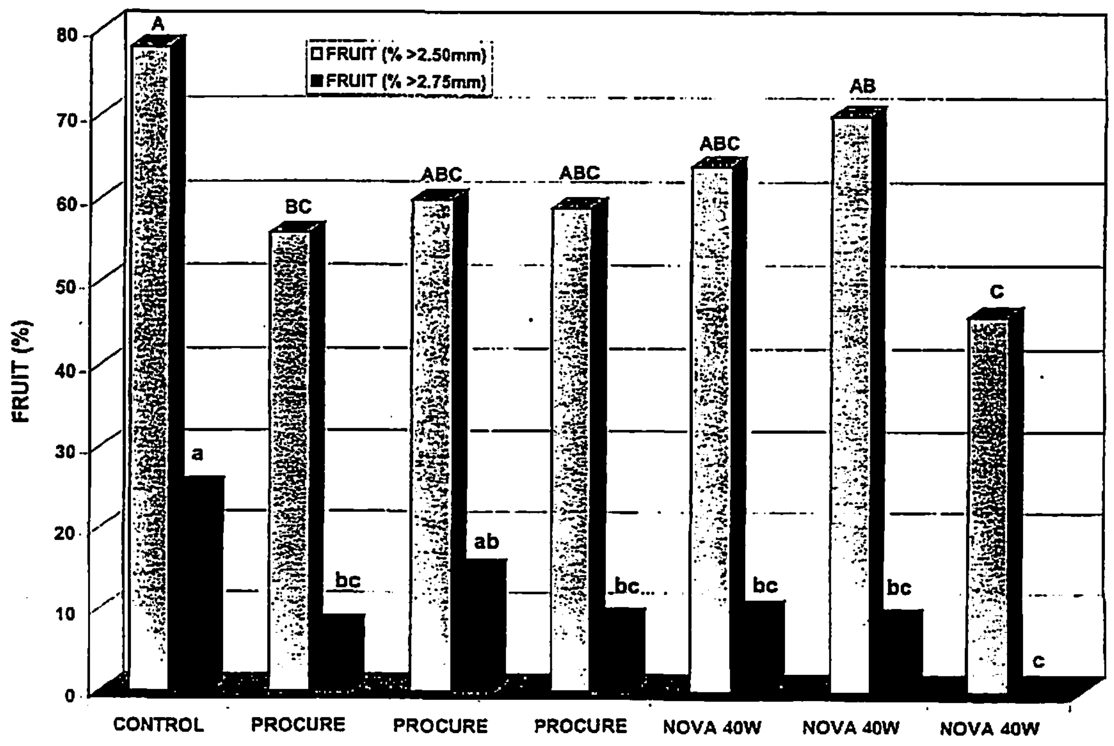
[y] Treatments (X) were applied with a low-pressure hand-wand sprayer except for the control and cover sprays which were applied airblast at 100gal/A.

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

INFLUENCE OF TWO STEROL INHIBITORS ON FRUIT SIZE ON 'GALA'/M.27
(2001)



INFLUENCE OF TWO STEROL INHIBITORS ON FRUIT SIZE OF 'GALA'/M.27
(2001)



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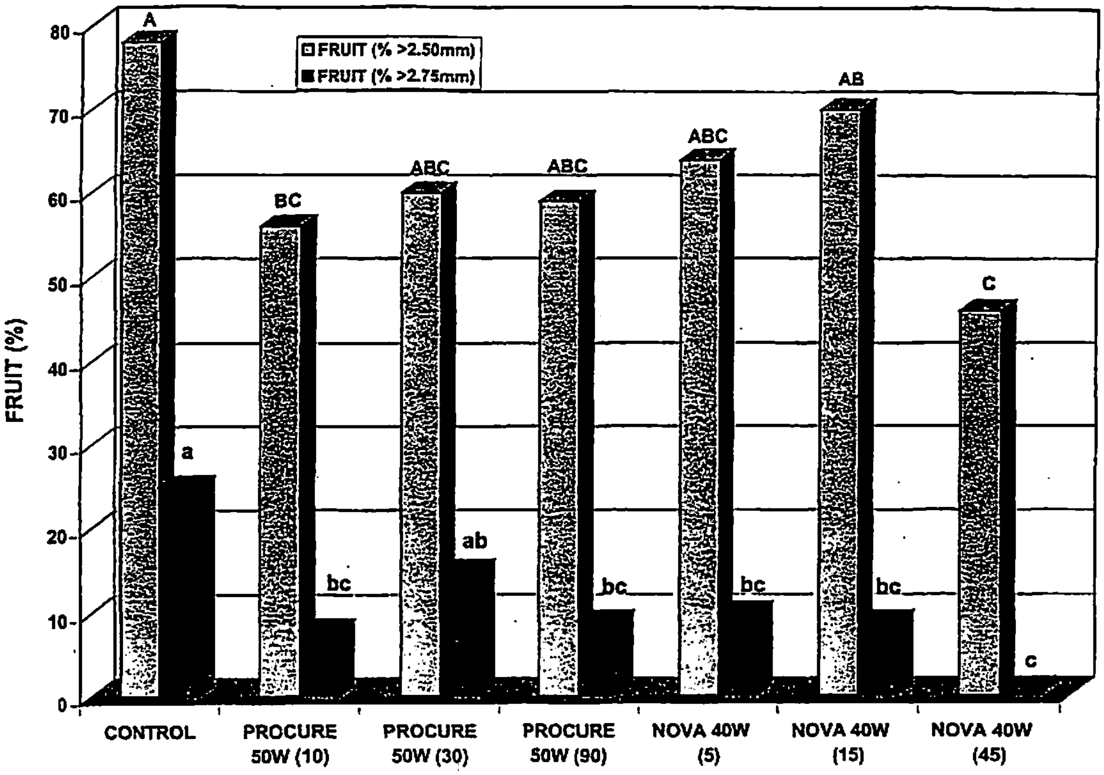
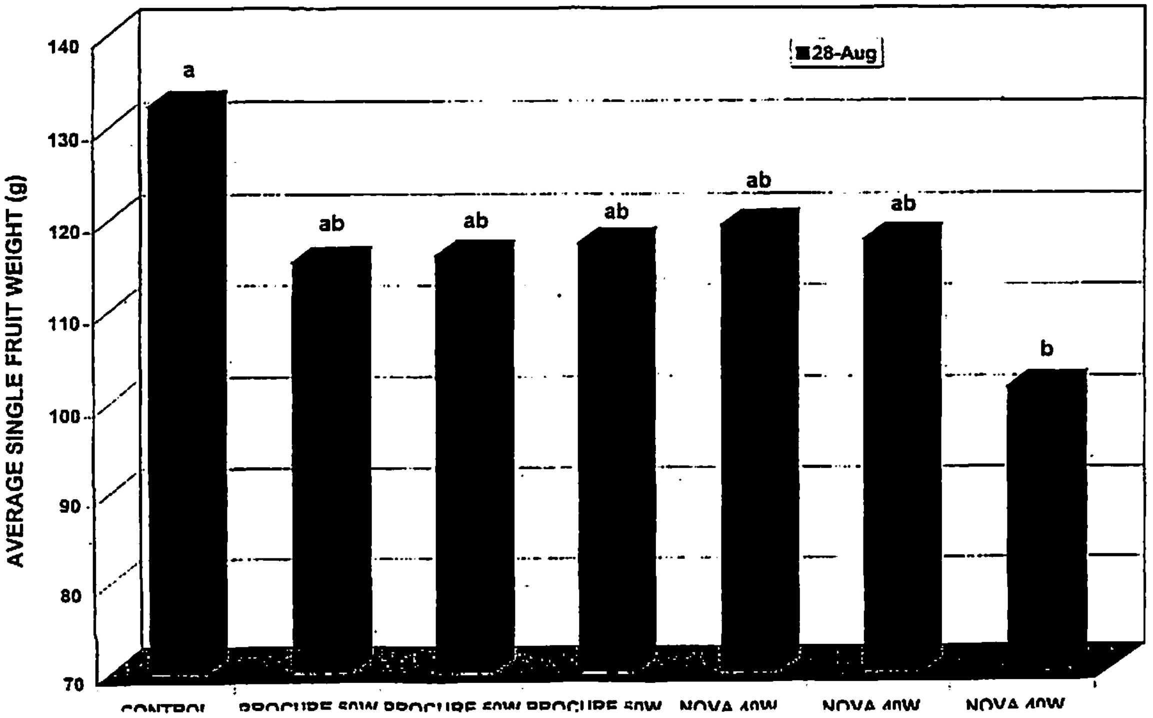


INFLUENCE OF TWO STEROL INHIBITORS ON AVERAGE FRUIT WEIGHT OF 'GALA'/M.27 (2001)



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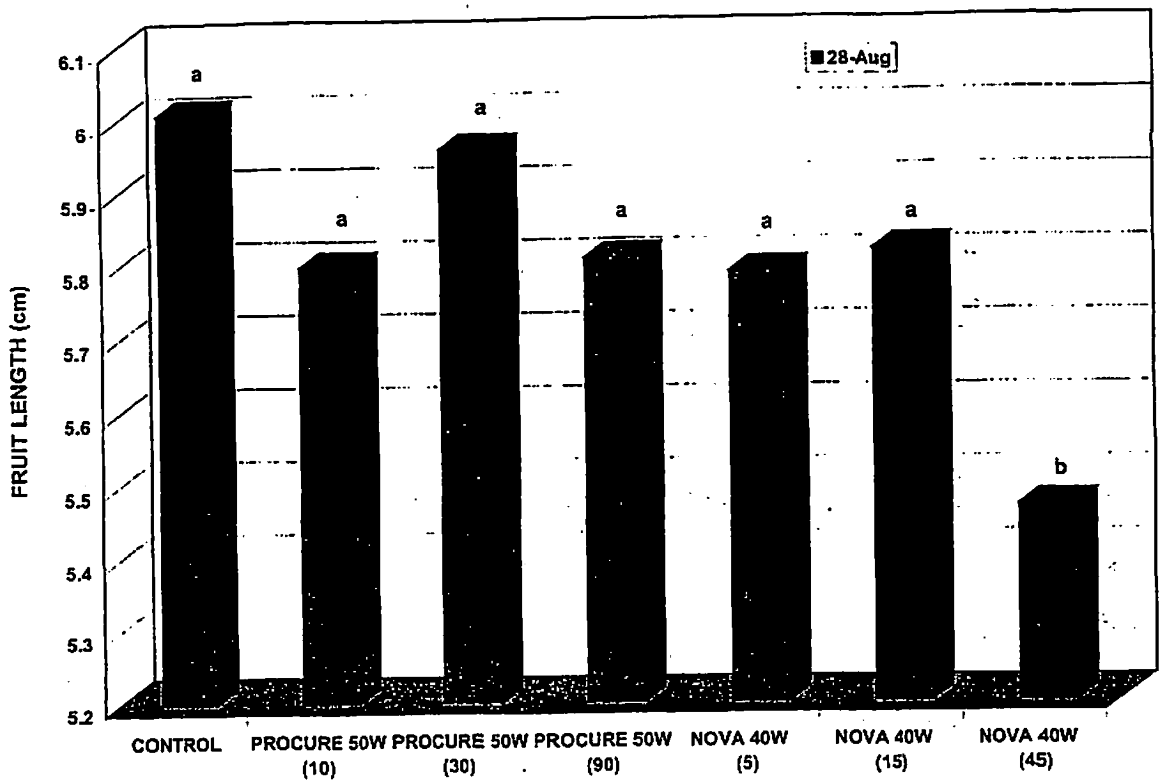

INFLUENCE OF TWO STEROL INHIBITORS ON LENGTH/DIAMETER RATIO OF 'GALA'/M.27 (2001)

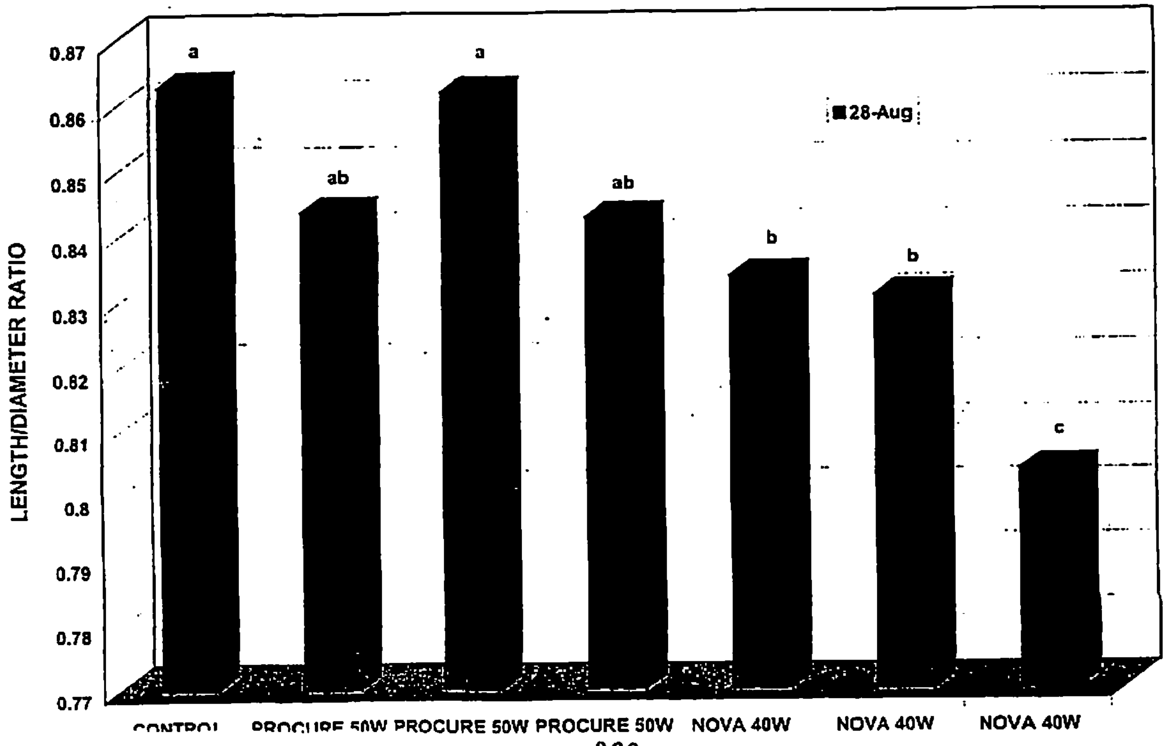

Table 15. Effect of 2 airblast ATS sprays on 'Bisco' (young block) fruit set and diameter. sprayed 12, 13 April 2001).

No.	Color	Treatment[ZY]	Rate/ 100 gal (block rate)	Rate/ 100 gal (block rate)	Fruit/cm^2 limb cross sectional area 29 May	Fruit diameter (inches) 20 Aug
1.	W	Control			12.4 a[x]	2.69 b
2.	Y	ATS	5680 ml	3 gal	1.6 b	3.49 a

[Z] Bloom: 12 April (30%), 13 April (80-90%) flowers open. ATS was applied 12 and 13 Apr 2001 with a airblast sprayer at 100 gal/acre.

[Y] All treatments including the control were hand thinned June 15.

[X] Mean separation within columns by t-test, $P \leq 0.05$.

Table 16. Effect of 2 airblast ATS sprays on 'Redhaven' (young block) fruit set and diameter.

No.	Color	Treatment[ZY]	Rate/ 100 gal (block rate)	Rate/ 100 gal (block rate)	Fruit/cm^2 limb cross sectional area 29 May	Fruit diameter (inches) 23 Jul
1.	W	Control			15.6 a[x]	2.41 b
2.	Y	ATS	5680 ml	3 gal	3.8 b	2.93 a

[Z] Bloom: 12 April (30%), 13 April (80-90%) flowers open. ATS was applied 12 and 13 Apr 2001 with a airblast sprayer at 100 gal/acre.

[Y] All treatments including the control were hand thinned June 18, 2001.

[X] Mean separation within columns by t-test, $P \leq 0.05$.

Table 17. Effect of 2 airblast ATS sprays on 'Cresthaven' (young block) fruit set and diameter, sprayed 12, 13 April 2001).

No.	Color	Treatment[ZY]	Rate/ 100 gal (block rate)	Rate/ 100 gal (block rate)	Fruit/cm^2 limb cross sectional area 29 May	Fruit diameter (inches) 20 Aug
1.	W	Control			17.3 a[x]	2.81 b
2.	Y	ATS	5680 ml	3 gal	3.4 b	3.33 a

[Z] Bloom: 12 April (30%), 13 April (80-90%) flowers open. ATS was applied 12 and 13 Apr 2001 with a airblast sprayer at 100 gal/acre.

[Y] All treatments including the control were hand thinned June 15.

[X] Mean separation within columns by t-test, $P \leq 0.05$.

(Not for publication or distribution, CSFWC 2001)

The Influence of Apogee and Its Combinations with Ethephon, Hydrogen Ion Concentration, Cations, and/or Adjuvants on Apple Tree Growth Control, Fruit Cracking, and/or Return Bloom

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Abstract. In 2001, Prohexadione-calcium technical grade 93.2% (PHCA) applied to 'Fuji'/M.9 trees in 3 applications in deionized water reduced tree growth somewhat. The addition of NH_4SO_4 to PHCA further suppressed tree growth. However, if PHCA was mixed in well water, PHCA did not suppress tree growth. Apogee + Regulaid (trt#6) in well water was not as effective as simply adding more NH_4SO_4; however, Regulaid may have had some additional influence but not statistically. If $CaCl_2$ (frequently used to reduce bitter pit and corkspot disorders) was added to Apogee + Regulaid, the calcium completely inhibited the growth suppression of Apogee. If NH_4SO_4 is added at the same rate as $CaCl_2$ (w/w) the growth suppression was completely restored. If Solubor was added to Apogee + Regulaid, the effectiveness in of Apogee is compromised but $MgS0_4$ did not. Apogee + Li-700 + Choice, a commercial water conditioner, provided the most effective growth suppression. Choice, among other ingredients, has NH_4SO_4 in the formulation. In one of three treatments, Apogee decreased the number of apples harvested on 11 Oct; even though the Apogee treated trees appeared to have more apples due to the inhibition of tree growth. The Apogee treatment that had the fewest fruit per tree, numerically, also had the largest fruit.

