FOR ADMINISTRATIVE USE ONLY

PROCEEDINGS
CUMBERLAND-SHENANDOAH FRUIT WORKERS CONFERENCE

66TH ANNUAL MEETING
KEARNEYSVILLE, WEST VIRGINIA

NOVEMBER 15 AND 16, 1990

The 1990 Cumberland-Shenandoah Fruit Workers Conference was hosted by North Carolina State University at the Priest Field Pastoral Center in Kearneysville, WV. The meeting was held on Thursday and Friday, November 15-16 with 49 registered participants. Turner Sutton was the Program Chair, Jim Walgenbach , Chair of the General Session and Entomology Section, Mike Parker, Chair of the Horticultural Section, and Elizabeth Brown, Chair of the Plant Pathology Section. There was a need for an updated mailing list and a sheet was circulated for such purposes.

Thursday morning a joint session was held with the following presentations:

Turner Sutton, North Carolina - "Alternaria Blotch--A New Disease Threat"
Steve Miller, West Virginia - "Varieties and Training Systems for the 1990's".
Ken Hickey, Pennsylvania - "EBDC Update"
Doug Pfeiffer, Virginia - "Status of Pheromone Disruption for Orchard Insect Control"
Dave Rosenberger, New York - "The Northeast LISA Apple Production Product"

Following the joint session, three concurrent sessions were conducted with 15 papers presented in Plant Pathology, seven in Entomology and four in Horticulture. In each session there was much interaction and discussion to supplement the reduced number of papers in some sessions.

The business meeting was conducted at 8:30 am on Friday, November 16. Jim Walgenbach of North Carolina chaired the meeting. Each state that was represented gave a report on the 1990 crop and problems that were present. Brief reports were also given from each of the concurrent sessions on the topics that were discussed in the respective sessions. The 1991 meeting is to be hosted by the USDA, and will be held the week before Thanksgiving on November 21 and 22. The consensus was that the Priest Field Pastoral Center was a nice facility for this meeting and that larger rooms are available for greater attendance. Concern was expressed for getting the 1990 Proceedings out in a timely manner. Therefore, December 15 was the deadline given for receiving papers to be included in the 1990 Proceedings which was to be compiled and bound by January, 1991.

Future meeting schedule:

1991 - USDA
1992 - Pennsylvania
1993 - West Virginia
1994 - New Jersey and South Carolina
1995 - Virginia
1996 - Maryland
1997 - North Carolina

Sincerely,

Michael L. Parker, Secretary

TABLE OF CONTENTS

ENTOMOLOGY

HORTICULTURE

PLANT PATHOLOGY

Fred Abeles
USDA, ARS
Kearneysville, WV 25430

Joseph G. Barratt
487 Reservoir Road
Gardners, PA 17324

Bruce A. Barrett
Rt. 1, Box 714
Shepherdstown, WV 25443

Alan Biggs
WVU Experiment Farm
Box 609
Kearneysville, WV 25430

Tara Baugher
WVU Experiment Farm
P.O. Box 609
Kearneysville, WV 25430

George W. Bowen
P.O. Box 1010
Spartanburg, SC 29304

Mark W. Brown
USDA, ARS
Rt. 2, Box 45
Kearneysville, WV 25430

Ross Byers
VPI & SU
2500 Valley Avenue
Winchester, VA 22601

Gerald Christenbury
224 McAdams
Clemson University
Clemson, SC 29634

Rob Crassweller
102 Tyson Building
Penn State University
University Park, PA 16802

Donald R. Daum
246 Ag Engineering Bldg.
Penn State University
University Park, PA 16802

John DeLong
103 Tyson Building
Penn State University
University Park, MD 16802

Jack C. Doney, Jr.
124 ASA
West Virginia University
Morgantown, WV 26505

Charles R. Drake
Dept. of Plant Path., Phys., & Weed Sci.
VPI and SU
Blacksburg, VA 24061

Galen P. Dively
Department of Entomology
University of Maryland
College Park, MD 20742

Edward Durner
Rutgers Fruit Research Center
RD 2, Box 38
Cream Ridge, NJ 08514

Kendall C. Elliott
124 ASA
West Virginia University
Morgantown, WV 26505

Jerry Frecon
Rutgers Cooperative Extension
N. Delsea Drive
Clayton, NJ 08312

Richard Funt
Department of Horticulture
Ohio State University
2001 Fyffe Court
Columbus, OH 43210

Al Gaus
P.O. Box 309
Penn State Fruit Research Lab
Biglerville, PA 17307

Michael Glenn
USDA, ARS
Rt. 2, Box 45
Kearneysville, WV 25430

Clyde S. Gorsuch
Department of Entomology
Clemson University
Clemson, SC 25430

Barbara Goulart
Department of Horticulture
Penn State University
University Park, PA 16802

George Green
Penn State University
P.O. Box 309
Biglerville, PA 17307

Bob Head
P.O. Box 400
Walhalla, SC 29691

Rick Heflebower
18330 Keedysville Road
Keedysville, MD 21756

Henry W. Hogmire, Jr.
WVU Experiment Farm
P.O. Box 303
Kearneysville, WV 25430

John M. Holbrendt
Penn State Fruit Research Lab
P.O. Box 309
Biglerville, PA 17307

Bill Horton
USDA, ARS
Rt. 3, Box 45
Kearneysville, WV 25430

Dan L. Horton
Department of Entomology
University of Georgia
Athens, GA 30602

R. L. Horsburgh
VPI & SU
2500 Valley Avenue
Winchester, VA 22601

Larry Hull
Penn State Fruit Research Lab
P.O. Box 309
Biglerville, PA 17307

James W. Johnson
Department of Entomology
Michigan State University
East Lansing, MI 48824

Skip Jubb
University of Maryland
18330 Keedysville Road
Keedysville, MD 21756

Walid Kaakeh
703 Toms Creek
Blacksburg, VA 24060

Joella C. Killian
Department of Biology
Mary Washington College
Fredericksburg, VA 22401

William C. Kleiner
751 Winding Road
Biglerville, PA 17307

Jim Kotcon
401 Brooks Hall
P.O. Box 6057
Morgantown, WV 26506

John L. Maas
Fruit Lab/USDA
BARC-W
Beltsville, MD 20705

Richard Marini
Department of Horticulture
VPI & SU
Blacksburg, VA 24061

George E. Mattus
706 Airport Road
Blacksburg, VA 24060

Stephen S. Miller
USDA, ARS, AFRS
Rt. 2, Box 45
Kearneysville, WV 25430

Stephen C. Myers
325 Southview Drive
Athens, GA 30605

Douglas Pfeiffer
Department of Entomology
VPI & SU
Blacksburg, VA 24061

Dean K. Polk
Rutgers Fruit Research Center
RD 2, Box 38
Cream Ridge, NJ 08514

Stuart Race
Dept. of Entomology
Cook College
Rutgers University
New Brunswick, NJ 08903

Ed Rajotte
106 Patterson Building
Penn State University
University Park, PA 16802

Greg Reighard
Sandhills Research Center
P.O. Box 23205
Columbia, SC 29224

John D. Ridley
Dept. of Horticulture
Clemson University
Clemson, SC 29634-0375

George C. Rock
605 Foxchase Court
Raleigh, NC 27606

H. A. Rollins, Jr.
Department of Entomology
VPI & SU
2500 Valley Avenue
Winchester, VA 22601

Robert J. Rouse
WREC
Box 619
Queenstown, MD 21658

Jeffrey J. Schmitt
Appalachian Fruit Res. Station
Rt. 2, Box 45
Kearneysville, WV 25430

John P. Sterrett
Building 1301
Ft. Detrick
Frederick, MD 21701

Claire Stuart
USDA, ARS
Rt. 2, Box 45
Kearneysville, WV 25430

John K. Springer
Rutgers R&D Center
RD 5, Northville Road
Bridgeton, NJ 08302

Gary Stutte
Department of Horticulture
UMCP
College Park, MD 20742-5611

Fred C. Swift
Rt. 2, Box 38
Rutgers Fruit Research Center
Cream Ridge, NJ 08514

Fumi Takeda
USDA, AfRS
Rt. 2, Box 45
Kearneysville, WV 25430

William H. Tietjen
Box 372
Rutgers University
Bloomsbury, NJ 08804

Jim Walgenbach
MHCRES
2016 Fanning Bridge Road
Fletcher, NC 28732

Christopher Walsh
Dept. of Horticulture
University of Maryland
College Park, MD 20742

Tony Watson
Edgefield County Agent
Edgefield, SC 29824

Bill Welker
USDA, AFRS
Rt. 2, Box 45
Kearneysville, WV 25430

G. R. Welsh
University of Maryland
18330 Keedysville Road
Keedysville, MD 21756

Joanne Whalen
Department of Entomology
University of Delaware
Newark, DE 19717-1303

Tony K. Wolf
VPI & SU
2500 Valley Avenue
Winchester, VA 22601

Keith S. Yoder
Winchester Agric. Expt. Stn.
2500 Valley Avenue
Winchester, VA 22601

Roger S. Young
WVU Experiment Farm
P.O. Box 609
Kearneysville, WV 25430

Eldon I. Zehr
Dept. Plant Path. & Phys.
Clemson University
Clemson, SC 29634

Floyd Hendrix
Department of Plant Pathology
University of Georgia
Athens, GA 30601

Walker Miller
Dept. Plant Path. & Phys.
Clemson University
Clemson, SC 29634

Ken Hickey
Penn State Fruit Research Lab
P.O. Box 309
Biglerville, PA 17307

Paul Steiner
Department of Botany
University of Maryland
College Park, MD 20742

Joe Barratt
Rt. 1. Box 714
Shepherdstown, WV 25443

Mike Ellis
Dept. of Plant Pathology
Ohio State University - OARDC
Wooster, OH 44691

Alan Jones
Dept. of Botany and Plant Pathology
Michigan State University
East Lansing, MI 48824

Dave Rosenberger
NYS Agric. Exp. Stn.
Cornell University
Box 727
Highland, NY 12528

Jim Travis
Plant Pathology
Penn State University
University Park, PA 16802

IMPROVEMENT OF BLUEBERRY MAGGOT TRAPPING METHODS - 1ST YEAR TRIALS, 1990

D. F. Polk, K. Samoil
Rutgers, The State University of New Jersey
Rutgers Fruit Research and Development Center, at Cream Ridge
Rutgers Blueberry/Cranberry Research Center, at Chatsworth

INTRODUCTION

Blueberry maggot, *Rhagoletis mendax* Curran, is one of the key blueberry pests in New Jersey. One to three mid-to-late season sprays are often directed solely at this insect. Flies are treated from the time they first emerge until just before picking. Adult flies are usually monitored with yellow sticky board traps, impregnated with protein hydrolysates and ammonium compounds. Red spheres may also be used for monitoring, as they are for apple maggot flies. There is no economic threshold known for interpretation of monitoring data.

Our long term objectives are to refine blueberry maggot trapping methods, and to establish economic threshold levels for this pest based on trap catches. The purpose of this study was to compare trap attractiveness of three shades of 8.5 cm diameter blue, and standard red balls, and a standard (Trece) yellow sticky board.

MATERIALS AND METHODS

Balls were either unbaited or baited (Consep Membranes Biolure for *R. pomonella*). Red plastic balls were painted with Rustoleum Horizon Blue #7726, Royal Blue #7727, and MAB Navy #50-21U. Traps were place on July 9, around the border of an abandoned field of 'Rubel' of approximately 9 acres, near Whitesbog, NJ. Balls were hung on 12" wires on the outside of bushes, about 2.5-3 feet off the ground. Yellow boards were hung in a vertical position on their own wires.

RESULTS AND DISCUSSION

None of the blue balls proved to be as attractive as the regular red ball, both baited and unbaited, or the yellow sticky board. Starting on the third week of monitoring, the unbaited red ball showed a significantly higher degree of attractiveness than the baited red ball and the yellow board. This indicates that volatiles may play a role in blueberry maggot trapping, but that the butyl hexanoate in apple maggot lures does not add attractiveness, and may even discourage flies from landing.

Table 1 Blueberry Maggot fly trap records - 1990

	Sampling Date						
TRAP	07/16	07/23	07/30	08/06	08/13	08/20	08/27
ROYAL (R)	4.0 b[1]	2.0 b	2.7 c	2.0 c	0.3 c	0.5 b	0.5 b
ROYAL L (RL)	2.8 b	2.4 b	4.5 c	2.3 c	2.2 bc	1.7ab	1.5ab
HORIZON (H)	4.5 b	4.2 b	4.5 c	2.8 c	2.0 bc	1.0 b	0.5 b
HORIZON L (HL)	1.4 b	1.8 b	2.2 c	1.8 c	1.8 bc	0.7 b	0.3 b
APPLE (A)	33.6a	24.8a	42.8a	16.8a	10.7a	3.8a	2.7a
APPLE L (AL)	39.0a	21.7a	24.5 b	13.8ab	8.7ab	2.2ab	1.7ab
YELLOW B (Y)	41.0a	24.3a	26.3 b	8.0 b	3.5 bc	0.3 b	0.3 b
TRUEBLUE (T)				3.8 c	1.8 bc	1.2 b	0.5 b

[1]Means followed by the same letter are not significantly different (DMRT P=.05).

Title: Control of Overwintering Larvae of Tufted Apple Bud Moth with Two Insecticides and a Herbicide

Authors: C. M. Felland, L. A. Hull, B A. Barrett
PSU Fruit Research Laboratory
Biglerville, PA 17307

Materials and Methods:

Thirty tufted apple bud moth (TABM) larvae collected in dead apple leaf shelters in late October 1989 were placed in each of twenty 0.37 m^2 wooden arenas located under apple trees in an established orchard. Each arena enclosed a dandelion plant and additional dead leaves and was covered with 1/2 inch mesh hardware cloth. Tanglefoot was applied to the inside edges of the arenas on 23 April 1990 to prevent larval escape. Pre-treatment larval weight and head capsule widths from two larvae per arena were taken on 24 April. Pre-treatment counts were not taken so as not to disturb the larvae and make them more exposed to pesticide treatments. Arenas were grouped by proximity and treated on 25 April with two insecticides, a herbicide, and a water control using a Bean herbicide sprayer calibrated to deliver 542 liters/ha (58 GPA). On 7 May all plant foliage and dead leaves were removed from the arenas and placed in paper bags. The soil surface was checked for larvae. Samples were stored at 40 °F until processing. Larvae and pupae were removed from the samples between 7 and 9 May and recorded as alive or dead. Live larvae were held on diet to confirm identification. Data was analyzed as a CRD and means separated at $\alpha = 0.05$ with Duncan's New Multiple Range test.

Results and Discussion:

Larval head capsule width and weight were 1.1 mm and 11 mg, respectively, on 24 April; no pupae were recovered in the pretreatment samples. All the treatments resulted in different control based on total TABM recovered alive and larvae recovered alive (Table 1). Best control was observed with Lorsban 4E with 84.4% percent fewer live larvae than in the water-treated control. Asana XL and Gramoxone Extra provided slightly higher than 50% and 25% control, respectively. No differences were observed in live pupae or in dead larvae recovered. Apparently not all the dead larvae were recovered 12 d after treatment. This tests suggests that relatively high control of overwintering TABM larvae may be obtained in the ground cover with traditional insecticides.

Table 1. Control of overwintering tufted apple bud moth larvae in ground cover arenas 12 days after treatment.

Treatment	Mean no. per arena						Percent control[1]		
	Live			Dead					
(lb AI/A)	Total	La.	Pu.	Total	La.	Pu.	Total	La.	Pu.
Lorsban 4E (0.87)	2.8a	2.0a	0.8a	1.2a	0.6a	0.6a	79.4	84.4	0.0
Asana XL 0.66 EC (0.044)	6.4b	5.8b	0.6a	3.6a	3.4b	0.2a	52.9	54.7	25.0
Gramoxone Extra (0.54)	10.0c	9.2c	0.8a	3.8a	3.0b	0.8a	26.5	28.1	0.0
Water control (---)	13.6d	12.8d	0.8a	2.0a	2.0ab	0.0a	---	---	---

Means within columns followed by the same letter are not significantly different (P < 0.05) Duncan's New Multiple Range Test.

[1]Percent control = 100 (1.0 - [mean no. alive in treatment/mean no. alive in control])

Title: Control of Late Instar Tufted Apple Bud Moth Larvae on Dandelions With Asana XL and Two Formulations of Lorsban

Authors: C. M. Felland and L. A. Hull
PSU Fruit Reseach Laboratory
Biglerville, PA 17307
(717) 677-6116

Materials and Methods:

Tufted apple bud moth (TABM) larvae feeding on dandelion plants growing in nursery flats (51 × 36 cm, Kaden Co., Dayton, OH) were treated with insecticides using a herbicide sprayer to test potential insecticides for use in ground cover management in the spring. Each flat contained six dandelion plants grown from seed. Approximately ten large field strain TABM larvae were placed on the plants in each flat one week before the test. Wire cones were placed over each plant to contain the larvae. A pre-treatment count was made on 2 - 3 Aug to determine the number of larvae that had established. The cones were removed and treatment was made on 3 Aug using a Bean herbicide sprayer calibrated to deliver 542 liters/ha (58 GPA). The cones were not replaced, but tape with insect trap coating (The Tanglefoot Co., Grand Rapids, MI) on the rims of the flats prevented larval escape. On 10 Aug all live and dead larvae and pupae were removed from the plants and held on treated foliage until 13 Aug, when the final mortality evaluation was made. Larvae stuck in the trap coating were not included in the analysis. Percent mortality was determined using the pre-treatment count and adjusted for control mortality using Abbott's Formula. When recovery exceeded the pre-treatment count, the pre-treatment count was adjusted. The data was analyzed as a completely randomized design by ANOVA and means separated at $\alpha = 0.05$ by the Duncan's New Multiple Range Test .

Results and Discussion:

The larvae developed quickly during this test, with 35% having pupated by the termination of the experiment. Only Asana XL provided greater mortality than the water control, but no greater mortality than either formulation of Lorsban.

Table 1. Toxicity of various insecticides to tufted bud moth larvae feeding on dandelion plants in an insectary, 3 - 13 August , Biglerville, PA.

Treatment (lb AI / A)	Mean no. recovered (% pupae) Alive	Mean no. recovered (% pupae) Dead	Mean no. missing	Percent mortality	Adjusted percent mortality[1]
Asana XL (0.044)	5.6a (39.3)	1.4a (14.3)	1.4a	29.4a	16.5
Lorsban 50W (0.87)	6.8a (50.0)	1.0a (0.0)	1.0a	25.7ab	12.2
Lorsban 4E (0.87)	7.2a (23.6)	1.0a (17.0)	1.0a	19.0ab	4.3
Water control	7.5a (36.0)	0.5a (34.0)	0.5a	15.4b	---

Means followed by the same letter are not different ($P = 0.05$, DNMRT)
[1]Mortality based on pre-treatment count and adjusted for control mortality using Abbott's Formula.

Title: Control of Late Instar Tufted Apple Bud Moth Larvae on Dandelions With Lannate 1.8L and Lorsban 4E

Authors: C. M. Felland and L. A. Hull
PSU Fruit Reseach Laboratory
Biglerville, PA 17307
(717) 677-6116

Materials and Methods:

Tufted apple bud moth (TABM) larvae feeding on dandelion plants growing in nursery flats (51 x 36 cm, Kaden Co., Dayton, OH)were treated with insecticides using a herbicide sprayer to test potential insecticides for use in ground cover management in the spring. Each flat contained six dandelion plants grown from seed. Field strain TABM larvae (ca. 10) were placed on the plants in each flat on 13 - 14 Aug 1990. Tape with Insect Trap Coating (The Tanglefoot Co, Grand Rapids, MI) on the rims of the flats prevented larval escape. A pre-treatment count was made on 16 Aug to determine the number of larvae that had established. At this time larvae that had pupated were replaced and larvae added to some flats with low establishment. A sample was made to determine larval instar. Treatment was made on 17 Aug using a Bean herbicide sprayer calibrated to deliver 935 liters/ha (100 GPA). All live and dead larvae and pupae were removed from the plants on 24 Aug. Larvae stuck in the trap coating were not included in the analysis. Percent mortality was determined using the pre-treatment count and adjusted for control mortality using Abbott's Formula. When recovery exceeded the pre-treatment count, the pre-treatment count was adjusted. The data was analyzed as a completely randomized design by ANOVA and means separated at $\alpha = 0.05$ by the Duncan's New Multiple Range Test.

Results and Discussion:

Age distribution of larvae on 16 Aug revealed a similar distribution as to what occurs in the field at the end of April (third instar through prepupa). Lannate 1.8L alone and in combination with Lorsban 4E gave higher control than Lorsban 4E alone or the water control. Higher percent pupae in the Lannate treatments suggests that in these treatments survival was skewed toward the larger larvae.

Table 1. Toxicity of various insecticides to tufted bud moth larvae feeding on dandelion plants in an insectary, 17 - 24 August , Biglerville, PA.

	Mean no. recovered (% pupae)				
Treatment (lb AI / A)	Alive	Dead	Mean no. missing	Percent Control	Adjusted percent control[1]
Lannate 1.8L (0.45)	4.25a (35.3)	1.25a (0.0)	3.25a	52.9a	45.7
Lorsban 4E (1.5)	9.00a (2.8)	0.25a (100.0)	1.25a	18.1b	5.5
Lannate 1.8L (0.225) & Lorsban 4E (0.75)	6.00a (12.5)	0.75a (33.3)	3.00a	41.4a	32.4
Water control	5.50a (9.1)	0.50a (50.0)	0.50a	13.3b	---

Means followed by the same letter are not different ($P = 0.05$, DNMRT).

[1]Mortality based on pre-treatment count and adjusted for control mortality using Abbott's Formula.

Title: Ground Cover Tufted Apple Bud Moth Management Studies with Asana XL in Commercial Apple Orchards during 1990

Authors: C. M. Felland and L. A. Hull
PSU Fruit Research Laboratory
Biglerville, PA 17303

Materials and Methods:

Asana XL was tank mixed with the standard herbicide applications for four commercial apple orchards to determine the effects of a spring ground cover application of Asana XL on overwintering tufted apple bud moth (TABM) larvae and adult Stethorus punctum. Within each orchard either Asana XL with herbicide or herbicide alone were assigned to one of two similar blocks of about 10 acres each. The applications were made in two orchards on 25 and 26 April (pink) and in two orchards between 9 and 14 May (petal fall). Asana XL was applied at 0.075 lb AI /acre in 74 to 119 gal. water per treated acre. The swath width ranged from 5 to 9 ft but did not include the entire area under the drip-line of the tree rows. Both the Asana XL treated blocks and the standard blocks for each commercial orchardist received the same routine schedule of insecticide throughout the season. Timed pre-treatment counts of six minutes were made under ten trees for each orchard and all TABM shelters were flagged. One week post-treatment all flagged shelters were examined and a record was made of location relative to the herbicide strip, larval presence, species, and condition (alive or dead). The X^2 test of homogeneity (α = 0.05) for dead and missing vs. live larvae within each region relative to the herbicide strip within each orchard was calculated. Brood 1 male TABM pheromone trap catch based on two traps and brood 1 egg mass density, fruit injury by broods 1 and 2, numbers of European red mites (ERM) per leaf, and Stethorus punctum (larvae, pupae, and adults) per 3 min. at eight sites were recorded in each treatment block. Fruit injury was based on 200 picks and all the drops at five sites per treatment block. The data for each orchard was analyzed by ANOVA and means separated at $\alpha = 0.05$ (F-test).

Results and Discussion:

A significant increase in mortality was observed in the herbicide strip of the Asana XL treatment over the standard in orchard A (Table 1). No differences in mortality were observed in the herbicide strip borders or outside of the herbicide strip. Pressure by first brood TABM was generally higher in Asana XL blocks than the standard (Table 2). No treatment effect on fruit injury was observed. Both ERM and Stethorus were at the same or higher densities in the Asana XL treatments than in the herbicide only treatments. These results suggest that the insecticide would have to be also applied outside the herbicide strip to achieve adequate control. We observed no evidence of a negative impact from a ground cover application of Asana XL on Stethorus.

Table 1. Mortality of overwintering tortricid larvae in different regions relative to the herbicide strip in four apple orchards following an application of Asana XL 0.66 EC (0.075 lb AI/A) along with standard herbicide during the pink stage (A & B) or petal fall stage (C & D), Adams Co., Spring 1990.

Treatment	Proportion TABM[1]	No. larvae dead or missing (no. larvae total) per position relative to herbicide strip		
		Inside	Border	Outside
Orchard A				
Asana XL	0.29	36 (37) ***[2]	20 (37) ns	18 (37) ns
Standard	0.57	3 (7)	3 (6)	4 (9)
Orchard B				
Asana XL	1.00	11 (11) ns	5 (7) ns	7 (13) ns
Standard	0.64	9 (12)	4 (8)	3 (8)
Orchard C				
Asana XL	0.75	1 (4) ns	0 (0) ---	0 (0) ---
Standard	1.00	0 (1)	0 (0)	0 (0)
Orchard D				
Asana XL	NA	0 (0) ---	0 (0) ---	0 (0) ---
Standard	1.00	3 (4)	0 (0)	0 (0)

[1]TABM=tufted apple bud moth; Coelostathma discopunctana Clemens comprised more than 90% of the other species found.
[2]Significance of χ^2 test of homogeneity for dead and missing vs. live larvae within each region relative to the herbicide strip within each orchard where larvae were present in both the Asana XL and standard treatments (***, $P < 0.001$; ns, $P > 0.05$).

Table 2. Tufted apple bud moth (TABM), motile European red mite (ERM), and Stethorus assessment in four orchards where Asana XL (0.66 EC) was applied at 0.075 lb AI/A to the herbicide strip during the pink stage (A & B) or petal fall stage (C & D), Adams Co., Summer 1990.

	Pretreatment	Mean TABM, mite and Stethorus ratings					
	overwintering	Brood 1 males	Brood 1 egg	No. injured apples per 100		ERM	Stethorus per 3
Treatment	TABM[1] / 6 min	per trap	mass / 10 min.	Brood 1	Brood 2	per leaf	min.
			Orchard A				
Asana XL	1.2a	704.5a	1.3b	3.2a	11.2a	1.5a	2.5a
Standard	0.8a	532.0a	0.3a	2.0a	9.6a	1.1a	1.1a
			Orchard B				
Asana XL	1.0a	858.5b	0.8a	6.1a	23.4a	6.1a	1.9a
Standard	0.9a	498.0a	0.1a	2.8a	20.0a	5.2a	0.3b
			Orchard C				
Asana XL	0.3a	723.5a	0.0a	0.5a	4.3a	10.7b	5.1a
Standard	0.1a	499.0a	0.1a	0.6a	3.3a	2.2a	0.3b
			Orchard D				
Asana XL	0.0a	689.0a	0.0a	1.4a	2.1a	2.3a	5.0a
Standard	0.1a	912.5b	0.1a	1.5a	3.3a	5.7a	7.1a

Means within site followed by the same letter are not different ($\alpha = 0.05$; F Test).

[1]Based on identified larvae

Title: Control of Tufted Apple Bud Moth Pupae and Adults with Asana XL

Authors: C. M. Felland and L. A. Hull
PSU Fruit Research Laboratory
Biglerville, PA 17307
(717) 677-6116

Materials and Methods:

Toxicity of Asana XL (esfenvalerate) to tufted apple bud moth (TABM) pupae in leaf shelters vs. exposed pupae was determined in a simulated ground cover application. Larvae from a laboratory colony were transferred from semi-synthetic diet to apple leaves during the fifth stadium and held in shell vials in an environmental chamber at 26.7 °C until pupation. Both pupae in sealed shelters and pupae that were exposed were removed every two to three days. All pupae were held at 15.6 °C until sufficient numbers were accumulated for the test. Before the test, five dandelion plants were transplanted from an untreated orchard into each of eight flats. Five pupae were placed on the soil surface under each plant: Sheltered pupae were placed under three plants and exposed pupae under two plants for totals of 15 and 10, respectively, per each of four replications. On 17 May, Asana XL and a water control were applied with a herbicide sprayer calibrated to deliver 542 liters/ha (58 GPA). After the treatment each dandelion was covered with a wire cone. The trays were held in an insectary for observations of pupal and adult mortality. Live adults observed inside the wire cones were removed at two to three day intervals. On 11 and 12 June the cones were removed and number of exuvia, dead pupae, and dead adults were recorded. The factors of treatment and pupal exposure were analyzed in a factorial arrangement using ANOVA at $\alpha = 0.05$.

Results and Discussion:

Both treatment and exposure factors were significant for the number of live adults recovered (Table 1). Higher survival of TABM was observed for sheltered than for the exposed pupae and in the water control than in the Asana XL treatment. Based on the recovery of live adults, mortality due to Asana XL was 59.4% for the sheltered pupae and 94.4% for the exposed pupae. The treatment effect is not significant based on the number of pupal exuvia recovered. Similar recovery of exuvia from the sheltered pupae in both treatments suggests that much mortality occurred in the adult stage. Although numerically more dead adults were recovered from the Asana XL treated sheltered pupae than in the other treatments, low recovery based on initial numbers suggests that some dead adults (and pupae) were missed or lost to scavengers. This study suggests that residual activity of Asana XL in the ground cover may provide some control of eclosing adults.

Table 1. Toxicity of Asana XL (esfenvalerate) to sheltered and exposed pupae and eclosing adults of tufted apple bud moth.