In 2001, prohexadione-calcium [formulated as 27.5% BAS-125 (Apogee™) or the technical 93.2% prohexadione-calcium (PHCA) to 'Empire'/Mark trees in deionized water did not reduced tree growth. Only the combination of Apogee+NH4SO4+Regulaid caused fruit cracking (21%) as compared to 7% in the control.

In 2000, the addition of Silwett-77 to NH_4SO_4 + Apogee further improved efficacy, but Urea, Regulaid, Oil, or Choice did not. The addition of $CaCl_2$ or KCl to NH_4SO_4 + Apogee spray was not detrimental to shoot growth suppression. Spraying $CaCl_2$ as a tank mix, before, or after Apogee spraying did not reduced efficacy in this experiment; but in 1999, $CaCl_2$ was detrimental. Adjusting the pH of the Apogee + NH_4SO_4+Regulaid spray to either pH=4 or pH=9 did not affect efficacy. Tank mixing Captan with Apogee + NH_4SO_4+Regulaid did not cause foliage injury or affect efficacy. The addition of ethephon at 1 pt/100 gal improved the efficacy of Apogee+NH_4SO_4+Regulaid. The additives Regulaid+$CaCl_2$+NH_4SO_4 alone did not cause injury or shoot growth suppression.

In 2000, GA_3 alone did not promote shoot growth, but GA_3 partially counteracted the shoot growth suppression of Apogee + NH_4SO_4 + Regulaid. In 2001, GA_3 inhibited flower bud formation alone or on trees sprayed with Apogee+NH_4SO_4.

In 1999, the 27.5% Apogee formulation in water was not as effective for suppression of tree growth as the 10% formulation when tank mixed using hard water (well water) or when mixed with $CaCl_2$. Ammonium sulfate prevented deactivation of Apogee by calcium and other cations in aqueous sprays. The additives, NH_4SO_4, $CaCl_2$, Regulaid, and/or Oil + L-77, alone had no effect on tree growth. Apogee plus L-77 + Oil was superior adjuvant to Regulaid for Apogee growth suppression.

Chemicals used: Prohexadione-calcium formulated as BAS-125 (Apogee™) (27.5%)(3-oxido-4-propionyl-5-oxo-3-cyclohexenecarboxylate), Regulaid® (a surfactant mixture, polyoxyethylenepolypropoxypropanol, alkyl 2-ethoxethanol, and dihydroxy propane 0.125% (v/v)); Silwet L-77 (silicon surfactant,); ethephon (2-chloroethyl phosphonic acid).

Introduction

In northern Virginia, over 80% of the apple crop is grown for processing. Many trees are propagated on vigorous rootstocks and require much pruning, especially in the tops. To reduce costs and labor needs, many growers prune every second or third year. When trees are not pruned, shading caused by tree growth in the current season is detrimental to pest control, fruit quality, and yield.

Several plant growth regulators have been evaluated for their potential to reduce vegetative growth of tree fruits, thereby reducing pruning costs and improving fruit quality. Several reviews (Faust, 1984; Looney, 1983; Luckwill, 1970; Miller, 1988; Williams, 1984) indicate that many of these regulators have effects of greater commercial value than control of vegetative growth.

The objectives of the experiments reported here were to evaluate the effectiveness of prohexadione-calcium [formulated as 27.5% BAS-125 (Apogee™) or the technical 93.2% prohexadione-calcium (PHCA), alone or in combinations with deionized water, well water high in calcium, calcium chloride, ammonium sulfate, spray-adjuvants, Ethrel for additional tree-growth control, and GA_3 for flower bud inhibition.

Materials and Methods

Data were analyzed by ANOVA and GLM procedures using SAS software (SAS Institute, 1985). Means were compared by single-degree-of-freedom contrasts, by linear and polynomial regressions, or Duncan's New Multiple Range Test depending upon the experimental design.

Expt. 1. In 2001, seventy-eight 6-year-old 'Fuji'/M.9 trees (6 blocks) were selected for 13 treatments (Table 1). Prohexadione-calcium (Apogee) was applied at 125 ppm (to drip) in 3 applications to the same trees at FB+7, FB+28, and FB+59 days. In addition, Regulaid, NH_4SO_4, Choice, LI-700, $CaCl_2$, Solubor, and $MgS0_4$ were applied in various combinations with

Apogee (formulated as 27.5% ai) or technical pro-hexadione-calcium (93.2% ai; PHCA) in deionized water or "hard" well water as potential adjuvants, or water conditioners as indicated in Table 1. Ten of the longest scaffold shoots were tagged around the periphery of each tree and their lengths were measured on July 13. During dormancy, the10 scaffold shoots will be pruned and the diameters and lengths of the basal and terminal shoots recorded. In addition, the nodes/cm of the basal 40 cm and nodes/cm of the upper 30 cm of shoots will be recorded. Trees will be pruned and the total length of the shoots longer than 30 cm, the weight and time required to prune, the number of cuts, and the pruning weights/cm^2 trunk cross-sectional area (TCSA) per tree will be recorded.

Expt. 2. In 2001, twenty-four 10-year-old 'Empire'/Mark trees (6 blocks) were selected for 4 treatments (Table 2). Prohexadione-calcium (PHCA, 93.2% ai) or Apogee (27.5% ai) was applied at 125 ppm (to drip) in 3 applications to the same trees at FB+9, FB+30 and FB+64 days. In addition Regulaid, NH_4SO_4, and/or Solubor, were applied in various combinations to determine if fruit cracking would occure as indicated in Table 2. On July 19, ten of the longest scaffold shoots were tagged around the periphery of each tree and their lengths were measured.

Expt. 3. In 2000, one hundred forty seven 6-year-old 'Fuji'/M.9 trees (7 blocks) were selected for 21 treatments (Table 3). Prohexadione-calcium (Apogee) was applied at 125 ppm (to drip) in 3 applications to the same trees at FB+4, FB+21, and FB+53 days. In addition, ethephon, Regulaid, NH_4SO_4, Oil, Choice, Li-700, Silwet L-77 NaCl, KCl ,$CaCl_2$, NaOH, HCl and Captan were applied in various combinations with Apogee as potential adjuvants, water conditioners, or to adjust pH as indicated in Table 3. On June 26, ten of the longest scaffold shoots were tagged around the periphery of each tree and their lengths were measured. During dormancy, the 10 scaffold shoots were pruned and the diameters and lengths of the basal and terminal shoots were recorded. In addition, the nodes/cm of the basal 40 cm and nodes/cm of the upper 30 cm of shoots were recorded. Trees were pruned and the total length of the shoots longer than 30 cm, the weight and time required to prune, the number of cuts, and the pruning weights/cm^2 trunk cross-sectional area (TCSA) per tree were recorded.

Expt. 4. In 2000, thirty two 6-year-old 'Fuji'/M.9 trees (8 blocks) were selected for 4 treatments (Table 4). Apogee + NH_4SO_4 + Regulaid was applied at 125 ppm (to drip) in 3 applications to the same trees at PF, PF+21, and PF+53 days. In addition, GA_3 was applied alone or in combination with Apogee + NH_4SO_4 + Regulaid and were compared for interference with Apogee effectiveness (Table 4). On June 26, ten of the longest scaffold shoots were tagged around the periphery of each tree and their lengths were recorded. During dormancy, the10 scaffold shoots were pruned and the diameters and lengths of the basal and terminal shoots were recorded. Trees were pruned and the total length of the shoots longer than 30 cm, the weight and the time required to prune, number of cuts, and the pruning weights/cm^2 trunk cross-sectional area (TCSA) per tree were recorded.

Expt. 5. In 1999, one hundred and two 5-year-old 'Fuji'/M.9 trees (6 blocks) were selected for 17 treatments (Table 5A and 5B). Apogee was applied (to drip in 3 applications to the same trees at 125 ppm) either alone or in combination with adjuvants or water conditioners (Table 5). Apogee applications were tested for efficacy using hard water, calcium chloride, ammonium sulfate, adjuvants (L-77 plus Oil), Regulaid, and/or two Apogee formulations. Shoot length of the longest 4 scaffold shoots were measured on 15 June 99. Data taken in the dormant season included the total length of shoots longer than 30 cm, weight and time required to prune, number of cuts, and pruning weights/cm^2 trunk cross-sectional area (TCSA) per tree.

Results and Discussion

Expt. 1. In 2001, Prohexadione-calcium technical grade 93.2% (PHCA) applied at 125 ppm to 'Fuji'/M.9 trees (dilute to drip) in 3 applications at FB+7, FB+28, and FB+59 days in deionized water reduced tree growth somewhat (trt#2), and the addition of NH_4SO_4 to PHCA further suppressed tree growth (trt#3)(Table 1A). However, if PHCA was mixed in well water (250ppm hardness), PHCA did not suppress tree growth (trt#4). Apogee (27.5% ai + some NH_4SO_4 sulfate in the formulation) + Regulaid (trt#6) in well water was not as effective as simply adding more NH_4SO_4 (trt#7); however, the Regulaid may have had some additional influence but not statistically (trt#8). If $CaCl_2$ was added to trt#6, the calcium completely inhibited the effect of the Apogee + Regulaid(trt#9); but if NH_4SO_4 was added at the same rate (w/w), the effectiveness was completely restored (trt#10). If Solubor is added to trt#2, the effectiveness of Apogee is compromised (trt#11), but $MgSO_4$ did not (trt#12). Apogee + Li-700 + Choice, a commercial water conditioner, was the most effective treatment (trt#13). Choice among other ingredients has NH_4SO_4 in the formulation (trt#13). Additional measurements will be taken in Jan 2002 after the summer growth period is complete to determine the amount of re-growth after July 13.

In one of three treatments harvested, Apogee decreased the number of fruit harvested on 11 Oct. (trt#9); even though the Apogee trees appeared to have more apples due to the inhibition of tree growth. Treatment#9 that had the fewest fruit numerically per tree also had the largest fruit.

Expt. 2. In 2001, prohexadione-calcium [formulated as 27.5% BAS-125 (Apogee™) or the technical 93.2% prohexadione-calcium (PHCA)] applied at 125 ppm to 'Empire'/Mark in 3 applications at FB+9, FB+30, and FB+64 days in deionized water did not reduced tree growth (Table 2A). Only the combination of Apogee+NH_4SO_4+Regulaid caused fruit cracking (21%) as compared to 7% in the control. Data from other experiments suggest that this combination is more effective as a result of increase absorption or activation of prohexadione-calcium; thus the cracking may be related to a higher concentration of prohexadione-calcium in the fruit or tree.

Expt. 3. In 2000, using hard well water, the addition of NH_4SO_4 to the Apogee sprays improved efficacy on June 26; but the addition of Urea, NaCl, KCl, $CaCl_2$ to Agogee was no better than Apogee alone (Table 3, Fig. 1, 2, 3, 4). The addition of Silwet L-77 to NH_4SO_4 + Apogee further improved efficacy, but Urea, Regulaid, Oil, or Choice did not. The addition of $CaCl_2$ or KCl to the NH_4SO_4 + Apogee spray was not detrimental to shoot growth suppression; neither were $CaCl_2$ or KCl to Apogee alone. Spraying $CaCl_2$ as a tank mix, before, or after Apogee spraying did not reduce efficacy in this experiment; but in 1999, experiment #5, $CaCl_2$ was detrimental. Adjusting the pH of the Apogee + NH_4SO_4+Regulaid spray to either pH=4 or pH=9 did not affect efficacy. Tank mixing Captan with Apogee + NH_4SO_4+Regulaid did not cause foliage injury or affect efficacy. The addition of ethephon at

1 pt/100 gal improved the efficacy of Apogee + NH_4SO_4+Regulaid. The additives Regulaid+$CaCl_2$+NH_4SO_4 alone did not cause injury or shoot growth suppression.

Data taken 5 Dec 2000 on average shoot length of the 10 longest shoots tagged on 26 June, showed no shoot inhibition by any of the Apogee sprays (Table 3); however pruning cuts/cm^2 trunk cross sectional area were similar to shoot length data taken on 26 June. Those trees inhibited most by the treatments based on the 10 tagged shoots on June 26 also grew the most by 5 December 2000. Tagging the strongest shoots on the tree for measurements ignores less vigorous shoots that are reflected by the pruning cut data.

Expt. 4. In 2000, GA_3 alone did not promote shoot growth, but GA_3 partially counteracted the shoot growth suppression of Apogee + NH_4SO_4 + Regulaid (Table 2, Fig. 5, 6, 7). In 2001, GA_3 inhibited flower bud formation alone or on Apogee + NH_4SO_4 + Regulaid treated trees (Table 4).

Expt. 5. In 1999, the 10% and the 27.5% Apogee formulations gave similar shoot growth suppression when applied with Regulaid or Oil plus L-77 (Table 5), Figure 8). The addition of $CaCl_2$ to the 27.5% Apogee (125ppm) formulation caused poorer growth control (trt #s 4,5,6 vs 7,10,14), but the addition of NH_4SO_4 restored the effectiveness of the mixture (trt #s 7,10,14, vs 8, 11,15). When using hard well water, Apogee plus NH_4SO_4 promoted better activity (trt #s 4,5,6 vs 8,11,15). The additives, NH_4SO_4, $CaCl_2$, 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).

Summary

The past three seasons' experiments suggest, the benefit of additional NH_4SO_4 on Prohexadione-calcium response may not be due to an adjustment of pH or counter acting hardness (as defined by high Ca concentration); but a direct effect on uptake and/or activity of the molecule. The possibility exists that NH_4SO_4 may provide sufficient inorganic energy to a proton pump that may increase the loading of Prohexadione-calcium into the plant, or that the equilibrium of the Prohexadione-calcium with the NH_4 ion is critical during the absorption and action of this biosynthetic inhibitor of gibberellin.

The use of ethephon with Apogee provided some additional suppression of tree growth; but since ethephon will cause fruit thinning, low rates must be chosen. The commercial water conditioner, Choice was as effective as NH_4SO_4 + Regulaid for counteracting the effect of Calcium. Solubor also Inhibited the activity of Apogee.

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Appreciation to David Carbaugh, Leon Combs, Seth Combs, Heath Combs, Jean Engleman, Tim Stern, Maurice Keeler, and Harriet Keeler for data collection, analysis, and technical assistance.

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Table 1A. Effect of Apogee (3 applications of 125ppm; 7 days AFB, 28 days AFB, 59 days AFB) on 'Fuji'/M.9 on apple tree growth applied in 2001.

No.	Color	Treatment Apogee (ppm)[z,y]	Rate/ gallon	Special sprays	Water hardness ppm (gpg)[x] 30 Apr		Ph of Mix 30 Apr		Avg. shoot length of longest 10 scaffold shoots (Jul 13)	Avg. length of shoots over 30 cm (Jul 13)	% of shoots over 30 cm /tree (Jul 13)	% of shoots over 40 cm /tree (Jul 13)
					Pre-mix	Post-mix	Pre-mix	Post-mix				
1.	W	Control			–	–	—	—	65.3 ab[w]	35.3 ab	100.0 a	100.0 a
2.	R	PHCA (93.2%)	0.5075g	Deionized Water	0 (0)	50 (3)	5.4	6.2	48.7 de	18.7 de	96.7 a	76.7 bc
3.	B	PHCA (93.2%) NH4SO4	0.5075g 1.72g	Deionized Water	0 (0)	50 (3)	5.4	6.3	33.4 gh	3.4 gh	61.7 bc	16.7 ef
4.	FO	PHCA (93.2%)	0.5075g	Well Water	250 (15)	250 (15)	7.7	7.9	66.7 a	36.7 a	100.0 a	98.3 a
5.	HP	PHCA (93.2%) NH4SO4	0.5075g 1.72g	Well Water	250 (15)	250 (15)	7.7	7.9	42.5 ef	12.5 ef	91.7 a	48.3 d
6.	Y	125, 125, 125 Regulaid	1.72g 4.73ml	Well Water	250 (15)	425 (25)	7.7	7.9	45.8 e	15.8 e	91.7 a	61.7 cd
7.	BK	125, 125, 125 NH4SO4	1.72g 1.72g	Well Water	250 (15)	250 (15)	7.7	7.8	33.3 gh	3.3 gh	63.3 bc	28.3 e
8.	RD	125, 125, 125 NH4SO4 Regulaid (1pt)	1.72g 1.72g 4.73ml	Well Water	250 (15)	425 (25)	7.7	8.1	30.8 gh	0.8 gh	48.3 c	15.0 ef
9.	BD	125, 125, 125 CaCl2 (2.0lb) Regulaid	1.72g 9.08g 4.73ml	Well Water	250 (15)	425 (25)	7.7	8.0	58.6 bc	28.6 bc	98.3 a	91.7 ab
10.	GD	125, 125, 125 +NH4SO4 +CaCl2 (2.0lb) +Regulaid	1.72g 9.08g 9.08g 4.73ml	Well Water	250 (15)	250 (15)	7.7	7.7	33.0 gh	3.0 gh	65.0 bc	16.7 ef
11.	RS	125, 125, 125 Solubor(1 lb/100) Regulaid (1pt)	1.72g 4.54g 4.73ml	Well Water	250 (15)	250 (15)	7.7	8.6	55.8 cd	25.8 cd	96.7 a	80.0 abc
12.	BS	125, 125, 125 MgS04 (5 lb/100) Regulaid (1pt)	1.72g 22.70g 4.73ml	Well Water	250 (15)	425 (25)	7.7	8.0	36.4 fg	6.4 fg	76.7 ab	25.0 e
13.	GS	125, 125, 125 +Li 700 +Choice	1.72g 4.73ml 9.46ml	Well Water	250 (15)	120 (7)	7.7	4.9	27.0 h	0.0 h	26.0 d	0.0 f

Contrasts:	Comparisons:	Pr>F	Pr>F	Pr>F	Pr>F
2 vs 4	Deionized water vs none	***	***	ns	*
2 vs 3	NH_4SO_4 vs none (PHCA-Deionized water)	***	***	**	***
4 vs 5	NH_4SO_4 vs none (PHCA-Well water)	***	***	ns	***
2,4 vs 3,5	NH_4SO_4 vs none (Apogee and PHCA)	***	***	**	***
6 vs 7	Regulaid vs NH_4SO_4 (Apogee)	**	**	**	**
6 vs 8	Apogee+Regulaid+NH_4SO_4 vs none	***	***	***	***
6 vs 9	Apogee+$CaCl_2$ vs none	**	**	ns	**
6 vs 11	Apogee+Regulaid+Solubor vs none	*	*	ns	ns
6 vs 12	Apogee+Regulaid+$MgSO_4$ vs none	*	*	ns	***
7 vs 8	Apogee+NH_4SO_4+Regulaid vs none	ns	ns	ns	ns
8 vs 10	Apogee+NH_4SO_4 vs none	ns	ns	ns	ns
8 vs 13	NH_4SO_4+Regulaid vs Li-700+Choice	ns	ns	*	ns
9 vs 10	Apogee+$CaCl_2$ vs none	***	***	**	***
9 vs 11	$CaCl_2$ vs Solubor (Apogee+Regulaid)	ns	ns	ns	ns
9 vs 12	$CaCl_2$ vs $MgSO_4$ (Apogee+Regulaid)	***	***	ns	***

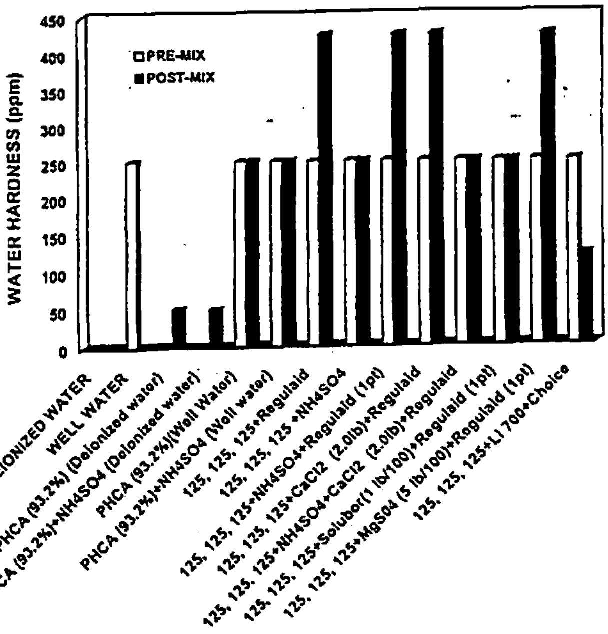
[z] Full bloom occurred April 23, 2001.

[y] Treatments were applied at PF (30 Apr), 23 days APF (23 May), and 52 days APF (21 June), with a low pressure hand-wand sprayer.

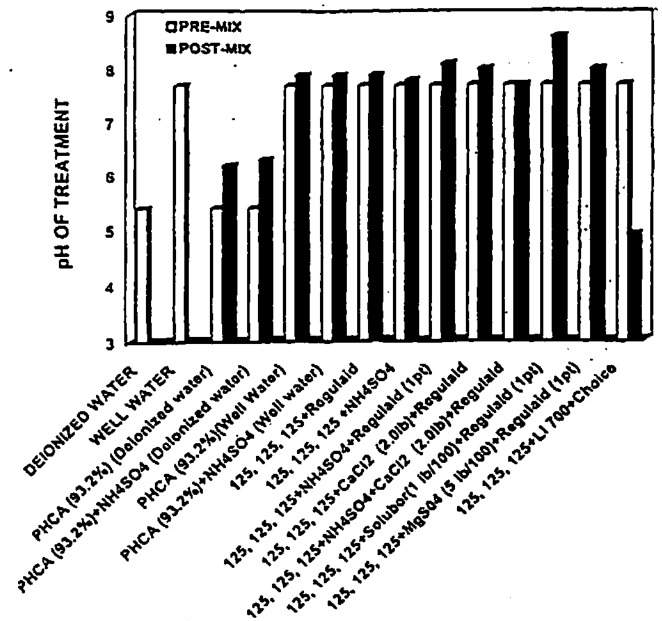
[x] Mean separation within columns by Duncan's New Multiple Range Test; ($P \leq 0.05$).

[w] Water hardness was determined by dipping a Hach Sofchek Water Hardness Test Strip into each mix with either deionized or well water. Guidelines for water hardness are as follows: soft=0-60ppm; moderate=61-120ppm; hard=121-180ppm; very hard=180ppm & over; (gpg)=grains per gallon: soft=0-1; slightly hard=1-3.5; moderately hard=3.5-7.0; hard=7.0-10.5; very hard=10.5 & over.

EFFECT OF APOGEE ON 'FUJI'/M.9 TREE GROWTH APPLIED IN 2001
(3 applications of 125ppm; 7 days AFB, 28 days AFB, 59 days AFB)



EFFECT OF APOGEE ON 'FUJI'/M.9 TREE GROWTH APPLIED IN 200
(3 applications of 125ppm; 7 days AFB, 28 days AFB, 59 days AFB)



EFFECT OF APOGEE ON 'FUJI'/M.9 TREE GROWTH APPLIED IN 2001
(3 applications of 125ppm; 7 days AFB, 28 days AFB, 59 days AFB)

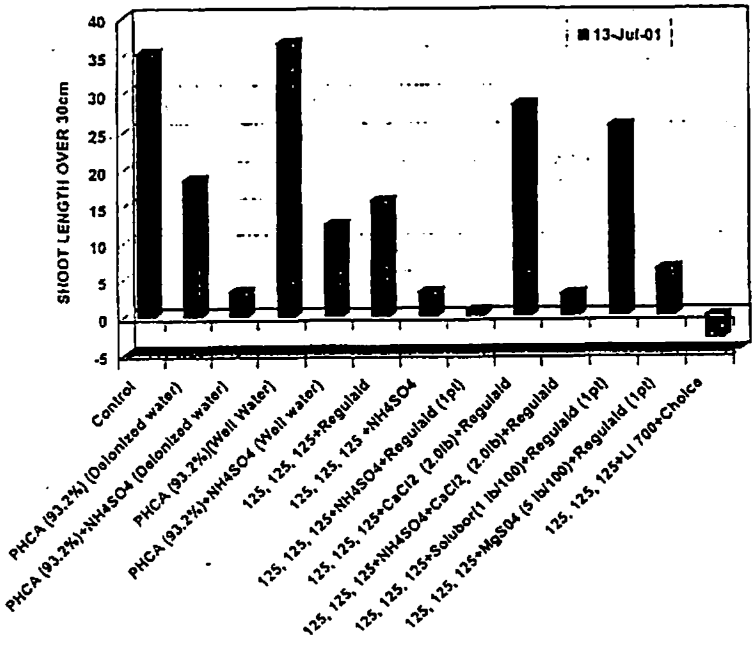


Table 1B. Effect of Apogee (3 applications of 125ppm; 7 days AFB, 28 days AFB, 59 days AFB) on 'Fuji'/M.9 on apple tree growth applied in 2001.

No.	Color	Treatment Apogee (ppm)[z,y]	Rate/ gallon	Special sprays	Water hardness ppm (gpg)[x] 30 Apr		Ph of Mix 30 Apr		Avg. shoot length of longest 10 scaffold shoots (Jul 13)	Avg. length of shoots over 30 cm (Jul 13)	% of shoots over 30 cm /tree (Jul 13)	% of shoots over 40 cm /tree (Jul 13)	Fruit/ trunk cross sectional area (11 Oct)	Average single fruit weight (11 Oct)	Total number of fruit per tree (11 Oct)
					Pre-mix	Post-mix	Pre-mix	Post-mix							
1.	W	Control			--	--	---	---	65.3 a[w]	35.3 a	100.0 a	100.0 a	10.5 a	155.2 ab	251 a
8.	RD	125, 125, 125 NH4SO4 Regulaid (1pt)	1.72g 1.72g 4.73ml	Well Water	250 (15)	425 (25)	7.7	8.1	30.8 b	0.8 b	48.3 b	15.0 b	7.1 ab	149.9 ab	204 a
9.	BD	125, 125, 125 CaCl2 (2.0lb) Regulaid	1.72g 9.08g 4.73ml	Well Water	250 (15)	425 (25)	7.7	8.0	58.6 a	28.6 a	98.3 a	91.7 a	5.6 b	166.8 a	172 a
13.	GS	125, 125, 125 +Li 700 +Choice	1.72g 4.73ml 9.46ml	Well Water	250 (15)	120 (7)	7.7	4.9	27.0 b	0.0 b	26.0 c	0.0 b	9.2 ab	137.8 b	258 a

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[z] Full bloom occurred April 23, 2001.

[y] Treatments were applied at PF (30 Apr), 23 days APF (23 May), and 52 days APF (21 June), with a low pressure hand-wand sprayer.

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

[w] Water hardness was determined by dipping a Hach Sofchek Water Hardness Test Strip into each mix with either deionized or well water. Guidelines for water hardness are as follows: soft=0-60ppm; moderate=61-120ppm; hard=121-180ppm; very hard=180ppm & over; (gpg)=grains per gallon: soft=0-1; slightly hard=1-3.5; moderately hard=3.5-7.0; hard=7.0-10.5; very hard=10.5 & over .

Table 2A. Effect of Apogee (3 applications of 125ppm; 9 days AFB, 30 days AFB, 64 days AFB) on 'Empire'/Mark on apple tree growth applied in 2001.

No.	Color	Treatment Apogee (ppm)^{zy}	Rate/ gallon	Water source	Water hardness ppm(gpg)^{w} (26 Apr) Pre-mix	Post-mix	Ph of Mix (26 Apr) Pre-mix	Post-mix	Avg. shoot length of longest 10 scaffold shoots (Jul 19)	Avg. length of shoots over 30 cm (Jul 19)	% of shoots over 30 cm/tree (Jul 19)	% of shoots over 40 cm/tree (Jul 19)
1.	W	Control			--	--	--	--	32.8 a^{x}	2.78 a	75.6 a	24.4 a
2.	R	PHCA (93.2%)	0.5075g	Deionized Water	0 (0)	0 (0)	5.4	6.7	27.1 a	0.00 a	66.1 a	33.9 a
3.	B	125, 125, 125 NH4SO4 Regulaid (1pt)	1.72g 1.72g 4.73ml	Well Water	250 (15gpg)	250 (15gpg)	7.5	7.9	22.8 a	0.00 a	65.9 a	34.1 a
4.	FO	125, 125, 125 Solubor (1 lb/100) Regulaid (1pt)	1.72g 4.54g 4.73ml	Well Water	250 (15gpg)	250 (15gpg)	7.5	8.6	32.0 a	2.03 a	71.1 a	29.0 a

^{z}Full bloom occurred April 17, 2001.

^{y}Treatments were applied at 26 Apr, 17 May, 22 June with a low pressure hand-wand sprayer.

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

^{w}Water hardness was determined by dipping a Hach Sofchek Water Hardness Test Strip into each mix with either deionized or well water. Guidelines for water hardness are as follows: soft=0-60ppm; moderate=61-120ppm; hard=121-180ppm; very hard=180ppm & over; (gpg)=grains per gallon: soft=0-1; slightly hard=1-3.5; moderately hard=3.5-7.0; hard=7.0-10.5; very hard=10.5 & over

Table 2B. Effect of Apogee (3 applications of 125ppm; 9 days AFB, 30 days AFB, 64 days AFB) on 'Empire'/Mark on apple tree growth applied in 2001.

No.	Color	Treatment Apogee (ppm)^{zy}	Rate/ gallon	Water source	Water hardness ppm(gpg)^{w} (26 Apr) Pre-mix	Post-mix	Ph of Mix (26 Apr) Pre-mix	Post-mix	Fruit /cm^{2} trunk cross sectional area (1 Oct 01)	Cracked fruit /cm^{2} trunk cross sectional area (1 Oct 01)	% fruit cracked per tree (1 Oct 01)	Number of cracked fruit per tree (cumulative) (1 Oct 01)	Average single fruit weight (1 Oct 01)
1.	W	Control			--	--	--	--	7.21 a^{x}	0.46 ab	7 b	14.4 ab	140 a
2.	R	PHCA (93.2%)	0.5075g	Deionized Water	0 (0)	0 (0)	5.4	6.7	6.30 a	0.47 ab	7 b	13.3 ab	155 a
3.	B	125, 125, 125 NH4SO4 Regulaid (1pt)	1.72g 1.72g 4.73ml	Well Water	250 (15gpg)	250 (15gpg)	7.5	7.9	4.90 a	0.94 a	21 a	22.8 a	149 a
4.	FO	125, 125, 125 Solubor (1 lb/100) Regulaid (1pt)	1.72g 4.54g 4.73ml	Well Water	250 (15gpg)	250 (15gpg)	7.5	8.6	4.54 a	0.37 b	9 b	9.3 b	150 a

^{z}Full bloom occurred April 17, 2001.

^{y}Treatments were applied at 26 Apr, 17 May, 22 June with a low pressure hand-wand sprayer.

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

^{w}Water hardness was determined by dipping a Hach Sofchek Water Hardness Test Strip into each mix with either deionized or well water. Guidelines for water hardness are as follows: soft=0-60ppm; moderate=61-120ppm; hard=121-180ppm; very hard=180ppm & over; (gpg)=grains per gallon: soft=0-1; slightly hard=1-3.5; moderately hard=3.5-7.0; hard=7.0-10.5; very hard=10.5 & over

Table 3. Effect of Apogee (3 applications of 125ppm; 4 days AFB, 21 days AFB, 53 days AFB) on 'Fuji'/M.9 on apple tree growth applied in 2000 and return bloom in 2001.