	Mean (SE) no. per plant[1]				Estimated percent mortality	
	Adults		Pupae			
Exposure	Live	Dead	Exuvia	Dead	Pupae[2]	Pupae & adults[3]
Asana XL 0.66 EC (0.044 lb AI/A)						
Sheltered	1.3 (0.2)	0.5 (0.1)	3.0 (0.3)	0.8 (0.3)	9.1	59.4
Exposed	0.1 (0.1)	0.0 (0.0)	0.1 (0.1)	1.3 (0.9)	92.3	94.4
Water control						
Sheltered	3.2 (0.6)	0.0 (0.0)	3.3 (0.6)	0.3 (0.0)	---	---
Exposed	1.8 (0.2)	0.2 (0.1)	1.3 (0.5)	0.3 (0.1)	---	---
Significance of ANOVA						
Treatment	0.001	ns	ns	ns	---	---
Exposure	0.01	0.05	0.001	ns	---	---
Treatment *Exposure	ns	0.05	ns	ns	---	---

[1]Initial number = 5.

[2]100(1 - [No. of pupal exuvium in shelter or exposed Asana XL/no. of pupal exuvium in sheltered or exposed water control])

[3]100(1 - [No. of live adults in shelter or exposed Asana XL/no. of live adults in sheltered or exposed water control])

ADULT PHENOLOGY AND CONTROL OF TUFTED APPLE BUDMOTH IN WESTERN NORTH CAROLINA

James F. Walgenbach & Charles R. Palmer
Mtn. Hort. Crops Res. & Ext. Ctr.
2016 Fanning Bridge Rd.
Fletcher, NC 28732

The tufted apple budmoth (TABM), Platynota idaeusalis, is considered the primary direct pest of apples in Henderson County, NC, which accounts for approximately 60% of the states 17,000 acres of bearing trees. The development of population resistance to organophosphorus (OP) insecticides has lead, in part, to increased levels of damage by this insect during the past 10 to 15 years. At the present time Penncap-M and Lorsban are the only OP insecticides that by themselves provide effective control of TABM. There is increasing grower interest, however, in using reduced-rate combinations of OP insecticides with the carbamate Lannate. The inclusion of Lannate with OP's offers the advantage of providing TABM ovicidal activity, and is less harmful to the mite predator Stethorus punctum compared with full rates of Lannate. Thus, a series of trials were conducted to determine the efficacy of various OP insecticides applied alone and in combination with Lannate, and to determine the effects these applications on subsequent mites populations.

An additional objective of this study was to study the phenology of adult TABM and the closely related variegated leafroller (VLR), Platynota flavedana. Little is known regarding the phenology and intensity of VLR in Henderson Co., and thus pheromone trapping studies were conducted to observe adult flight occurrences of both TABM and VLR.

Materials and Methods

Insecticide Studies. Two separate studies were conducted to determine the efficacy of various insecticides for control of TABM; a replicated small plot study in a commercial apple orchard, and non-replicated large plot trial conducted in three commercial apple orchards. The replicated trial was conducted in an eight-year-old block of apples (cv. Taylor Romes) where populations are suspected of being moderately resistant to Guthion. Trees were planted at a density of 116 trees per acre and tree row volume was estimated at 175 gpa. Plots consisted of three tree treatments, and treatments were arranged in a randomized complete block design with three replications. All insecticide applications were made at 175 gpa through a handgun sprayer operating at 150 psi. Triton B-1956 spreader sticker was added to all spray solutions. Other than treatment applications, an application of Lorsban 50W (2.0 lb/A) to all trees at petal fall was the only insecticide applied. The grower's standard fungicide program was applied with an airblast sprayer at two week intervals throughout the season. Treatments consisted of various OP and carbamate insecticides applied on May 18, 31, June 13 (corresponding to cover sprays 2, 3 and 4, respectively), and August 17, and an untreated control. Estimates of TABM damage by brood I and II larvae were made on August 20 and September 18, respectively. Damage was estimated by recording the number of damaged apples per 100 observed on each of the three treatment trees.

Large plot studies were conducted in three separate orchards in Henderson County. Treatment size consisted of the acreage covered by a single spray tank of material. Insecticide treatments varied among test sites, but consisted of Larvin 3.2F (applied under an EUP), and Penncap-M 2F and Lorsban 50W applied alone and at reduced-rate tank-mixes with Lannate. There were no untreated controls in this aspect of the study. Since the objective was to determine the effectiveness of different insecticides against TABM, insecticide treatments differed among plots only during TABM oviposition periods. Oviposition periods for the first generation corresponded to cover sprays 2-4 (mid May through mid June), and for the second generation in mid August and early September. TABM damage estimates were obtained by observing 100 apples on each of six trees/treatment. Mite populations were recorded in each treatment (10 leaves from each of six trees/treatment) at two-week intervals during June and early July to determine the effects of the various treatments on mite populations. Descriptions of each orchard and method of application are as follows:

Orchard M: Five treatments were incorporated into a 15 acre block of approximately 15-year-old 'Rome Beauty' trees planted at a density of ca. 100 trees/acre. In addition, three additional treatments were incorporated into a 9 acre block of approximately 25-year-old 'Golden Delicious' trees also planted at 100 trees/acre. All materials were applied with a 300 gal airblast sprayer delivering 100 gpa. Insecticide treatments were applied on May 18 and 31 (brood I) and on August 17 and September 3 ('Romes' only). With the exception of an application of Guthion at petal fall, no other insecticides were applied after bloom. Brood I and II injury was estimated on August 22 and September 24 in the 'Romes', respectively, and total injury was estimated in 'Golden Delicious' on September 11.

Orchard N: Four treatments were incorporated into a 20 acre block of 'Red Delicious' trees ranging in age from 7 to 20 years old. All materials were applied with a 500 gal airblast sprayer delivering 100 gpa. Insecticide treatments were applied on May 17, 31 and June 14. Additional insecticides applied to all treatments included Lorsban at petal fall, and an application of Guthion and Penncap-M two weeks apart during July. Damage estimates were obtained on August 16, and the crop was harvested the following week.

Orchard O: Four treatments were incorporated into a 10 acre block of approximately 25-year-old 'Red Delicious' trees planted at a density of 75 trees/acre. All materials were applied with a 500 gal airblast sprayer delivering 250 gpa. Insecticide treatments were applied on May 18, 28 and June 7. Additional insecticides applied to all treatments consisted of Lorsban at petal fall and 1st cover, and alternating applications of Guthion and Lorsban at two week intervals from June 14 to July 26. Damage estimates were obtained on August 16, and the crop was harvested the following week.

Pheromone Trapping. TABM and VLR adult (male) populations were monitored in six apple orchards in Henderson County. The McConnell and Staton (Dana community) and Byers (Edneyville community) orchards are in the primary apple production area of Henderson Co.; Edney and Justus orchards (Fruitland community) are located on the fringe of the primary production area, and the Mountain Horticultural Crops Research Station (MHCRS) orchard is located approximately 10 from these areas. In each orchard three sex pheromone traps each of TABM and VRL were erected in mid April and monitored weekly until late October. Oviposition was monitored in each orchard by conducting a 20 minute search for egg masses in three locations per orchard (one hr total) for brood I early May to late June, and for brood II from early August to late September.

Results

Pheromone Trapping. Seasonal TABM pheromone trap catches and oviposition are shown in Fig. 1. Although the time of occurrence of first and second generation flights was consistent among the different orchards (i.e., first generation during May and June, second generation during August and September), there were considerable differences in the numbers of moths caught and duration of flight periods. Trap catches were higher, and first and second generation flights were of longer duration in the McConnell, Byers and Staton orchard, all of which are in the middle of the primary production area. Trap catches were lower in numbers and shorter in duration in orchards on the fringe (Edney and Justus) and outside (MHCRS) the main production area. In the McConnell and Byers orchard, there also appeared to be a bimodal flight pattern during both generations, which was also observed in these orchards in 1990.

The intensity of oviposition was related to the intensity of adult pheromone trap catches. Eggs populations, as well as pheromone trap catches, were highest in·the McConnell orchard, followed by the Byers and Staton orchards. Eggs, either fresh or hatched, were very difficult to detect in the remaining orchards where pheromone trap catches were low. First generation eggs were not detected until the flight was well underway, whereas second generation oviposition was more closely related to second generation pheromone trap catches.

Pheromone trap catches of VLR were similar to those of TABM, both in time of occurrence and duration of flight periods (Fig. 2). The number of moths caught, however, were considerably less than TABM catches and averaged only one-fourth the catch of TABM traps. These data indicate that, similar to TABM, VLR populations are most intense in the primary production. Pheromone trap catches alone, suggest that TABM is the primary leafroller species occurring in Henderson county.

Replicated Insecticide Trials. TABM damage was moderate in this trial with 6.0 and 12.1% damage caused by brood I and II larvae, respectively (Table 1). All insecticides provided excellent control of brood I larvae, with Guthion + Lannate and Penncap-M (4.0 pt/A) being the only treatments where first brood damage was observed. With the exception of Guthion applied alone, all insecticide treatments significantly reduced damage below that in the untreated control. Penncap-M applied alone at 4 and 6 pts/acre, and at a reduced rate with Lannate provided the highest levels of control. Damage in the Larvin and Lorsban (alone and tank-mixed with Lannate) treatments was significantly higher compared with either Penncap-M at 4.0 or 6.0 pts/A. The increased level of damage recorded in the Larvin and Lorsban treatments compared with Penncap-M may have been due to the one month interval between the last application of materials and damage assessment rather than a lack of efficacy, because these insecticides have a shorter residual activity than encapsulated methyl-parathion (Penncap-M).

Large Plot Insecticide Trials. TABM damage occurring in the various test orchards is shown in Table 2. Brood I damage in orchards N and O was low, ranging form 0 to 2.3%. Comparable levels of control were obtained with all materials in these orchards, although Larvin and Penncap-M appeared to be slightly more effective than the Lorsban treatments in Orchard O.

There was a heavy fruit load on the 'Golden Delicious' in Orchard M, which contributed to the high damage in this trial. Penncap-M was slightly more effective at 6 pts/A (6.8% damage) than at 4 pts/A (9.0 pts/A). TABM populations are known to be highly resistant to Guthion in this orchard, and the Lannate + Guthion treatment did not provide acceptable levels of control. Brood I damage in the 'Romes' in Orchard M was low, and Lorsban + Lannate was the only treatment in which damage exceeded 0.5%. Brood II damage was considerably higher with damage reaching 8.2% in the Lorsban + Lannate treatment. Penncap-M + Lannate provided the highest level of control (2.8% damage) while Lorsban (3 lb/A), Penncap-M (4 pts/A) and Larvin (1 qt/A) all applied alone provided intermediate levels of control.

Mite populations were very low and did not exceed 1 mite/leaf in Orchard M on any sample date. However, mites did increase to relatively large numbers in Orchards N and O in early July (Fig. 3). In orchard N, populations appeared to increase more quickly in the Larvin and Penncap-M treatments compared with Lorsban or Penncap-M + Lannate. By July 11, mite populations were considerably higher on trees sprayed with Penncap-M compared with all other insecticides. A similar trend was observed in Orchard O, where highest mite populations were recorded in the Penncap-M treatment.

Conclusions

Pheromone trapping studies suggest that the VLR is considerably less important than TABM throughout Henderson County, although the time and pattern of male adult flight of the two species was closely correlated. In insecticide trials where TABM pressure was relatively intense (i.e. small plot replicated trials and Orchard M in large plot trials), Penncap-M applied alone and at a reduced-rate tank-mix with Lannate provided slightly better control than Lorsban or Larvin. Lorsban applied alone at 3 lb/A was slightly more effective than the reduced rate tank-mix of Lorsban + Lannate. The reduced-rate tank-mix of either Lorsban or Penncap-M with Lannate, as well as Larvin, did not appear to aggravate European red mite and twospotted spider mite populations, which is a potential concern about the extensive use of this combination of chemicals.

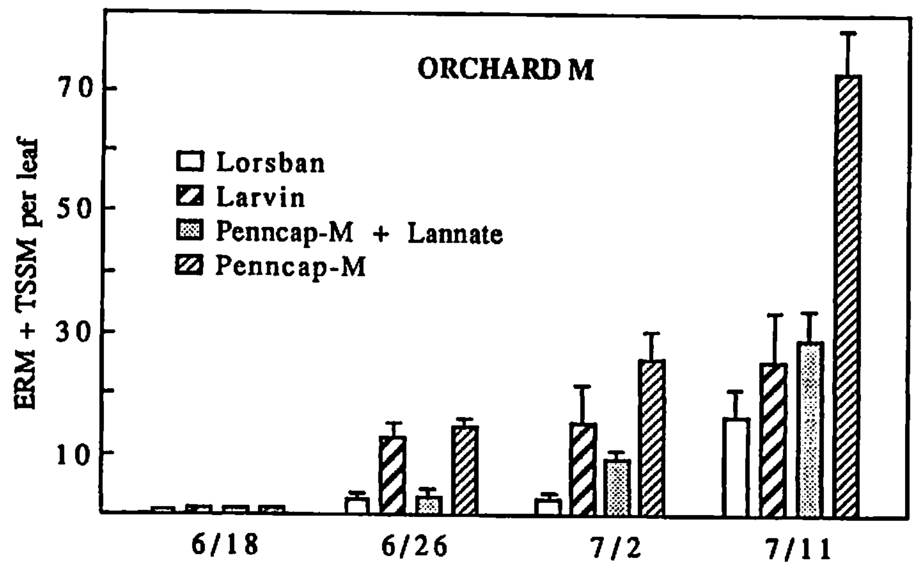
Table 1. Tufted apple budmoth damage to apples (cv. Law Romes) treated with different insecticides on May 18 and 31, June 13 and August 17. Dana, NC 1990

Insecticide	Rate/acre	Brood I (8/20)	Brood II (9/18)
Larvin 3.2F	1.0 qt	0.0 a	5.0 bc
Lorsban 50W	3.0 lb	0.0 a	4.8 bc
Lorsban 50W + Lannate 1.8L	1.5 lb 1.5 pt	0.0 a	6.1 bc
Guthion 35WP	2.85 lb	0.0 a	7.9 cd
Guthion 35WP + Lannate 1.8L	1.4 lb 1.5 pt	1.0 a	5.8 c
Penncap-M 2F	4.0 pt	0.3 a	1.2 a
Penncap-M 2F	6.0 pt	0.0 a	1.6 a
Penncap-M 2F + Lannate 1.8L	2.0 pts 1.5 pts	0.0 a	2.0 ab
Control	-	6.0 b	12.1 d

[a]Means in the same column followed by the same letter are not significantly different by LSD ($P < 0.05$).

Table 2. Tufted apple budmoth damage to apples sprayed with various insecticides in three different apple orchards. Henderson Co., NC 1990

		% Damaged Apples (±SEM)				
		Orcahrd M	Orchard M		Orchard N	Orchard O
Insecticide	Rate/Acre	(G. Delicious) 9/11	(Rome) 8/22	9/24	(R. Delicious) 8/16	(R. Delicious) 8/16
Lorsban 50W + Lannate 1.8L	1.5 lb 1.5 pt	-	2.5 (0.6)	8.2 (1.2)	-	1.0 (0.4)
Lorsban 50W	3.0 lb	-	0.0	5.3 (0.6)	2.3 (1.5)	1.0 (0.7)
Larvin 3.2F	2.0 pts	-	0.0	5.7 (0.6)	1.7 (0.8)	0.0
Penncap-M 2F + Lannate1.8L	2.0 pt 2.0 pt	-	0.3 (0.2)	2.8 (0.5)	2.0 (0.7)	-
Penncap-M 2F	4.0 pts	9.0 (0.5)	0.2 (0.2)	4.2 (0.8)	1.8 (0.3)	0.0
Penncap-M 2F	6.0 pts	6.8 (1.6)	-	-	-	-
Guthion 35WP + Lannate 1.8 L	1.0 lb 2.0 pts	13.2 (1.2)	-	-	-	-



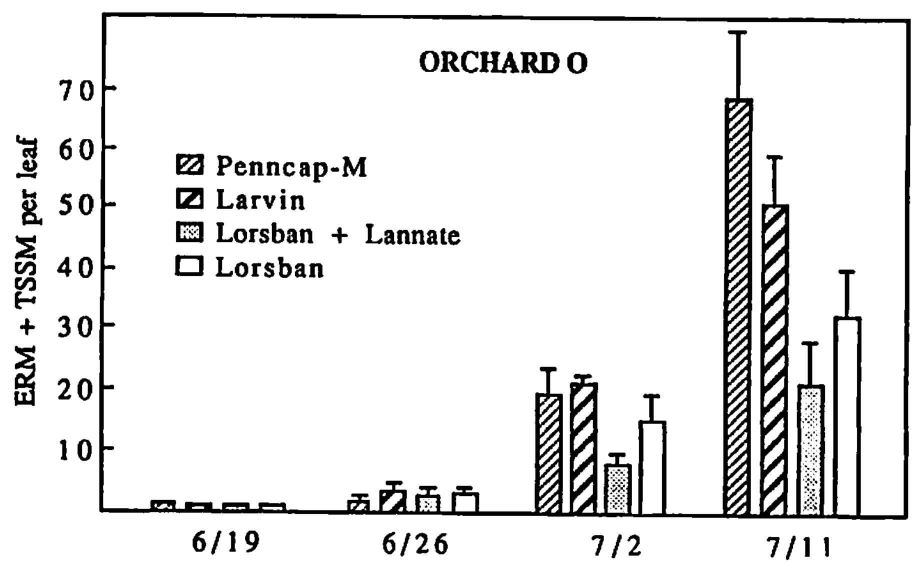


Figure 1. Mite (European red mite + twospotted spider mite) populations on apples (cv. Red Delicious) treated with different insecticides. Vertical bars represent SEM. Henderson Co., NC 1990.

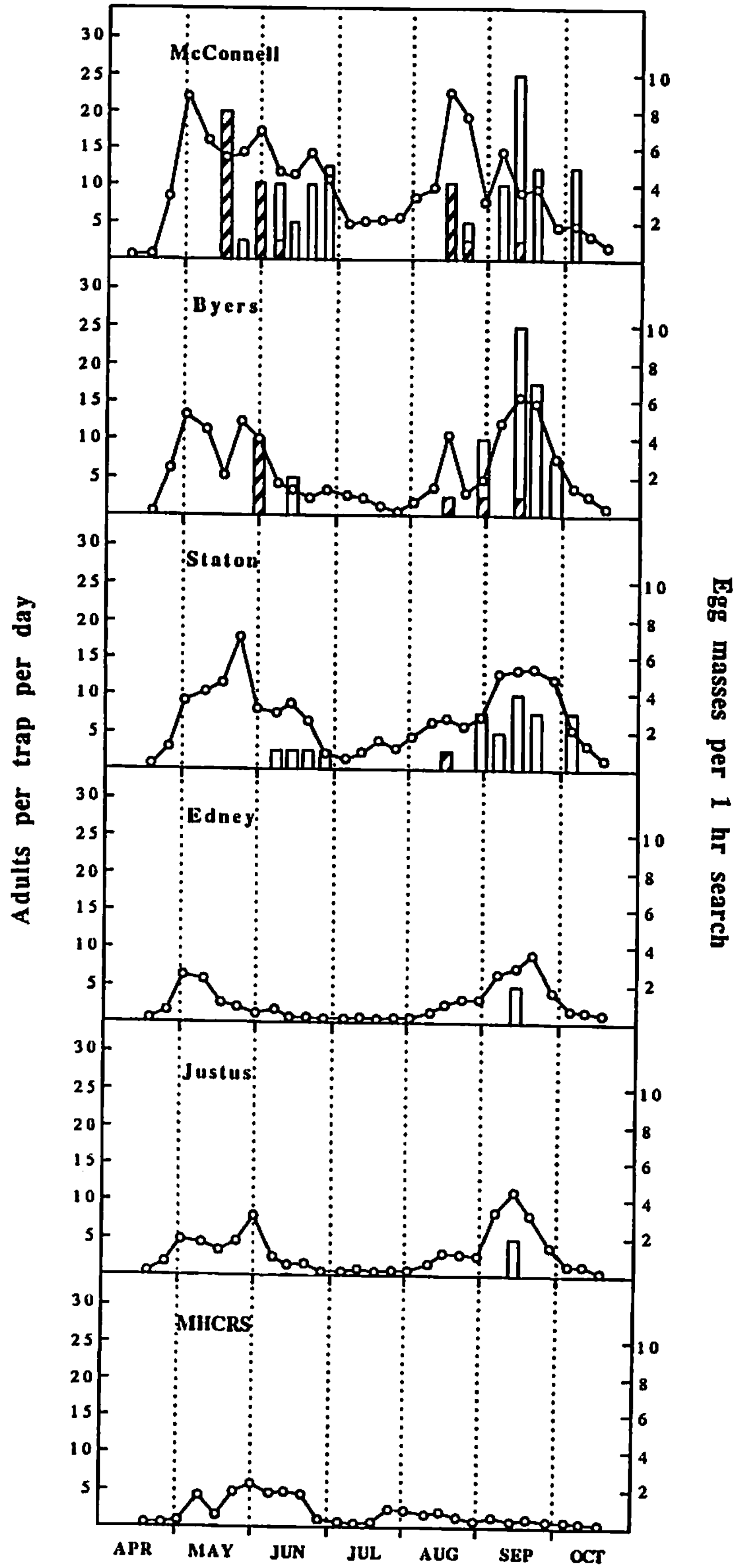


Figure 2. Tufted apple budmoth pheromone trap catches (-o-) and oviposition (▨ fresh eggs; □ hatched eggs) in six commercial apple orchards in Henderson County, NC. 1990

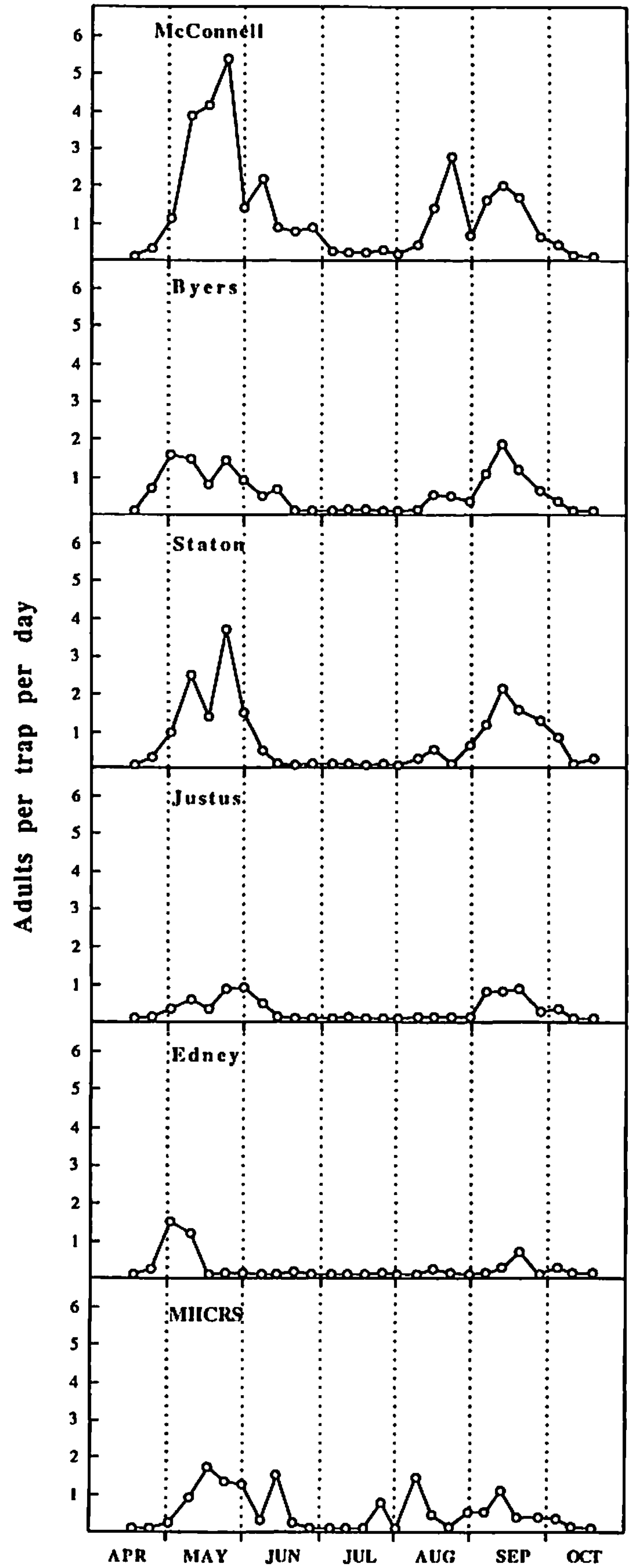


Figure 2. Variegated leafroller pheromone trap catches in six commercial apple orchards in Henderson County, NC 1990

PERFORMANCE OF PREDATOR-TOXIC MITICIDES ON APPLES

James F. Walgenbach & Charles R. Palmer
Mtn. Hort. Crops. Res. & Ext. Ctr.
2016 Fanning Bridge Rd.
Fetcher, NC 28732

Management of European red mite (ERM) and twospotted spider (TSSM) on apples in North Carolina is an integrated system that relies on mite predators and the use of selective insecticides to preserve predators. In North Carolina, the phytoseiid mite *Ambyseius fallacis* and the coccinelid *Stethorus punctum* are the primary predators of ERM and TSSM. Remedial applications of miticides are reserved for when mites exceed action threshold levels of 7 mites (before July 1) or 10 mites (after July 1) per leaf.

The most commonly used miticides for remedial control of mites in North Carolina are Omite, Kelthane and Carzol. All of these materials are considered to be relatively non-toxic to *S. punctum*, but in laboratory studies only Omite has been found to be non-toxic to *A. fallacis*. However, the effects of removing *A. fallacis* populations with applications of Carzol or Kelthane on subsequent ERM and TSSM populations is unknown. Thus, a trial was conducted to determine the potential for ERM and/or TSSM resurgence following the use of Kelthane or Carzol.

Materials & Methods

A block of ca. 20 year-old 'Red Delicious' apple trees in a commercial apple orchard in Haywood Co. served as the test site for this trial. Trees were planted at a density of 116 trees/acre, and tree row volume was estimated at 200 gpa. Plots consisted of four tree treatments, and treatments were arranged in a randomized complete block design with three replications. A delayed dormant oil application was applied to all trees in mid-March, followed by an application of Guthion (1.0 lb[AI]/A) on April 3. A killing freeze on April 8 destroyed virtually all flowers and a minimal insecticide program was maintained the remainder of the season.

Treatments consisted of Omite 30W (2.4 b[AI]/A), Kelthane 50WP (1.5 lb[AI]/A), Carzol 92SP (0.75 lb[AI]/A), Carzol (0.75 lb[AI]/A) + 0.5% Sol-Oil (97% oil concentrate) and an untreated control. Each miticide treatment was applied on July 16 and 23, using a handgun sprayer operating at 150 psi and delivering 175 g/p. Triton B-1956 spreader sticker was added to all spray solutions, except the Carzol + Oil treatment, at the rate of 4 oz/100 gallons.

Mite populations were monitored by removing 10 leaves from the middle two trees of each treatment, placing them through a mite brushing machine and counting the number of ERM, TSSM and *A. fallacis*. *S. punctum* populations were monitored in each treatment by conducting a three minute search on the middle two trees of each treatment.

Results & Discussion

Seasonal mite and predator population trends in the untreated control are shown in Figure 1. Mite populations remained low through mid June, increased rapidly from mid June through mid July, and decreased to low numbers by mid August. The rapid decrease in ERM and TSSM populations in mid July was largely the of *S. punctum*. Populations of this predator closely followed ERM and TSSM populations, and exhibited a characteristic predator-prey interaction. Conversely, *A. fallacis* populations gradually increased in density throughout the season, with peak densities of 2.8 mites/leaf recorded on July 30.

At the time of the first application of treatments on June 16, overall mite populations averaged 29.2/leaf, of which 31% were ERM and 69% TSSM. All materials significantly reduced populations below those in the untreated by three days post application (Table 1). Treatments appeared to be equally effective in suppressing ERM at both 3 and 7 days after the July 16 application, while TSSM populations were significantly lower in the Kelthane treatment compared with the Carzol treatments 7 days after the July 16 application. However, there were no significant differences among miticide treatments in overall mite control following the first application. The addition of Sol-Oil at 0.5% to Carzol did not appear to increase the level of mite suppression. Mite populations were declining when the second application was made on July 23, and ERM + TSSM decreased to less than 1 per leaf in all miticide treatments by July 30 (Table 2).

S. punctum populations were most intense when mite populations were highest, and populations of this predator were related to the density of pest mite in the various treatments (Table 3). Although adult and larval populations were slightly higher in the Carzol treatments compared with Kelthane and Omite, these differences were not significant. Populations were significantly higher in the untreated control compared with all miticide treatments on July 23 and 30.

A. fallacis populations in the various treatments are shown in Figure 2. The safety of Omite to *A. fallacis* is evident in that populations were not adversely affected, compared with the control, after the July 23 or 30 applications. Conversely, populations in both the Kelthane and Carzol treatments were lower than those in the untreated after both applications. These reduced populations in the Kelthane and Carzol treatments appeared to be direct effects of the chemical rather than a predator response to lower prey numbers, because predator populations continued to increase in the Omite treatment where prey populations were similar to Kelthane and Carzol treatments. However, two important points concerning the effects of Kelthane and Carzol should be noted. First, *A. fallacis* populations were not reduced after either application, but rather these chemicals appeared to prevent populations from increasing as they did in the untreated control. Secondly, the negative effects of both Kelthane and Carzol appeared to be relatively short term, *A. fallacis* did increase to densities present in the control within one week of the Carzol and four weeks of the Kelthane application.

Conclusions

This trial demonstrated that the non-selective miticides Kelthane and Carzol can negatively affect populations of the phytoseiid mite *A. fallacis* for one to four weeks after application. However, the overall level of ERM and TSSM control provided by these materials did not differ from that provided by Omite, which did not affect *A. fallacis* populations. The coccinelid predator *S. punctum* appeared to be of greater importance in reducing ERM and TSSM than *A. fallacis*, and the preservation of this predator through selective insecticide use is likely more crucial to short-term mite management than the use of selective miticides.

Table 1. European red mite (ERM) and twospotted spider mite (TSSM) populations on apples (cv. Red Delicious) treated with various miticides on July 16. Haywood Co., NC 1990

		Mites per leaf[a]								
		Pre-spray (7/16)			7/19			7/23		
Treatment	Rate/A	ERM	TSSM	ERM+TSSM	ERM	TSSM	ERM+TSSM	ERM	TSSM	ERM+TSSM
Kelthane 50WP	3.0	10.8	17.8	28.6	7.8 a	10.5 ab	18.3 a	3.9 a	1.2 a	5.1 a
Omite 30W	8.0	6.4	25.6	32.0	5.4 a	10.7 ab	16.1 a	4.7 a	4.6 ab	9.3 a
Carzol 92SP	0.75	14.5	24.6	39.1	4.9 a	5.6 a	10.5 a	3.9 a	6.6 b	10.5 a
Carzol 92SP + Sol-Oil	0.75 0.5% soln.	9.8	18.2	28.0	5.4 a	6.2 a	11.6 a	2.7 a	5.9 b	8.6 a
Untreated Control	-	4.4	13.8	18.2	12.4 b	22.7 b	35.1 b	10.3 b	10.7 c	20.9 b

[a]Means in the same column followed by the same letter are not significantly different by Duncan's multiple range test ($P < 0.05$).

Table 2. European red mite (ERM) and twospotted spider mite (TSSM) populations on apples (cv. Red Delicious) treated with various miticides on July 23. Haywood Co., NC 1990.

		Mites per leaf[a]								
		7/30			8/13			8/29		
Treatment	Rate/A	ERM	TSSM	ERM+TSSM	ERM	TSSM	ERM+TSSM	ERM	TSSM	ERM+TSSM
Kelthane 50WP	3.0	0.2 a	0.4 a	0.6 a	0.1 a	0.1 a	0.1 a	0.1 a	0.1 a	0.2 a
Omite 30W	8.0	0.6 a	0.3 a	0.9 a	0.1 a	0.1 a	0.1 a	0.0 a	0.0 a	0.0 a
Carzol 92SP	0.75	0.7 a	0.2 a	0.9 a	0.1 a	0.0 a	0.1 a	0.1 a	0.0 a	0.1 a
Carzol 92SP + Sol-Oil	0.75 0.5% soln.	0.3 a	0.1 a	0.4 a	0.0 a	0.0 a	0.0 a	0.3 a	0.3 a	0.3 a
Untreated Control	-	3.1 b	6.8 b	9.9 b	0.3 a	0.2 a	0.5 a	0.1 a	0.0 a	0.1 a

[a]Means in the same column followed by the same letter are not significantly different by Duncan's multiple range test ($P < 0.05$).

Table 3. *Stethorus punctum* adult and larval populations on apples (cv. Red Delicious) treated with various miticides on July 16. Haywood Co., NC 1990

		Stethrous punctum per 3 min. search[a]							
		7/10 (pre-spray)		7/20		7/23		7/30	
Treatment	Rate/A	adults	larvae	adults	larvae	adults	larvae	adults	larvae
Kelthane 50WP	3.0	-	-	1.0 a	3.7 a	0.6 a	3.0 a	0.5 a	0.0 a
Omite 30W	8.0	-	-	1.7 a	2.0 a	0.0 a	0.3 a	1.5 a	0.5 a
Carzol 92SP	0.75	-	-	4.0 a	8.3 a	1.3 a	4.3 a	0.0 a	1.5 a
Carzol 92SP + Sol-Oil	0.75 0.5% soln.	-	-	4.0 a	7.0 a	3.3 a	5.6 a	0.0 a	0.0 a
Untreated Control	-	8.0	0.5	17.7 a	10.3 a	10.0 b	20.0 b	10.5 b	19.0 b

[a]Means in the same column followed by the same letter are not significantly different by Duncan's multiple range test ($P < 0.05$).

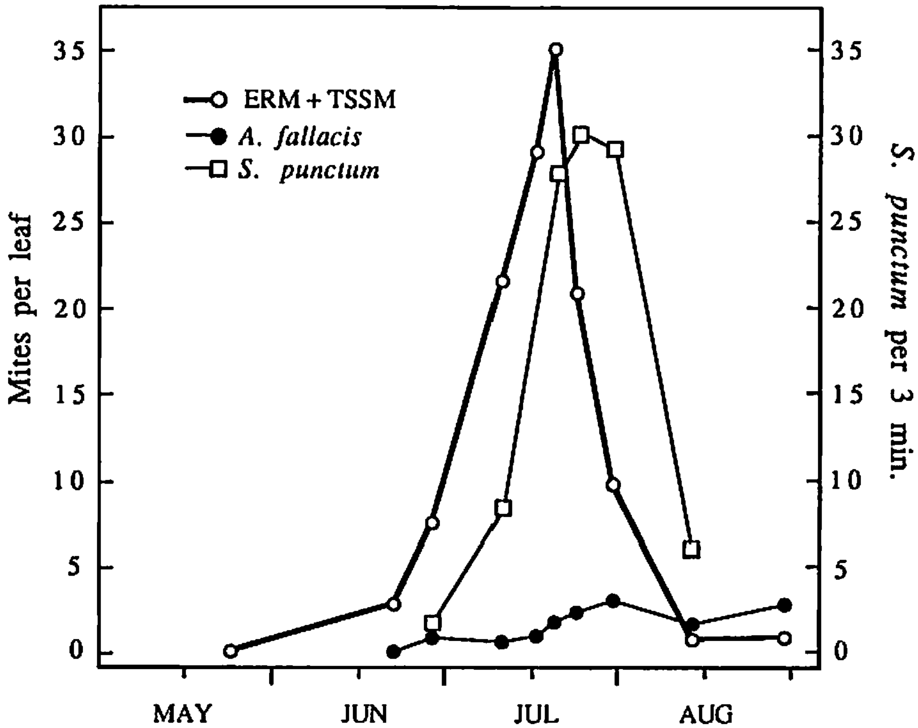


Figure 1. Mite and predator populations on untreated apples (cv. Red Delicious) in Haywood Co. 1990

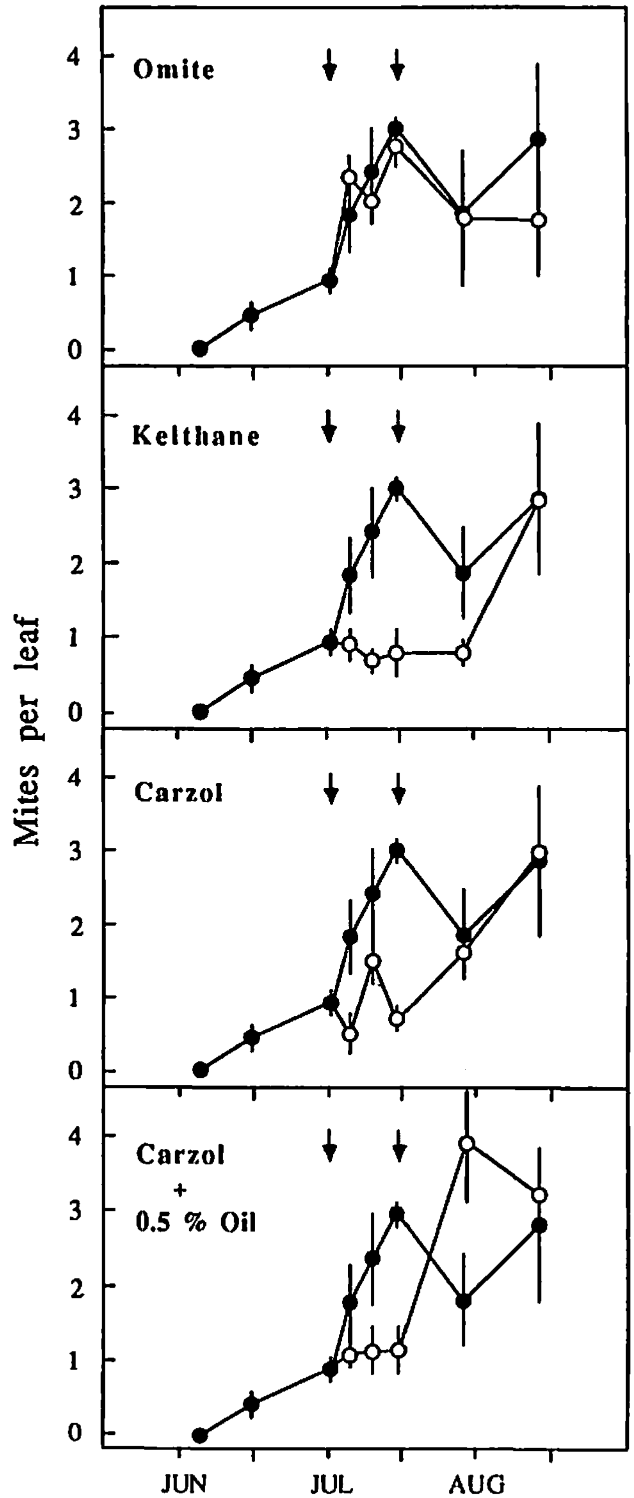


Figure 2. *Amblyseius fallacis* populations on apples treated with different miticides on July 16 and 23 (arrows). Open circles (○) represent popualtions in miticide treatments and closed circles (●) represent populations in the untreated control. Verticle lines represent SEM.

NOT FOR PUBLICATION

Henry W. Hogmire, Jr.,
Tim Winfield, and
Robert Cheves
WVU Experiment Farm
P. O. Box 609
Kearneysville, WV 25430
(304) 876-0983

APPLE: *Malus domestica* Borkh. 'Red Delicious'
European red mite; *Panonychus ulmi* (Koch)
Mite predator; *Stethorus punctum* (LeConte)

ACARICIDE EVALUATION EXPERIMENT I, 1990: This test was conducted in a one third acre block of 5-yr-old 'Redchief' trees on M26, which measured 10.5 ft. in height and 6.5 ft. in width and were planted at a spacing of 10 x 15 ft. The experimental design consisted of 4 single-tree plots in a randomized block design, with each replicate surrounded by at least one unsprayed tree on each side. Acaricides were applied to runoff on 3 Jul with a handgun attached to a Durand-Wayland 100 LTS sprayer operated at 100 psi. Each tree received approximately one half gallon of spray (ca. 145 GPA). Other materials applied separately to all treatments were Agristrep, Asana, Benlate, Captan, Dimethoate, Guthion, Lannate, Manzate 200, Nova, Oil, Penncap-M, Polyram, Rubigan, Sevin, Solubor, Topsin-M, and Zineb. European red mite control was evaluated by sampling 25 leaves from the periphery of each tree, removing mites with a mite-brushing machine, and counting active stages with a binocular microscope. The effect of treatments on *S. punctum* was determined by counting adults and larvae observed in 3 min around the periphery of test trees.

There was no significant difference in mite control between the middle and high rate of EL-436, which were significantly better than the low rate. The low rate of EL-436 provided mite control comparable to Kelthane and Omite, which were not significantly different.

NOT FOR PUBLICATION

				European red mites/leaf				S. punctum/3 min	Accumulated mite-days
No.	Treatment	Rate/100 gal	lb AI	2 Jul	11 Jul	17 Jul	24 Jul	24 Jul	2 to 24 Jul
1.	Kelthane 50 W	454 g	0.50	1.1 b	2.6 b	2.1 bc	1.7 bcd	6.8 c	43.6 bc
2.	Omite 6 EC	237 ml	0.38	2.2 a	2.3 b	3.1 bc	2.1 ab	8.5 bc	54.3 b
3.	EL-436 1.67 SC	17 ml	0.007	1.8 ab	2.5 b	3.8 ab	1.7 abc	23.8 ab	56.9 b
4.	EL-436 1.67 SC	34 ml	0.014	1.2 b	1.0 c	2.1 bc	0.8 d	11.8 bc	29.5 cd
5.	EL-436 1.67 SC	68 ml	0.028	1.1 b	0.8 c	1.8 c	1.0 cd	5.3 c	26.0 d
6.	Untreated	------	-----	0.9 b	11.5 a	7.4 a	2.9 a	50.8 a	148.8 a

Means in a given column followed by the same letter are not significantly different (P = 0.05; DMRT).

NOT FOR PUBLICATION

Henry W. Hogmire, Jr.,
Tim Winfield, and
Robert Cheves
WVU Experiment Farm
P. O. Box 609
Kearneysville, WV 25430
(304) 876-0983

APPLE: *Malus domestica* Borkh. 'Red Delicious'
European red mite (ERM); *Panonychus ulmi* (Koch)
Mite predator; *Stethorus punctum* (LeConte)

ACARICIDE EVALUATION EXPERIMENT II, 1990: This test was conducted in a 0.6 acre block of 11-yr-old 'Topred' trees on MM106, which measured 14 ft. in height and 10 ft. in width and were planted at a spacing of 14 x 14 ft. The experimental design consisted of 4 single-tree plots in a randomized block design, with each replicate surrounded by at least one unsprayed tree on each side. Acaricides were applied to runoff on 19 Jun and 17 Jul with a handgun attached to a Durand-Wayland 100 LTS sprayer operated at 100 psi. Each tree received approximately 1.5 gallon of spray (ca. 333 GPA). Other materials applied separately to all treatments were Agristrep, Benlate, Captan, Dimethoate, Dithane Z-78, Guthion, Lannate, Lorsban, Nova, Oil, Penncap-M, Polyram, Rubigan, Sevin, Solubor, Topsin-M, and Zineb. European red mite control was evaluated by sampling 25 leaves from the periphery of each tree, removing mites with a mite-brushing machine, and counting active stages with a binocular microscope. The effect of treatments on *S. punctum* was determined by counting adults and larvae observed in 3 min around the periphery of test trees.

Although the difference in mite control among rates of 801,757 was not significant, the high rate maintained mite populations at a lower level than the low and middle rates, which were comparable. The low and middle rates were similar in mite control to Omite, whereas the high rate was significantly more effective than Omite. Oil used in combination with the low rate of 801,757 did not improve mite control.

No.	Treatment	Rate/100 gal	lb AI	European red mites/leaf 18 Jun	26 Jun	2 Jul	9 Jul	16 Jul
1.	801,757 20 EC	142 ml	0.06	1.3 a	0.5 b	1.5 bc	5.8 bc	13.7 bc
2.	801,757 20 EC	284 ml	0.12	2.9 a	0.9 b	1.6 bc	6.6 bc	13.5 bc
3.	801,757 20 EC	474 ml	0.20	1.8 a	0.6 b	0.6 c	2.9 c	9.1 c
4.	801,757 20 EC Sun 6 E Oil	142 ml 947 ml	0.06 + ----	2.0 a	0.8 b	1.5 bc	8.4 b	18.3 bc
5.	Omite 6 EC	237 ml	0.38	1.2 a	1.1 b	3.4 b	8.7 b	21.8 b
6.	Untreated	-------	----	1.3 a	6.6 a	11.6 a	36.0 a	122.3 a

Means in a given column followed by the same letter are not significantly different (P = 0.05; DMRT).

No.	Treatment	Rate/100 gal	lb AI	ERM/leaf 23 Jul	S. punctum/3 min 24 Jul	Accumulated mite-days 18 Jun to 23 Jul
1.	801,757 20 EC	142 ml	0.06	1.9 b	8.0 cd	179.1 bc
2.	801,757 20 EC	284 ml	0.12	2.4 b	4.5 d	177.6 bc
3.	801,757 20 EC	474 ml	0.20	1.9 b	3.8 d	107.9 c
4.	801,757 20 EC Sun 6 E Oil	142 ml 947 ml	0.06 + ----	3.9 b	9.8 c	225.6 bc
5.	Omite 6 EC	237 ml	0.38	1.8 b	34.8 b	254.8 b
6.	Untreated	-------	----	16.1 a	153.3 a	1290.7 a

Means in a given column followed by the same letter are not significantly different (P = 0.05; DMRT).

NOT FOR PUBLICATION

Henry W. Hogmire, Jr.
and Tim Winfield
WVU Experiment Farm
P. O. Box 609
Kearneysville, WV 25430
(304) 876-0983

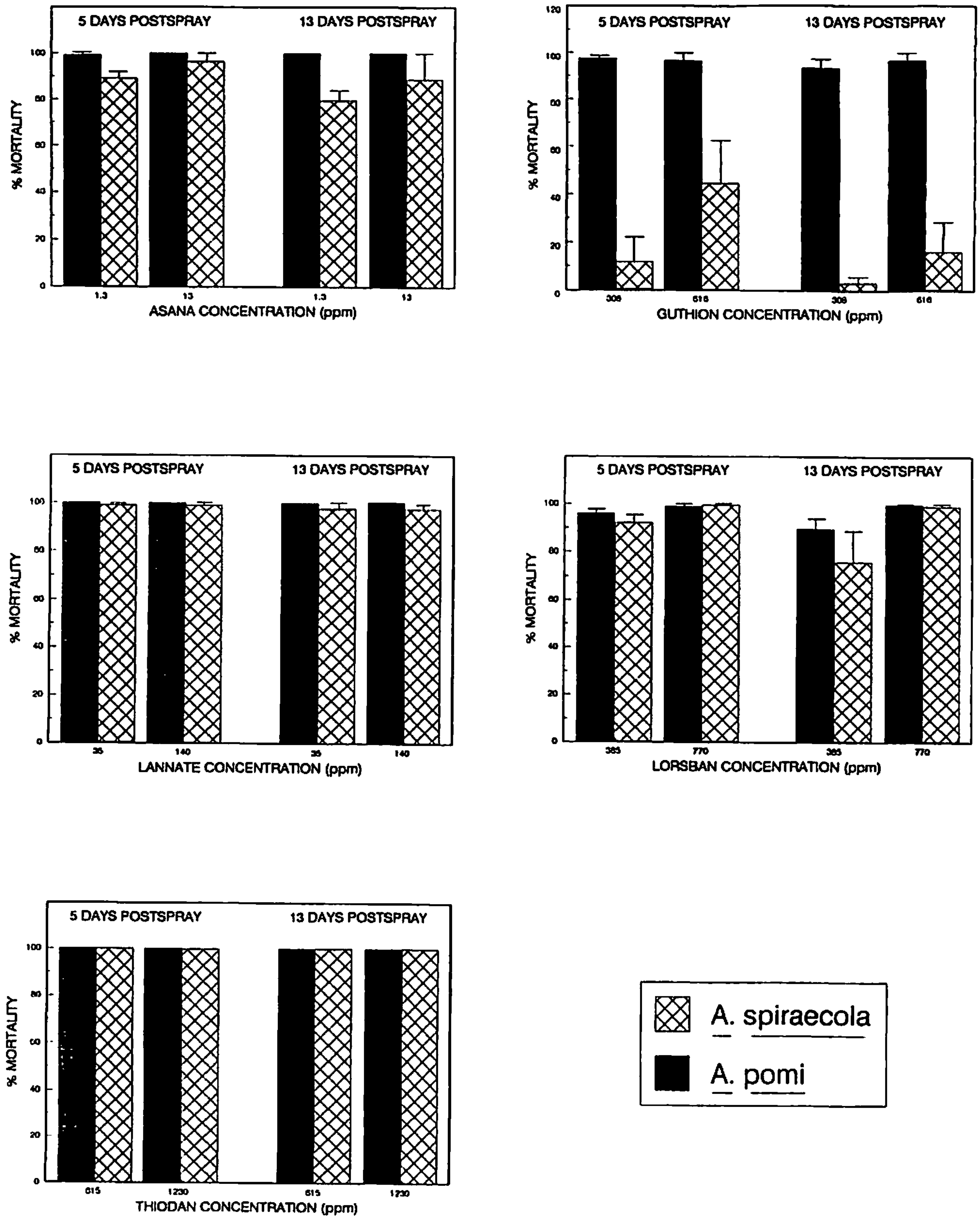
Mark W. Brown and
Jeff J. Schmitt
USDA-ARS AFRS
45 Wiltshire Road
Kearneysville, WV 25430
(304) 725-3451

APPLE: *Malus domestica* Borkh. 'Rome'
Apple aphid; *Aphis pomi* DeGeer
Spirea aphid; *Aphis spiraecola* Patch

TOXICITY OF INSECTICIDES TO TWO APHID SPECIES ON APPLE, 1990: This experiment was conducted in a one acre block of 4-yr-old trees on M-7A, which measured 9 ft in height and 7 ft in width and were planted at a spacing of 18 x 24 ft. The experimental design consisted of 5 single-tree plots in a randomized block design. Two modified two-liter plastic bottle cages were installed over the end of a branch on opposite sides of each tree. A piece of string was tied to the central leader and the neck of the bottle to help support the cage. On 1 May, two adults and three nymphs of apple aphid and spirea aphid, from laboratory colonies, were introduced into separate cages on each tree. On 18 May, bottle cages were removed to count aphids, and branches were treated with insecticides applied to runoff with a Century sprayer equipped with a handgun and operated at 100 psi. Insecticides and concentrations in ppm AI (oz form/100 gal) included Asana XL 1.3 (0.23), 13 (2.0); Guthion 35W 308 (11.4), 616 (22.8); Lannate 1.8L 35 (2.0), 140 (8.0); Lorsban 50W 385 (10.0), 770 (20.0); Thiodan 50W 615 (16.0), 1230 (32.0). Postspray counts were taken on 23 and 31 May, and percentage mortality was calculated for each date.

A. pomi was more susceptible than *A. spiraecola* to Asana at one tenth the field rate, and to Guthion at field rate and twice the field rate. There was no significant difference in susceptibility of the two aphid species to Lannate, Lorsban and Thiodan.

NOT FOR PUBLICATION



NOT FOR PUBLICATION

Henry W. Hogmire, Jr.,
Tim Winfield, and
Robert Cheves
WVU Experiment Farm
P. O. Box 609
Kearneysville, WV 25430
(304) 876-0983

APPLE: *Malus domestica* Borkh. 'Rome'
European red mite; *Panonychus ulmi* (Koch)
Mite predator (SP); *Stethorus punctum* (LeConte)
Rose leafhopper (RLH); *Edwardsiana rosae* (L.)
Japanese beetle (JB); *Popillia japonica* Newman
Spotted tentiform leafminer (STLM); *Phyllonorycter blancardella* (F.)
Codling moth (CM); *Cydia pomonella* (L.)
Tufted apple bud moth (TABM); *Platynota idaeusalis* (Walker)
Redbanded leafroller (RBLR); *Argyrotaenia velutinana* (Walker)

BIOLOGICAL AND BOTANICAL INSECTICIDE EVALUATION, 1990: This experiment was conducted in a one acre block of 4-yr-old trees on M-7A, which measured 9 ft. in height and 7 ft. in width and were planted at a spacing of 18 x 24 ft. The experimental design consisted of a single one-quarter acre block (25 trees) for each of four treatments. Data were taken from 5 single-tree replications in the center of each plot. Insecticides were applied with a Swanson DA500A airblast sprayer, which traveled at 2.4 mph and delivered a spray volume of 100 gal/acre. Dates of application were 24 May; 5, 15, and 25 Jun; 5, 16, and 26 Jul; 11 and 28 Aug; 6 and 18 Sep. Other insecticides applied separately to all treatments before 24 May included Asana, Oil, and Pounce. Other materials applied separately to all treatments were Agristrep, Benlate, Captan, Dithane M-45, Folpet, NAA, Nova, Polyram, Rubigan, and Topsin-M. European red mite control was evaluated by sampling 20 leaves from the periphery of each tree, removing mites with a mite-brushing machine, and counting active stages with a binocular microscope. The effect of treatments on *S. punctum* was determined by counting adults and larvae observed in 3 min around the periphery of test trees. RLH control was evaluated by counting nymphs on 25 leaves selected from the periphery of each tree. The effect of treatments on JB was determined by counting beetles and injured leaves on each tree. Control of STLM was evaluated by counting mines observed in 5 min while walking around the periphery of each tree. The effect of treatments on fruit-feeding insects was determined by scoring for injury 500 apples/treatment (100/replication) plus all fallen apples sampled on 26 Sep.

Sabadilla provided the best control of mites, whereas Ryania was most effective against rose leafhopper, japanese beetle, spotted tentiform leafminer and codling moth. Javelin provided the most effective control of tufted apple bud moth and redbanded leafroller.

NOT FOR PUBLICATION

No.	Treatment	Rate/a	lb AI	European red mites/leaf				SP/3 min	Accumulated mite-days
				19 Jun	3 Jul	25 Jul	1 Aug	2 Aug	19 Jun to 1 Aug
1.	Javelin W	454 g	0.064	2.9 (0.45)	1.2 (0.20)	2.6 (0.17)	1.6 (0.28)	4.0 (2.35)	84.6 (6.76)
2.	Ryania	3632 g	0.009	2.3 (0.56)	1.1 (0.11)	4.5 (0.59)	2.2 (0.40)	4.2 (0.66)	108.8 (8.47)
3.	Sabadilla	4540 g	0.080	0.8 (0.29)	0.5 (0.19)	2.1 (0.13)	1.6 (0.22)	2.2 (0.74)	51.1 (5.75)
4.	Untreated	------	-----	0.6 (0.07)	0.4 (0.08)	3.5 (0.28)	1.8 (0.42)	2.2 (1.07)	68.3 (3.47)

Values are means (± SE).

No.	Treatment	Rate/acre	lb AI	RLH/25 leaves	20 Jul		14 Aug
				3 Jul	JB/tree	JB inj lvs/tree	STLM/5 min
1.	Javelin WG	454 g	0.064	40.8 (11.10)	58.6 (15.3)	598.4 (46.9)	18.0 (4.47)
2.	Ryania	3632 g	0.009	1.2 (0.37)	46.0 (11.5)	417.0 (47.2)	2.6 (0.51)
3.	Sabadilla	4540 g	0.080	4.4 (1.33)	55.4 (11.0)	497.6 (32.1)	6.4 (1.17)
4.	Untreated	------	-----	16.6 (2.87)	113.4 (19.4)	722.6 (48.0)	28.0 (3.49)

Values are means (± SE).

NOT FOR PUBLICATION

No.	Treatment	Rate/acre	lb AI	% Injury		
				CM	TABM & RBLR	ALL INSECTS
1.	Javelin WG	454 g	0.064	1.6 (1.02)	2.8 (0.51)	5.2 (1.55)
2.	Ryania	3632 g	0.009	0.0 (0.00)	4.1 (0.83)	4.3 (0.94)
3.	Sabadilla	4540 g	0.080	3.2 (1.84)	5.2 (1.11)	8.5 (2.16)
4.	Untreated	------	-----	5.1 (1.65)	11.3 (1.91)	16.9 (2.95)

Values are means (± SE).

NOT FOR PUBLICATION

Henry W. Hogmire, Jr.,
Tim Winfield, and
Robert Cheves
WVU Experiment Farm
P. O. Box 609
Kearneysville, WV 25430
(304) 876-0983

APPLE: *Malus domestica* Borkh. 'Rome Beauty', 'Golden Delicious'
Spirea aphid (SA); *Aphis spiraecola* Patch
White apple leafhopper (WALH); *Typhlocyba pomaria* McAtee
Spotted tentiform leafminer (STLM); *Phyllonorycter blancardella* (F.)
European red mite (ERM); *Panonychus ulmi* (Koch)
Mite predator (SP); *Stethorus punctum* (LeConte)
Codling moth (CM); *Cydia pomonella* (L.)
Tufted apple bud moth (TABM); *Platynota idaeusalis* (Walker)
Redbanded leafroller (RBLR); *Argyrotaenia velutinana* (Walker)

INSECTICIDE EVALUATION, 1990: This experiment was conducted in a 5.4 acre block of 36-yr-old trees, which measured 16.5 ft. in height and 23 ft. in width and were planted at a spacing of 20 x 40 ft. The experimental design consisted of 6 single-tree plots (3 'Rome Beauty', 3 'Golden Delicious') in a randomized block design. Insecticides were applied with a Swanson DA500A airblast sprayer, which traveled at 2.4 mph and delivered a spray volume of 300 gal/acre at the delayed dormant stage and 100 gal/acre for the remainder of the season. Dates of application were 22 Mar (delayed dormant [DD]), 5 Apr (prepink [PP]), 14 May (petal fall [PF]), 31 May (first cover [1C]), 14 Jun (second cover [2C]), 28 Jun (third cover [3C]), 16 Jul (fourth cover [4C]), 27 Jul (fifth cover [5C]), 13 Aug (sixth cover [6C]), 28 Aug (seventh cover [7C]) and 6 Sep (eighth cover [8C]). Other materials applied separately to all treatments were Agristrep, Benlate, Captan, Dithane Z-78, Folpet, Manzate 200, NAA, Nova, Polyram, Rubigan, Solubor, Topsin-M, and Zineb. Control of SA was evaluated by counting infested leaves on each of 10 terminals and aphids on the most infested leaf/terminal around the periphery of each tree. The effect of treatments on WALH was determined by counting nymphs on 25 leaves selected from the periphery of each tree. Control of STLM was evaluated by counting mines observed in 5 minutes around the periphery of each tree. Treatment effect on ERM was determined by sampling 33 leaves from the periphery of each 'Rome Beauty' tree, removing mites with a mite-brushing machine, and counting active stages with a binocular microscope. Impact of treatments on *S. punctum* was determined by counting adults and larvae observed in 3 min around the periphery of test trees. Control of fruit-feeding insects was determined by scoring for injury 600 apples/treatment (100/replication) plus all fallen apples sampled on 26 Sep. Fruit picked from 'Golden Delicious' trees were rated for finish on a scale of 0-5, 5 being worst.

Danitol and programs including Lorsban provided excellent suppression of European red mites. Good *Stethorus punctum* populations were seen in most treatments. EXP 60145A had no effect on mites or *Stethorus punctum*, but provided excellent control of white apple leafhopper, spotted tentiform leafminer and leafrollers. The high rate of EXP 60145A was significantly more effective in the control of codling moth than the low and middle rate, which provided similar control. A season long program of Larvin + Lorsban resulted in the highest level of fruit russeting.