No.	Treatment Apogee (ppm)^{zy}	Rate/ gallon	Special sprays	Ph of Mix?? (20 Apr 00)	Avg. shoot length of longest 10 scaffold shoots (26 Jun 00)	Avg. length of shoots over 30 cm (26 Jun 00)	% of shoots over 30 cm/tree (26 Jun 00)	% of shoots over 40 cm/tree (26 Jun 00)	Avg. shoot length of longest 10 scaffold shoots (5 Dec 00)	Avg. shoot weight of longest 10 scaffold shoots (g) (5 Dec 00)	Avg. basal diameter of longest 10 scaffold shoots (mm) (5 Dec 00)	Number of pruning cuts /cm^2 /tree trunk cross sectional area (18 Dec 00)	Number of pruning cuts per tree (18 Dec 00)	Weight of pruning cuts per tree (kg) (18 Dec 00)	Return bloom (visual rating) (0-100%) (25 Apr 01)
1.	Control			7.6	56.5 ab^{x}	26.5 ab	100.0 a	94.3 ab	76.3 a	38.0 ab	12.0 ab	2.35 a	82.0 ab	1.92 cd	70.7 bc
2.	125, 125, 125	1.72g		7.9	43.5 cd	13.5 cd	95.7 ab	64.3 bcd	69.8 a	32.4 ab	11.4 ab	1.90 bcd	65.3 bcd	2.00 cd	70.7 bc
3.	125, 125, 125 NH4SO4	1.72g 1.72g		7.6	34.8 efg	4.8 efg	72.9 bcd	21.4 efg	66.3 a	31.3 ab	11.5 ab	1.44 ef	58.4 cd	2.03 cd	83.6 ab
4.	125, 125, 125 UREA	1.72g 1.72g		7.8	47.6 cd	17.6 cd	94.3 ab	74.3 abcd	75.8 a	37.0 ab	12.1 ab	1.78 bcde	77.9 abc	3.19 abc	72.9 bc
5.	125, 125, 125 NH4SO4 Regulaid (1pt)	1.72g 1.72g 4.73ml		7.7	34.3 efg	4.3 efg	70.0 bcd	21.4 fg	64.8 a	28.2 b	10.8 b	1.46 ef	57.6 cd	1.89 cd	83.3 ab
6.	125, 125, 125 NH4SO4 Oil (1qt)	1.72g 1.72g 9.46ml		7.5	31.0 gh	1.0 gh	62.9 cd	5.71 g	75.4 a	31.8 ab	11.4 ab	1.75 bcde	68.9 abcd	1.77 cd	67.1 bc
7.	125, 125, 125 +Choice +LI-700	1.72g 4.73ml 4.73ml		4.7	32.4 fgh	2.4 fgh	60.0 cd	22.9 fg	74.7 a	34.4 ab	11.4 ab	1.68 bcdef	60.6 bcd	1.80 cd	80.7 ab
8.	125, 125, 125 NH4SO4 + Silwet L-77	1.72g 1.72ml 1.2ml		7.6	30.7 gh	0.7 gh	45.7 d	8.6 g	75.0 a	34.0 ab	11.5 ab	1.49 def	57.0 cd	1.90 cd	71.4 bc
9.	125, 125, 125 Na Cl (1.5lb)	1.72g 1.72g		7.6	40.3 def	10.3 def	74.3 abc	50.0 def	66.6 a	29.9 ab	11.0 ab	1.64 cdef	59.4 bcd	1.68 cd	77.9 abc
10.	125, 125, 125 K Cl	1.72g 1.72g		7.6	45.5 cd	15.5 cd	98.3 a	76.7 abcd	78.0 a	37.0 ab	12.0 ab	2.01 abc	74.7 abc	2.44 bcd	73.3 bc
11.	125, 125, 125 CaCl2 (1.5lb)	1.72g 6.81g		7.6	50.6 bc	20.6 bc	95.7 ab	72.9 abcd	72.1 a	36.3 ab	11.9 ab	1.85 bcde	73.0 abcd	2.34 bcd	73.6 bc
12.	125, 125, 125 +NH4SO4 Regulaid +CaCl (1.5lb)	1.72g 6.81g 4.73ml 6.81g	Tank mixed (High rate NH4)	7.4	34.1 efg	4.1 efg	72.9 bcd	17.1 fg	77.9 a	36.1 ab	11.7 ab	1.68 bcdef	68.9 abcd	2.46 bcd	74.3 abc
13.	125, 125, 125 +NH4SO4 Regulaid +CaCl (1.5lb)	1.72g 1.72g 4.73ml 6.81g	Tank mixed (Low rate NH4)	7.5	45.8 cd	15.8 cd	87.1 ab	68.6 bcd	78.7 a	40.1 ab	11.9 ab	1.66 cdef	66.4 abcd	2.55 bcd	73.6 bc
14.	125, 125, 125 Regulaid Ca Cl	1.72g 4.73g 6.81g	Tank mix	7.5	48.9 bcd	18.8 bcd	100.0 a	87.1 ab	74.3 a	33.0 ab	11.5 ab	1.65 cdef	63.0 bcd	2.82 bcd	67.9 bc
15.	125, 125, 125 Regulaid Ca Cl	1.72g 4.73ml 6.81g	 Post-trt	8.0 7.5	50.4 bc	20.4 bc	87.1 ab	80.0 abc	81.0 a	41.2 ab	12.3 ab	1.73 bcde	74.8 abc	3.81 ab	72.9 bc
16.	CaCl 125, 125, 125 Regulaid	6.81g 1.72g 4.73ml	Pre trt	7.6 7.6	41.9 cde	11.9 cde	94.3 ab	51.4 cde	71.8 a	32.9 ab	11.2 ab	1.58 def	58.6 cd	1.91 cd	79.3 abc
17.	125, 125, 125 NH4SO4 Regulaid HCl	1.72g 1.72g 4.73ml	Acidic pH=4.0	3.9	30.6 gh	0.6 gh	41.4 d	7.1 g	66.9 a	28.2 b	11.0 ab	1.60 def	61.1 bcd	1.87 cd	78.6 abc
18.	125, 125, 125 NH4SO4 Regulaid Na OH	1.72g 1.72g 4.73	Basic pH=9.0	8.9	31.1 gh	1.1 gh	57.1 cd	8.6 g	74.0 a	32.1 ab	11.5 ab	1.62 cdef	61.6 bcd	1.53 d	77.9 abc
19.	125, 125, 125 NH4SO4 Regulaid Captan	1.72g 1.72g 4.73ml 9.08g		7.6	32.8 fgh	2.8 fgh	62.9 cd	11.4 g	68.0 a	30.7 ab	11.0 ab	1.46 ef	56.6 cd	1.71 cd	76.1 abc
20.	125, 125, 125 +NH4SO4 +Regulaid (1pt) +Ethephon	1.72g 1.72g 4.73ml 4.73ml		6.3	24.6 h	0.0 h	15.7 e	1.4 g	67.1 a	31.4 ab	10.9 ab	1.28 f	50.9 d	2.18 cd	90.0 a
21.	Regulaid +CaCl (1.5lb) +NH4SO4	4.73ml 6.81g 6.81g		7.4	63.4 a	33.4 a	100.0 a	98.6 a	82.2 a	45.1 a	12.7 a	2.07 ab	87.9 a	4.47 a	63.6 c

3 cont.

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 Apogee	***	***	ns	*	ns	ns	ns	**	ns	ns	ns
2 vs 3	Apogee (NH_4SO_4 vs none)	*	*	ns	***	ns	ns	ns	**	ns	ns	ns
2 vs 4	Apogee (Urea vs none)	ns	ns	ns	ns	ns	ns	ns	ns	*	ns	ns
2 vs 9	Apogee (NaCl vs none)	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
2 vs 10	Apogee (K Cl vs none)	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
2 vs 11	Apogee ($CaCl_2$ vs none)	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
3 vs 4	Apogee (NH_4SO_4 vs Urea)	**	**	ns	***	ns	ns	ns	ns	ns	ns	ns
3 vs 5	Apogee + NH_4SO_4 (Regulaid vs none)	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
3 vs 6	Apogee + NH_4SO_4 (Oil vs none)	ns	ns	ns	ns	ns	ns	ns	**	ns	ns	*
3 vs 7	Apogee (NH_4SO_4 vs Choice+LI700)	ns	ns	ns	ns	ns	ns	ns	*	ns	ns	ns
3 vs 8	Apogee (NH_4SO_4 vs Silwet L-77)	ns	ns	*	ns	ns	ns	ns	ns	ns	ns	ns
3 vs 9	Apogee (NH_4SO_4 vs NaCl)	ns	ns	ns	*	ns	ns	ns	ns	ns	ns	ns
3 vs 10	Apogee (NH_4SO_4 vs KCl)	*	*	ns	***	ns	ns	ns	ns	ns	ns	ns
3 vs 11	Apogee (NH_4SO_4 vs $CaCl_2$)	***	***	ns	***	ns	ns	ns	ns	ns	ns	ns
5 vs 6	Apogee + NH_4SO_4 (Regulaid vs Oil)	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	*
5 vs 7	Apogee + NH_4SO_4 (NH_4SO_4 Regulaid vs Choice+LI700)	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
5 vs 8	Apogee + NH_4SO_4 (Regulaid vs Silwet L-77)	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
5 vs 12	Apogee + NH_4SO_4 + Regulaid ($CaCl_2$ vs none -high rate)	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
5 vs 13	Apogee + NH_4SO_4 + Regulaid ($CaCl_2$ vs none-low rate)	**	**	ns	***	ns	ns	ns	ns	ns	ns	ns
5 vs 14	Apogee + NH_4SO_4 + Regulaid ($CaCl_2$ vs none)	***	***	*	***	ns	ns	ns	ns	ns	ns	*
12 vs 13	Apogee + NH_4SO_4 + Regulaid ($CaCl_2$-high rate vs $CaCl_2$-low rate)	**	**	ns	***	ns	ns	ns	ns	ns	ns	ns
12 vs 14	Apogee + Regulaid (NH_4SO_4 vs none)	***	***	*	***	ns	ns	ns	ns	ns	ns	ns
14 vs 15	Apogee + Regulaid (Tank mix $CaCl_2$ vs post-treatment $CaCl_2$)	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
14 vs 16	Apogee + Regulaid (Tank mix $CaCl_2$ vs pre-treatment $CaCl_2$)	ns	ns	ns	**	ns	ns	ns	ns	ns	ns	ns
15 vs 16	Apogee + Regulaid (Post-treatment $CaCl_2$ vs pre-treatment $CaCl_2$)	*	*	ns	*	ns	ns	ns	ns	ns	**	ns
17 vs 5	Apogee + NH_4SO_4 + Regulaid (pH 4.0 vs pH 7.7)	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
18 vs 5	Apogee + NH_4SO_4 + Regulaid (pH 9.0 vs pH 7.7)	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
19 vs 5	Apogee + NH_4SO_4 + Regulaid (Captan vs none)	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
20 vs 5	Apogee + NH_4SO_4 + Regulaid (ethephon vs none)	*	*	***	ns	ns	ns	ns	ns	ns	ns	ns
21 vs 1	Controls (Additives vs none)	ns	ns	ns	ns	ns	ns	ns	ns	ns	***	ns

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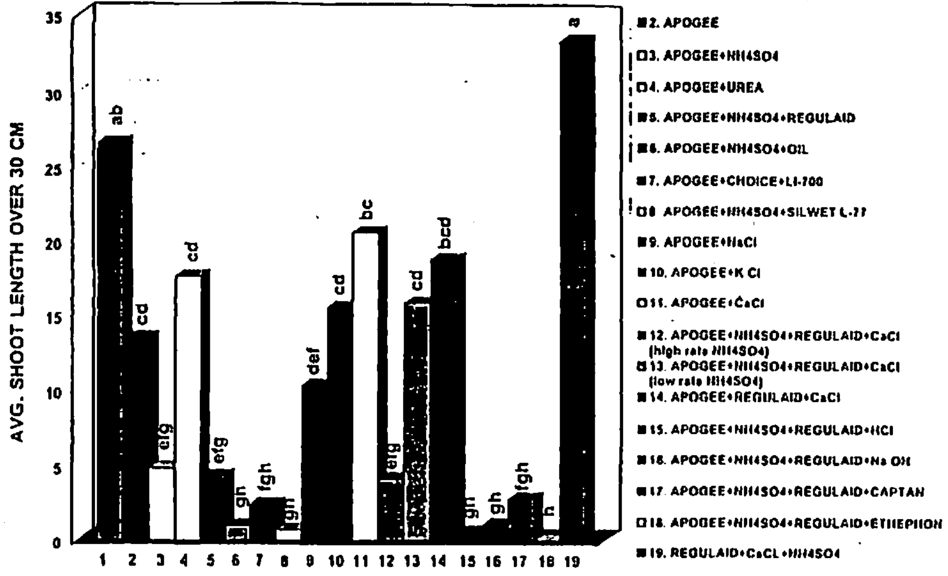
[z] Full bloom occurred April 16, 2000.

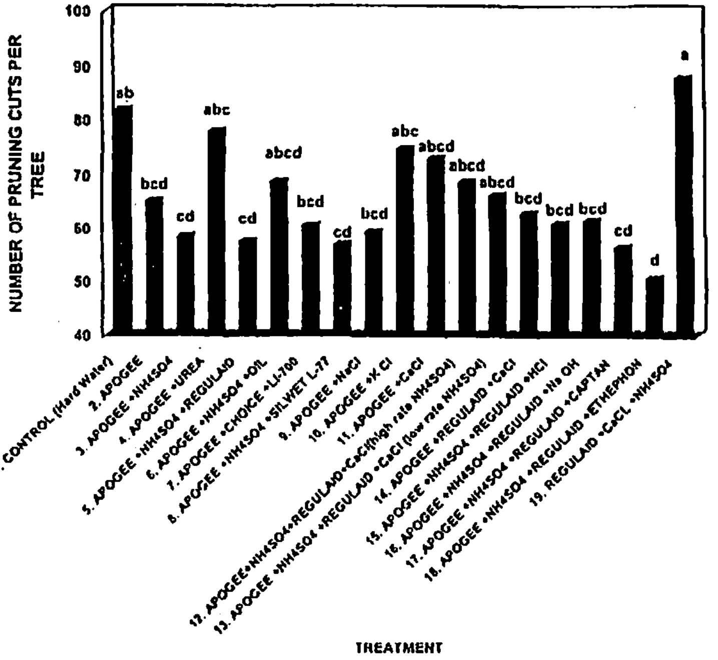
[y] Treatments were applied at 20 April, 12 May, and 8 June with a low pressure hand-wand sprayer.

[x] Mean separation within columns by Duncan's New Multiple Range Test; ($P \leq 0.05$). Percentage data was transformed to arcsin before analysis.

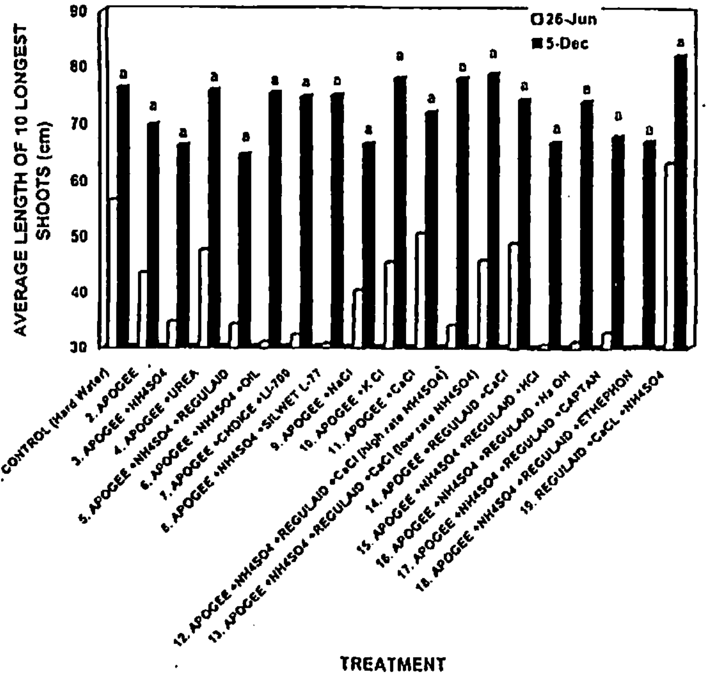
INFLUENCE OF APOGEE ON FUJI APPLE TREE GROWTH (SHOOTS OVER 30cm) (JUNE 26, 2000)



EFFECT OF APOGEE APPLIED AT PF, 21 DAFB, 53 DAFB, ON 'FUJI'/M.9 APPLE TREE GROWTH DECEMBER 18, 2000



EFFECT OF APOGEE APPLIED AT PF, 21 DAFB, 53 DAFB, ON 'FUJI'/M.9 APPLE TREE GROWTH



EFFECT OF APOGEE APPLIED AT PF, 21 DAFB, 53 DAFB, ON 'FUJI'/M.9 APPLE TREE GROWTH DECEMBER 18, 2000

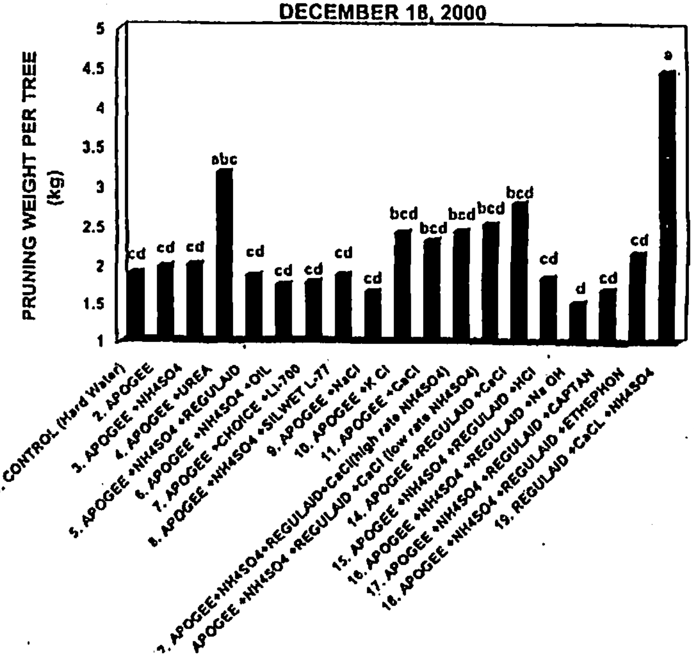


Table 4. Effect of Apogee (3 applications of 125ppm; PF, 21 days AFB, 53 days AFB), gibberellin, and adjuvants on 'Fuji'/M.9 on apple tree growth applied in 2000 and return bloom and fruit set in 2001.

No.	Color	Treatment Apogee (ppm)^{zy}	Rate/ gallon	Ph of Mix	Shoots over 30 cm (% of 10 longest) (June 26)	Shoots over 40 cm (% of 10 longest) (June 26)	Avg. shoot length of longest 10 scaffold shoots (cm) (June 26)	Avg. shoot length of longest 10 scaffold shoots (cm) (Nov 28)	Avg. shoot weight of longest 10 scaffold shoots (g) (Nov 28)	Avg. basil diameter of longest 10 scaffold shoots (mm) (Nov 28)	Number of cuts per tree (Dec 8)	Number of cuts per cm^2 of trunk cross sectional area (Dec 8)	Weight of pruning cuts per tree (kg) (Dec 8)	Flowering clusters/cm^2 limb cross sectional area (26 Apr 01)	% Spurs flowering (visual) (0-100%) (26 Apr 01)	Canopy density (visual) (0-100%) (26 Apr 01)	% Spurs flowering x Canopy density /1000 (26 Apr 01)	Fruit cm^2. limb cross sectional area (18 Jun 01)
1.	W	Control		7.4	100.0 a^w	100.0 a^w	67.3 a^x	100.7 a	65.1 a	13.9 a	102.0 a	2.44 a	3.79 a	4.39 b	81 b	78 b	6.19 b	3.74 ab
2.	R	125, 125, 125 NH4SO4 Regulaid (1pt)	1.72g 1.72g 4.73ml	7.8	60.0 b	11.3 b	31.6 c	69.8 b	32.9 b	11.5 b	59.3 b	1.73 b	1.52 b	6.60 a	92 a	88 a	8.25 a	4.25 a
3.	B	125, 125, 125 NH4SO4 Regulaid (1pt) GA3 (total 640ppm)	1.72g 1.72g 4.73ml 25.2ml	7.4	100.0 a	96.0 a	50.9 b	74.3 b	41.6 b	12.2 b	85.1 a	2.39 a	2.29 ab	1.75 c	54 c	68 c	4.28 c	2.24 ab
4.	FO	GA3 (total 640ppm)	25.2ml	7.3	100.0 a	100.0 a	69.4 a	85.1 ab	48.2 ab	12.5 ab	102.9 a	2.79 a	3.50 a	1.44 c	37 d	62 c	3.06 d	1.26 b

^{zy}Full bloom occurred April 14, 2000.Treatments were applied at April 24, May 7 and June 9 respectively with a low pressure hand-wand sprayer.