NOT FOR PUBLICATION

No.	Treatment	Rate/acre	lb AI	Time of application	European red mites/leaf 13 Jun	10 Jul	18 Jul	SP/3 min 19 Jul	mite-days 10 to 18 Jul
1.	Lorsban 4 EC	710 ml	0.75	DD	0.46 a	3.9 bcd	2.6 d	13.7 de	26.2 cd
	Guthion 35 W	908 g	0.70	PF,1C					
	Lorsban 50 W	908 g	1.00	2C-8C					
2.	Sun 6 E Oil	22.7 l	----	DD	0.52 a	4.1 bcd	2.9 d	19.3 cde	28.1 cd
	Guthion 35 W	908 g	0.70	PF,1C					
	Lorsban 50 W	680 g	0.75 +						
	Lannate 1.8 L	710 ml	0.34	2C,3C,6C-8C					
	Lorsban 50 W	908 g	1.00	4C,5C					
3.	Lorsban 4 EC	710 ml	0.75 +		0.18 a	5.0 bcd	4.3 bcd	18.0 cde	37.4 cd
	Sun 6 E Oil	22.7 l	----	DD					
	Guthion 35 W	908 g	0.70	PF,1C					
	Lorsban 50 W	680 g	0.75 +						
	Asana XL 0.66 EC	34 ml	.006	2C,3C,6C-8C					
	Lorsban 50 W	908 g	1.00	4C,5C					
4.	Lorsban 4 EC	710 ml	0.75 +		------	9.2 abc	10.2 abc	21.3 bcde	77.6 abc
	Sun 6 E Oil	22.7 l	----	DD					
	Guthion 3 F	888 ml	0.70	PF,1C,4C,5C					
	Guthion 3 F	444 ml	0.35 +						
	Lannate 1.8 L	710 ml	0.34	2C,3C,6C-8C					
5.	Pounce 3.2 EC	178 ml	0.15 +		------	13.6 a	14.4 a	29.7 a-e	111.8 a
	Sun 6 E Oil	22.7 l	----	DD					
	Guthion 35 W	908 g	0.70	PF,1C,4C,5C					
	Penncap-M 2 F	710 ml	0.37 +						
	Lannate 1.8 L	710 ml	0.34	2C,3C,6C-8C					

Means in a given column followed by the same letter are not significantly different (P = 0.05; DMRT).

NOT FOR PUBLICATION

No.	Treatment	Rate/acre	lb AI	Time of application	European red mites/leaf 13 Jun	10 Jul	18 Jul	SP/3 min 19 Jul	mite-days 10 to 18 Jul
6.	Asana XL 0.66 EC	178 ml	0.03 +		------	10.4 ab	12.8 ab	42.7 abc	93.0 ab
	Sun 6 E Oil	22.7 l	----	DD					
	Guthion 35 W	908 g	0.70	PF,1C,4C,5C					
	Penncap-M 2 F	710 ml	0.37 +						
	Lannate 1.8 L	710 ml	0.34	2C,3C					
	Penncap-M 2 F	1420 ml	0.74	6C-8C					
7.	Phosphamidon 8 EC	355 ml	0.75	PP	------	1.9 d	3.1 d	10.3 de	19.9 d
	Guthion 35 W	908 g	0.70	PF					
	Penncap-M 2 F	1420 ml	0.74	1C,4C-7C					
	Danitol 2.4 EC	474 ml	0.30	2C,3C,8C					
8.	Dimethoate 4 EC	710 ml	0.75	PP	------	2.7 cd	3.2 cd	7.3 e	23.7 d
	Larvin 3.2 F	592 ml	0.50 +						
	Lorsban 50 W	454 g	0.50	PF-8C					
9.	Dimethoate 4 EC	710 ml	0.75	PP	------	7.9 abc	9.1 a-d	49.3 ab	68.1 a-d
	EXP 60145A 20 SC	118 ml	0.05	PF-8C					
10.	Dimethoate 4 EC	710 ml	0.75	PP	------	7.7 abc	5.0 bcd	39.3 a-d	50.6 bcd
	EXP 60145A 20 SC	237 ml	0.10	PF-8C					
11.	Dimethoate 4 EC	710 ml	0.75	PP	------	8.1 abc	5.3 a-d	56.7 a	53.6 bcd
	EXP 60145A 20 SC	355 ml	0.15	PF-8C					
12.	Untreated	------	----		------	4.5 bcd	3.6 cd	10.7 de	32.4 cd

Means in a given column followed by the same letter are not significantly different (P = 0.05; DMRT).

NOT FOR PUBLICATION

No.	Treatment	Rate/acre	lb AI	Time of application	11 Jun SA inf lvs/term	11 Jun SA/most inf leaf	15 Aug WALH/25 lvs	15 Aug STLM/5 min
1.	Lorsban 4 EC	710 ml	0.75	DD	6.1 a	239.6 a	18.0 a	192.5 a
	Guthion 35 W	908 g	0.70	PF,1C				
	Lorsban 50 W	908 g	1.00	2C-8C				
2.	Sun 6 E Oil	22.7 l	----	DD	5.9 a	181.6 abc	1.7 c	65.0 b
	Guthion 35 W	908 g	0.70	PF,1C				
	Lorsban 50 W	680 g	0.75 +					
	Lannate 1.8 L	710 ml	0.34	2C,3C,6C-8C				
	Lorsban 50 W	908 g	1.00	4C,5C				
3.	Lorsban 4 EC	710 ml	0.75 +		5.8 a	202.4 ab	10.0 b	27.3 b
	Sun 6 E Oil	22.7 l	----	DD				
	Guthion 35 W	908 g	0.70	PF,1C				
	Lorsban 50 W	680 g	0.75 +					
	Asana XL 0.66 EC	34 ml	.006	2C,3C,6C-8C				
	Lorsban 50 W	908 g	1.00	4C,5C				
4.	Lorsban 4 EC	710 ml	0.75 +		5.8 a	180.9 abc	3.2 c	39.8 b
	Sun 6 E Oil	22.7 l	----	DD				
	Guthion 3 F	888 ml	0.70	PF,1C,4C,5C				
	Guthion 3 F	444 ml	0.35 +					
	Lannate 1.8 L	710 ml	0.34	2C,3C,6C-8C				
5.	Pounce 3.2 EC	178 ml	0.15 +		5.6 ab	163.0 bc	3.2 c	61.5 b
	Sun 6 E Oil	22.7 l	----	DD				
	Guthion 35 W	908 g	0.70	PF,1C,4C,5C				
	Penncap-M 2 F	710 ml	0.37 +					
	Lannate 1.8 L	710 ml	0.34	2C,3C,6C-8C				

Means in a given column followed by the same letter are not significantly different ($P = 0.05$; DMRT).

NOT FOR PUBLICATION

No.	Treatment	Rate/acre	lb AI	Time of application	11 Jun SA inf lvs/term	11 Jun SA/most inf leaf	15 Aug WALH/25 lvs	15 Aug STLM/5 min
6.	Asana XL 0.66 EC	178 ml	0.03 +		5.4 ab	233.7 a	11.2 b	76.0 b
	Sun 6 E Oil	22.7 l	----	DD				
	Guthion 35 W	908 g	0.70	PF,1C,4C,5C				
	Penncap-M 2 F	710 ml	0.37 +					
	Lannate 1.8 L	710 ml	0.34	2C,3C				
	Penncap-M 2 F	1420 ml	0.74	6C-8C				
7.	Phosphamidon 8 EC	355 ml	0.75	PP	5.5 ab	227.3 ab	4.0 c	0.8 d
	Guthion 35 W	908 g	0.70	PF				
	Penncap-M 2 F	1420 ml	0.74	1C,4C-7C				
	Danitol 2.4 EC	474 ml	0.30	2C,3C,8C				
8.	Dimethoate 4 EC	710 ml	0.75	PP	3.8 e	158.6 bcd	3.2 c	17.0 c
	Larvin 3.2 F	592 ml	0.50 +					
	Lorsban 50 W	454 g	0.50	PF-8C				
9.	Dimethoate 4 EC	710 ml	0.75	PP	4.9 bc	117.9 cd	1.2 c	13.2 c
	EXP 60145A 20 SC	118 ml	0.05	PF-8C				
10.	Dimethoate 4 EC	710 ml	0.75	PP	4.0 de	115.0 cd	1.2 c	9.8 c
	EXP 60145A 20 SC	237 ml	0.10	PF-8C				
11.	Dimethoate 4 EC	710 ml	0.75	PP	4.3 cde	93.1 d	1.2 c	1.5 d
	EXP 60145A 20 SC	355 ml	0.15	PF-8C				
12.	Untreated	------	----		4.5 cd	119.2 cd	14.0 a	179.5 a

Means in a given column followed by the same letter are not significantly different (P = 0.05; DMRT).

NOT FOR PUBLICATION

No.	Treatment	Rate/acre	lb AI	Time of application	% Injury CM	% Injury TABM & RBLR	% Clean	Finish rating
1.	Lorsban 4 EC	710 ml	0.75	DD	13.6 bcd	6.3 bcd	80.0 bc	2.13 ab
	Guthion 35 W	908 g	0.70	PF,1C				
	Lorsban 50 W	908 g	1.00	2C-8C				
2.	Sun 6 E Oil	22.7 l	----	DD	8.0 cde	8.2 bc	83.7 abc	1.96 b
	Guthion 35 W	908 g	0.70	PF,1C				
	Lorsban 50 W	680 g	0.75 +					
	Lannate 1.8 L	710 ml	0.34	2C,3C,6C-8C				
	Lorsban 50 W	908 g	1.00	4C,5C				
3.	Lorsban 4 EC	710 ml	0.75 +		8.4 cde	10.6 b	80.8 bc	2.07 ab
	Sun 6 E Oil	22.7 l	----	DD				
	Guthion 35 W	908 g	0.70	PF,1C				
	Lorsban 50 W	680 g	0.75 +					
	Asana XL 0.66 EC	34 ml	.006	2C,3C,6C-8C				
	Lorsban 50 W	908 g	1.00	4C,5C				
4.	Lorsban 4 EC	710 ml	0.75 +		6.1 de	8.5 bc	85.4 abc	2.12 ab
	Sun 6 E Oil	22.7 l	----	DD				
	Guthion 3 F	888 ml	0.70	PF,1C,4C,5C				
	Guthion 3 F	444 ml	0.35 +					
	Lannate 1.8 L	710 ml	0.34	2C,3C,6C-8C				
5.	Pounce 3.2 EC	178 ml	0.15 +		9.2 bcde	7.0 bc	83.8 abc	2.06 ab
	Sun 6 E Oil	22.7 l	----	DD				
	Guthion 35 W	908 g	0.70	PF,1C,4C,5C				
	Penncap-M 2 F	710 ml	0.37 +					
	Lannate 1.8 L	710 ml	0.34	2C,3C,6C-8C				

Means in a given column followed by the same letter are not significantly different (P = 0.05; DMRT).

NOT FOR PUBLICATION

No.	Treatment	Rate/acre	lb AI	Time of application	% Injury CM	% Injury TABM & RBLR	% Clean	Finish rating
6.	Asana XL 0.66 EC	178 ml	0.03 +		6.2 de	6.4 bc	87.5 abc	2.02 b
	Sun 6 E Oil	22.7 l	----	DD				
	Guthion 35 W	908 g	0.70	PF,1C,4C,5C				
	Penncap-M 2 F	710 ml	0.37 +					
	Lannate 1.8 L	710 ml	0.34	2C,3C				
	Penncap-M 2 F	1420 ml	0.74	6C-8C				
7.	Phosphamidon 8 EC	355 ml	0.75	PP	4.8 e	6.1 bcd	90.6 ab	2.05 ab
	Guthion 35 W	908 g	0.70	PF				
	Penncap-M 2 F	1420 ml	0.74	1C,4C-7C				
	Danitol 2.4 EC	474 ml	0.30	2C,3C,8C				
8.	Dimethoate 4 EC	710 ml	0.75	PP	7.1 cde	4.5 bcd	88.4 abc	2.22 a
	Larvin 3.2 F	592 ml	0.50 +					
	Lorsban 50 W	454 g	0.50	PF-8C				
9.	Dimethoate 4 EC	710 ml	0.75	PP	16.5 b	4.6 bcd	78.9 c	2.00 b
	EXP 60145A 20 SC	118 ml	0.05	PF-8C				
10.	Dimethoate 4 EC	710 ml	0.75	PP	14.5 bc	4.3 cd	81.2 abc	2.09 ab
	EXP 60145A 20 SC	237 ml	0.10	PF-8C				
11.	Dimethoate 4 EC	710 ml	0.75	PP	5.2 e	2.8 d	91.7 a	2.10 ab
	EXP 60145A 20 SC	355 ml	0.15	PF-8C				
12.	Untreated	------	----		44.9 a	18.0 a	35.4 d	1.95 b

Means in a given column followed by the same letter are not significantly different (P = 0.05; DMRT).

NOT FOR PUBLICATION

Henry W. Hogmire, Jr.,
Tim Winfield, and
Robert Cheves
WVU Experiment Farm
P. O. Box 609
Kearneysville, WV 25430

PEACH: *Prunus persicae* (L.) 'Sunhigh', 'Loring'
Lesser peachtree borer; *Synanthedon pictipes* (Grote & Robinson)

LESSER PEACHTREE BORER CONTROL, 1990: This experiment was conducted in a 0.7 acre block of 12-yr-old trees, which measured 11 ft. in height and 13 ft. in width and were planted at a spacing of 20 x 20 ft. The experimental design consisted of 6 single-tree plots (3 'Sunhigh', 3 'Loring') in a randomized block design. Insecticides were applied to runoff on 5 and 25 Jun with a handgun attached to a Durand-Wayland 100 LTS sprayer operated at 100 psi. Each tree received approximately 2 gallon of spray (ca. 218 GPA) which was primarily directed at wounds on the trunk and branches. Other materials applied separately to all treatments were Benlate, Captan, Parathion, Rovral, Sevin, and Topsin-M. Insecticides were evaluated by counting and removing pupal cases from the trunk and branches at a height of 1 - 6 ft on 1, 14, and 29 Aug; 17 Sep; 1 Oct. Counts on each date were summed to arrive at a season total for each tree. Pupal cases were removed from all trees on 19 Jul prior to taking counts.

Lorsban and the high rate of Asana provided comparable control of lesser peachtree borer.

No.	Treatment	Rate/100 gal	lb AI	Pupal cases/tree 1 Aug to 1 Oct
1.	Asana XL 0.66 EC	90 ml	0.015	4.3 ab
2.	Asana XL 0.66 EC	174 ml	0.029	2.5 b
3.	Lorsban 4 EC	1420 ml	1.50	2.5 b
4.	Untreated	-------	-----	7.0 a

Means in a given column followed by the same letter are not significantly different (P = 0.05; DMRT)

CONTROL OF WOOLLY APPLE APHIDS ON ROOTS

M. W. Brown[1], J. J. Jaeger[2], A. E. Pye[3] and J. J. Schmitt[1]

1 USDA-ARS-Appalachian Fruit Research Station, 45 Wiltshire Road, Kearneysville, WV 25430
2 Rohm & Haas Co., 3413 Seven Oaks Road, Midlothian, VA
3 BioLogic, 418 Briar Lane, Chambersburg, PA

Woolly apple aphid populations on branches and other above-ground portions of the apple tree can be easily controlled by using the right chemicals at the right time. Root inhabiting populations are not so easily managed. There are no easy sampling methods and a pest such as this often reaches high densities before it is noticed. Frequent outbreaks of woolly apple aphids on branches is a good indication that there are large populations on roots. Root-feeding aphids by themselves can cause a reduction in apple tree growth (Brown and Schmitt 1990) and even tree mortality when planted with infested rootstock (Sherbakoff and McClintock 1935). We evaluated the control of woolly apple aphid on roots using insect parasitic nematodes and an experimental systemic aphicide, RH-7988.

Materials and Methods

Nematodes.. Woolly apple aphids were exposed to the nematode, *Neoaplectana carpocapsae*, in petri dishes to see if the nematode would infect the aphid. A 1.5 to 3.0 cm section of apple stem infested with 30 to 100 woolly apple aphids was placed in a petri dish with moist sand. In each of five dishes, about 2700 nematodes were added, another five dishes were not inoculated with nematodes. Daily observations were made for five days. Dead aphids were examined for evidence of nematode infection.

Two field tests with nematodes were conducted. Nematodes were applied in a broadcast spray directed to the soil under six-year-old trees, concentrating the spray around the tree trunk and root sprouts. Sixteen trees were treated on 28 July 1989, and eighteen trees were used as controls. Approximately 3.675 million nematodes were applied under each tree in 7.5 l (2 gal) water, at a rate of 376,600 nematodes/m^2 (35,000/ft^2). The soil, moist from 1.25 cm rainfall three days earlier, was wetted with 19 l (5 gal) water per tree prior to nematode application. Another 3.8 cm rain fell on 30 July, two days after treatment. The second test was the application of nematodes as a topdressing mixed with peat moss on 25 September 1989. On five four-year-old trees, nematodes in a vermiculite substrate (Scanmask, BioLogic) were added to the topdressing of 946 cm^3 (1 qt) wet peat moss (376,600 nematodes/m^2) and another 5 trees received only the peat moss topdressing. Prior to treatment, the soil under each tree was wetted with 15 l (4 gal) water and after treatment, another 15 l water was sprayed on the topdressing. Trees from both studies were uprooted on 26 October 1989, to evaluate woolly apple aphid populations on roots.

RH-7988.. Seventy-two 'Delicious' trees were planted in May 1989. In July 1989, the roots of half the trees were artificially infested with woolly apple aphids from a laboratory colony. RH-7988 was applied to the trees as a foliar spray at 0.07 and 0.14 kg ai/ha (1/16 and 1/8 pounds ai/A; or 0.17 and 0.34 g ai/tree) and soil drench at 0.28 and 0.56 kg ai/ha (1/4 and 1/2 pounds ai/A; or 0.68 and 1.35 g ai/tree) on 7 June 1990. The study was designed as a Latin Square with two tree plots (one of each pair of trees was artificially infested with aphids) replicated twice for each method of application. The foliar spray was applied with 1.25 l (1/4 gal) water per tree and the soil drench was with 7.5 l (2 gal) water per tree. The number of woolly apple aphid colonies above the ground were counted every two weeks prior to treatment. After treatment, counts were made every one to two weeks. Half of the trees, one Latin Square from each application method, were uprooted on 5 July 1990 to evaluate control of active colonies on roots; the remaining trees were uprooted and evaluated on 12-14 October 1990.

Results and Discussion

Nematodes. The presence of nematodes in the petri dish study increased the mortality rate of woolly apple aphids (Fig. 1). By the second day, after inoculation, two of the five treated dishes had 100% mortality while the control dishes ranged from 3 to 57%, average of 24%, mortality. Five to 10% of the dead aphids from the treated dishes examined contained living nematodes internally. Nematodes were able to enter woolly apple aphids but were unable to reproduce because the aphids were too small. The presence of the nematode, however, did lead to mortality even without physical infection, most likely through physical damage and action of pathogenic microflora associated with the nematode.

The broadcast spraying of nematodes did seem to have an effect on the numbers of woolly apple aphid colonies. The treated trees had an average of 0.8 root colonies per tree and the control trees had 1.6 colonies per tree (X^2=7.30, d.f.=3, $p < 0.10$). There was no difference in amount of root galling between treated control trees showing that control and treated trees had been equally infested. The topdressing treatment had no effect on woolly apple aphid populations on roots. These two field studies were small and with low aphid populations. There is, however, an indication that using nematodes to control woolly apple aphids on the roots of apple trees in an orchard is possible.

RH-7988. Results of the insecticide treatment on above-ground populations of woolly apple aphids is shown in Table 1. There were no pretreatment differences among plots. All mean separations were done with 95% confidence intervals around the sample means. Both the foliar and soil drench applications reduced woolly apple aphid populations. The soil drench at 0.28 kg ai/ha significantly reduced the number of aphid colonies for one week after treatment and for 2 weeks at 0.56 kg ai/ha. In the foliar test, number of aphid colonies was significantly reduced for two and three weeks at 0.07 and 0.14 kg ai/ha, respectively. After 9 July, the woolly apple aphid population was too low to reveal any differences. The population reduction in all plots after treatment was expected. In West Virginia, woolly apple aphid populations peak in early June and decrease throughout the summer (MWB, unpublished data). Plots were treated at the peak aphid density to ensure enough aphids were present for a meaningful test.

Although the number of colonies on roots was small, only two of the nine colonies were on treated trees (Table 2). Both the foliar and soil drench applications significantly reduced the number of root colonies (X^2=4.66, $p < 0.05$; X^2=6.83, $p < 0.01$; respectively). The analysis did not include different rates, only control versus treated. In October, only 5 trees had colonies on the roots (3 on control trees, 2 on trees receiving the low rate), too few on which to make meaningful conclusions.

RH-7988 is an effective aphicide against woolly apple aphid. It controlled both above-ground and below-ground aphids with a foliar spray and with a soil drench application.

References

Brown, M. W. and J. J. Schmitt. 1990. Growth reduction in nonbearing apple trees by woolly apple aphids (Homoptera: Aphididae) on roots. J. Econ. Entomol. 83:1526-1530.

Sherbakoff, C. D. and J. A. McClintock. 1935. Effect of crown gall, hairy root, and woolly aphids on apple trees in the orchard. Phytopathology 25:1099-1103.

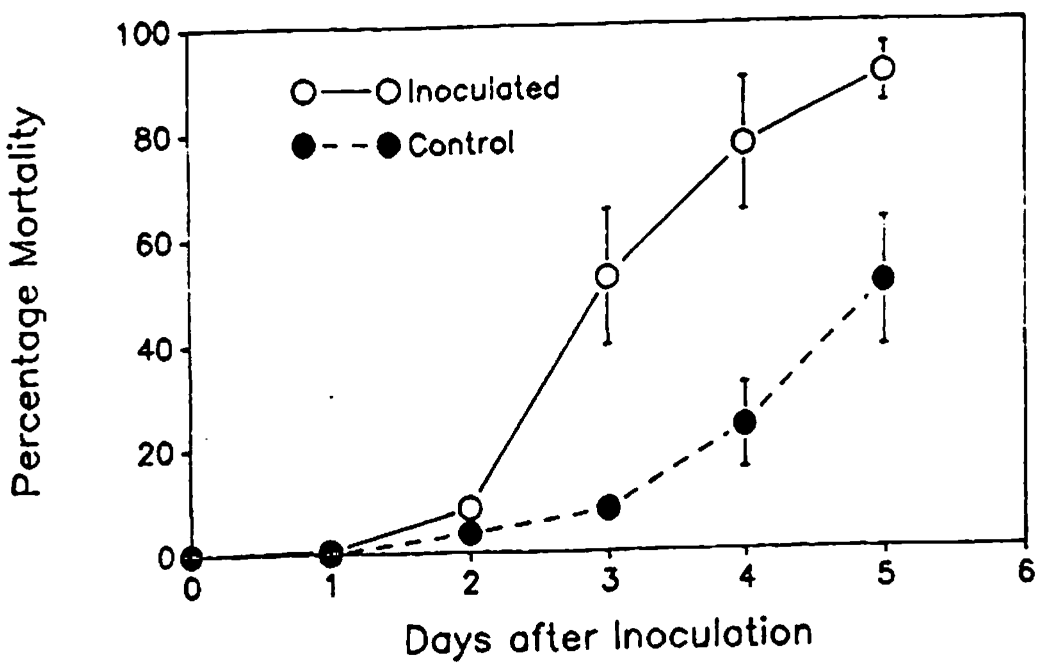


Figure 1. Percentage mortality of woolly apple aphids in petri dishes inoculated with the nematode <u>Neoaplectana</u> <u>carpocapsae</u> and uninoculated control, five dishes per treatment.

Table 1. Number of above-ground woolly apple aphid colonies per tree before and after treatment with the systemic aphicide, RH-7988. Numbers followed by a different letter are significantly different within row and within method of application as determined by 95% confidence intervals.

	Soil Drench			Foliar Spray		
Date	Control	0.28[1]	0.56	Control	0.07	0.14
8 May	1.54	0.00	0.18	0.00	0.67	0.17
16 May	0.54	0.42	0.45	1.33	0.67	0.58
22 May	3.09	3.83	2.54	3.67	3.00	4.50
29 May	2.00	1.00	1.36	1.58	1.50	1.25
5 June	10.36 a	9.92 a	9.45 a	13.33 a	14.83 a	13.67 a
7 June			Plots Treated			
11 June	6.18 a	1.50 b	0.45 c	4.67 a	0.58 b	0.08 c
14 June	5.09 a	2.50 b	1.45 c	3.75 a	1.00 b	0.50 b
21 June	3.45 a	1.42 a	1.36 b	2.50 a	0.67 b	0.67 b
28 June	2.54 a	0.92 a	1.00 a	1.17 a	0.50 a	0.08 b
9 July	0.83 a	0.33 a	0.00 b	0.17 a	0.50 a	0.17 a

[1] Application rate given in kg ai/ha.

Table 2. Number and percentage of woolly apple aphid colonies on the roots of apple trees, 5 July, 1990.

	Soil Drench			Foliar Spray		
	Control	0.28[1]	0.56	Control	0.07	0.14
Number of colonies	3	0	1	4	1	0
Percent trees infested	60	0	20	67	17	0

[1] Application rate is given in kg ai/ha.

Mating Disruption of Codling Moth - 1990

D. G. Pfeiffer, J. C. Killian, M. W. Lachance, and W. Kaakeh
Virginia Polytechnic Institute & State University
Blacksburg, VA 24061
Mary Washington College, Fredericksburg, VA 22401

I. Introduction:

Codling moth (CM), Cydia pomonella (L.), has been the subject of mating disruption research in Europe and North America. Efforts have been made in Virginia since 1987 (Pfeiffer et al. 1987), although work was most intensive in 1989 (Pfeiffer et al. 1989). Research was undertaken in 1990 to gain further experience with this tactic against CM.

II. Materials and Methods:

Daleville Orchard - Mating disruption of CM was performed in a 1.9-ha (4.7-acre) block at Daleville (Botetourt Co.), primarily comprised of 'Red Delicious', also including 'Golden Delicious'. The pheromone-treated block was isolated, but with a small abandoned block nearby. The control block is ca. 1.6 km (1 mi) away, surrounded by additional commercial apple orchard. Shin Etsu CM pheromone dispensers were placed on 12 April, at the rate of 1000/ha (400/acre). Tree spacing was 300 trees/ha (120/acre). The grower has been advised to spray the two border rows to prevent immigration of gravid females, but this was not done. No insecticide sprays were applied after petal fall, except for propargite (Omite 30W, Uniroyal Inc., Spencer St., Naugatuck, Conn.) on half of the block for ERM and the grower was advised to spray the disruption block for CM because damage had reached 5%. Leafrollers were controlled using mating disruption. Summer pruning was performed in July.

Three pheromone traps were placed in each block and monitored weekly. Damage was assessed weekly by examining at least 200 fruit in each of the blocks (pheromone-treated, control, and abandoned). Only 'Golden Delicious' were included because of low 'Red Delicious' set caused by spring frosts. On 4 September (harvest), 300 fruit were collected each block center and periphery. Fruit were brought to the laboratory for a thorough examination, including views into the calyx.

Fincastle Orchard - A block near Fincastle (Botetourt Co.) was treated with dispensers on 12 April. This block was 1.8 ha (4.5 acres), comprised of 'Red Delicious' (67%) and 'Golden Delicious' (33%). Tree spacing was 325 trees/ha (130/acre). Dispensers were placed at the same rate. The control block, of similar composition, was ca. 0.4 km (0.25 mi) away from the block treated with pheromone. No insecticide sprays were applied after petal fall. Damage was assessed as in the Daleville block. Leafrollers were controlled using mating disruption. A small portion of the disruption block was treated with microencapsulated methyl parathion for a localized population of Japanese beetle, Popillia japonica Newman. Propargite was applied once for ERM control.

Batesville Orchard - Codling moth was the target of mating disruption in a 4-ha (10-acre) block, primarily 'Winesap', at Batesville (Albemarle Co.). The control block, also primarily 'Winesap', was ca. 0.4 km (0.25 mi) away from the pheromone-treated block. A different type of dispenser was employed in this study (Consep Membranes). This dispenser is intended to be applied three times per season. Dispensers were placed at 200/ha (80/acre) on 30 March and 27 June; a third placement was to have been made on 27 August but was not received from the company. Tree spacing was 300 trees/ha (120/acre). Four CM pheromone traps were placed in both pheromone-treated and control blocks and were checked weekly. The grower agreed to refrain from all insecticide sprays after petal fall until recommended otherwise.

Damage was assessed on 28 June; 100 fruit were sampled in each corner of the block, and 200 in the block center. Harvest data were not obtained because a very light crop and resulting rapid harvest by the grower.

Criglersville Orchard - A 2-ha (5-acre) CM disruption block was located in an organic orchard at Criglersville. Shin-Etsu dispensers were placed by the grower on 16 April at the rate of 1000/ha (400/acre). Tree spacing was variable in the pheromone treated block. The control was treated with Bacillus thuringiensis. An abandoned block was nearby. This orchard had high levels of CM damage in 1988 and 1989. Damage was assessed on 5 July, after the first generation of CM, and on 7 September, after the second generation.

Winchester Orchard - Two 2-ha (5-acre) CM mating disruption plots were located in Winchester. Shin Etsu dispensers were placed on 20 April at the rate of 1000/ha (400/A). The grower had allocated a small part of his acreage to organic production and another small portion to transitional production. The large majority of the operation was conventional. One disruption plot was placed among each of the conventional and organic sections; there was also a control plot associated with each production type. The grower employed a consultant to scout the orchard. This scout performed weekly monitoring of the three CM traps per plot and assessments of damage.

Roseland Orchard: Shin Etsu dispensers were placed in 2.8 ha (7 acres) of a 'Red Delicious' block in Roseland

(Nelson Co.). Dispensers were placed on 26 April. Tree spacing was 325 trees/ha (130/acre).

III. Results and Discussion:

Trap data - Total disruption of male attraction to traps was achieved at Daleville and Fincastle (Figs. 1-2). Trap shutdown was not total at Batesville (Fig. 3). This may have been partly due to insufficient placement of dispensers, especially considering that no males were collected earlier in the season when flight activity was greater in the area. Flight data are unavailable for the Criglersville orchard because of defective trap lures. Total trap shutdown was achieved at the Batesville, Winchester and Roseland orchards.

Damage data - Weekly damage data from Daleville orchard are shown in Fig. 4. Damage at harvest time was 5.5%, 0%, and 58% in the mating disruption, conventional and abandoned blocks, respectively. In the intensive harvest sample, damage was 1.1% and 0.3% in the control center and edge, respectively, and 4.7 and 7.3% in the center and edge of the pheromone-treated block. This reflects the immigration problem often seen in disruption blocks where perimeter sprays are not employed.

The effect of pruning off some of the dispensers unknown; as many as possible were replaced in tree but certainly some remained on ground. Charmillot (1990) reported a trial where CM pheromone dispensers were placed on the ground. Trap shutdown occurred but important damage occurred rapidly.

Very little damage was seen in the Fincastle blocks in the weekly sampling. In the intensive harvest sample, no damage was seen in the conventional block; 0.7% damage was seen in both the edge and center of the pheromone-treated block.

In the 5 July sample at the Criglersville orchard, CM-damaged fruit in the disruption, organic, and abandoned blocks were 12.5%, 10%, and 25.5%, respectively. In the 7 September harvest count, little difference was seen among the blocks. There were 18%, 19% and 20% damaged fruit in the disruption, control and abandoned blocks, respectively. Apparently as the season progressed, mating disruption was not able to contain the population pressure. Since only *B. thuringiensis* was applied to the control the similarity in injury to the abandoned is not surprising.

No fruit were available for damage analysis at the Roseland orchard because of spring frost injury.

IV. References Cited:

Charmillot, P. J. 1990. Mating disruption technique to control codling moth in western Switzerland. p. 165-182. In: R. L. Ridgway, R. M. Silverstein & M. N. Inscoe (eds.). Behavior-Modifying Chemicals for Insect Management: Applications of Pheromones and Other Attractants. Marcel Dekker, N.Y. 761 p.

Pfeiffer, D. G., W. Kaakeh, & J. C. Killian. 1989. Mating disruption of codling moth - 1989. Proc. 65th Cumberland-Shenandoah Fruit Workers' Conf., Harper's Ferry WV. Nov. 16-17.

Pfeiffer, D. G., J. C. Killian, R. L. Horsburgh, & K. S. Yoder. 1987. Pheromone disruption of codling moth - 1987. Proc. 63rd Cumberland-Shenandoah Fruit Workers' Conf., Harper's Ferry WV. Nov. 19-20.

Fig. 1

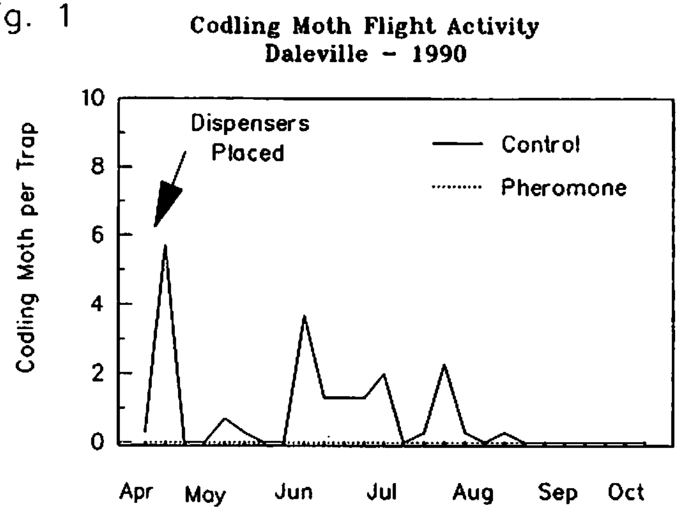


Fig. 2

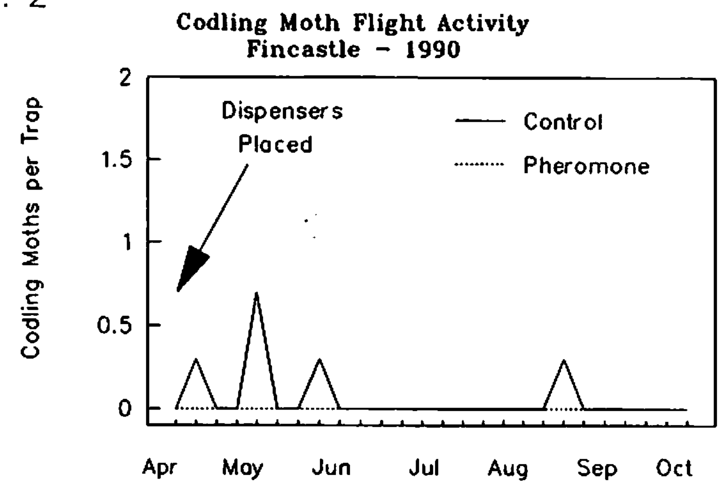


Fig. 3

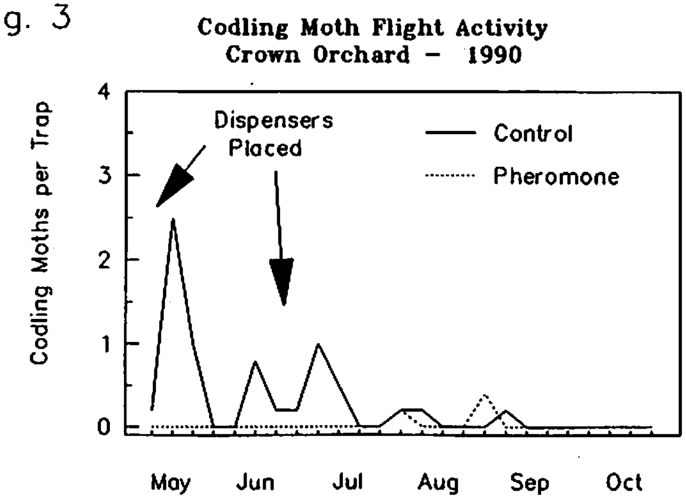
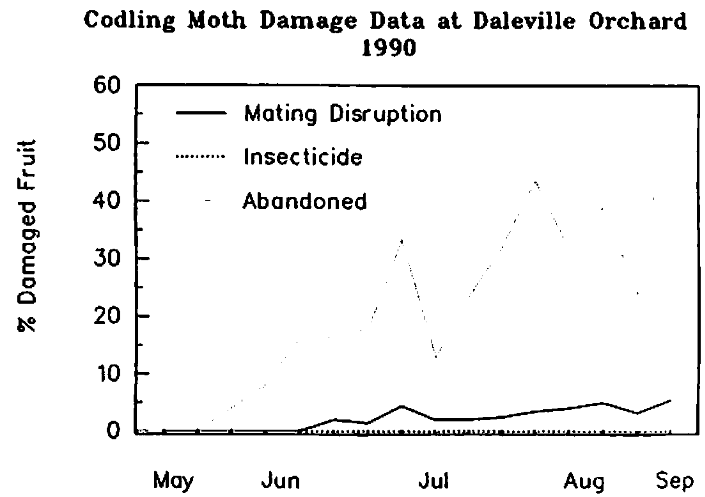


Fig. 4



Mating Disruption of Leafrollers - 1990

D. G. Pfeiffer, W. Kaakeh, M. Lachance and J. C. Killian
Virginia Polytechnic Institute & State University
Blacksburg, VA 24061
Mary Washington College, Fredericksburg, VA 22401

I. Introduction:

Mating disruption efforts against leafrollers, initiated in 1989 in Virginia apple orchards (Pfeiffer & Kaakeh 1989), were continued. Results have been promising to date in Virginia, where the main leafroller pest is variegated leafroller (VLR), Platynota flavedana (Clemens). The blend used in 1989 [E,Z-11-tetradecenyl acetate 96% (E:Z 70:30); E,Z-11-tetradecenol 2% (E:Z 70:30); and Z-9-dodecenyl acetate 2%] was intended to be a generic blend, effective on several leafroller species. However, small plot studies in 1989 showed that a blend approximating the natural pheromone of VLR, E-11-tetradecenol (70%); Z-11-tetradecenol (30%), was actually superior at reducing orientation to pheromone traps by both VLR and tufted apple budmoth (TBM), Platynota ideausalis Walker. In the present study, the natural pheromone blend of VLR was used. The primary target for mating disruption was VLR, but data were also collected on TBM and redbanded leafroller (RBL), Argyrotaenia velutinana (Walker).

II. Materials and Methods:

Daleville Orchard - Mating disruption was performed in a 1.9-ha (4.7-acre) block at Daleville (Botetourt Co.), primarily comprised of 'Red Delicious', also including 'Golden Delicious'. Tree spacing was 300 trees/ha (120/acre). The pheromone-treated block was isolated, but with a small abandoned block nearby. The control block was ca. 1.6 km (1 mi) away, surrounded by additional commercial apple orchard. Pheromone dispensers were placed on 12 April. Dispensers were placed at the rate of 1000/ha (400/acre). No insecticide sprays were applied after petal fall, except for the two edge rows. Codling moth was controlled using mating disruption. On 22 August, the grower was advised to spray the disruption block for CM because damage had reached 5%. Propargite (Omite 30W, Uniroyal Inc., Spencer St., Naugatuck, Conn.) was applied in half of the block for ERM. Summer pruning was performed in July.

Fincastle Orchard - A block near Fincastle (Botetourt Co.) was treated with dispensers on 12 April. This block was 1.8 ha (4.5 acres), comprised of 'Red Delicious' (67%) and 'Golden Delicious' (33%). Tree spacing was 325 trees/ha (130/acre). Dispensers were placed at the same rate. The control block, of similar composition, was ca. 0.4 km (0.25 mi) away from the block treated with pheromone. Codling moth was controlled using mating disruption. A small portion of the disruption block was treated with microencapsulated methyl parathion for a localized population of Japanese beetle, Popillia japonica Newman. Propargite was applied once for ERM control.

Spring Valley Orchard - A 4.0-ha (10-acre) block was treated at Spring Valley (Albemarle Co.). Tree spacing was 362 trees/ha (145/acre). Dispensers were placed on 13 April. Codling moth was controlled using mating disruption. The control block was unsprayed.

In all blocks, pheromone traps for VLR, TBM, and RBL were monitored weekly. Three traps per species (four at Spring Valley) were placed in the disruption and control blocks. Because of the untested nature of the pheromone dispensers, and the high potential for damage by LR, damage was also assessed weekly by examining at least 200 fruit in each of the blocks (pheromone-treated, control, and abandoned). On 4 September (harvest), 300 fruit were collected from each block center and periphery at Daleville and Fincastle. Fruit were brought to the laboratory for a thorough examination, including views into the calyx. The harvest sample was collected on 11 October at Spring Valley. No fruit were collected from the control block because of an extremely light crop and the resulting rapid harvest by the grower.

III. Results and Discussion:

Flight data: Trap capture data for the three orchards are shown in Figs. 1-3 for VLR, Figs. 4-6 for TBM and Figs. 7-9 for RBL. In the Daleville block, the following reductions in trap captures were achieved: VLR - 99.9%, TBM - 85.4%. In the Fincastle block: VLR - 98.8%, TBM - 68.4%. In the Spring Valley block: VLR - 93.6%, TBM - 51.9%. RBL captures were not reduced in any of the blocks; in fact numbers were generally higher in the disruption blocks. The lack of disruption for RBL is not surprising since the acetates comprising RBL pheromone (Roelofs et al. 1975) are not present in VLR pheromone (Hill et al. 1977). There are several possible explanations for the higher trap captures of RBL in VLR-pheromone treated blocks. VLR pheromone permeation could have improved orientation of RBL to its pheromone traps. Rothschild (1974) reported that dodecyl acetate permeation increased trap captures of oriental fruit moth in its pheromone traps. This could arise by a "foreign" compound altering the response of a species to its pheromone, or, alternatively, by being a general locomotor stimulant. Another explanation may be that RBL is well controlled in conventional blocks and fewer adults are available to be caught. However the control block at Spring Valley was unsprayed. A third explanation could be that since disruption blocks tend to be isolated from main orchard tracts; there may have been greater population pressure from RBL resulting from immigration from wild hosts.

Damage assessment: In the weekly assessments of leafroller injury at Daleville, damage reached 18% in the abandoned block, 2% in the disruption block, and 1.0% in the conventional block (Fig. 10). Damage from *Platynota* spp. was light during the first generation, increasing in the fall, as described by Chapman and Lienk (1971). At Fincastle, very little leafroller damage was seen during weekly monitoring in either mating disruption or conventional block. On 4 September, there was 1.0% injury versus 0.5% in the disruption and conventional blocks, respectively.

Because of the specific differences in pheromone composition, damage in the intensive harvest count was classed into *Platynota* versus RBL damage. At Daleville, *Platynota* injury was found on 0.3% of fruit in both center and periphery of the disruption block. *Platynota* injury reached 1.1% in both center and periphery of the conventional block. RBL-injured fruit was 2.3% and 2.0% in the periphery and center, respectively, of the disruption block; this type of damage was not seen in the conventional block. RBL was sometimes found in the webbed calyx of the fruit, as described by Chapman and Lienk (1971). At Fincastle, no leafroller-damaged fruit were detected in the conventional block. *Platynota* damage reached 0.3% and 1.7% in the center and periphery, respectively, of the disruption block. RBL-injured fruit were 0% and 1.7% in the center and periphery, respectively, of the disruption block.

The effect of pruning off some of the dispensers in the Daleville block is unknown; as many as possible were replaced in trees but certainly some remained on ground. Charmillot (1990) reported a trial where codling moth pheromone dispensers were placed on the ground. Trap shutdown occurred but important damage occurred rapidly.

European red mite was generally at lower densities in pheromone-treated blocks (Figs. 11-12). The population in the pheromone-treated block at Daleville looks higher, but this population started in the sprayed periphery and because of a long delay in remedial spray, spread into part of the block interior.

IV. References Cited:

Chapman, P. J., & S. E. Lienk. 1971. Tortricid fauna of apple in New York (Lepidoptera: Tortricidae). N.Y. State Agric. Exp. Stn. Spec. Publ.

Charmillot, P. J. 1990. Mating disruption technique to control codling moth in western Switzerland. p. 165-182. In: R. L. Ridgway, R. M. Silverstein & M. N. Inscoe (eds.). Behavior-Modifying Chemicals for Insect

Management: Applications of Pheromones and Other Attractants. Marcel Dekker, N.Y. 761 p.

Hill, A. S., R. T. Cardé, W. M. Bode & W. L. Roelofs. 1977. Sex pheromone components of the variegated leafroller moth, Platynota flavedana. J. Chem. Ecol. 3: 369-376.

Pfeiffer, D. G., & W. Kaakeh. 1989. Mating disruption of leafrollers - 1989. Proc. 65th Cumberland-Shenandoah Fruit Workers' Conf., Harpers Ferry WV.

Roelofs, W. L., A. S. Hill & R. T. Cardé. 1975. Sex pheromone components of the redbanded leafroller, Argyrotaenia velutinana (Lepidoptera: Tortricidae). J. Chem. Ecol. 1: 83-89.

Rothschild, G. H. L. 1974. Problems in defining synergists and inhibitors of the oriental fruit moth pheromone by field experimentation. Entomol. Exp. Appl. 17: 294-302.

Fig. 1

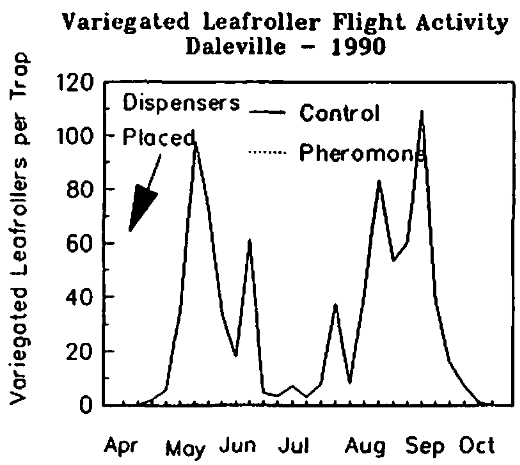


Fig. 2

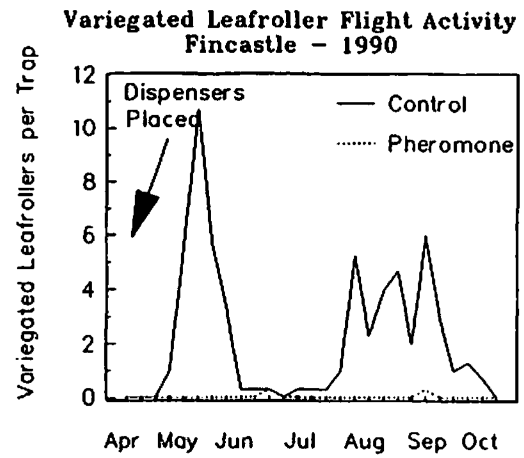


Fig. 3

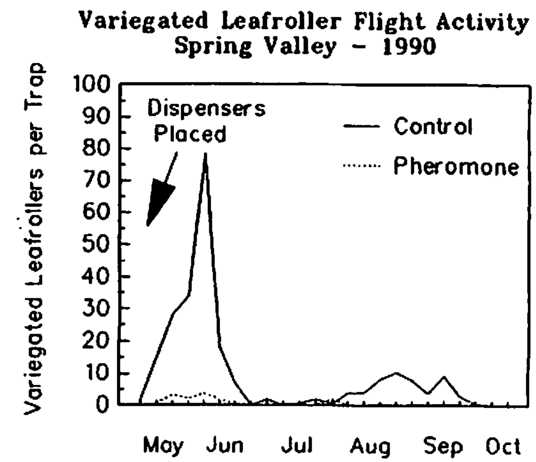


Fig. 4

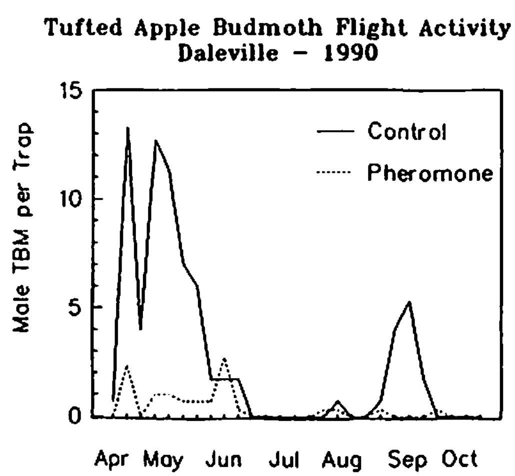


Fig. 5

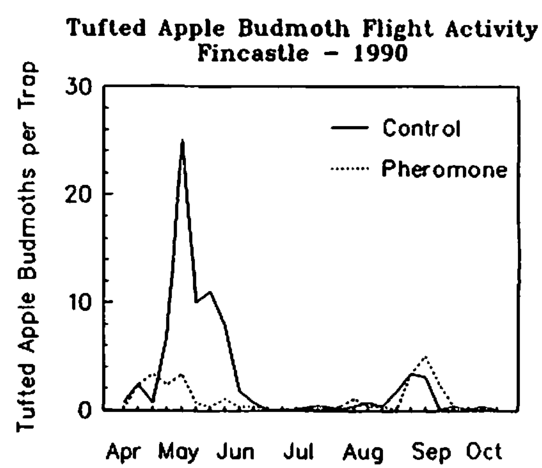


Fig. 6

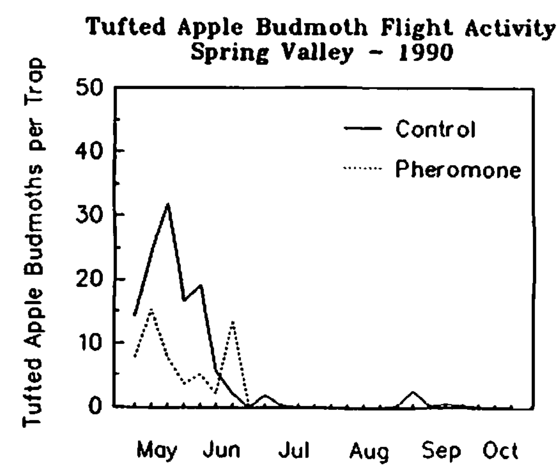


Fig. 7

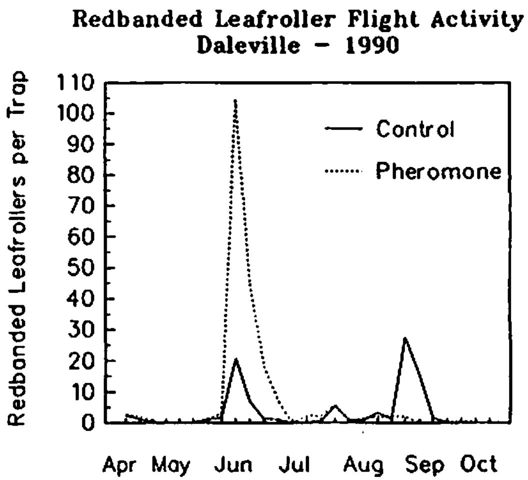


Fig. 8

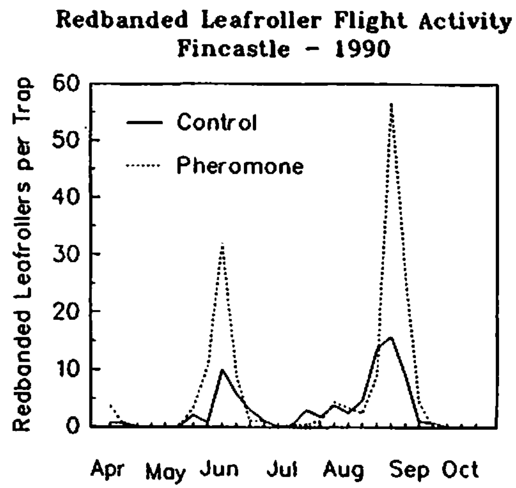


Fig. 9

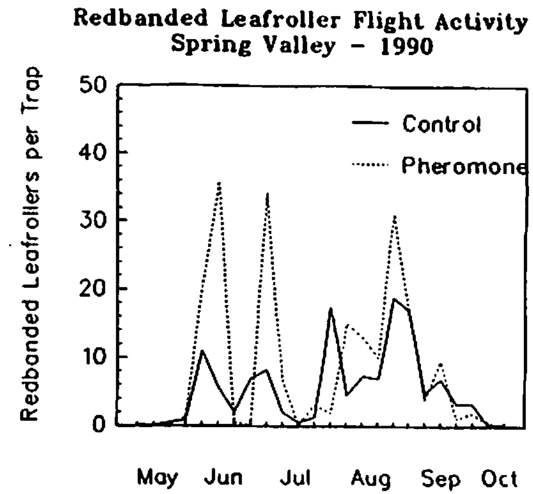


Fig. 10

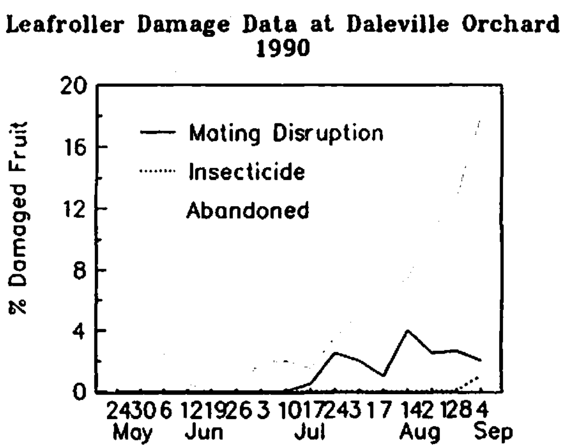


Fig. 11

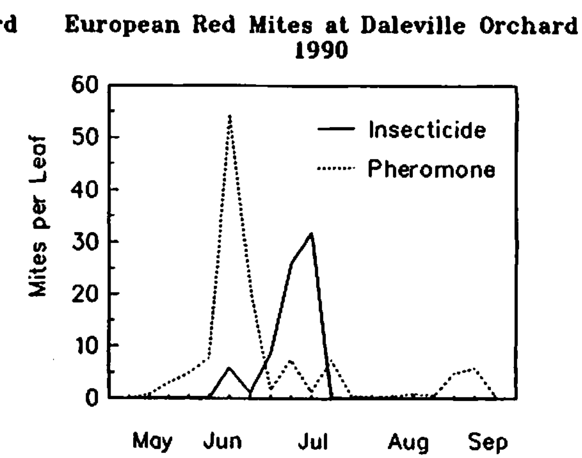
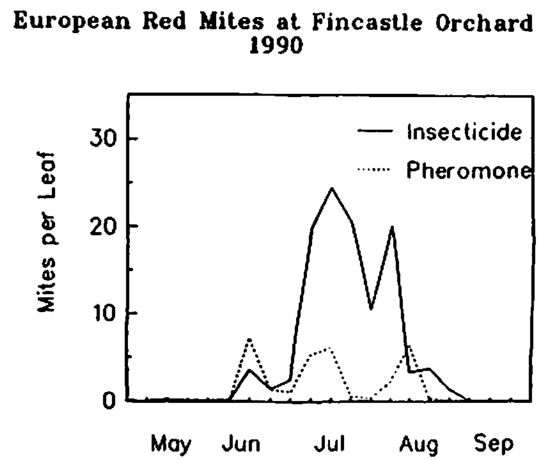


Fig. 12



Grape Berry Moth Mating Disruption - 1990

D. G. Pfeiffer & T. K. Wolf
Department of Entomology, and Winchester Agric. Exp. Stn.
Virginia Polytechnic Institute & State University

Introduction

A pheromone preparation (GBM-ROPE™) has recently received EPA registration for grape berry moth (GBM) control using mating disruption. Shin Etsu pheromone dispensers contain 88 mg of (Z)-9-dodecenyl acetate (90%) and (Z)-11-tetradecenyl acetate (10%). Successful results have been obtained in New York using this technique (Dennehy et al. 1990a,b).

Materials and Methods

'Chardonnay' blocks were selected as research blocks at Prince Michel Vineyard (Madison Co.) and at Meredyth Vineyard (Fauquier Co.), 2.8-ha and 1.2-ha, respectively. Both had a similar conventionally treated control block nearby. All blocks were adjacent to mixed deciduous woodland. Pheromone dispensers (ties) were placed on 21 May at Prince Michel Vineyard, and on 23 May at Meredyth Vineyard. Three commercially available pheromone traps were placed in each block and were monitored weekly to determine disruption of orientation to point sources of pheromone.

First generation damage was assessed on 11 and 13 June at Prince Michel and Meredyth, respectively; % infested clusters were recorded on at least 200 clusters per on two rows at block edges near woodland, and two rows in block interiors. Damage was assessed at harvest (7 and 9 September at Prince Michel and Meredyth, respectively). Twenty clusters each from an edge row and the center of the blocks were retrieved to the laboratory for cluster dissections to determine % infested berries. Botrytis had infected GBM-infested clusters at Prince Michel. Black rot and other bunch rots were in various stages of infection in both blocks at Meredyth, making it difficult to determine GBM infestation in the field.

Results and Discussion

Prince Michel Vineyard:

Trap Shutdown: Reduction of captures in traps was 100% for most of the season (Fig. 1). Low numbers were caught in two consecutive weeks in the disruption block, during a peak of GBM activity after harvest.

Fruit counts: % Infested clusters (11 June)

	pheromone	control
edge	40.2%	38.5%
inter.	6.0%	21%%

% Infested berries (Harvest, 7 September)		
edge	33.7%	41.4%
inter.	17.3%	19.7%

Meredyth Vineyard:

Trap Shutdown: Trap captures were reduced in the disruption block by 100% (Fig. 2).

Fruit counts: % Infested clusters (13 June)

	pheromone	control
edge	16.8%	0.3%
inter.	4.8%	0.3%

Damage assessment is still underway for Meredyth. Damage is much lower than at Prince Michel; 0.1% of berries were damaged by GBM in the center of the pheromone-treated block.

Dennehy et al. (1990b) showed that even 1000 dispensers/ha (400/A) can fail under very high GBM pressure. This is the upper end of the range of application rate on the GBM-ROPE™ label (500-1000/ha).

Further research is needed on the suitability of this tactic in grape cultivars that are susceptible to *Botrytis*. Most (92%) of Virginia's production is comprised of wine grapes, varieties excluded from New York studies because of low damage thresholds (Dennehy et al. 1990b). Dennehy (1990b) felt that mating disruption for GBM was not as suitable for *vinifera* varieties as with processing grapes because of lower thresholds resulting from *Botrytis* susceptibility (although work in this area was underway). Promising results have been obtained in Europe against the European grape berry moth, *Eupoecilia ambiguella* Hübner, and the grape vine moth, *Lobesia botrana* Denis & Schiffermüller (Descoins (1990), so use of the tactic should be summarily dismissed in European-style cultivars in North America.

References Cited

Dennehy, T. J., C. J. Hoffman, J. P. Nyrop & M. C. Saunders. 1990a. Development of low-spray, biological and pheromone approaches for control of grape berry moth, *Endopiza viteana* Clemens, in the eastern United States. p. 261-282. In: N. J. Bostanian, L. T. Wilson & T. J. Dennehy (eds.). Monitoring and Integrated Management of Arthropod Pests of Small Fruit Crops. Intercept, Andover. 301 p.