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

^{w}Percentage data was transformed to arcsin before analysis.

Table 5A. Effect of Apogee and adjuvants 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	Avg. shoot length of longest top 2 shoots (cm) 16 Dec 99	Avg. shoot length of longest 5 scaffold shoots (cm) 16 Dec 99	Avg.weight of top 2 shoots (g) 16 Dec 99	Avg.weight of 5 scaffold shoots (g) 16 Dec 99	Avg. basal diameter of 5 longest scaffold shoots (cm) 16 Dec 99	Total length of shoots over 30 cm 16 Dec 99	Number of cuts per tree 25 Feb 00	Weight of cuts per tree (kg) 25 Feb 00	Number of cuts per cm^2 cross sectional area tree 25 Feb 00
1.	W	Control			51.7 a^{x}	54.6 a	53.0 a	13.8 a	10.6 a	0.712 a	930.4 a	75.6 a	3.164 a	2.683 a
2.	Y	125, 125, 125 Regulaid	4.375g 4.4ml	10%	36.2 c	45.0 abc	37.1 ef	10.9 abc	7.3 bcd	0.672 abcd	293.4 efg	64.1 ab	3.207 a	2.222 ab
3.	BK	125, 125, 125 + Oil + L-77	4.375g 8.8ml 1.1ml	10%	32.6 c	37.5 cd	33.4 f	8.2 bc	5.8 d	0.573 de	181.0 fg	63.1 ab	2.578 a	2.449 ab
4.	YS	125, 125, 125	1.591g	27.5%	43.6 b	44.8 abc	46.7 bc	9.9 abc	9.4 abc	0.669 abcd	650.3 bcd	66.1 ab	2.901 a	2.425 ab
5.	GS	125, 125, 125 Regulaid	1.591g 4.4ml	27.5%	36.3 c	40.5 bcd	36.9 ef	8.2 bc	6.4 cd	0.604 abcde	403.2 def	62.7 ab	3.276 a	2.260 ab
6.	PBKS	125, 125, 125 + Oil + L-77	1.591g 8.8ml 1.1ml	27.5%	34.5 c	34.8 de	34.1 f	7.0 c	5.7 d	0.557 e	175.1 fg	60.1 b	2.786 a	2.346 ab
7.	OBKS	125, 125, 125 CaCl (1.5lb)	1.591g 6.3g	27.5%	46.9 ab	53.6 a	49.7 abc	13.2 ab	9.2 abc	0.696 ab	740.9 ab	67.6 ab	3.288 a	2.444 ab
8.	HPS	125, 125, 125 NH4SO4	1.591g 6.3g	27.5%	32.1 c	31.5 de	31.4 f	7.0 c	5.1 d	0.586 cde	92.1 g	59.9 b	3.229 a	2.142 ab
9.	RCK	125, 125, 125 +CaCl (1.5lb) +NH4SO4	1.591g 6.3g 6.3g	27.5%	35.0 c	34.0 de	35.6 ef	7.1 c	6.7 cd	0.647 abcde	163.8 fg	62.0 ab	2.731 a	2.359 ab
10.	OCK	125, 125, 125 Regulaid CaCl	1.591g 4.4ml 6.3g	27.5%	44.1 b	49.2 ab	44.9 cd	10.8 abc	7.5 bcd	0.632 abcde	601.1 bcd	66.0 ab	2.940 a	2.680 a
11.	HPCK	125, 125, 125 Regulaid NH4SO4	1.591g 4.4 6.3g	27.5%	31.2 c	31.9 de	32.5 f	7.0 c	6.6 cd	0.654 abcde	151.0 fg	61.1 b	2.651 a	2.381 ab
12.	YRS	125, 125, 125 Regulaid +CaCl (1.5lb) +NH4SO4	1.591g 4.4ml 6.3g 6.3g	27.5%	36.1 c	38.7 cd	40.3 de	9.4 abc	9.2 abc	0.692 abc	310.4 efg	62.3 ab	3.311 a	2.274 ab
13.	OBKD	125,125,125 + Oil + L-77 +CaCl (1.5lb) +NH4SO4	1.591 8.8ml 1.1ml 6.3g 6.3g	27.5%	33.1 c	32.4 de	32.0 f	7.1 c	5.4 d	0.589 bcde	113.9 g	64.6 ab	2.918 a	2.503 ab
14.	PBKD	125, 125, 125 + Oil + L-77 CaCl (1.5lb)	1.591g 8.8ml 1.1ml 6.3g	27.5%	43.2 b	46.8 abc	44.1cd	10.9 abc	7.4 bcd	0.607 abcde	473.7 cde	58.0 b	2.451 a	2.474 ab
15.	RBKD	125, 125, 125 + Oil + L-77 NH4SO4	1.591g 8.8ml 1.1ml 6.3g	27.5%	31.5 c	26.1 e	32.2 f	6.2 c	6.4 cd	0.645 abcde	158.0 fg	61.7 ab	3.582 a	1.991 b

16.	GD	Regulaid +CaCl (1.5lb) +NH4SO4	4.4ml 6.3g 6.3g	47.1 ab	54.0 a	51.5 ab	13.3 a	10.0 ab	0.680 abcd	557.7 bcd	66.3 ab	3.098 a	2.586 ab
17.	OD	+ Oil + L-77 +CaCl (1.5lb) +NH4SO4	8.8ml 1.1ml 6.3g 6.3g	47.8 ab	52.1 a	49.7 abc	12.7 ab	9.3 abc	0.710 a	664.3 bc	64.4 ab	3.495 a	2.374 ab

Contrasts:	Comparisons:	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F
2 vs 5	Apogee Formulation 10% vs 27.5%	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
2,3 vs 5,6	Apogee Formulation 10% vs 27.5%	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
4 vs 5	Regulaid vs No regulaid (+Apogee)	**	ns	***	ns	*	ns	*	ns	ns	ns
2,5,12 vs 3,6,13	Regulaid vs oil+L-77 (+Apogee)	*	*	**	ns	**	**	**	ns	ns	ns
7,10,14 vs 8,11,15	CaCl vs NH_4SO_4 (+Apogee)	***	***	***	***	**	ns	***	ns	ns	ns
7,10,14 vs 9,12,13	CaCl vs CaCl+NH_4SO_4 (+Apogee)	***	***	***	**	ns	ns	***	ns	ns	ns
4,5,6 vs 7,10,14	CaCl vs none (+Apogee)	***	***	***	**	ns	ns	**	ns	ns	ns
4,5,6 vs 8,11,15	NH4SO4 vs none (+Apogee)	***	***	***	ns	ns	ns	***	ns	ns	ns
16 vs 1	Additives vs none (No Apogee)	ns	ns	ns	ns	ns	ns	**	ns	ns	ns
17 vs 1	Additives vs none (No Apogee)	ns	ns	ns	ns	ns	ns	*	ns	ns	ns

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[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=1.8 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 5B. Effect of Apogee on 'Fuji'/M.9 on apple tree growth applied in 1999.

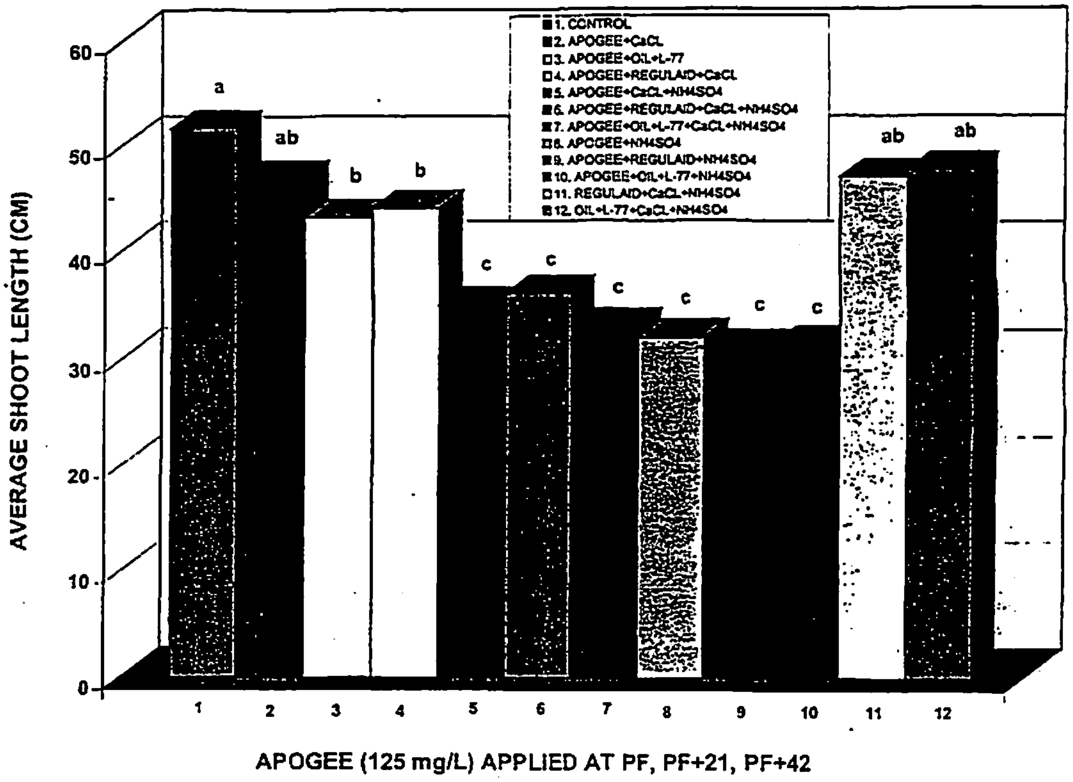
No.	Color	Treatment Apogee (ppm)[z][y]	Salt	Formulation	Avg. shoot length of longest 4 scaffold shoots (cm) 15 June 99	Fruit diameter (cm) (Oct 7)	Length/ diameter ratio (Oct 7)	Fruit firmness (lb) (Oct 7)	Soluble solids (Oct 7)	Starch (0-8) (Oct 7)	Fruit color (Oct 7)	Single fruit weight (g) (Oct 7)
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 Regulaid NH4SO4	1.591g 4.4 6.3g	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

[z] Full bloom occurred April 30 1999.

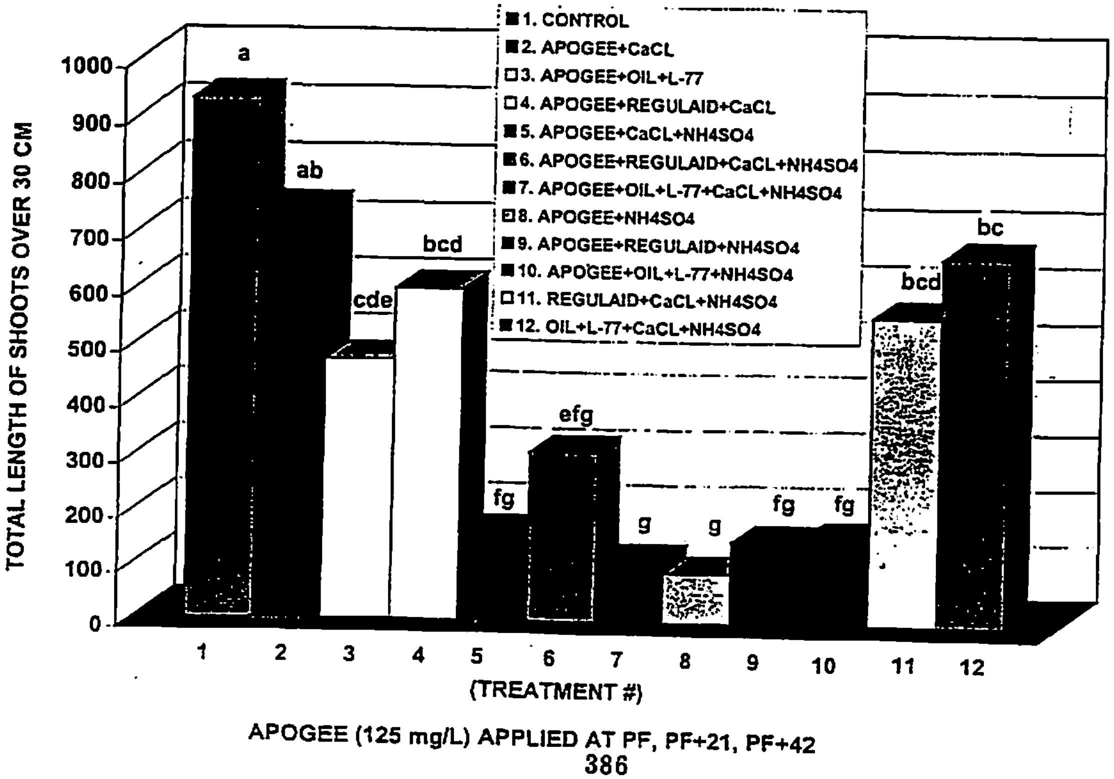
[y] Treatments were applied at PF, PF+21, PF+42 days with a low pressure hand-wand sprayer. Chemical rates were as follows: Apogee=0.125 g/L (125 mg/L); NH_4SO_4=1.8 g/L; CaCl=1.8 g/L; Regulaid=1.257 ml/L.

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

INFLUENCE OF APOGEE ON APPLE TREE GROWTH OF FUJI /M9
(JUNE 15, 1999)



INFLUENCE OF APOGEE ON APPLE TREE GROWTH OF FUJI /M.9
(DECEMBER 16,1999)



2001 'York Imperial' Apple Thinning Trial

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In 2001, a thinning experiment was conducted on 'York Imperial' apples that had a mean diameter of 17.5 mm but ranged from 14 to over 20 mm in diameter. The trees were located in a block of trees owned by Crestmont Orchards, of Idaville, PA near Route 34. The experiment used a randomized complete block design with 6 blocks (single tree plots) and 7 treatments. The treatments were various combinations of Ethrel, Sevin or Vydate, Fruitone N and oil (Table 1).

Table 1. List of treatments in the 2001 'York Imperial' apple thinning experiment.

Trmt. No.	Treatment Name	Chemical	Rate	Method[1]
1.	Check	--	--	--
2.	Ethrel + Sevin	Sevin XLR Ethrel	1 qt per 100 gallons dil. equil. 1.5 pt per 100 gallons dil. equil.	Airblast @ 100 GPA
3.	Ethrel + Sevin + Oil	Sevin XLR Ethrel Oil	1 qt per 100 gallons dil. equil. 1.5 pt per 100 gallons dil. equil. 1 gallon per acre	Airblast @ 100 GPA
4.	Ethrel + Sevin + Fruitone N	Sevin XLR Ethrel Fruitone N	1 qt per 100 gallons dil. equil. 1.5 pt per 100 gallons dil. equil. 15 ppm dilute equivalent	Airblast @ 100 GPA
5.	Ethrel + Sevin + Oil + Fruitone N	Sevin XLR Ethrel Oil Fruitone N	1 qt per 100 gallons dil. equil. 1.5 pt per 100 gallons dil. equil. 1 gallon per acre 15 ppm dilute equivalent	Airblast @ 100 GPA
6.	Ethrel + Vydate + Fruitone N	Vydate Ethrel Fruitone N	4 pts. per Acre 1.5 pt per 100 gallons dil. equil. 15 ppm dilute equivalent	Airblast @ 100 GPA
7.	Ethrel + Vydate + Fruitone N + Oil	Vydate Ethrel Fruitone N Oil	4 pts. per Acre 1.5 pt per 100 gallons dil. equil. 15 ppm dilute equivalent 1 gallon per acre	Airblast @ 100 GPA

Sprays were applied on May 29 and there was little wind and the temperature was 72 to 63F. On June 4 the fruit were counted on 2 data limbs per tree. The number of fruits on the data limbs was counted on July 9 and on Sept. 17. The data for the 7 treatments, expressed as the percentage of fruits removed, was statistically analyzed by an AOV and the Duncan's Multiple Range test was used to separate means. An AOV was used to analyze the following treatment contrasts: Oil-No oil, Vydate-Sevin and Fruitone N-No Fruitone N. All treatments sped up fruit drop compared to the check that had about 17% and 15% fruit drop during the 2 intervals (Table 2).