Dennehy, T. J., W. L. Roelofs, E. F. Taschenberg & T. N. Taft. 1990b. Mating disruption for control of grape berry moth in New York vineyards. p. 223-240. In: R. L. Ridgway, R. M. Silverstein & M. N. Inscoe (eds.). Behavior-Modifying

Chemicals for Insect Management: Applications of Pheromones and Other Attractants. Marcel Dekker, N.Y. 761 p.

Descoins, C. 1990. Grape berry moth and grape vine moth in Europe. p. 213-222. In: R. L. Ridgway, R. M. Silverstein & M. N. Inscoe (eds.). Behavior-Modifying Chemicals for Insect Management: Applications of Pheromones and Other Attractants. Marcel Dekker, N.Y. 761 p.

Fig. 1 Grape Berry Moth Flight Activity
Prince Michel Vineyard - 1990

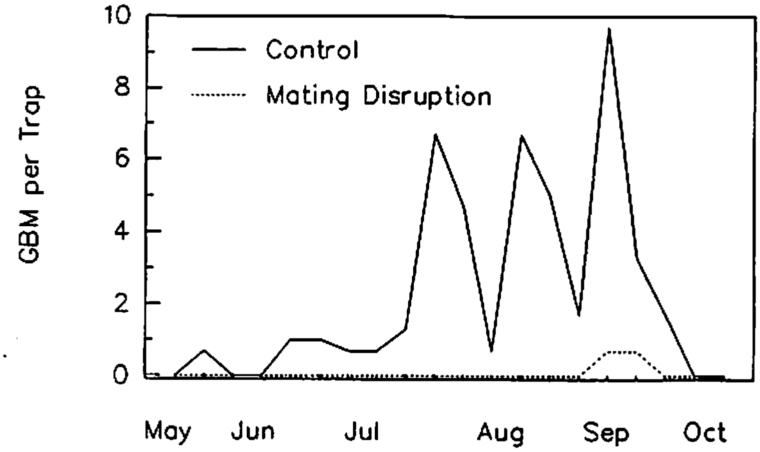
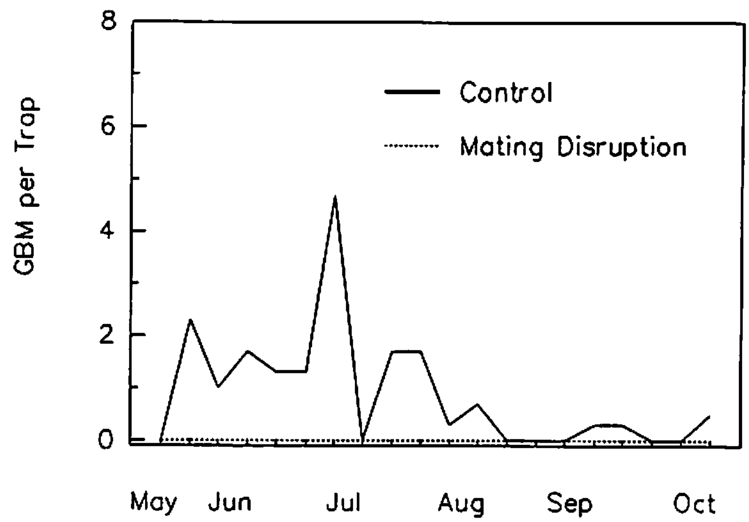


Fig. 2 Grape Berry Moth Flight Activity
Meredyth Vineyard - 1990



Phenology of Grape Berry Moth in Virginia - 1990

D. G. Pfeiffer & T. K. Wolf
Department of Entomology, and Winchester Agric. Exp. Stn.
Virginia Polytechnic Institute & State University

Introduction

Grape berry moth (GBM), Endopiza viteana Clemens, is a potentially serious pest of Virginia vineyards. Population pressure has been low during the early years of the growth of the state's vineyards; preliminary studies of this species' phenology indicated a bivoltine population, but numbers were so low that conclusions were tenuous (Pfeiffer et al. 1990).

Three generations of GBM were reported in Delaware (Dozier et al. 1932). Gleissner (1943) reported two full generations in some Pennsylvania vineyards, with a partial third in others. Such bi- and trivoltine infestations were found in vineyards separated by as little as one mile. Three generations were reported in Ontario (Roberts & Simpson 1982), and one and one-half to two generations in New York (Taschenberg 1948, Riedl & Taschenberg 1984).

Materials and Methods

In the spring of 1990, GBM pheromone traps were distributed to 11 growers in various parts of the state. In addition, the authors monitored five vineyards, so that study sites included the Delmarva Peninsula, Piedmont, Blue Ridge, Shenandoah Valley and Roanoke Valley. When feasible growers were instructed in person on identification of GBM and a sumac moth (SM), Episimus argutanus (Clemens), also attracted to GBM pheromone traps (Jubb 1973). Otherwise, photographs were provided. Stamped postcards were provided to growers for submitting weekly trap counts. Four grower data sets were complete.

Results and Discussion

Vineyards were highly variable in their GBM populations. Several had populations so low as to make it difficult to discern generations, as noted by Pfeiffer et al. (1990). Several vineyards, however, had high populations that indicated three, four, or, perhaps, five generations.

Dennehy (1990) reported 504^{o}D (base 7.3^{o}C) [939.2^{o}D (base 45.1^{o}F)] for GBM to develop from egg to adult. An attempt will be made to relate temperature records from stations near each vineyard with emergence patterns. Comparison of Steeles Tavern temperature data with Ladd flight data yielded a close match between predicted and observed peaks of GBM activity.

Recently, Townsend (1990) reported three full generations and a partial fourth in southern Missouri. Dennehy et al. (1990) reported three distinct generations in New York, notwithstanding the results of Taschenberg (1948) and Riedl and Taschenberg (1984). Dennehy et al. (1990) maintained that earlier studies may have failed to disclose first generation adults partly because populations were monitored in commercial vineyards, where insects were often in low numbers. Populations must be monitored in wild grapes, where it is easier to find adults and eggs. But most accounts of bivoltine populations describe the same period of onset of first generation activity as that given by Dennehy et al. (1990), near bloom time. Further research is needed on reasons for differences in numbers of generation given in various studies.

Factors affecting magnitude of populations: if have more generations, greater potential for increase; populations becoming adapted to vineyards (reflecting youth of Virginia grape industry); relative cold in different areas. Dennehy et al. (1990) found pest status related to frequency of lethal cold temperature in winter (-24.3^{o}C).

Roberts and Simpson (1982) recommended area-wide trapping rather than records from individual vineyards. This is supported by studies to date in Virginia. Furthermore it may be difficult to relate pheromone trap captures with damage, because there were high levels of damage in the Ladd vineyard, with relatively low captures, and low damage at the Banjo Shack vineyard, with higher trap captures.

References Cited

Dennehy, T. J., C. J. Hoffman, J. P. Nyrop & M. C. Saunders. 1990. Development of low-spray, biological and pheromone approaches for control of grape berry moth, Endopiza viteana Clemens, in the eastern United States. p. 261-282. In: N. J. Bostanian, L. T. Wilson & T. J. Dennehy (eds.). Monitoring and Integrated Management of Arthropod Pests of Small Fruit Crops. Intercept, Andover. 301 p.

Dozier, H. L., L. L. Williams & H. G. Butler. 1932. Life history of the grape-berry moth in Delaware. Univ. Del. Agric. Exp. Stn. Bull. 176. 47 p.

Gleissner, B. D. 1943. Biology and control of berry moth in the Erie grape belt. Penn. State Coll. Agric. Exp. Stn. Bull. 451. 74 p.

Jubb, G. L. 1973. Catches of _Episimus argutanus_ in grape berry moth sex-pheromone traps in Pennsylvania. J. Econ. Entomol. 66: 1345-1346.

Pfeiffer, D. G., T. J. Boucher, M. W. Lachance & J. C. Killian. 1990. Entomological research in Virginia (U.S.A) vineyards. p. 45-61. _In_: N. J. Bostanian, L. T. Wilson & T. J. Dennehy (eds.). Monitoring and Integrated Management of Arthropod Pests of Small Fruit Crops. Intercept, Andover. 301 p.

Riedl, H., & E. F. Taschenberg. 1984. Grape berry moth _Endopiza viteana_ Clemens. Grape IPM Insect Ident. Sheet No. 1. N.Y. Agric. Exp. Stn., Geneva. 2 p.

Roberts, W. P. & C. M. Simpson. 1982. Monitoring and predicting spray dates for the grape berry moth on the Niagara Peninsula. Ont. Minist. Agric. Food Factsheet 212-632.

Taschenberg, E. F. 1948. Evaluation of spray programs for the control of the grape berry moth, _Polychrosis viteana_ Clemens. N.Y. Agric. Exp. Stn. Tech. Bull. 283. 59 p.

Townsend, H. G. 1990. Grape insect pest monitoring and IPM in the Missouri Ozarks. p. 117-129. _In_: N. J. Bostanian, L. T. Wilson & T. J. Dennehy (eds.). Monitoring and Integrated Management of Arthropod Pests of Small Fruit Crops. Intercept, Andover. 301 p.

REPORT FOR THE 1990 CUMBERLAND-SHENANDOAH FRUIT WORKERS CONFERENCE

Virginia Polytechnic Institute and State University
Virginia Agricultural Experiment Station - Winchester
Winchester, Virginia 22601

Robert L. Horsburgh[1]

The apple crop in 1990 in Northern Virginia was reduced by a combination of the preceding dry season and several periods of freezing temperatures in late April. Temperatures during the season were very close to average for this particular region. Rainfall was slightly above average in April, May and September and considerably above average in August. June, on the other hand, was very dry with 3.25 inches less rainfall than normal.

	Precipitation (inches) 1990	78 yr avg	Mean temperature (F) 1990	69 yr avg
April	3.45	3.14	55.3	54.6
May	4.40	3.91	62.6	63.1
June	0.54	3.79	73.2	72.4
July	5.33	3.89	76.7	76.7
August	4.74	3.76	73.8	74.0
September	2.73	2.86	67.1	68.0

Rosy aphid populations were again light and readily controlled in most orchards. Apple aphid was a problem during much of the spring and early summer due to continuous terminal growth but was less severe than in 1989. The lush terminal growth also provided for continuous development of succeeding generations of apple leafminer (*Lyonetia speculella*) on both bearing and nonbearing trees. This insect too was generally less severe than a year ago. Growers also had difficulty controlling the white apple leafhopper (*Typhlocyba pomaria*). A few serious outbreaks of *Panonychus ulmi* and some mixed populations of *T. pomaria* and *Edwardsiana rosae* (Linneaus) (the rose leafhopper) were encountered, but *Tetranicus urticae* Koch (the twospotted spider mite) was not a serious pest. The predatory thrips *Leptothrips mali* was again more abundant than usual and *Stethorus punctum* numbers were normal or greater for this area. *Orius insidiosus* and *Chrysopid* spp were significant predaceous species in those orchards where mites were a problem. Coccinellids played a significant role in aphid suppression. The leafroller complex was fairly well managed in Northern Virginia early in the season. However, the increase in late season damage from redbanded leafroller noted last year continued and was more severe in 1990. Growers will have to design leafroller species specific spray programs and pay more attention to timing of applications in the future. Codling moth continued to cause problems where lapses in spray schedules occurred.

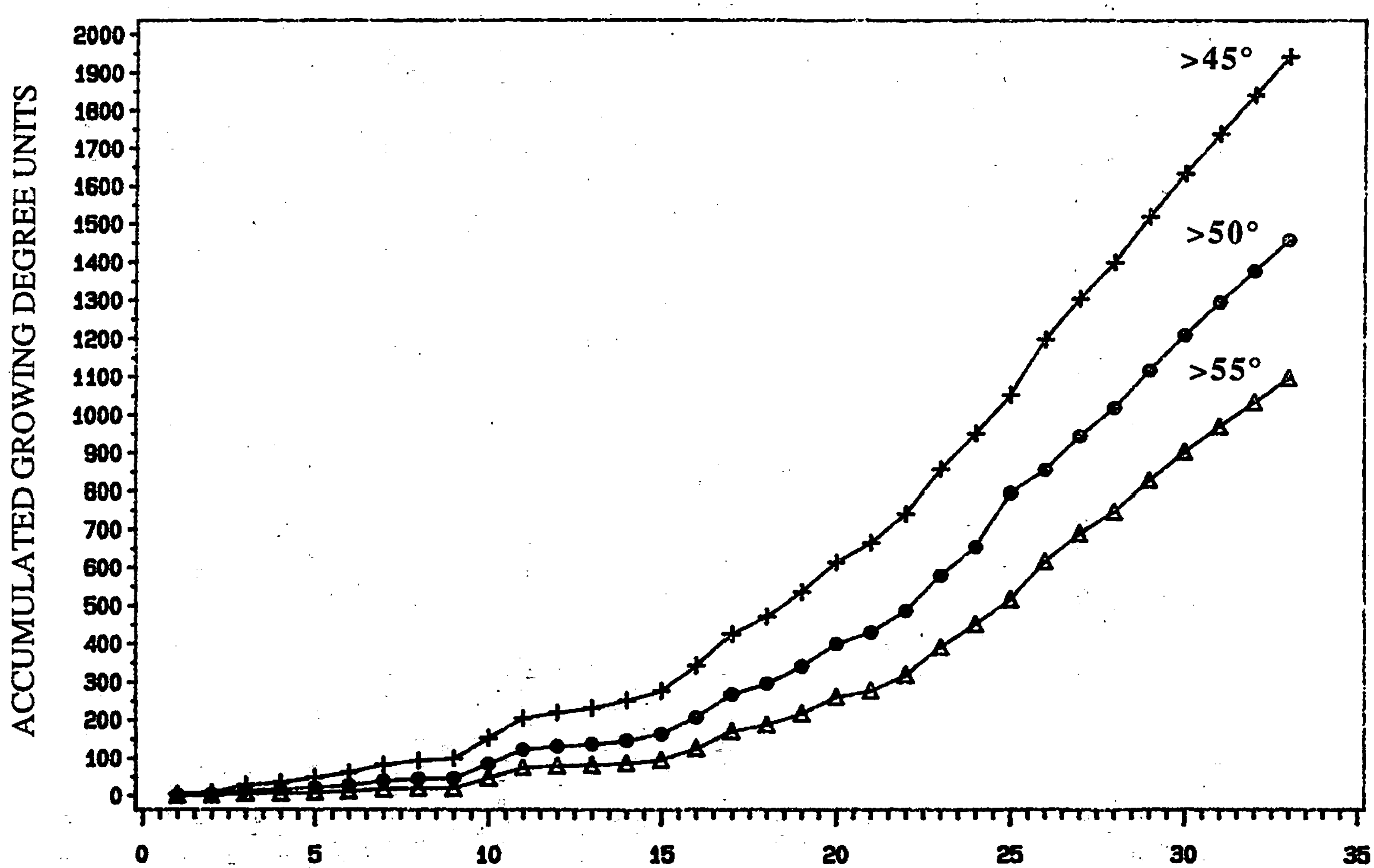
I wish to thank all the cooperators who supported our research efforts in 1990.

[1] Professor of Entomology and Superintendent

CUMULATIVE GROWING DEGREE DAYS

WINCHESTER AGRICULTURAL EXPERIMENT STATION

RESEARCH FARM, RELIEF, VA



0 TO 33 WEEKS AFTER JANUARY 9, 1990

APPLE: <u>Malus</u> <u>domestica</u> Borkh 'Rome'
European red mite; <u>Panonychus</u> <u>ulmi</u> (Koch)
<u>Stethorus</u> <u>punctum</u> (Lec)

R. L. Horsburgh and S. W. Kilmer
Winchester Agricultural Experiment Station
Virginia Polytechnic Institute and State University
Winchester, VA 22601

APPLE, MITICIDE EVALUATIONS, 1990: Treatments were applied to 8 year old Nittany trees (on MM7A roots) using single tree plots arranged in a randomized block design and replicated 4 times. Trees were sprayed to runoff using a Bean hydraulic sprayer operating at 400 psi. Plot 1 was sprayed with 60 sec oil at delayed dormant (DD) and Carzol 92 SP at petal fall (PF). Plot 2 received Morestan in the pink (P) and Carzol at PF, and plot 3 was treated with Morestan 25WP at P and Carzol SP after the European red mite population reached a threshold of 3 mites per leaf. All other treatments were applied when mite populations in the orchard reached this predetermined threshold. To estimate the threshold level, 10 randomly selected leaves (1 per tree) were picked at chest height while walking diagonally across the orchard. The mites and eggs were counted with the aid of a binocular microscope. The count of 24 May, 1990 averaged 3.3 mites and 9.5 mite eggs per leaf. During the remainder of the season mites and eggs were counted by randomly selecting 20 leaves per replicate, brushing them onto a sticky glass plate and counting all motile mites and viable eggs with a binocular microscope (Table 1). Mite predators were kept out of these treatments prior to treatment with applications of permetherin. When predators began to appear in the plots, they were counted during a 3 min. observation of each tree and recorded. These data are presented in the tables.

Treatments 1 through 7 gave adequate control of motile mites and slightly less control of mite eggs until the 12 Jun count. After that data, mite control was borderline but the number of eggs present was too high. High predator <u>(Stethorus</u> <u>punctum)</u> numbers (Table 2) after 2 Jul made the data confusing in so far as relative toxicities are concerned. The experimental compounds (treatments 8 through 14) were very effective at both mite and mite egg suppression, but appeared to be quite harsh on the predator. Omite (treatment 7) at the 2 lb rate appeared to about equal the low rate of Expt. Compound 1 (treatment 8). No phytotoxic effects of any treatments on the fruit or foliage was observed.

Table 1. 1990 Miticide Experiment - mite and egg count data[1]

Plot	Materials and rates	Spray dates	5/30 ERM	5/30 Mite eggs	6/12 ERM	6/12 Mite eggs	7/2 ERM	7/2 Mite eggs	7/27 ERM	7/27 Mite eggs
1	Oil (60 sec) 2 gal (DD) + Carzol 92SP 5.8 oz (PF)	3/28	0.00	0.06	0.00 a	0.56 cd	1.73 b-e	22.90 abc	1.74 abc	9.21 ab[2]
2	Carzol 92SP 5.2 oz/100 (PF) + Morestan 12 oz (P)	4/13 5/25 7/6	0.06	0.06	0.41 bc	1.75 bcd	4.11 ab	45.13 a	1.41 abc	9.23 ab
3	Carzol 92SP 5.8 oz (T); Morestan 12 oz (P)	5/25	0.22	0.98	0.72 ab	5.25 b	2.11 bcd	56.02 a	0.99 bc	7.99 ab
4	Vendex 4L 5.33 fl oz/100 (T)	5/25 7/6	0.11	0.48	0.12 bc	1.11 cd	1.06 b-f	14.17 a-d	1.13 abc	13.83 a
5	Kelthane 50W 1 lb/100 (T)	5/25 7/6	0.11	0.37	0.46 bc	2.33 bc	3.59 abc	33.75 ab	0.65 c	14.31 a
6	Omite 30W 1 lb/100 (T)	5/25 7/6	0.11	0.88	0.19 bc	0.26 cd	1.58 b-f	21.13 abc	1.34 abc	10.40 ab
7	Omite 30W 2 lb/100 (T)	5/25	0.11	0.11	0.00 c	0.16 d	0.76 def	7.87 b-e	2.16 abc	13.13 a
8	Experimental Cpd. 1 20W 4 oz/100 (T)	5/25	0.12	0.78	0.00 c	0.18 d	0.26 def	7.02 b-e	2.72 ab	7.71 ab
9	Experimental Cpd. 1 20W 6.4 oz/100 (T)	5/25	0.00	0.41	0.00 c	0.00 d	0.36 def	2.68 de	2.70 ab	7.24 ab
10	Experimental Cpd. 1 20W 9.6 oz/100 (T)	5/25	0.00	0.84	0.06 c	0.27 cd	0.00 f	2.60 de	0.97 bc	6.67 ab
11	Experimental Cpd. 2 139.56 ml/100 (T)	5/25	0.41	2.16	0.00 c	0.45 cd	0.85 c-f	7.89 b-e	2.99 a	15.79 a
12	Experimental Cpd. 2 279.56 ml/100 (T)	5/25	0.23	0.92	0.00 c	0.31 cd	0.44 def	4.96 cde	2.40 ab	14.03 a
13	Experimental Cpd. 2 418 ml/100 (T)	5/25	0.11	0.51	0.00 c	0.06 d	0.12 ef	1.58 e	1.58 abc	4.19 b
14	Experimental Cpd. 2 139.56 ml/100 + oil 2 gal (T)	5/25	0.23	0.73	0.00 c	0.29 cd	0.83 c-f	7.02 b-e	2.11 abc	7.30 ab
15	Control (fungicide only)	5/25	0.56	1.04	1.20 a	19.65 a	8.38 a	72.11 a	1.62 abc	9.02 ab

[1] Data was transformed to $\log_{10}(X + 1)$ for analysis. Arithmetic means are presented.

[2] Numbers in the same column followed by the same letter are not significantly different ($p = .05$), DMRT.

ERM = European red mite; P = pink; PF = petal fall; DD = delayed dormant; T = threshold

Table 2. Miticide Experiment, 1990 - predator data*[1,2]

Plot	Materials and rates/100 gal	Spray dates			8 Jun SpA	8 Jun SpL	8 Jun ChE	25 Jun SpA	25 Jun SpL	25 Jun ChE	10 Jul SpA	10 Jul SpL	10 Jul ChE
1	Oil (60 sec) 2 gal (DD) + Carzol 92SP 5.8 oz (PF)	3/28			0.25	0.00	0.00	0.25 b	0.00 c	0.00 b	9.00 a	0.75 c	5.50 a
2	Carzol 92SP 5.2 oz/100 (PF) + Morestan 12 oz (P)	4/13	5/25	7/6	0.00	0.00	0.25	0.50 b	1.50 c	0.75 ab	3.00 bc	5.00 b	3.25 ab
3	Carzol 92SP 5.8 oz (T); Morestan 12 oz (P)	4/13	5/25		0.50	0.00	0.00	1.50 b	7.50 b	0.25 b	18.00 a	6.50 b	2.75 ab
4	Vendex 4L 5.33 fl oz/100 (T)		5/25	7/6	0.00	0.00	0.25	0.00 b	0.25 c	0.75 ab	0.75 c	0.00 c	2.00 b
5	Kelthane 50W 1 lb/100 (T)		5/25	7/6	0.25	0.00	0.00	0.25 b	1.00 c	0.00 b	0.75 c	0.25 c	3.25 ab
6	Omite 30W 1 lb/100 (T)		5/25	7/6	0.00	0.00	0.00	0.00 b	0.00 c	0.00 b	0.75 c	0.00 c	2.00 ab
7	Omite 30W 2 lb/100 (T)		5/25		0.00	0.00	0.00	0.00 b	0.00 c	1.75 a	3.75 bc	0.00 c	3.25 ab
8	Experimental Cpd. 1 20W 4 oz/100 (T)		5/25		0.00	0.00	0.00	0.25 b	0.00 c	0.00 b	1.00 c	0.00 c	1.75 b
9	Experimental Cpd. 1 20W 6.4 oz/100 (T)		5/25		0.00	0.00	0.25	0.00 b	0.00 c	0.00 b	0.75 c	0.00 c	1.50 b
10	Experimental Cpd. 1 20W 9.6 oz/100 (T)		5/25		0.00	0.00	0.00	0.25 b	0.00 c	0.25 b	0.50 c	0.00 c	2.75 ab
11	Experimental Cpd. 2 139.56 ml/100 (T)		5/25		0.00	0.00	0.00	0.25 b	0.00 c	0.25 b	2.25 c	0.00 c	2.75 ab
12	Experimental Cpd. 2 279.56 ml/100 (T)		5/25		0.00	0.00	0.00	0.00 b	0.00 c	0.25 b	0.75 c	0.00 c	1.50 b
13	Experimental Cpd. 2 418 ml/100 (T)		5/25		0.00	0.00	0.00	0.00 b	0.00 c	0.50 b	0.25 c	0.00 c	3.25 ab
14	Experimental Cpd. 2 139.56 ml/100 (T) + oil 2 gal (T)		5/25		0.00	0.00	0.00	0.00 b	0.00 c	0.50 b	4.50 bc	1.50 c	3.25 ab
15	Control (fungicide only)		5/25		0.25	0.00	0.00	3.25 a	13.00 a	0.00 b	18.50 a	13.25 a	4.00 ab

* SpA = *Stethorus punctum* (Lec) adults
SpL = *Stethorus punctum* (Lec) larvae
ChE = Chrysopid eggs
DD = delayed dormant; P = pink; PF = petal fall; T = threshold

[1]Data transformed to $\sqrt{X + .5}$ for analysis, arithmetic means presented.
[2] Numbers in the same column followed by the same letter are not significantly different (p = .05), DMRT.

APPLE: <u>Malus domestica</u> Borkh 'Rome'
European red mite; <u>Panonychus ulmi</u> (Koch)
Two spotted spider mite;
<u>Tetranychus urticae</u> Koch
Predatory <u>Coccinellid</u> sp.;
<u>Stethorus punctum</u> (LeConte)
Anthocorid predator of mites:
<u>Orius insidiosus</u> (Say)
Predatory thrip; <u>Leptothrips mali</u> (Ewing)
Apple aphid; <u>Aphis pomi</u> DeGeer
Redbanded leafroller;
<u>Argyrotaenia velutinana</u> (Walker)
Variegated leafroller;
<u>Platynota flavedana</u> (Clemens)
Tufted apple budmoth;
<u>Platynota idaeusalis</u> (Walker)
Rosy apple aphid;
<u>Dysaphis plantaginea</u> (Passerini)
Gypsy moth; <u>Lymantria dispar</u> (Linnaeus)

R. L. Horsburgh and S. W. Kilmer
Winchester Agricultural Experiment Station
Virginia Polytechnic Institute and State University
Winchester, VA 22601

APPLE, SEASONAL INSECTICIDE EVALUATIONS, 1990: Experimental insecticide treatments were applied in a comparative test to 15 year old York and 13 year old Redspur Delicious trees. Originally the test was established in the Redspur Delicious orchard, but was moved to the York trees following bloom because of poor fruit set in the Delicious planting. A randomized block design was used and each treatment was replicated 4 times. Trees were sprayed to runoff using a Bean hydraulic sprayer operating at 400 psi. Treatments were applied on 16 Mar, 2 Apr, 16 May, 31 May, 13 Jun, 26 Jun, 12 Jul, and 2 Aug. Mite populations were evaluated by randomly selecting 20 leaves per replicate (10 on 7 Jun), brushing onto a sticky glass plate and counting all motile mites and viable mite eggs with a binocular microscope (Table 1). Predators of mites were evaluated by counting the numbers observed during a 3 minute observation period (Table 2). Rosy apple aphid colonies per tree were counted on the Redspur Delicious trees during a 2 minute visual observation period per tree (Table 5).

The ground cover was closely mowed and all drop apples collected will be examined for insect injury weekly from mid Aug to harvest. This drop fruit was graded for insect damage (Table 3) and the first two weeks 'drops' were graded for fruit finish (Table 4). Harvest samples of 50 apples per replicate were collected and evaluated for insect injury. Drop fruit finish was graded on a scale of 1-5 with 1 being the best. Rosy apple aphid populations did not reach population levels sufficient to provide meaningful data although this orchard has a history of problems with this pest (Table 5).

Table 1. Seasonal insecticide experiment (York), 1990 (mite counts)

Treatments and amt/100 gal[5,6]	7 Jun[1,2] ERM/ leaf	7 Jun[1,2] Mite eggs/ leaf[4]	7 Jun[1,2] TSSM/ leaf	12 Jun[1,3] ERM/ leaf	12 Jun[1,3] Mite eggs/ leaf[4]	12 Jun[1,3] TSSM/ leaf	20 Jun[1,3] ERM/ leaf	20 Jun[1,3] Mite eggs/ leaf[4]	20 Jun[1,3] TSSM/ leaf
11 Guthion 35W 10.67 oz	0.92 c	6.16 cd	0.00 b	2.74 bc	15.87 b	0.10 b	2.39 b	12.50 ab	0.40 b[7]
12 Guthion 3F 10.00 fl oz	5.64 ab	56.41 a	2.57 a	9.29 ab	227.56 a	0.56 ab	41.66 a	122.88 a	3.05 a
13 Penncap M 16.0 fl oz + Danitol 2.4E 2.67 fl oz	0.32 c	1.20 d	0.00 b	1.78 c	6.11 b	0.12 b	0.49 b	2.62 c	0.15 b
14 Larvin 3.2F 10.67 fl oz	2.27 ab	12.80 bc	0.19 b	5.59 b	107.89 a	0.12 b	21.05 a	62.53 a	3.04 a
15 Guthion 35W 10.67 oz + Danitol 2.4E 5.33 fl oz at 5 mites/leaf, alternate materials thereafter	6.38 ab	38.63 ab	0.92 b	8.16 ab	158.96 a	0.10 b	1.68 b	47.20 a	0.06 b
16 Check (fungicide only)	14.13 a	54.85 a	0.50 b	17.58 a	257.82 a	1.18 a	36.06 a	85.10 a	2.72 a

[1] Data was transformed to log 10 (X + 1) for analysis.
[2] Sample size per replicate = 10 leaves
[3] Sample size per replicate = 20 leaves
[4] P. ulmi and T. urticae eggs included together
[5] Treatment spray dates = 5/16, 6/13, 6/26, 7/12, 8/2
[6] Omite-30WP 1 lb/100 gal included on 6/26 in plots 11, 12, 14
[7] Numbers in the same column followed by the same letter are not significantly different (P .05, DMRT).

Spray dates: delayed dormant 3/16 (Delicious)
pre-pink 4/2 (Redspur Delicious); 4/2 (York)
ERM = European red mite; TSSM = two spotted spider mite; mite eggs = ERM eggs + TSSM eggs.

Table 2. Seasonal insecticide experiment (York), 1990
Predator evaluations[1,2]- number per tree per 3 minute observation

Treatments and amt/100 gal	8 Jun SPAD	8 Jun LMA (NS)	8 Jun CHE (NS)	21 Jun SPAD	21 Jun SPL	21 Jun OIN (NS)	21 Jun LMN (NS)	21 Jun CHE (NS)
11 Guthion 35W 10.67 oz	1.25 b	0.50	0.25	0.00 c	1.50 ab	0.00	0.00	0.00
12 Guthion 3F 10.00 fl oz	5.50 a	0.00	0.00	5.25 a	9.00 a	0.00	0.25	0.75
13 Penncap M 16.0 fl oz + Danitol 2.4E 2.67 fl oz	0.00 b	0.00	0.25	0.00 c	0.00 b	0.00	0.00	0.00
14 Larvin 3.2F 10.67 fl oz	1.00 b	0.00	0.00	0.75 bc	1.25 ab	0.50	0.00	0.00
15 Guthion 35W 10.67 oz + Danitol 2.4E 5.33 fl oz at 5 mites/leaf, alternate materials thereafter	1.50 b	0.00	0.00	0.00 c	0.00 b	0.00	0.00	0.00
16 Check (fungicide only)	1.75 b	0.50	0.50	2.25 b	4.25 ab	0.00	0.00	0.50

[1] Data was transformed to $\sqrt{X + 0.5}$ for analysis, arithmetic means tabulated.
[2] Numbers in the same column followed by the same letter are not significantly different (P = .05), DMRT.

SPAD = *Stethorus punctum* adult
SPL = *Stethorus punctum* larva
CHE = *Chrysopa* spp. egg
OIN = *Orius insidiosus* nymph
LMN = *Leptothrips mali* nymph
NS = not significant

SEASONAL INSECTICIDE TRIAL 1990 (4)
'Red Yorking'

Table 3. Evaluation of drop apples, harvested fruit and drop apples + harvested fruit for injury by redbanded leafroller, tufted apple budmoth and lepidopterous larvae (5)

Treatments and amt/100 gal	Total drop apples				Harvested fruit				Harvested fruit + total drop apples				
	No. of drops (1)	RBLR (3)	TABM (3)	LEP (1)	No. of apples (1)	RBLR (3)	TABM (2)	LEP (1)	Total (1)	Mean (1)	RBLR (3)	TABM (3)	LEP (1)
11 Guthion 35W 10.67 oz	2647	7.72 ab	2.33 b	1.92 a	50	9.25 a	4.00 b	0.75 a	2697	76.47	7.88 ab	2.50 b	7.88
12 Guthion 3F 10.00 fl oz	2593	8.19 ab	3.01 b	1.75 a	50	4.75 b	1.50 b	1.00 a	2643	75.62	7.85 ab	3.13 b	7.85
13 Penncap M 16.0 fl oz + Danitol 2.4E 2.67 fl oz	2131	4.56 bc	1.61 b	1.53 a	50	2.50 b	2.25 b	0.25 a	2183	61.35	4.35 bc	1.68 b	4.35
14 Larvin 3.2F 10.67 fl oz	1960	2.53 c	1.00 b	1.89 a	50	1.75 b	2.50 b	1.00 a	2010	58.17	2.45 c	1.15 b	2.50
15 Guthion 35W 10.67 oz + Danitol 2.4E 5.33 fl oz at 5 mites/leaf, alternate materials thereafter	2204	6.58 abc	1.94 b	1.44 a	50	5.25 b	2.00 b	0.00 a	2254	58.17	6.70 abc	1.95 b	6.70
16 Check (fungicide only)	2857	10.56 a	5.86 a	2.36 a	50	3.75 b	5.75 a	1.00 a	2907	80.92	9.89 a	5.85 a	9.88

(1) Means are not significantly different (p = 0.05, DMRT).
(2) Means followed by the same letter are not significantly different (p = 0.0549, DMRT).
(3) **Means followed by the same letter are not significantly different (p = 0.05, DMRT).
(4) Data not transformed for analysis.
(5) LEP = Lepidopterous feeding injury consisting of minor feeding scars primarily caused by wind blown gypsy moth (*Lymantria dispar* (L) larval immigrants during the bloom period.
Numbers in the same column followed by the same letter are not significantly different, P = .05, DMRT, unless otherwise noted (1) (2).

Table 4. Seasonal insecticide experiment
Drop apple finish rating[1]

Treatments and amt/100 gal	Tree no.	13 Aug 90 No. drops	13 Aug 90 Stem russet average	13 Aug 90 Russet average	13 Aug 90 Treatment avg. Stem russet	13 Aug 90 Treatment avg. Russet	21 Aug 90 No. drops	21 Aug 90 Stem russet average	21 Aug 90 Russet average	21 Aug 90 Treatment avg. Stem russet	21 Aug 90 Treatment avg. Russet
11 Guthion 35W 10.67 oz	A	19	3.53	1.78			18	3.35	2.50		
	B	26	3.46	1.83	3.61	1.82	34	3.36	2.47	3.53	2.44
	C	7	3.29	1.86			5	3.75	2.50		
	D	14	4.14	1.82			24	3.65	2.27		
12 Guthion 3F 10.00 fl oz	A	27	3.58	1.57			25	3.21	2.00		
	B	46	3.40	1.86	3.76	1.70	60	3.32	2.41	3.48	2.28
	C	15	4.17	1.80			30	3.64	2.13		
	D	26	3.88	1.57			33	3.76	2.59		
13 Penncap M 16.0 fl oz + Danitol 2.4E 2.67 fl oz	A	26	3.28	1.75			30	3.45	2.32		
	B	26	3.56	1.96	3.48	1.96	30	3.70	2.78	3.58	2.59
	C	26	3.35	1.95			32	3.50	2.33		
	D	26	3.71	2.19			19	3.66	2.95		
14 Larvin 3.2F 10.67 fl oz	A	17	3.68	1.53			23	3.43	2.24		
	B	22	3.27	1.64	3.58	1.56	15	3.47	2.33	3.49	2.20
	C	29	3.94	1.56			47	3.41	1.88		
	D	14	3.43	1.50			20	3.65	2.35		
15 Guthion 35W 10.67 oz + Danitol 2.4E 5.33 fl oz at 5 mites/leaf, alternate materials thereafter	A	14	3.18	1.63			23	3.30	2.10		
	B	31	3.58	1.81	3.61	1.71	55	3.26	2.09	3.32	2.15
	C	30	3.91	1.83			24	3.11	2.08		
	D	6	3.75	1.58			14	3.59	2.32		
16 Check (fungicide only)	A	26	3.42	1.33			37	3.56	1.81		
	B	31	3.38	1.69	3.66	1.60	23	3.68	1.93	3.53	2.21
	C	2	4.50	1.75			5	3.60	2.40		
	D	15	3.35	1.63			24	3.28	2.69		

[1]Rated from 1-5 with 1 being the least russetted.

Table 5. Seasonal insecticide experiment
Rosy apple aphid viable colonies/tree (Redspur Red Delicious)[1,2]

Treatment and rate/100 gal	Colonies/tree (avg of 4 reps/trt) 2 min observation/tree 14 May 90	21 Jun 90
1. Lorsban 4E 1 pt (DD)	0.00	0.00
2. Lorsban 4E 1 pt + oil 6E 2 gal (DD)	0.00	0.00
3. Oil 6E 2 gal (DD)	0.00	0.00
4. Oil 6E 2 gal (DD)	0.00	0.00
5. Oil 6E 2 gal (DD)	0.00	2.25
6. Oil 6E 2 gal (DD)	0.75	5.00
7. Oil 6E 2 gal (DD)	0.00	0.00
8. Check, no oil	0.00	0.00

[1]Data not analyzed
[2]Test discontinued on Red Delicious after bloom.

Other post bloom treatments were scheduled. Test was moved to York because of poor fruit set.

SEASONAL INSECTICIDE TRIAL 1990
'Red Yorking'

Table 6. Total drop apples between 8/13 and 10/13/90

	Treatment					
Date	11	12	13	14	15	16
8/13	66	114	93	82	81	73
8/21	81	148	119	105	116	83
9/1	249	240	249	208	261	248
9/8	161	173	143	102	145	188
9/21	186	205	138	165	155	193
9/29	310	324	263	226	294	332
10/6	300	310	272	243	248	358
10/14	1294	1079	854	829	904	1382
TOTAL	2647	2593	2131	1960	2204	2857
Avg/ tree	662	648	533	490	551	714

Each figure = total for four replicate trees per treatment.

APPLE: _Malus domestica_ Borkh
'Golden Delicious'

R. L. Horsburgh and S. W. Kilmer
Winchester Agricultural Experiment Station
Virginia Polytechnic Institute and State University
Winchester, VA 22601

APPLE, EVALUATION OF PESTICIDE EFFECTS ON U.S. GRADE AND FRUIT FINISH, 1990: The effect of the insecticides Lorsban 4E, Guthion 35W and Lorsban 50W was evaluated on the fruit on mature Golden Delicious apple trees. The materials at rates and times noted in the table were applied to run off with a Bean hydraulic sprayer operating at 400 psi. There were 4 single tree replicates of each treatment in the experiment. All treatments and the control received 7 fungicidal sprays of Rubigan 6 oz/A + Benlate 6 oz/A. Twenty fruit per replicate were examined on the trees and evaluated for side russet and stem end russet. These apples were placed into grade categories according to U.S. Grade standards. No phytotoxic symptoms were observed at the time of the field examination 27 Jul.

Table 1. Finish evaluation of 'Golden Delicious' fruit

Treatments and rates/100 gal	Timing	Russet[1] rating	Stem end[2] russet	% U.S. Grade[3] Extra fancy	Fancy	No. 1	Utility
1 Lorsban 4E 1.0 pt	DD	1.69 a[4]	3.05 ab	21 a	69 a	6 a	4 a
Guthion 35W 10.67 oz	1C,2C						
Lorsban 50W 10.67 oz	3C-7C						
2 Lorsban 4E 1.0 pt + oil 6E 2.0 gal	DD	1.69 a	3.29 ab	31 a	49 ab	18 a	3 a
Guthion 35W 10.67 oz	1C,2C						
Lorsban 50W 8.0 oz	3C-7C						
3 Oil 6E 2.0 gal	DD	1.87 a	4.25 a	15 a	65 ab	16 a	4 a
Guthion 35W 10.67 oz	1C,2C						
Lorsban 50W 10.67 oz	3C-7C						
4 Oil 6E 2.0 gal	DD	1.61 a	2.70 b	36 a	48 ab	15 a	1 a
Guthion 35W 10.67 oz	1C-7C						
5 Check		1.60 a	3.50 ab	37 a	45 b	16 a	1 a

[1]Rating scale: 0 = no lenticel development; 1 = small lenticel enlargement; 2 = lenticels rough and raised to touch; 3 = some russet between lenticels; 4 = considerable russetting other than lenticels; 5 = severe russet.

[2]Rating scale: 0 = no stem end russet; 5 = severe stem end russet.

[3]U.S. grade standards were equivalent to russet scale: extra fancy = 0-1.49; fancy = 1.50-2.49; U.S. No. 1 = 2.50-3.49; utility = 3.5-5.0.

[4]Mean separation between columns by Duncan's multiple range test, 5% level.

LABORATORY SCREENING OF THE EXPERIMENTAL MITICIDE, EXPERIMENTAL MATERIAL 1, TO STETHORUS PUNCTUM (LEC.) ADULTS

VIRGINIA AGRICULTURAL EXPERIMENT STATION
WINCHESTER, VIRGINIA, 1990

by

Dr. R. L. Horsburgh and S. W. Kilmer

Tests were conducted in the laboratory at 84 fahrenheit degrees in a well lighted, ventilated room. Lighting and ventilation were continuous during the test. Four acaricidal mixtures and a water control were included in this experiment. Four test chambers were prepared with each solution making a total of 25 test chambers in the test. Chamber preparation was as follows.

Materials were measured and mixed with 1 gallon (3.79 l) of water in separate glass battery jars. Individual apple leaves (Red Yorking cultivar), infested with an abundance of Panonychus ulmi (Koch) mites and eggs, were dipped, and the petioles, wrapped in cotton, inserted through holes in the plastic lids of 120 ml plastic containers filled with water. The lids in reality consisted of two lids stapled together so separate upper chambers to contain the treated leaves were formed when other 120 ml. plastic containers were inverted, placed over the treated leaves and attached to their covers. The bottom of each upper chamber had previously been removed and replaced with a very fine nylon meshed screen to provide ventilation and reduce condensation. The chambers, lids, and cotton were not dipped in the test solutions.

The limbs from which the leaves were taken were from the control trees in another experiment and had received no insecticidal sprays after bloom.

Ten S. punctum adults (unsexed), collected from nearby mite infested apple trees, were placed in each of the twenty-five test chambers soon after the leaves had thoroughly dried on July 17. The insects were examined under a binocular microscope and categorized as either live or dead after twenty-four hours (Jul.18), and forty-eight hours (Jul. 19) had elapsed. Insects were considered to be dead if they exhibited no detectable movement after several minutes observation and probing with a dissecting needle. Means for the live and dead specimens in the five replicates with each material were calculated. The data were corrected for control mortality by Abbott's formula. (Table 1).

The survivorship of 12% of S. punctum adults at the .05lb.ai/100gal. rate of the experimental miticide suggests that there could be a place for this material in integrated mite control programs at this or lower rates. However the efficacy of the lower rates against phytophagous mites would have to be determined. The mortality percentages at higher rates of this material gave mortalities similar to Omite at the 2 lb. per 100 gal rate. This rate of Omite is higher than that generally used by commercial growers in Virginia who use 1 lb. or 1 1/2 lbs. per 100 gal. Recovery of the predator population would be slowed by applications of the experimental material, however if the application was made at a time when the first generation predators were present and not while second generation beneficials were active it is possible that recovery would take place in time to play a significant role in suppressing later developing mite populations if they should occur .

....

Table 1. Toxicity of an experimental acaricide (Exp. compound 1) to *Stethorus punctum* (Lec.)[1] adults.[2]

Compound	% Mortality
Exp. compound 1, 20WP, 0.013 g ai/l (0.05 lb ai/100 gal)	
24 hr. exposure	62.00
48 hr. exposure	87.98
Exp. compound 1, 20WP, 0.09 g ai/l (0.081b.ai/100gal.)	
24 hr. exposure	80.00
48 hr. exposure	95.99
Exp. compound 1, 20 WP 0.14 g ai/l (0.12 lb. ai/100 gal.)	
24 hr. exposure	84.00
48 hr. exposure	93.99
Omite 30 WP 0.77g ai/l (0.151b. ai/25 gal.)	
24 hr. exposure	58.00
48 hr. exposure	100.00
Water	
24 hr. exposure	00.00
48 hr. exposure	14.00

Reference

1. Healy,M.J.R.1952. A table of Abbott's correction for natural mortality. Ann. Appl. Biol. 39:211-12.

Footnotes

1. Not separated by sex.
2. Data corrected for natural mortality with Abbott's formula.

EVALUATION OF EXPERIMENTAL COMPOUND 1 FOR ITS EFFECT ON THE LADYBUG PREDATOR STETHORUS PUNCTUM (LEC) 1990

R. L. Horsburgh and S. W. Kilmer
Virginia Agricultural Experiment Station - Winchester

The experimental miticide (Experimental Compound 1) was included in the 1990 miticide evaluation experiment conducted at this station. In that evaluation very good suppression of the European red mite (Panonychus ulmi (Koch)) by the chemical was demonstrated. However, there appeared to be rather serious mortality of Stethorus punctum (Lec.) as a result of the treatments. Therefore, two additional experiments with this compound were performed. The first was an in orchard test in which S. punctum was the primary species of concern, and the second (previously reported) was an experiment in which the toxicity of Exp. Cpd. 1 to Stethorus punctum was measured under laboratory conditions. This is a report of the results of the in orchard test mentioned above.

Exp. Cpd. 1 was applied on 5 Jul, in four treatments (a water control was included) to mite infested 9 year old 'Nittany' apple trees at the research station farm. The single tree treatments were arranged in a random block design and each was replicated 4 times as was the control. Mite and predator counts were made on two occasions (19 and 27 Jun), prior to treatment in an attempt to insure the presence of adequate numbers of the predator. Predators were counted (Table 1) by circling each tree and recording all observed during a timed 3 min observation period. Mites and mite eggs per leaf were determined by randomly collecting 20 leaves from each tree in the experiment, brushing the mites onto sticky glass plates and counting the mites, eggs, and predators under magnification with a binocular microscope (Table 2).

The fruit on each tree was also examined (20 apples per tree) and given a numerical rating from 1-5 for fruit finish with 1 having the best finish. Subsequently these numerical values were used to separate the fruit into the 4 USDA fruit grades of Extra Fancy, Fancy, Number 1, and Utility. These data are presented in Table 3.

No significant differences were detected in the predator populations on the trees selected for the experiment when examined prior to the treatment applications (Table 1). However, following treatment (5 Jul) counts (8 Jul) revealed significant reductions in the Stethorus punctum population as a result of the treatments.

Reductions of P. ulmi populations as a result of the treatments are also evident when pre-treatment and post-treatment counts are compared (Table 2).

No down-grading of the fruit occurred as a result of any of the treatments (Table 3). There were no phytotoxic effects on fruit or foliage noted in the experiment that could be attributed to the treatments.

Table 1. Predator observations (3 min per replicate), 1990

Treatment[1] and rate per 100 gal	Jun 19 (pre-treatment) SPAD[2]	SPL[2]	O1[2]	CHE[2]	Jun 27 (pre-treatment) SPAD[2]	SPL[2]	O1[2]	CHE[2]	Jul 8 (48 hours after treatment) SPAD[2]	SPL[2]	O1[2]	CHE[2]	CHL[2]
16. Exp. Cpd. 1 4.72 fl oz	0.50 a	2.75 a	0.50 a	0.75 a	1.00 a	6.50 a	0.25 a	0.75 a	2.50 b	0.50 b	0.00 a	0.75 a	0.25 a
17. Exp. Cpd. 1 9.45 fl oz	2.00 a	0.50 a	0.00 a	0.50 a	0.75 a	1.75 a	0.50 a	0.25 a	1.00 b	0.25 b	0.00 a	1.00 a	0.25 a
18. Exp. Cpd. 1 14.13 fl oz	0.50 a	0.75 a	0.00 a	0.50 a	2.00 a	5.50 a	1.00 a	1.00 a	1.00 b	0.00 b	0.25 a	1.25 a	0.00 a
19. Exp. Cpd. 1 4.72 fl oz + 60 sec oil 32 oz	1.25 a	1.25 a	0.00 a	0.50 a	2.25 a	15.75 a	1.25 a	1.00 a	3.00 b	0.50 b	0.00 a	0.25 a	0.25 a
20. No miticide	1.25 a	0.50 a	0.00 a	0.50 a	2.00 a	10.50 a	0.25 a	1.50 a	18.00 a	5.75 a	0.25 a	1.75 a	0.50 a

[1]Treatments applied Jul 5, 1990.
[2]NS = not significant, $P < .05$.

SPAD = *Stethorus punctum* adults; SPL = *Stethorus punctum* larvae; O1 = *Orius insidiosus* (all stages); CHE = *Chrysopa* spp. eggs

Table 2. Analysis of[1] mite and predator counts[2] resulting from leaf[3] brushing

Treatment and rate per 100 gal	19 Jun 90							7 Jul 90						
	ERM	ERME	TSSM	PHYT	SPA	SPL	SPE	ERM	ERME	TSSM	PHYT	SPA	SPL	SPE
16. Exp. Cpd. 1 4.72 fl oz	3.10 a	14.49 a	3.17 a	0.06 a	0.06 a	0.00 a	0.00 a	1.42 a	38.72 a	0.46 a	0.00 a	0.00 a	0.06 a	0.06 a
17. Exp. Cpd. 1 9.45 fl oz	5.21 a	23.21 a	1.52 a	0.06 a	0.00 a	0.00 a	0.06 a	5.86 a	47.42 a	0.19 a	0.00 a	0.00 a	0.00 a	0.00 a
18. Exp. Cpd. 1 14.13 fl oz	2.95 a	23.83 a	1.24 a	0.00 a	0.00 a	0.00 a	0.06 a	2.44 a	41.07 a	0.49 a	0.00 a	0.00 a	0.15 a	0.11 a
19. Exp. Cpd. 1 4.72 fl oz + 60 sec oil 32 oz	5.21 a	35.39 a	2.36 a	0.00 a	0.00 a	0.00 a	0.00 a	2.18 a	32.65 a	0.32 a	0.00 a	0.00 a	0.06 a	0.06 a
20. No miticide	3.46 a	24.94 a	1.98 a	0.00 a	0.00 a	0.00 a	0.06 a	6.24 a	33.04 a	0.66 a	0.00 a	0.00 a	0.21 a	0.00 a

Treatment and rate per 100 gal	17 Jul 90						
	ERM	ERME	TSSM	PHYT	SPA	SPL	SPE
16. Exp. Cpd. 1 4.72 fl oz	0.15 b	21.54 a	0.00 b	0.00 a	0.00 a	0.00 a	0.06 a
17. Exp. Cpd. 1 9.45 fl oz	0.11 b	31.36 a	0.00 b	0.00 a	0.00 a	0.00 a	0.00 a
18. Exp. Cpd. 1 14.13 fl oz	0.36 b	32.04 a	0.00 b	0.00 a	0.00 a	0.00 a	0.06 a
19. Exp. Cpd. 1 4.72 fl oz + 60 sec oil 32 oz	0.11 b	20.09 a	0.06 b	0.00 a	0.00 a	0.00 a	0.00 a
20. No miticide	4.64 a	44.08 a	1.39 a	0.06 a	0.00 a	0.25 a	0.36 a

[1]Data transformed to $\sqrt{X + 1}$ for analysis. Back transformed means are presented as number/leaf.
[2]Numbers in the same column followed by the same letter are not significantly different (P = .05; DMRT).
[3]Sample size = 20 leaves/replicate.

ERM = European red mites; ERME = European red mite eggs; TSSM = two spotted spider mites;
PHYT = Phytoseiid mites; SPA = *S. punctum* adults; SPL = *S. punctum* larvae; SPE = *S. punctum* eggs

Table 3. Finish evaluation of 'Nittany' apples in Exp. Cpd. 1 experiment

Treatment and rate per 100 gal	% U.S. Grade [1,2,3] Extra Fancy	Fancy	No. 1	Utility
16. Exp. Cpd. 1 4.72 fl oz	55 a	36 a	8.75 a	0.00 a
17. Exp. Cpd. 1 9.45 fl oz	48 a	34 a	17.58 a	0.00 a
18. Exp. Cpd. 1 14.13 fl oz	60 a	33 a	6.19 a	0.75 a
19. Exp. Cpd. 1 4.72 fl oz + 60 sec oil 32 oz	50 a	40 a	9.63 a	0.00 a
20. No miticide	58 a	36 a	6.25 a	0.00 a

[1]Rating scale: 0 = no lenticel development; 1 = small lenticel enlargement; 2 = lenticels rough and raised to touch; 3 = some russet between lenticels; 4 = considerable russetting other than lenticels; 5 = severe russet.

[2]U.S. grade standards were equivalent to russet scale: extra fancy = 0-1.49; fancy = 1.50-2.49; U.S. No. 1 = 2.50-3.49; utility = 3.5-5.0.

[3]Mean separation between columns by Duncan's multiple range test, 5% level.

LABORATORY SCREENING OF THE EXPERIMENTAL MITICIDE. EXPERIMENTAL MATERIAL 2, TO STETHORUS PUNCTUM (LEC.) ADULTS

VIRGINIA AGRICULTURAL EXPERIMENT STATION
WINCHESTER, VIRGINIA, 1990

by

Dr. R. L. Horsburgh and S. W. Kilmer

Tests were conducted in the laboratory at 84 fahrenheit degrees in a well lighted, ventilated room. Lighting and ventilation were continuous during the test. Five acaricidal mixtures and a water control were included in this experiment. Five test chambers were prepared with each solution making a total of 30 test chambers in the test. Chamber preparation was as follows.

Materials were measured and mixed with 1 gallon (3.79 l) of water in separate glass battery jars. Individual apple leaves (Red Yorking cultivar), infested with an abundance of Panonychus ulmi (Koch) mites and eggs, were dipped, and the petioles, wrapped in cotton, inserted through holes in the plastic lids of 120 ml plastic containers filled with water. The lids in reality consisted of two lids stapled together so separate upper chambers to contain the treated leaves were formed when other 120 ml. plastic containers were inverted, placed over the treated leaves and attached to their covers. The bottom of each upper chamber had previously been removed and replaced with a very fine nylon meshed screen to provide ventilation and reduce condensation. The chambers, lids, and cotton were not dipped in the test solutions.

The limbs from which the leaves were taken were from the control trees in another experiment and had received no insecticidal sprays after bloom.

Ten S. punctum adults (unsexed), collected from nearby mite infested apple trees, were placed in each of the thirty test chambers soon after the leaves had thoroughly dried on July 30. The insects were examined under a binocular microscope and categorized as either live or dead after twenty-four hours (Aug 1), and forty-eight hours (Aug 2) had elapsed. Insects were considered to be dead if they exhibited no detectable movement after several minutes observation and probing with a dissecting needle. Means for the live and dead specimens in the five replicates with each material were calculated. The data were corrected for control mortality by Abbott's formula. (Table 1).

The survivorship of 32% of S. punctum adults at the higher rate of the experimental miticide gives hope that there could be a place for this material in integrated mite control programs. The mortality percentages at the lower rates did not indicate a direct dosage response. Obviously, combination with oil would not be appropriate in integrated programs because of the high predator mortality when this combination was used. From the standpoint of predator survivorship, the experimental acaricide out-performed the standard Omite 30 WP at the 2 lb. per 100 gal rate.

....

Table 1. Toxicity of an experimental acaricide (Exp. compound 2) to *Stethorus punctum* (Lec.)[1] adults.[2]

Compound	% Mortality
Exp. compound 2, 20WP 0.075g ai/l (7.1g ai/25 gal.)	
24 hr. exposure	34.00
48 hr. exposure	73.70
Exp. compound 2, 20 WP 0.15g ai/l (14.2g ai/25 gal.)	
24 hr. exposure	24.00
48 hr. exposure	35.97
Exp. compound 2, 20 WP 0.075g ai/l (7.1g ai/25 gal.) plus 60 sec.oil 9.46 ml/gal. (8oz./25gal.)	
24 hr. exposure	100.00
48 hr. exposure	---.--
Exp. compound 2, 20 WP 0.25g ai/l (23.6g ai/25 gal.)	
24 hr. exposure	40.00
48 hr. exposure	67.97
Omite 30 WP 0.77g ai/l (0.151b. ai/25 gal.)	
24 hr. exposure	58.00
48 hr. exposure	100.00
Water	
24 hr. exposure	00.00
48 hr. exposure	12.00

Reference

1. Healy, M. J. R. 1952. A table of Abbott's correction for natural mortality. Ann. Appl. Biol. 39:211-12.

Footnotes

1. Not separated by sex.
2. Data corrected for natural mortality with Abbott's formula.

APPLE: Malus domestica Borkh
'Red Yorking'
Redbanded leafroller:
Argyrotaenia velutinana (Walker)
Tufted apple budmoth:
Platynota idaeusalis (Walker)

R. L. Horsburgh
Winchester Agricultural Experiment Station
Virginia Polytechnic Institute and State University
Winchester, VA 22601

APPLE: EVALUATION OF PYRELLIN E.C. IN DIP WATER TO CONTROL REDBANDED LEAFROLLER AND TUFTED APPLE BUDMOTH LARVAE ON APPLES BEFORE PLACEMENT IN STORAGE, 1990. This test was conducted to gather preliminary data on the possibility of controlling redbanded leafroller (RBLR), and tufted apple budmoth larvae (TABM) adhering to fruit before it is placed in storage. Since most apples enter packing sheds via a water dump, and since the insecticide under test is registered for use on harvested produce, including fruit, adding the toxicant to the dip water appeared to be a possible, practical control method.

Test No. 1: Thirty apples with RBLR larvae adhering to the surfaces of the fruit were collected from a bin of drop apples collected from under the trees in a commercial apple orchard on October 20. Larvae were disturbed as little as possible during collection and leaves covering the larval sites were left in place. Each infested apple was marked by sticking an aluminum shingle nail into the fruit some distance from the location of the insect. The infested fruit was randomly distributed among the fruit filling a one bushel packing crate. Fifty gallons of water was placed in a galvanized tank and twelve fl. oz. of Pyrellin E.C. was added to, and thoroughly mixed with the water. A wooden cover was held on top of the fruit to keep it in the crate while the crate was immersed in the pesticide solution for one minute. Following dipping, the crate was placed on an outside, roofed, loading dock where it remained until the larvae were examined twenty-four hours later.

Test No. 2: This test, conducted on October 26, 1990, was similar in most respects to test No. 1. However, the apples came from a different grower and a different orchard. In test 2, a plastic garbage bag was placed under the crate after dipping in an attempt to capture exiting larvae. Prior to this test the grower had reported a heavy population of TABM in this orchard but it was found to be RBLR when the larvae for the test were collected.

Results, Test No. 1: Of the thirty larvae dipped in the Pyrellin E.C. solution, only 14 were recovered. Of these, four showed no signs of any movement when prodded with a blunt steel probe; five responded to probing with slight leg movement, and five were still active.