G. M. Greene

Table 2. The influence of 2001 postbloom thinners on the percent of fruit removed and return bloom of York Imperial apple trees (MS2001Thin).

a. treatment effects

Treatment Name	Percent of fruit removed 6/4-7/9	Percent of fruit removed 7/9-9/17	Percent of fruit removed 6/4-9/17	Mean fruit weight (g)
Check	16.9 a	14.6 c	31.4 a	173
Ethrel + Sevin	54.8 b	6.4 ab	61.2 b	187
Ethrel + Sevin + Oil	45.7 b	7.0 b	52.7 b	185
Ethrel + Sevin + Fruitone N	82.0 c	1.2 a	83.3 c	201
Ethrel + Sevin + Fruitone N + Oil	84.0 c	1.0 a	85.0 c	192
Ethrel + Vydate + Fruitone N	77.5 c	1.4 a	78.9 c	194
Ethrel + Vydate + Fruitone N + Oil	79.5 c	1.3 a	80.8 c	179
AOV P - Value Table				
Rep	.5961	.8039	.2649	.
Treatments	.0001	.0001	.0001	.

b. oil effects

Treatment name	Percent of fruit removed 6/4-7/9	Percent of fruit removed 7/9-9/17	Percent of fruit removed 6/4-9/17
No Oil	71.4 a	3.0 a	74.4 a
Oil	69.7 a	3.1 a	72.8 a
AOV P - Value Table			
Treatments	.5842	.9620	.5628

c. Vydate vs Sevin effects

Treatment name	Percent of fruit removed 6/4-7/9	Percent of fruit removed 7/9-9/17	Percent of fruit removed 6/4-9/17
Vydate	78.5 a	1.3 a	79.8 a
Sevin	83.0 a	1.1 a	84.1 a
AOV P - Value Table			
Treatments	.2380	.9017	.2163

d. Fruitone N vs no Fruitone N

Treatment name	Percent of fruit removed 6/4-7/9	Percent of fruit removed 7/9-9/17	Percent of fruit removed 6/4-9/17
Fruitone N	83.0 a	1.1 a	84.1 a
no Fruitone N	50.2 b	6.7 b	57.0 b
AOV P - Value Table			
Treatments	.0001	.0036	.0001

[z] In part a 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.

By July 9 all treatments significantly increased the percentage of fruits removed compared to the Check treatment. The Ethrel + Sevin and the Ethrel + Sevin + Oil treatments removed significantly fewer fruits than the 4 treatments that contained Fruitone N. During the period from July 9 to Sept. 17 the Check treatment lost 14.7% of it's fruit while the Ethrel + Sevin and the Ethrel + Sevin + Oil treatments lost 6-7% of their fruits. The four treatments that contained Fruitone N lost very few fruit during this period indicating that a more rapid thinning job was accomplished.

By Sept 17 the Check treatment has lost 31% of it's fruit and the Ethrel + Sevin and the Ethrel + Sevin + Oil treatments had removed between 53 and 61% of the fruits. The four treatments that contained Fruitone N removed between 79 and 85% of the fruit.

No differences were evident for the Oil-No oil and the Vydate-Sevin contrasts at any time during the season. By Sept. 17, Fruitone N compared to the No Fruitone N treatment increased the fruit removal of the Ethrel + Sevin treatment regardless of whether oil was present or not, 84 and 57%, respectively.

This research has shown that 17-mm diameter 'York Imperial' apples can be successfully thinned with aggressive thinning programs.

Acknowledgements: Thanks is expressed to Pete Cutshall, Bashar Jarjour and Sharon Riley who did the actual work involved in this experiment. The financial support of AMVAC Chem. Co. through Paul Vaculin is gratefully acknowledged.

Use of PGRs to Regulate Cropping in 'York Imperial' Apples

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Introduction

Regulating the cropping level of 'York Imperial' apple trees has proven to be a very difficult if not impossible task when using fruit thinning alone. The use of PGRs that can influence the return bloom of apples may offer some promise to facilitate return bloom enhancement of 'York Imperial' apple trees. Two experiments were conducted in 2000 at the Fruit Res. and Ext. Center in Biglerville, PA.

Experiment 1

Materials and Methods

Experiment 1 was conducted on 8th leaf 'York Imperial'/M.26 apple trees that were growing in Block 4A. The trees were growing in a tree spacing experiment and were spaced 8, 10 or 12 feet apart in the row and the rows were 16 feet apart. Prior to establishing the experiment the bloom on the trees had been rated in 1999 and in 2000 on a 1-5 scale (1 = None to Very light bloom 0 to 10%, 5 = Very heavy bloom 90 to 100% - "snowball bloom"). Trees for the experiment were selected that had a bloom density rating of 5.0. The experiment utilized a randomized complete block design with 6 blocks. The 6 treatments consisted of a factorial arrangement of 3 fruit thinning levels (none, 3 and 6 inch spacing) and 2 levels of Ethrel (none and some). Treatment details are listed in Table 1 and the sprays were applied with a dilute hand gun sprayer. All treated trees were guarded on each side by a tree that was not used in the experiment.

Full bloom was on April 28. The June 16 Ethrel spray was applied from 0630-0730 and it was foggy and humid with a light breeze and the temperature was 76F. The second spray was applied on June 30 from 1245-1345 and there was a light gusty wind and it was 75F. The total yield of the trees was measured in 1998 and 1999 prior to the experiment and also following treatment application in 2000 and also in 2001. The B and I values as described by Cripps (1981) were determined. A full bloom density rating was performed in 2001. 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

The trees in this experiment were extremely biennial for blooming and yield (Tables 2 and 3). All trees had a very light bloom in 1999 and a "snowball bloom" in 2000. Following the 2000 treatments neither Ethrel nor thinning increased the 2001 bloom density ratings (Table 2). However, both Ethrel and thinning reduced the 2000 yields (Table 3). Ethrel did not increase the 2001 yields but, at the 12 % probability level, the 2001 yields were increased by the thinning treatments. At the 7% level of probability the I values were impacted by the thinning treatments.

Experiment 2

Materials and Methods

Experiment 2 was conducted on 'York Imperial'/M.26 trees that had been planted in 1986, 1991 or 1993 in Blocks 4A and 11. The trees in Block 4A were growing in a tree spacing experiment and were spaced 8, 10 or 12 feet apart in the row and the rows were 16 feet apart. The trees in Block 11 were widely spaced. The experiment utilized a randomized complete block design with 6 blocks. The different age trees were in different statistical blocks. The ProGibb treatments are listed in Table 4. Prior to establishing the experiment the bloom on the trees had been rated in 1999 and in 2000 on a 1-5 scale (1 = None to Very light bloom 0 to 10%, 5 = Very heavy bloom 90 to 100% - "snowball bloom"). Trees for the experiment were selected that had a bloom density rating of 1.0. The sprays were applied with a dilute hand gun sprayer. All treated trees were guarded on each side by a tree that was not used in the experiment. Full bloom was on April 28.

After treatment application return bloom was rated in 2001 as previously explained and yield was determined in 2000 and in 2001. The B and I values as described by Cripps (1981) were determined. 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

The trees in this experiment were extremely biennial for blossoming and yield prior to treatment application (Tables 5 and 6). All trees had a "snowball bloom" in 1999 and a very light bloom in 2000 (Table 5). Following the 2000 treatments there was almost no crop in 2000.

There was not a statistically significant effect on the 2001 bloom density ratings. However all the ProGibb treatments had numerically lower bloom density ratings than the Check treatment but the P value was only 25%. Perhaps at this stage of the research growers would be satisfied with trying treatments that had a 25% chance of altering the flowering of 'York Imperial' trees.

Following the 2000 treatments, as expected, there was almost no crop in 2000 because there were almost no blossoms on the trees. At the 25% level of probability the 2000 treatments influenced the 2001 bloom density ratings and all of the ProGibb treatments had numerically lower ratings. There was not a statistically significant effect of the 2000 ProGibb treatments on the 2001 crop at the 5% level of probability. However all the ProGibb treatments had numerically smaller yields than the Check treatment but the P value was only 29%. Perhaps at this stage of the research growers would be satisfied with trying treatments that had a 29% chance of altering the cropping of 'York Imperial' trees.

Experiments 1 and 2

Summary

It was hoped that these treatments would have a statistically significant effect on return bloom and cropping in the year following treatment application but that was not usually the case. In the Ethrel and hand thinning experiment, hand thinning, heavily cropped trees in 2000 increased the 2001 cropping level.

In the ProGibb experiment, at about the 25% level of probability, ProGibb appeared to interrupt the biennial flowering of 'York Imperial' trees and to reduce cropping. Further research is needed to develop more effective treatments that will be useful in aiding in the regulation of 'York Imperial' cropping.

Reference

Cripps, J.E.L. 1981. Biennial patterns in apple tree growth and cropping as related to irrigation and thinning. J. Hort. Sci. 56(2):161-168

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Table 1. The list of treatments for the 2000 Ethrel and thinning experiment on 'York Imperial' apple trees (MS2000YIRet2).

Trmt. No.	Treatment Name	Hand thinning	Chemical Timing	Chemical	Rate	Method^1
1	Check	None	--	--	--	--
2	3 Inch thinned	3 inches	--	--	--	--
3	6 Inch thinned	6 inches	--	--	--	--
4	Ethrel	None	June 16, 30	Ethrel	47.3 ml/10 gal	Dil. HG
5	Ethrel + 3 Inch thinned	3 inches	June 16, 30	Ethrel	47.3 ml/10 gal	Dil. HG
6	Ethrel + 6 Inch thinned	6 inches	June 16, 30	Ethrel	47.3 ml/10 gal	Dil. HG

Table 4. The list of treatments for the 2000 ProGibb experiment on 'York Imperial' apple trees (MS2000YIRet1).

Trmt. No.	Treatment Name	Timing	Chemical	Rate	Method^1
1.	Check	--	--	--	--
2	Weekly (12).	June 14, 21, 28. July 5, 12, 19, 26, Aug. 2, 9, 16, 23, 30.	ProGibb 4%	320 ppm 378 ml /10gal	Dilute HG
3	Every other week (6).	June 14, 28, July 12, 26, Aug. 9, 23.	ProGibb 4%	320 ppm 378 ml /10gal	Dilute HG
4	Every third week (4).	June 14, July 5, 26, Aug. 16	ProGibb 4%	320 ppm 378 ml /10gal	Dilute HG
5	Every fourth week (3).	June 14, July 12, Aug. 9.	ProGibb 4%	320 ppm 378 ml /10gal	Dilute HG

Table 2. The influence of hand thinning and Ethrel sprays on the bloom density ratings of York Imperial apples (MS2000YIRet2).

a. treatment effects

	Bloom Density Rating[z]		
Treatment Name	1999	2000	2001
Check	1.0 a[y]	5.0	1.6 a
3 Inch thinned	1.1 a	5.0	1.2 a
6 Inch thinned	1.0 a	5.0	1.9 a
Ethrel	1.2 a	5.0	1.1 a
Ethrel + 3 Inch thinned	1.0 a	5.0	1.4 a
Ethrel + 6 Inch thinned	1.0 a	5.0	2.2 a
AOV P-Value Table			
Rep	.6195	.	.6372
Trmt	.5043	.	.4429

b. Ethrel and hand thinning effects

	Bloom Density Rating		
Ethrel effect	1999	2000	2001
No Ethrel	1.0 a	5.0	1.6 a
Ethrel	1.1 a	5.0	1.6 a

Thinning effect			
none	1.1 a	5.0	1.4 a
3 inch	1.0 a	5.0	1.3 a
6 inch	1.0 a	5.0	2.0 a
AOV P-Value Table			
Rep	.6195	.	.6372
Ethrel	.5677	.	1.0000
Thinning	.5409	.	.1627
Ethrel x thinning	.2452	.	.6042

[z] Bloom density rating values: 1 = None to very light bloom 0 to 10%, 2 = Light bloom 10 to 30%, 3 = medium or moderate bloom 30 to 70%, 4 = Heavy bloom 70 to 90%, 5 = Very heavy bloom 90 to 100% - snowball bloom

[y] 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 3. The influence of hand thinning and Ethrel sprays on the yield, I and B values of York Imperial apples (MS2000YIRet2).

a. treatment effects

	Yield (kg/tree)				I Values			Average I Value	B Value
Treatment Name	1998	1999	2000	2001	1998-1999	1999-2000	2000-2001	1998-2001	1998-2001
Check	24.9 a[z]	3.7 a	61.3 c	6.5 a	.78 a	.90 a	.80 ab	.83 a	100 a
3 Inch thinned	22.4 a	5.8 a	42.1 ab	6.6 a	.60 a	.76 a	.72 ab	.69 a	100 a
6 Inch thinned	19.2 a	2.6 a	37.4 ab	16.7 a	.80 a	.88 a	.51 ab	.73 a	83 a
Ethrel	16.9 a	5.6 a	45.8 bc	2.5 a	.56 a	.80 a	.90 b	.75 a	100 a
Ethrel + 3 Inch thinned	15.3 a	1.0 a	24.8 a	13.9 a	.87 a	.92 a	.51 ab	.77 a	92 a
Ethrel + 6 Inch thinned	19.5 a	3.3 a	35.2 ab	18.4 a	.75 a	.85 a	.46 a	.69 a	92 a
AOV P-Value Table									
Rep	.1226	.6322	.2746	.5700	.3560	.5732	.1978	.8844	.8519
Trmt	.3483	.5300	.0182	.3443	.3980	.4015	.2228	.8811	.5587

b. Ethrel and hand thinning effects

	Yield (kg/tree)				I Values			Average I Value	B Value
Ethrel effect	1998	1999	2000	2001	1998-1999	1999-2000	2000-2001	1998-2001	1998-2001
No Ethrel	22.0 a	4.0 a	46.1 b	10.1 a	.72 a	.85 a	.67 a	.75 a	94 a
Ethrel	17.2 a	3.2 a	34.7 a	12.1 a	.74 a	.86 a	.61 a	.73 a	94 a
Thinning effect									
none	20.9 a	4.7 a	53.6 b	4.5 a	.67 a	.85 a	.85 b	.79 a	100 a
3 inch	18.8 a	3.4 a	33.5 a	10.3 ab	.73 a	.84 a	.62 ab	.73 a	96 a
6 inch	19.4 a	2.9 a	36.3 a	17.5 b	.78 a	.87 a	.48 a	.71 a	88 a
AOV P-Value Table									
Rep	.1226	.6322	.2746	.5700	.3560	.5732	.1978	.8844	.8519
Ethrel	.0756	.6664	.0299	.7097	.9832	.8626	.6052	.8208	1.0000
Thinning	.7098	.7935	.0150	.1172	.7844	.8777	.0739	.6697	.2876
Ethrel x thinning	.3876	.1974	.4048	.6028	.1091	.1040	.5131	.6526	.5103

[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 5. The influence of ProGibb on the bloom density ratings of York Imperial apples (MS2000YIRet1).

Treatment Name	Bloom Density Rating[z] (1-5)		
	1999	2000	2001
Check	5.0 a[y]	1.0	4.4 a
Weekly Pro-Gibb (12).	5.0 a	1.0	3.9 a
Every other week Pro-Gibb (6).	5.0 a	1.0	3.8 a
Every third week Pro-Gibb (4).	4.6 a	1.0	3.7 a
Every fourth week Pro-Gibb (3).	5.0 a	1.0	4.2 a
AOV P - Value Table			
Rep	.4362	NA	.0627
Trmt	.4362	NA	.2552

[z] Bloom density rating values: 1 = None to very light bloom 0 to 10%, 2 = Light bloom 10 to 30%, 3 = medium or moderate bloom 30 to 70%, 4 = Heavy bloom 70 to 90%, 5 = Very heavy bloom 90 to 100% - snowball bloom

[y] 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 6. The influence of ProGibb on the yield, I and B values of York Imperial apples (MS2000YIRet1).

Treatment Name	Yield (kg/tree)				I Value			Mean I value	B value
	1998	1999	2000	2001	98-99	99-00	00-01	98-01	98-01
Check	9.4 a[z]	86 ab	0.00 a	60.0 a	.84 a	1.00 a	1.00 a	.94 a	100
Weekly Pro-Gibb (12).	17.9 a	140 c	1.10 a	70.9 a	.74 a	.98 a	.97 a	.90 a	100
Every other week Pro-Gibb (6).	7.0 a	115 bc	0.00 a	67.9 a	.83 a	1.00 a	1.00 a	.94 a	100
Every third week Pro-Gibb (4).	15.0 a	140 c	1.69 a	87.8 a	.73 a	.94 a	.91 a	.86 a	100
Every fourth week Pro-Gibb (3).	7.6 a	82 a	0.00 a	62.1 a	.80 a	1.00 a	1.00 a	.93 a	100
AOV P - Value Table									
Rep	.0020	.0001	.5850	.0001	.0161	.5368	.5257	.0443	.
Trmt	.3698	.2779	.5850	.2922	.5105	.5368	.5257	.2638	.

[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.

Not for Citation or Publication
Without Consent of the Author

The Effect of Continuous and Periodic Whole-Tree Shade On the Performance of 'Ginger Gold'/M.9 Apple Trees [1]

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The influence of sunlight on apple tree growth and fruit development has been well documented (Ferree, 1985; Jackson, 1980). Training systems have been developed and are recommended to growers that maximize light exposure (Robinson, et al., 1991). However, a major portion of the apple tree's canopy is subjected to shade during most daylight hours each day. When shading reduces light levels, fruit bud formation is reduced and the buds that are formed are often small and weak (Auchter, et al., 1926). Several days of continuous shade soon after bloom can reduce fruit set (Byers, et al., 1990). Shade reduces shoot growth and leaf weight, but may increase leaf size (Jackson and Palmer, 1977a). Lack of adequate light levels can also reduce yield (Jackson and Palmer, 1977b; Hunter and Proctor, 1986) and lower fruit quality (color, firmness, soluble solids concentration) (Heinicke, 1966; Jackson, et al., 1971).

Over the years the author has observed apparent differences in cropping when whole trees or portions of the canopy are naturally shaded in the morning compared to shade in the afternoon hours. The purpose of the present study was to evaluate the effect of shade when applied to whole apple trees during a given period of time each day on a season-long basis. Imposed shade treatments were compared to trees grown under natural sunlight conditions.

Materials and Methods

'Ginger Gold'/M.9 apple trees were planted in a solid block of three rows with 20 trees per row in 1996. Border trees, consisted of 'Pink Lady', 'GoldRush', and 'Liberty', each on M.9 rootstock, planted as a single row on both sides of the test block and on the end of each test row. Trees were spaced 2.4 m apart in rows spaced 4.9 m apart and were oriented in a north-south direction. Trees were headed to about 76 cm at planting and trained as a central leader with a metal pole supported by one wire at a height of 1.5 m above the ground. Trees received the local recommended cultural and pest management program throughout the study. A weed-free strip was maintained under the tree canopy on both sides of the row from the trunk to the drip line. In the first growing season a mechanical rotary hoe was used to obtain the weed-free strip and recommended

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herbicides were used in the following years. A dilute foliar spray of 6-BA (400 mg·L^{-1}) was applied in early May of the second leaf to encourage branch development. All trees were delayed dormant pruned on an annual basis in Apr after counting flower buds.

Shade treatments were initiated about 3 to 4-weeks after full bloom (FB), beginning in the third leaf (1998) and repeated in 1999 through 2001, except in the first year (1998) when mechanical problems with the shade shelters delayed application of the treatments until 7 weeks after FB. Shade treatments were terminated each year on 30 September. The following treatments were applied to two adjacent trees with 4 replicated plots per treatment: 1) natural sunlight [check (C)], 2) constant or continuous shade (CS) 24 hours per day, 3) partial shade (PS) applied daily from 0800 to 1100 HR, 4) PS applied daily from 1100 to 1400 HR, and 5) PS applied daily from 1400 to 1700 HR. By 2001 tree size had increased so the shade shelters used for the PS treatments could only accommodate a single tree per plot. The time for PS treatment was altered in 2001 so that trees originally shaded at 0800 to 1100 HR were shaded at 0700 to 1330 HR and trees originally shaded at 1400 to 1700 HR received shade from 1330 to 2000 HR daily. Trees that were originally shaded from 1100 to 1400 HR were not artificially shaded in 2001. In addition, four trees in the CS plots were not artificially shaded in 2000, but the shade was reapplied in 2001. Likewise, four original C trees were given CS in 2000 and then treated as C trees in 2001.

Special steel structures were designed and built to surround the test trees and support the shade material in this study (Fig. 1).

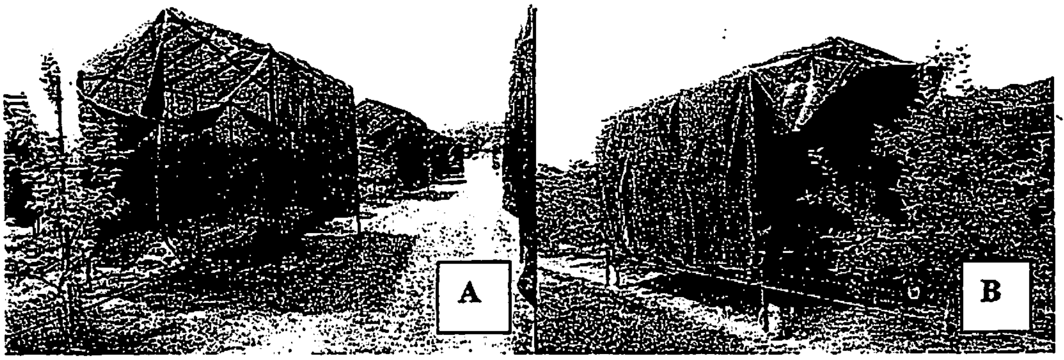

Fig. 1. Shade shelters used to apply constant shade (CS) (A) or partial shade (PS) (B) to 'Ginger Gold'/M.9 apple trees. Structures used for CS and PS were the same dimensions except rubber tired wheels were added to the PS shelters to facilitate positioning at specific times each day.

The shade shelters measured 2.43 m wide by 5.67 m long and 3.23 m tall at the highest point in the center. A black polypropylene shade fabric (Hummert International, St. Louis, MO) providing 73% or 95% actual shade was used. The 73% shade material was used for the CS treatments throughout the study. The PS treated trees had 73% shade in 1998 and 1999 and 95% shade in 2000 and 2001. Shade cloth was applied over the top (roof) of the shade shelters and extended down the sides to within about 45 cm of the ground. For the CS shelters all four sides were enclosed (Fig 1A), but only the sides parallel to the row were covered in the PS shelters (Fig 1B). Metal poles were secured to each end of the shelter's roof extending about 1.0 m down the tree row and the shade cloth was placed over these poles forming an awning (Fig 1B). This provided more uniform shade to test trees in the PS test plots. The PS shade shelters were connected to a cable and winch system operated by a time clock that was designed to pull the shelter over the test tree plots at the designated time each day. At the end of the day or at dawn the next day the PS shelters were manually repositioned at the end of each row in preparation for the daily shade treatments.

Canopy photosynthetic photon flux (PPF) levels and canopy temperature were recorded continuously in one tree representing each treatment. Air temperature was recorded with an Optic StowAway Temp data logger (Spectrum Technologies, Inc., Plainfield, IL) placed in a white wooden weather shelter attached to the upper tree post support wire. PPF was recorded at 10-min intervals with a quantum light sensor (models 3600 and 3668, Spectrum Technologies, Inc.) attached to a pole erected in the tree canopy and located half way between the center of the canopy and the drip-line of the tree at a height of 2.0 m. Incident PPF and ambient air temp were recorded in a vacant tree spot in the block as described above. Only a select portion of the voluminous temperature and light data will be reported at this time.

Response variables measured annually included trunk diameter, bloom cluster count, fruit count and weight at harvest, internal fruit quality (firmness, soluble solids, and starch index rating) at harvest, current season shoot length, and leaf and shoot carbohydrate levels. Yield efficiency (YE) and bloom efficiency were computed from trunk cross-sectional area (TCSA) data. Only the effects on bloom, tree growth, fruit weight, and yield will be reported at this time. Trunk diameter was measured 20 cm above the graft union. Shoot length was the mean of 20 terminals selected at random per tree. Bloom cluster count was the total number of blossom clusters per tree taken between pink and full bloom. Fruit was harvested in August when the starch index rating reached a 3.0 level (Blanpied and Silsby, 1992). Data was analyzed using SAS ANOVA (SAS Institute, Cary, NC) and means separated with Duncan's new multiple range test.

Results and Discussion

One growing season of CS (73%) reduced trunk diameter of 'Ginger Gold'/M.9 (Table 1). The annual increase in trunk diameter during the next three growing seasons for CS trees was equal to or less than that for the check trees. As a result, CS trees had a smaller trunk diameter after 4 growing seasons than check trees or trees shaded in the afternoon or trees receiving 3 years PS from 1100 to 1400 HR followed by a no shade year. PS (73%) applied from 0800 to 1100 HR reduced trunk diameter after one and two growing seasons, but trunk diameter of these trees was not different from check trees after a third and fourth year of PS. It is suggested that PS in the early part of the day imposes a stress on the younger trees that is overcome as the tree ages. The negative effect of CS on trunk diameter appears to be reduced if trees are given a natural sunlight environment for one year. In contrast, one year of CS applied to an older tree (fifth leaf, 2000) did not result in reduced trunk size. Limited information has been reported concerning the effect of whole-tree shade on trunk growth, but these results appear to agree with reports on the effects of shade on tree size (Auchter, et al., 1926; Jackson and Palmer, 1977a).

Shoot growth was not recorded at the conclusion of the first year (1998) of shade treatments. There was no difference in shoot extension growth among treatments after two seasons (1999) (Fig.2). However, in the third season of treatment those trees receiving CS for 3 years or CS only in 2000 (C-C-CS) had longer shoots than C or PS trees. Jackson and Palmer (1977a) and Moran and Rom (1991) also reported an increase in stem length from shade treatments, but their effect was noted in the first year of treatment. The lack of shoot growth response to CS in 1999 is not easily explained since trees receiving CS for the first time in 2000 responded with increased shoot growth. However, the results suggest that reserves for growth were not limiting in 2000, but were limiting in 1999.

Bloom clusters per cm^2 TCSA were reduced after one year of CS, but PS (73%) had no effect (Table 2). In subsequent years, CS treated trees had numerically fewer bloom clusters than check trees but the differences were not significant from check trees. Since a heavy bloom often follows light bloom years (Westwood, 1978), it appears these CS trees were attempting to recover from the initial shade effect in 2000. Two years (1998 and 1999) of PS (73%) at all time periods reduced the number of bloom clusters in 2000. Bloom count for PS treated trees in 2001 was not different from check trees, as might be expected following a year of reduced bloom. There was a trend toward a reduced bloom count on trees treated as C trees for 2 seasons followed by one year of CS, but differences were not significant.

Shade treatments had no effect on fruit numbers at harvest in the first year (1998) (Table 3). The delay in application of the shade material until 7-weeks after FB was apparently sufficient to allow normal fruit set to occur (Byers, et al., 1990). Fruit numbers were reduced in CS treated trees in the second season of treatment, as might be expected. In subsequent years all CS and PS treatments showed reduced fruit numbers at harvest compared to check trees. The reduction in 2000 can be directly related to the reduction in bloom in 2000. Trees treated as C trees in the first two years followed by a CS treatment in the third year and then returned to C treatment in the fourth year did not have reduced fruit numbers in 2001. However, when trees were given CS in 1998-1999, left unshaded in 2000 and were returned to CS in 2001, there appeared to be a slight recovery in fruit count at harvest when not shaded, but there was a dramatic reduction in fruit count when the trees were given CS the following year. These results suggest that shade treatments may have had a direct effect on fruit set in 2001, a response not evident in 1999. While shade treatments were applied at about the same time after FB in these two years, the stage of fruit development may have differed. No data was taken on the size of fruitlets at the time shade materials were applied.

There was little or no effect of shade treatment on mean fruit weight (data not shown) except in the first year of shading when fruit from CS treated trees was smaller than C fruit (179 g/fruit for CS vs. 230 g/fruit for C fruit). When C trees were shaded in 2000 and not shaded in 2001, fruit size was reduced in 2001 compared to trees that had never been shaded.

Yield (data not shown) and YE (kg fruit per cm^2 TCSA) (Table 4) produced results similar to that for fruit count at harvest. CS reduced yields and YE. Trees shaded for 4 years, initially from 0800 to 1100 HR and later from 0700 to 1330 HR, showed reduced yields and YE similar to those trees that received CS during the same period.

Mean temperatures for June 2001 showed differences ($P \leq 0.05$) between ambient and shade treatments during the two daily time periods. Mean temperature for trees under 73% and 95% shade during the 0700 to 1330 HR was 23.1°C and 22.7°C, respectively compared to 26.2°C for the ambient temperature. Temperatures during the 1330 to 2000 HR period differed between the two levels of shade (27.2°C for 73% shade vs 26.5°C for 95% shade) and with ambient temperature (28.4°C). Mean incident light levels, measured as PPF ($\mu mol \cdot m^{-2} \cdot s^{-1}$), for June 2001 were 934 and 791 for the periods 0700 to 1330 HR and 1330 to 2000 HR, respectively. Light levels measured under 73% and 95% shade for these same periods were slightly less than that expected from levels calculated for 27% and 5% of the mean incident light.

Conclusions

The following conclusions have been drawn from these whole-tree shade studies.

- Constant shade (CS) at 73% reduced bloom, yield, and trunk diameter, but increased shoot growth in some years.
- Partial shade (PS) on a daily basis may reduce bloom, fruit numbers at harvest, and yield, but had little or no effect on shoot length. There appears to be some cumulative effect of PS over time (years). PS at 95% has a greater effect than 73% PS. Shade applied early in the day (0800 to 110 HR or 0700 to 1330 HR) has a greater effect than shade applied only at mid-day (1100 to 1400 HR) or in the latter half of the day (1400 to 1700 HR or 1330 to 2000 HR).
- Trees can respond to and recover from CS (73%) in one season
- Whole-tree shade significantly reduces canopy temperature and incident PPF.
- Younger trees (third leaf) may respond differently than older trees (sixth leaf) to shade.

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Table 1. Effect of whole-tree constant shade (CS) and partial shade (PS) treatments on the trunk diameter of young 'Ginger Gold'/M.9 apple trees planted in 1996.

Treatments [z]		Trunk diameter (cm)			
1998 –2000	2001	1998	1999	2000	2001
Check (C)	C	4.20 a[y]	4.70 ab	5.70 a	6.62 a
Constant Shade (CS)	CS	3.33 c	3.90 c	4.24 c	4.85 b
PS 0800-1100[x]	PS 0700-1330	3.76 b	4.41 b	5.15 ab	5.91 ab
PS 1100-1400	C	3.86 ab	4.64 ab	5.49 ab	6.36 a
PS 1400-1700	PS 1330-2000	4.27 a	5.03 a	5.79 a	6.65 a
CS-CS-C	CS	----	----	4.86 bc	5.67 ab
C-C-CS	C	----	----	5.07 ab	5.87 ab

[z] See text for details of individual shade treatments.
[y] Mean separation within columns by Duncan's new multiple range test, $P = 0.05$.
[x] Hours daily during which shade imposed.

Fig. 2. Effect of whole-tree constant shade (CS) or partial shade (PS) treatments on shoot growth of 4th (1999) and 5th (2000) leaf 'Ginger Gold'/M.9 apple trees. Shade treatments applied 1998 through 2000; see text for description of shade treatments. No statistical differences in 1999; letters for 2000 bars represent differences between treatments, Duncan's multiple range test, $P = 0.05$.

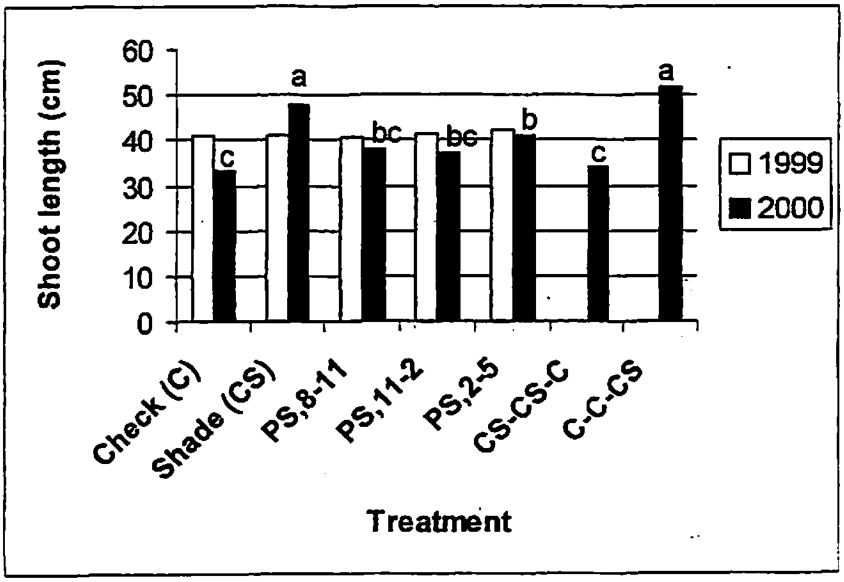

Table 2. Effect of whole-tree constant shade (CS) or partial shade (PS) treatments on the bloom of young 'Ginger Gold'/M.9 apple trees planted in 1996.

Treatment[z]	Bloom clusters per cm² TCSA		
1998 - 2000	1999	2000	2001
Check (C)	23.6 a[y]	22.4 a	26.0 ab
Constant Shade (CS)	7.4 b	16.1 ab	14.8 b
PS 0800 – 1100 HR	23.4 a	10.0 b	27.8 ab
PS 1100 – 1400 HR	22.7 a	8.6 b	31.2 a
PS 1400 – 1700 HR	17.2 a	10.5 b	25.3 ab
CS-CS-C	----	----	27.8 ab
C-C-CS	----	----	19.6 ab

[z] See text for details of individual shade treatments.

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

[x] Hours daily during which shade imposed.

Table 3. The effect of whole-tree constant shade (CS) or partial shade (PS) treatments on the number of fruit at harvest in 'Ginger Gold'/M.9 apple trees planted in 1996.

Treatments [z]		Fruit count at harvest (no./tree)				Cumul.
1998 –2000	2001	1998	1999	2000	2001	1998-'01
Check (C)	C	29 a[y]	94 a	196 a	302 a	621
Constant Shade (CS)	CS	30 a	18 b	22 c	23 d	93
PS 0800-1100[x]	PS 0700-1330	35 a	80 a	76 bc	79 cd	270
PS 1100-1400	C	42 a	110 a	82 bc	172 b	406
PS 1400-1700	PS 1330-2000	31 a	101 a	109 b	147 bc	388
CS-CS-C	CS	----	-----	74 bc	16 d	138
C-C-CS	C	----	-----	51 bc	279 a	453

[z] See text for details of individual shade treatments.
[y] Mean separation within columns by Duncan's new multiple range test, $P = 0.05$.
[x] Hours daily during which shade imposed.

Table 4. The effect of whole-tree constant shade (CS) or partial shade (PS) treatments on yield efficiency in 'Ginger Gold'/M.9 apple trees planted in 1996.

Treatments [z]		Yield efficiency (kg/cm^2 TCSA)			
1998 –2000	2001	1998	1999	2000	2001
Check (C)	C	0.50 b[y]	1.03 a	1.50 a	1.74 a
Constant Shade (CS)	CS	0.67 ab	0.33 b	0.34 c	0.29 d
PS 0800-1100[x]	PS 0700-1330	0.70 ab	0.96 a	0.77 bc	0.57 d
PS 1100-1400	C	0.78 a	1.14 a	0.74 bc	1.15 b
PS 1400-1700	PS 1330-2000	0.47 b	0.95 a	0.89 bc	0.77 c
CS-CS-C	CS	-----	-----	0.97 b	0.18 d
C-C-CS	C	-----	-----	0.38 c	1.77 a

[z] See text for details of individual shade treatments.
[y] Mean separation within columns by Duncan's new multiple range test, $P = 0.05$.
[x] Hours daily during which shade imposed.

Mechanism for Sooty Blotch Susceptibility of Apple Fruit

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Abstract

Sooty blotch (SB) on apple fruit is an epiphyte, and therefore nutrition for growth and development must be acquired at the cuticle. Determination of the nutritional basis supporting the fungi could lead to understanding fruit susceptibility and development of resistant varieties. Previous work determined that SB growth was not supported by components of the cuticle and therefore the nutritional basis for growth must be derived from carbohydrates leaching from within the fruit. In experiment I, the presence of substrates was determined on the cuticle of apple fruit either untreated or treated with Gibberellins 4+7 (GA) at two-week intervals. Total carbohydrates collected increased due to the application of GA. In experiment II, sooty blotch incidence was determined on paired limbs of 9 varieties of apples from a disease resistant block either untreated or treated with bi-weekly applications of 0.5% apple juice (AJ) to selected limbs. If the incidence of SB increased due to the application of apple juice, it can be reasoned that sugars from within the fruit leaching to the surface of the cuticle support SB growth and therefore could play a part in determining fruit susceptibility. SB incidence doubled on fruit treated with apple juice compared to the control, 25.5% compared to 11.6% of the fruit respectively.

Keywords: *Peltaster fructicola, Leptodontidium elatius, Geastrumia polystigmatis,* Schizithyrium pomi

Introduction

Sooty blotch (SB) is a disease complex of apples, caused by *Peltaster fructicola* Johnson, Sutton & Hodges, *Leptodontidium elatius* (G. Mangenot) De Hoog and *Geastrumia polystigmatis* Batista & M.L. Farr, and other organisms. SB is an epiphytic disease, favored by warm, humid summer weather, causing superficial dark blemishes of mycelial growth on the cuticles of fruit rendering them unsightly and unacceptable for the fresh fruit market. In the eastern United States, SB affects 5-15% of fruit annually despite summer long fungicide protection on a 10-14 day schedule (Main and Gurtz, 1988). Incidence of SB in normal years in the Southeast without fungicide control would be 100 percent.

Control of SB is based on cultural practices such as pruning which facilitates drying of fruit on the tree (Cooley et al., 1991b), and fungicides applied on a 2 week schedule throughout the summer. The variety of apple plays an important part in determining SB susceptibility, however the factors that contribute to susceptibility are unknown. Environment modification influences the incidence of SB growth Open trees develop less SB than a dense canopy. SB disease is epiphytic in nature and fungal growth does not penetrate the cuticle. Histological examination did not reveal penetration of the cuticle of apple fruit by any of the fungi of apple sooty blotch complex (Johnson et.al., 1997).

The incidence of SB has increased in NY and NE in past years in response to changes in registration such as the loss of EBDC and benzimidazole fungicides as well as changes in fungicide use strategies (Cooley et.al, 1991a). Rosenberger (1996) found ground cover management effective at reducing SB in the lower half of trees over a three-year study. Advanced IPM practices in Massachusetts reduced summer fungicide use by 1.1 spray, or 26%, compared to conventional applications for controlling SB, by considering summer pruning and ascospore maturity and potential ascospore dose (Cooley and Autio 1997).

During fungicide field trials, it was observed that fruit rots (*Botryosphaeria dothidea* (Moug.: Fr.) Ces. & DeNot. And *Colletotrichum* spp.) were equal or more severe on fungicide treated fruit than non-sprayed controls. (Venkatasubbaiah and Sutton, 1995). This observation lead to the discovery that, the fungi causing SB and flyspeck produce toxins, which inhibit fungi that cause fruit rots. Four identified toxins also caused necrosis on leaves of apple and other species. Antagonists of disease are also found as components of leaf surface. Some instances of disease resistance depend on component compounds of the cuticles that inhibit fungal growth.

In earlier work, no components of the apple cuticle could support or inhibit fungal growth. Further, cultures of *P. fructicola* and *L. elatius* did not grow on 5 major component compounds of the cuticle unless dilute apple juice was included, indicating that the nutritional basis for growth was not the cuticle (Belding et.al. 2000).

Sooty blotch does not readily grow on russetted portions of apple cuticles even though the cuticular wax composition is not altered. Russet is a suberized surface considered impermeable to water and presumably to nutrients. All permeable plant surfaces, whether external as in glands or nonwaxy surfaces, or internal as in uncutinized walls, are leaky and nutrient rich (Tukey, 1970).

The purpose of the first experiment was to determine if carbohydrate leachates are present on the surface of the cuticle and to what amounts. The second purpose of the first experiment was to determine if GA altered leaching of apple cuticular carbohydrates if they are present. Gibberellins (GA) are commercially used to alter the cuticle of apples on the trees. Early in the season, GA is used to reduce russet formation on susceptible apple varieties, and later in the season, GA is applied to prevent cracking of apples presumably by increasing the elasticity of the cuticle.

Materials and Methods

Experiment I (Snyder Farm)- Two trees each of 'Brae burn', 'Gala', and 'Starkspur Supreme' were selected from a variety collection located on the Rutgers Snyder Research and Extension Farm in Pittstown, New Jersey. Selected trees had fruit on the lower branches that were positioned suitably for sampling by immersion in elevated containers. Fruit with intact cuticles were selected from paired trees of 'Braeburn', 'Gala', and 'Starkspur Supreme'. One tree of each cultivar was treated at two week intervals with 1.25mls Provide /L water using a hand wand sprayer with no surfactant (Valent Biosciences Corp., Libertyville, IL). Immediately before the collection of fruit leachates, in situ fruit were spray rinsed with deionized water, then fruit were submerged in deionized water for 60 minutes to allow leachates to diffuse into the water. Leachate samples were collected only from fruit with intact cuticles. Samples were stored frozen and then lyophilized for analysis. Soluble solids were determined for three representative fruit from each cultivar to establish the potential for leachates present at the time of sampling.

In 1997, Oregon Spur was included along with Braeburn and Gala since the StarkSpur Supreme did not set an adequate crop. Sampling: At 4-week intervals, 5 fruit with intact cuticles were selected from each cultivar / treatment combination. With minimal handling, fruit length and diameter were measured for estimation of surface area. Fruit were rinsed with deionized water using a hand sprayer prior to leachate collection. Fruit in situ were submerged in deionized water for 60 minutes to collect carbohydrates leaching from the fruit cuticle. Leachate samples were stored frozen at –26 degrees C until they could be freeze dried (lyophilized) for analysis.

Fruit diameter measurements were converted to estimate surface area for standardization of leachate quantification. Diameters were used to calculate the surface area of a sphere of those dimensions. Actual surface area of apples correlates well to corresponding sphere estimates calculated from diameter measurements (R^2=0.93) (Belding 1996).
Selected samples were analyzed qualitatively and quantitatively for carbohydrate composition using HPLC as compared to standard sugars. Samples from each cultivar by treatment by date combination were tested for total carbohydrates using Anthrone reagent. Dried samples were resolubilized into water, combined with anthrone reagent and quantified on a spectrophotometer compared to an eight point standard sample set. Data was analyzed by SAS (Cary NC, USA) statistical software using the Proc Anova and Waller-Duncan Mean separation t-test.

Experiment II-
Upon the results of the first experiment, learning that sugar carbohydrates are present on the fruit surface, a follow up experiment was conducted at a location more favorable to development of SB. The purpose of the second experiment was to determine if the incidence of SB would increase on apple fruit if apple juice were supplied to the surface of otherwise resistant fruit. It was hypothesized that if increased SB incidence occurred by increasing the carbohydrates on the surface, then the mechanism of fruit susceptibility would be determined.

Nine apple cultivars, Coop 27, HF8-151, Coop 10, PA28-132, CS1-66, D102-352, D99-15, TN10-31, and HE14-30 were selected for use from a block of disease resistant apple varieties located at the Rutgers Fruit Research Center, in Cream Ridge NJ. At 2-week intervals, fruit on selected limbs were treated with 0.5% apple juice in de-ionized water using handheld sprayers to the point of run off. Apple juice was selected for quality purposes from a single batch of domestically produced juice (Martinelli's & Co., Watsonville, CA) that did not include juice concentrate and had no added sugar or preservatives.

At 4-week intervals, 5 fruit with intact cuticles were selected from each cultivar and treatment combination. With minimal handling, fruit length and diameter were measured for estimation of surface area. Fruit were then placed in containers for collection of surface residues. Fruit were submerged in deionized water for 60 minutes to collect water-soluble surface residues and leachate materials. Leachate/surface residue samples were stored frozen at –26 degrees C until lyophilized. Samples were collected every 4 weeks until harvest. Twenty-five fruit per treatment were collected on October of 1999 and 2000 and evaluated for disease incidence and surface carbohydrates. Representative fruit samples had the identification of SB confirmed by

T.B. Sutton of North Carolina State University, Raleigh, NC. Data was analyzed by SAS (Cary NC, USA) statistical software using the Proc Anova and Waller-Duncan Mean separation t-test.

Results and Discussion

SB has been shown to be epiphytic in nature and therefore all nutrients for growth and development need to be present on the fruit surface. In previous work, SB was not supported when cultured in vitro on components of the apple fruit cuticle or on complete cuticular compounds. Further, SB has not been observed growing on russetted portions of the fruit where the cuticles have become impermeable. Sooty blotch germination in the laboratory was greatly increased by pretreatment of conidia in 0.05% apple juice. In the first experiment, initial analysis of the leachate samples by HPLC determined that 4 sugars were present; sorbitol, fructose, glucose and sucrose (Figure 1). Sugars were present from the first sampling date in July, and were still present but in much larger quantities at fruit maturity. These carbohydrates were present on the surface in sufficient quantity and are likely candidates to be the substrates supporting SB growth on the surface of apples.

In the second experiment where apple juice (AJ) was applied to fruit despite the adverse drought conditions, average SB incidence doubled on treated fruit compared to the untreated control, 25.5% compared to 11.6% of fruit respectively (Figure 2).
Apple juice application did not affect the incidence of fruit rots and insect damage. Flyspeck incidence and fruit skin damage increased slightly due to sugar applications (Data not shown). This evidence indicates that susceptibility to SB may be determined by the presence of carbohydrates on the cuticle and that the amount of substrate can influence the incidence of SB. Combining the facts that SB is epiphytic, that the components of the cuticle do not support growth, that pretreatment of conidia with apple juice is required for germination, and that SB does not grow on russetted surfaces impermeable to fruit leachates, it can be concluded that SB growth is dependent upon leaching carbohydrates from within apple fruit.

Since sooty blotch susceptibility may be linked to the permeability of the fruit surface to internal carbohydrates, cuticular waxes and not the cutin play the primary role in determining permeability of the cuticle and therefore may determine susceptibility. Further, it is conceivable that if the leaching of these carbohydrates could be controlled either through variety improvement, cultural practices, or cuticle manipulation, then the growth of SB could also be controlled.

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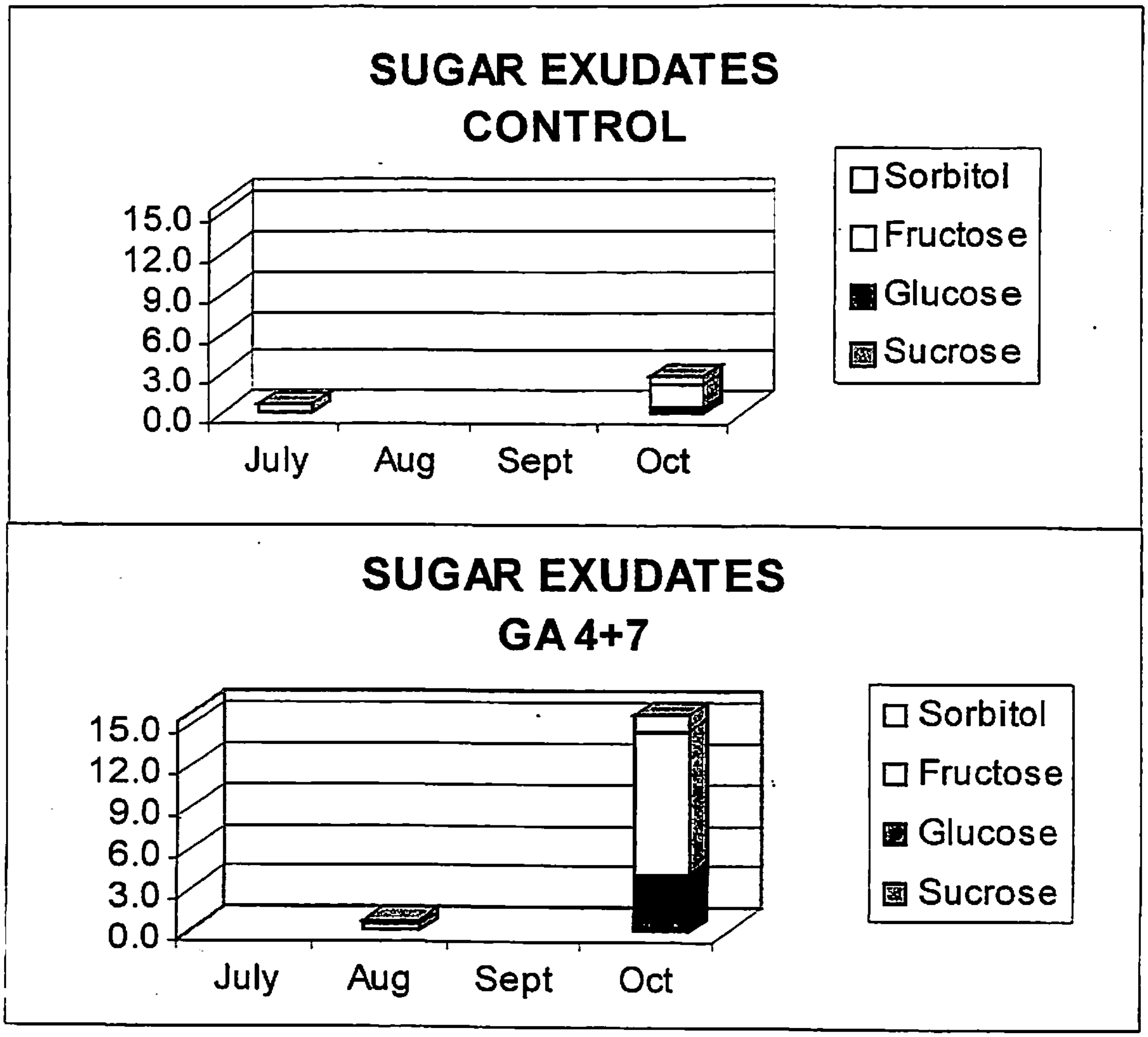

Figure 1. Preliminary analysis of sugars leaching from the cuticle of apple fruit either untreated (upper) or treated with GA every 2 weeks (lower).

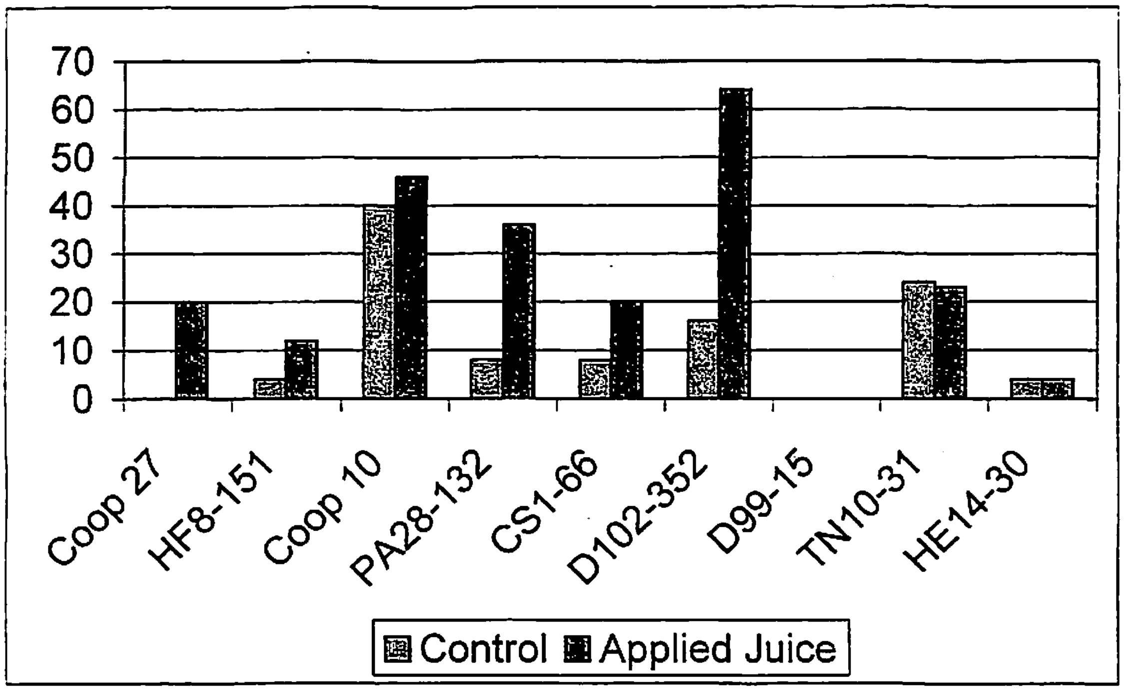

Figure 2. Sooty blotch incidence (percent of fruit) with minimal fungicide program, either control fruit of the 9 cultivars, or after being treated with 0.05% apple juice at two week intervals.