Comments: (1) In future tests provision should be made to capture migrating larvae. (2) A strong odor of Pyrellin was detected on the wooden crate and fruit after the dipping procedure. (3) Some fresh feeding was noted after the fruit was dipped but the total amount of fresh feeding appeared to be greatly reduced. (4) Some larvae left secure, secluded feeding sites after dipping. This was expected because of the excitant properties of Pyrellin E.C. Possibly some of these larvae would be washed away in the dip water in a commercial dipping operation.

Results, Test No. 2: On examination twenty-four hours after dipping, twenty-one of the thirty RBLR larvae in the test were recovered. Of the twenty-one larvae recovered, two were crushed between apples during the dipping procedure; fourteen were live, active and appeared to be healthy; three responded to probing with slight leg movement; two made no movement when probed and were classified as dead. Five of the live larvae were recovered from the plastic under the crate.

Comments: (1) Based on the results of these two tests, it is doubtful that dipping the fruit to control RBLR could be justified economically. (2) The length of time that the odor from Pyrellin persisted on the fruit might also be a problem and should be determined if the dipping possibility is pursued further. (3) Differential species response to dipping larvae in Pyrellin may occur. Evaluation of the pesticide on TABM populations might be considered for 1991. If so, the work would best be done in mid-summer or early fall. (4) No tests were conducted using the pesticide as a foliar spray.

Title: Cellulase activity in developing apple fruits.

Authors: Fred B. Abeles and Charles L. Biles
USDA Appalachian Fruit Research Station
45 Wiltshire Road
Kearneysville WV 25430

Abstract. Changes in cellulase, polygalacturonase, and total protein were measured during the growth and ripening of three apple cultivars (Malus sylvestris Mill 'Stark Lodi',' Paulared', and 'Golden Delicious') with the view of establishing the role of these cell wall degrading enzymes in fruit development. No endo-polygalacturonase activity was evident at any stage of apple development. Cellulase was present in young expanding fruit and decreased in activity as the fruit reached full size and ripened. Proteins with molecular weights of 24-, 26- and 67-kD increased during ripening. The SDS-PAGE studies suggest that the 67-kD protein could be cellulase and increased during ripening. The decrease in enzyme activity may be due to the inability of available extraction techniques to release an active form of this enzyme from apple cell walls.

Introduction. The mechanism for softening in apples is not known. The loss of wall material noted in ultrastructural or cell wall composition studies may be due to either the synthesis of cell wall degrading enzymes, the continued action of enzymes already present in the fruit or to some other, as yet unknown, cell wall degradative mechanism. The two cell wall degrading enzymes most frequently associated with fruit softening are cellulase and polygalacturonase (PG). While the role of these enzymes in softening in fruits have been studied, there is no information on the role of cellulase and little on PG in apple ripening. It should be noted that an exo-PG from apple has been described (Bartley, 1978; Bartley and Knee, 1982).

The observations reported here were all made during the period from cell expansion (four weeks after full bloom) to the point at which fruit were producing large amounts of ethylene and at least 50% of the fruit had abscised from the tree. In a preliminary report we found that mature apples had low levels of cellulase (Abeles and Takeda, 1990). In this report we expanded these observations to include the changes in cellulase and PG activity in three cultivars during the period of cell expansion growth and ripening. Cellulase from 'Golden Delicious' was purified and found to have a molecular weight of 67 kD.

Materials and methods. Apples (Malus sylvestris Mill) used in this study were either early ripening ('Stark Lodi', 'Paulared') or midseason ('Golden Delicious') cultivars grown on 10-year-old trees. Fruit were picked weekly from four weeks after full bloom, at which time they had sufficient size for flesh firmness measurements. Samples were weighed, and flesh firmness measured. Other samples were placed in containers for ethylene production measurements or frozen at -20°C for subsequent protein extractions.

The methods used to measure ethylene, cellulase, polygalacturonase, have been described earlier (Abeles and Takeda, 1989, 1990). . Because of space limitations, other details of the techniques used here can be obtained by contacting the authors.

Results. Fig. 1 indicate a continuous decrease in firmness during the period of fruit growth and ripening. Fig. 2 shows that there was no change in the rate of softening during ripening as characterized by an increased ethylene production. Of the cultivars studied, 'Stark Lodi' matured first, followed by 'Paulared' and 'Golden Delicious'. Fig. 3 shows the cellulase activity of acetone powder extracts during ripening. In general, all cultivars showed the greatest amount of cellulase activity during the growth phase of fruit development. A reduction in activity ('Paulared') or no activity ('Stark Lodi' and 'Golden Delicious') was observed when the fruit were mature and ripe. Fig. 4 shows that no polygalacturonase activity, in terms of the reduction of viscosity of polygalacturonic acid solutions was evident in acetone powder extracts of 'Paulared' and 'Golden Delicious' fruit.

Fig. 5 shows the proteins isolated by the phenol-protein extraction technique. This technique, which extracts most of the proteins from tissue, also showed an increase in 24-kD and 26-kD proteins. In addition, an increase in a 67-kD protein was evident in all cultivars during ripening.

Fig. 6 shows that three peaks of cellulase activity were obtained after acetone powder proteins were run over a Pharmacia HPLC MonoQ column. The insert shows the results of electrophoretic separation of peaks of cellulase activity. The first cellulase fraction, with more basic proteins, contained a number of proteins. The more acidic proteins, cellulase fractions 2 and 3 had a single protein with a molecular weight of about 67-kD. The apple cellulase obtained from the substrate affinity column is shown in lane 4.

Discussion. We did not observe an increase in the rate of softening of apple fruit attached to the tree during the ethylene climacteric. This is unlike other fruit such as peach, tomato and avocado where softening is associated with the climacteric. Softening of apples attached to the tree may be due to a thinning of cell walls during fruit expansion. Penetrometer studies do not distinguish between walls which become thinner as a result of growth and those in which softening is due to loss of cell cohesion. However, since softening continues in storage after growth stops, it is plausible that some factor must control apple softening. The results shown in Fig. 4 showed that apples did not contain measurable amounts of endo-PG. Most climacteric and nonclimacteric fruit exhibit an increase in cellulase during ripening. In apples the opposite appears to be true. Cell free cellulase activity was greatest in immature fruit and either decreased or remained constant as the fruit matured. The cellulase measured in these experiments may play a role in growth as opposed to ripening. Chromatographic studies indicated that there are three apple cellulase isozymes. Two of the acidic isoenzymes, and the cellulase purified by affinity column chromatography, have molecular weights in the 67-kD range. Fig. 6 shows that in addition to 24- and 26-kD proteins, an increase in a 67-kD protein was also evident in all three cultivars. Possibly, cell wall degrading enzymes are too firmly attached to cell walls during ripening to be dislodged by the extraction techniques used here.

Legends for figures.

Fig. 1. Flesh firmness of apples during growth and ripening. The values shown are the means of 16 determinations taken on 4 fruits.

Fig. 2. Ethylene production expressed as uL/ kg ·h of apples attached to the tree during growth and ripening. At the last harvest date 50% of the fruit had abscised.

Fig. 3. Cellulase activity of apples during growth and ripening. Fruit samples were harvested and frozen at dates indicated for subsequent cellulase analysis. Cellulase activity was measured as the percent reduction in viscosity of a 2% solution of CMC compared to water controls. Negative numbers indicated loss of viscosity. LSD values shown in this and the subsequent figure, and differences in means greater than the LSD are significantly different at the 5% level.

Fig. 4. Polygalacturonase activity of apples during growth and ripening. Polygalacturonase activity was measured as the percent reduction of viscosity of a 4% solution of sodium polygalacturonic acid compared to water controls.

Fig. 5 SDS-PAGE patterns of proteins (30 ug protein per lane) from the phenol extraction method from three apple cultivars 'Stark Lodi', 'Paulared' and 'Golden Delicious'. The E (early) in the left lane represents fruit harvested three weeks before the onset of the climacteric and R (ripe) fruit from the last harvest date. Molecular weight standards are shown in the left lane.

Fig. 6. Separation of cellulase isoforms on Sephadex MonoQ. Upper part of the figure shows the change in absorbence at 240 nm during the period of the column run. The lower part of the figure indicates the results of viscosity assays indicating the presence of three isoforms of cellulase at 1 = 2 min, 2 = 16 min, and 3 = 18 min. The insert shows the appearance of these three MonoQ fractions after SDS-PAGE electrophoresis on the Pharmacia PhastGel system using silver stain. The first lane of this composite photograph is the molecular weight standard lane, 1 = the 2 min fraction, 2 = the 16 min, fraction 3 = the 18 min fraction and 4, cellulase purified by the cellulose affinity column technique.

Literature Cited.

Abeles, F. B. and F. Takeda. 1989. HortScience. 24:851.

Abeles, F. B. and F. Takeda. 1990. Scientia Hortic. 42:269-275.

Bartley. I. M. 1978. Phytochemistry 17:213-216.

Bartley, I. M., and M. Knee. 1982. Food Chem. 9:47-58.

Bartley, I. M., M. Knee, and M. A. Casimir. 1982. J. Exptl. Bot. 33:1248-1255.

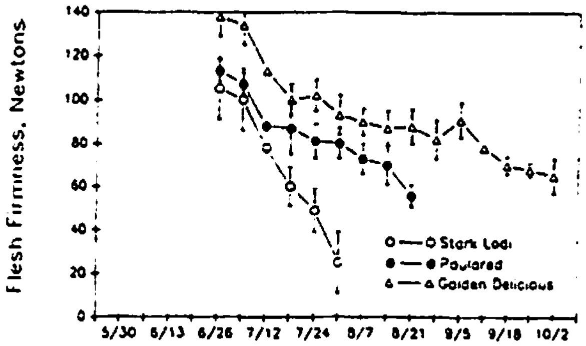


Fig. 1 DATE

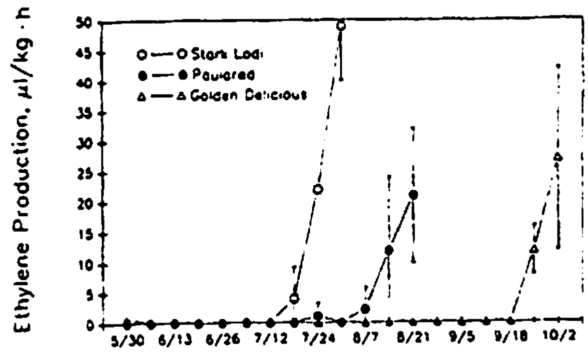


Fig. 2 DATE

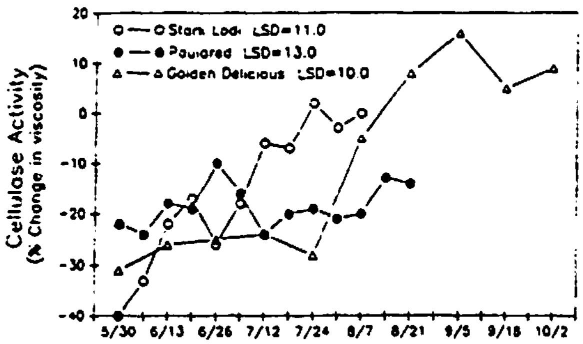


Fig. 3 DATE

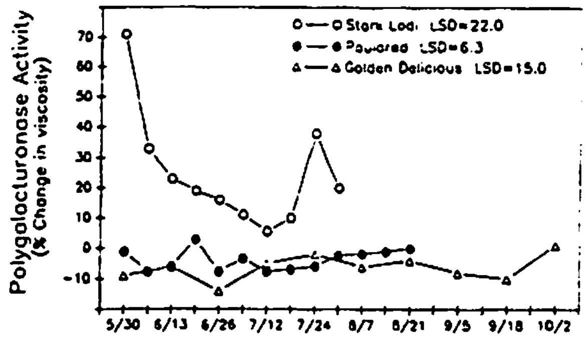


Fig. 4 DATE

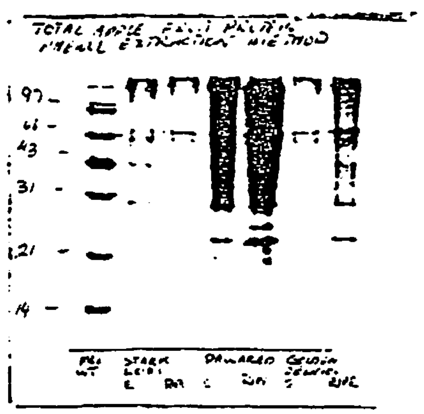


Fig. 5

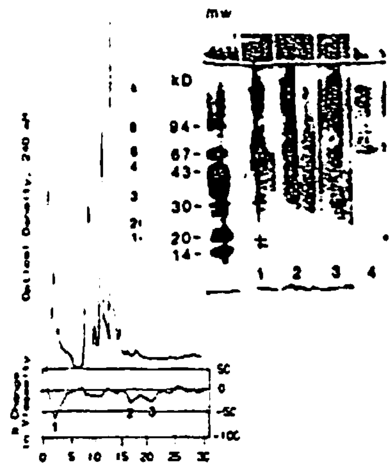


Fig. 6

Comparison of Four Peach Training Systems

William C. Olien, John D. Ridley, and D.C. Coston
Department of Horticulture
Clemson University, Clemson, SC 29634-0375

Introduction:

A number of high density peach training systems have improved potential for early yields, yield/acre over bearing years, and fruit quality, over the standard open center form planted at low density (ca. 100 trees/acre) (eg. papers in Childers & Sherman, 1988). Promising tree forms include variations of the central leader (spindle), perpendicular-Y (V, Tatura trellis), hedge row, and meadow orchard. High density systems generally require increased management and input in order to fully realize their potential advantages. High density systems have been evaluated in a number of studies under generally optimum conditions of cultural management, and as such are comparisons of the potential performance of these systems. The present study evaluates three high density systems relative to standard low density open center trees, under conditions of periodic drought stress (no irrigation) and reduced pruning management. These are restrictions frequently faced by growers. The question asked was, how sensitive are these systems to loss of bearing advantage under pressure of restricted management?

Materials and Methods:

"Redhaven'/Lovell trees were planted in spring 1985 in a randomized complete block design with two replicate, 4-row plots of four training systems: standard open center system (OC), central leader (CL), Y-trellis (YT), and modified meadow orchard (MO). Rows were approximately 140 feet long. The inside two rows of each plot were used in data collection. Planting density and tree size were as follows:

Table 1:

Training System	Tree spacing (feet) Row		In-row	Trees /Acre	Trunk height to first scaffold (inch)	Trunk Diameter (inch) 1987	1990
Open Center	20	x	20.0	109	14	3.0	5.3
Central Leader	15	x	6.5	447	10	2.6	4.0
Y-Trellis	15	x	3.5	830	14	1.9	2.9
Meadow Orchard	10	x	3.0	1452	8	---	3.5

Row spacings of OC, CL, and YT were designed to accommodate orchard equipment currently owned by growers. Training and pruning of OC was as described by Myers (1989), CL as described by Bargioni et al. (1983), and MO as the "intensive meadow orchard system" described by Erez (1982). The Y-trellis was modified from the Tatura trellis described by Chalmers et al. (1978). Two scaffolds/tree were angled 60° from horizontal, perpendicular to the row. Each leg of the "Y" was supported by a single wire 8 feet above the ground, with 8 feet between the wires.

CL and YT, but not OC or MO, trees were summer pruned once/year postharvest by hand during July. Recommendations for fruit thinning and weed, pest, and disease control were followed in all years. The plots were not irrigated, resulting in periodic drought stresses (severe in 1988) and spring frosts. Restricted pruning management in 1987 and 1988 led to internal canopy shading.

Fruit was harvested at commercial shipping ripeness in 3 to 4 harvests, ranging over years from 15 June through 7 July. In 1990, fruit samples were sorted into six weight categories using a computerized grading line, corresponding to minimum fruit diameters in inches of 0-2", 2-2.25", 2.25-2.5", 2.5-2.75", 2.75-3", and over 3". Quality of fruit samples was assessed after 3 weeks cold storage from minimum fruit diameter, flesh firmness, ground color (Delwiche & Baumgardner, 1983), juice pH, titratable acidity, and soluble solids content.

Results and Discussion:

All three intensive systems bore their first crop in 1986, but OC trees did not bear until 1987 (Table 2). Yields/acre in 1987 were greatest for YT, least for OC, and intermediate for CL (MO was not measured). The advantage of CL, YT, and MO in producing early yields is critical in offsetting orchard establishment costs. By 1990, total yield/acre of CL trees dropped to the lowest of all four systems. YT trees still produced the highest yields, with OC and MO intermediate and not significantly different from either extreme. Differences in total yield in 1990 were also reflected in amount of fruit graded between 2.25 and 2.75 inch minimum diameter. Fruit quality parameters measured in 1990 did not differ among treatments, so average values over all systems are presented (Table 3).

Table 2:

Training System	Total Yield (ton/acre) 1986	1987	1990	1990 Yield by Fruit Size (ton/acre) 0" - 2.25"	2.25"- 2.75"	over 2.75"	Fruit/Acre (thou/acre) 1987	1990
OC	0.0 b	3.8 a	4.7 ab	0.9	3.5	0.3	29	37 ab
CL	0.8 a	7.4 b	2.9 b	0.4	2.3	0.3	62	20 b
YT	0.5 a	9.2 c	5.7 a	1.4	4.2	0.1	84	50 a
MO	0.8 a	---	4.1 ab	0.6	3.2	0.3	--	29 ab

Table 3:

Year	Minimum Diameter (inch)	Skin Ground Color (chip)	Flesh Firm. (lb)	Juice pH	Titratable Acidity[z] (%)	Soluble Solids (%)	Acid[z]/ Fruit (g)	Sugar/ Fruit (g)
1987	2.2	---	---	---	---	---	---	---
1990	2.3	5.9	6.3	4.1	0.6	11	0.17	3.1

[z]Acid expressed as equivalent amount of malic acid.

By 1990, CL, YT, and MO formed a continuous canopy down the row, in contrast to the widely spaced OC trees. The OC, YT, and especially CL trees suffered excessive shading and reduced bearing surface. Thus the CL system had high early potential, but poor yield stability under restricted management conditions. The YT system had high early yields, but also demonstrated the greatest ability to produce good yields of high quality fruit under nonideal conditions.

Literature Cited:

Bargioni, G., F. Loreti, and P.L. Pisani. 1983. Performance of peach and nectarine in a high density system in Italy. HortScience 18:143-146.

Chalmers, D., B. van den Ende, and L. van Heek. 1978. Productivity and mechanization of the Tatura trellis orchard. HortScience 13:517-521.

Childers, N.F. and W.B. Sherman (eds.). 1988. The peach, 4th edition. Horticultural Pub., Gainesville, FL.

Delwiche, M.F. and R.A. Baumgardner. 1983. Ground color measurements of peach. J. Amer. Soc. Hort. Sci. 108:1012-1016.

Erez, A. 1982. Peach meadow orchard: Two feasible systems. HortScience 17:138-142.

Myers, S.C. 1989. Open center tree training. In: S.C. Myers (ed.). Peach Production Handbook. Georgia Ext. Ser. Hdbk. 1.

Development of an Automated Multi-purpose Irrigation System for Strawberry

B. Goulart
Assistant professor of Pomology

P. Heinemann
Assistant professor of Agricultural Engineering

T. Stombaugh
Graduate assistant in Agricultural Engineering

T. Morrow
Professor of Agricultural Engineering

M. Safaeian
Research aide in Horticulture

The Pennsylvania State University
University Park, PA 16802

Irrigation is used for many purposes in strawberry production. Aside from alleviating water stress, water is applied for frost protection during bloom and for evaporative cooling to alleviate heat stress during the bearing season. Currently, the determination of when to apply water is largely dependent on the perceptions and convenience of the individual grower. While research has been conducted in automating irrigation for frost protection of apple, peach and citrus (Duffy, 1984; Gerber, and Harrison, 1964, Heinemann and Morrow, 1986; Perry et al., 1980, Phillips, J.R. 1982), little work has been done on strawberry, and still less on the use of such a system for evaporative cooling. Goulart and Gardner (1987) found that an automated system was feasible for both control and monitoring temperature in strawberries, and found that berry size was increased when plants were sprinkled, as compared to simple application of water to the soil surface.

The objective of this experiment was to develop and evaluate an automated multi-purpose irrigation system for strawberry.

In spring of 1989, a one and one-half acre plot of alternating rows of 'Lateglow' and 'Earliglow' strawberries was planted in a Hagerstown silt loam soil at the Russell E. Larson Agricultural Research Center at Rock Springs, Pennsylvania. Plants were maintained according to standard recommendations (Goulart, et al., 1989). An irrigation system was installed which utilized all polyvinyl chloride (PVC) components, and was equipped with an injector. A thorough description of the system and experimental design can be found in Heinemann et al., 1989.

For frost protection work, an expert system was installed on a 640K DOS computer which determined when to apply water and application rates based on averaged relative humidity, wind speed and temperature measurements at several locations. Two minisprinkler type nozzles (Dan, red and Naan, yellow) were compared to a grower control (conventional impact type nozzles) and a non-irrigated control on 'Earliglow' strawberry plants. Mini-sprinkler nozzles were chosen after testing for uniformity and flow rate, rather than relying solely on manufacturers specifications.

The expert system operating the irrigation system for frost protection worked well, with percent bud kill comparable to the conventional (Rainbird) control, and all systems superior to the untreated control (Table 1).

Table 1. Percentage of dead flower buds due to the frost of May 12, 1990.

treatment[1] (sprinkler)	avg % kill postfrost
Dan	1.7B
Naan	0.3B
Rainbird	2.6B
none	52.3A
p(F)	0.001

[1]Treatments analyzed using an analysis of variance. Means separated using the Waller-Duncan Mean Separation Test. Means with different letters are significantly different at the 0.001 level.

Bud temperature differed from air temperature (at a 1.5 meter height) as much as 4 C, stressing the importance of sensing temperature at bud level, and preferably using a thermocouple inserted into the bud (Figure 1).

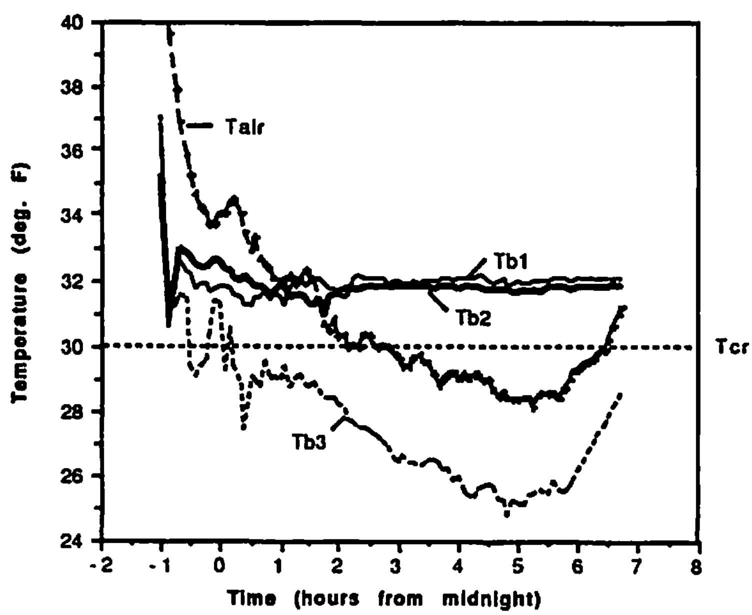


Figure 1. Air temperature vs. bud temperature during the frost of May 12. "Tair" indicates air temperature at 1.5 m., "Tb1" indicates temperature of buds subjected to Naan sprinklers, "Tb2" indicates temperature of buds subjected to Dan sprinklers, "Tb3" indicates temperature of unsprinkled buds, and Tcr is the temperature below which buds will be damaged (critical temperature).

Predictably, yield was decreased significantly on the the non-treated control, with the most substantial difference occurring in the early portion of the season (Figure 2).

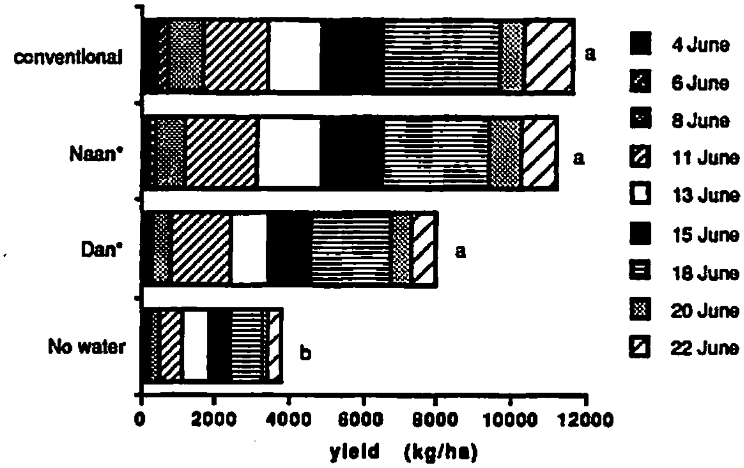


Figure 2. Effect of frost protection irrigation type on marketable yield of 'Earliglow' strawberry:1990. *brand of minisprinkler.

Average berry size was not affected by sprinkler type (Table 2), though size was smaller on the berries from the no water treatment as compared to any other treatment on 4 June and 8 June (data not shown). This difference was presumably due to the fact that the larger (earlier) primary flowers had been killed in the frost. In spite of an absence of competition for resources and an abundance of water, the berries could not compensate for fewer numbers of cells with enlargement due to water uptake.

Table 2. Influence of frost protection sprinkler type on size and yield of 'Earliglow' strawberry: 1990 summary data.

Treatment	Total yield (kg/h)	% marketable	mean berry size (g)
Dan minisprinkler	3050.67a	76.2	9.73
Naan minisprinkler	3881.42a	83.9	9.73
No water	1615.33b	64.5	9.17
Conventional	4230.75a	79.5	9.25
p(F)	0.03	0.20	0.91

For **Evaporative Cooling** research, 'Lateglow' strawberry plants were treated with minisprinklers (Naan, white: model 5164), minisprinklers with Ronilan injection, trickle irrigation via biwall or an unwatered control. Again, minisprinklers were chosen for uniformity and flow rate. The Naan sprinklers delivered 3.971 liters/minute, with distribution ranging from 0.38-0.51 cm/hour in the measurement area of the strawberry plots. Delivery rate of the biwall irrigation tube was calculated to be between 0.41-0.60 cm/hour .Temperature differences were monitored in each of 4 replications, with thermocouple sensors located at mid-canopy and in a firm ripe fruit. The system was programmed to monitor all temperatures every minute, and turn the sprinklers on when the mean berry temperature reached 29.5C. Berry temperatures were observed to reach much higher temperatures than ambient (data not shown), so the system turned on several times during the season, in spite of the unseasonably cool temperatures. However, few physiological effects were detected, probably due to the unusually cool harvest season. No differences were found in marketable yield, berry size or berry shelflife, and yield was within an acceptable range (Table 3).

Table 3. Influence of irrigation treatment on yield of 'Lateglow' strawberry: 1990.

Treatment	yield (kg/ha) marketable	cull	total	% marketable	size (g/berry)
Minisprinkler	17615.6	2667.7	20283.3	87.005	11.025
Minisprinkler + inj.	17536.4	3476.1	21012.6	84.065	10.844
Trickle	22820.3	3539.1	26359.0	86.202	11.059
Control	20906.6	2992.1	23898.7	87.225	11.472
p(F)	0.42	0.063	0.23	0.50	0.95

For the larger portion of the season, no differences were detected among treatments in leaf water potential, however on 4 and 5 July 1990 (at the very end of the harvest), ambient temperatures reached 31.5C, resulting in differential stress on the various treatments as illustrated in Figure 3. Integral values (the area between each line and the horizontal axis) indicate that only the control differed significantly from the other three treatments, so that (in this case) the trickle irrigation treatment alleviated stress as well as the minisprinkler treatments.

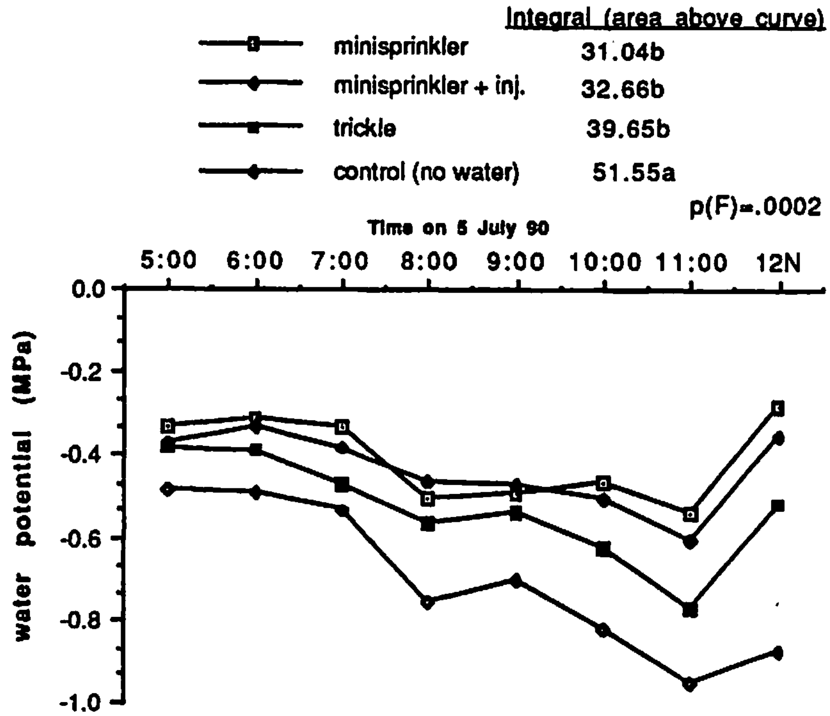


Figure 3. Influence of sprinkler type on 'Lateglow' strawberry leaf water potential: 1990.

Concluding remarks

The multi-purpose automated irrigation system worked well in controlling frost on the two frost incidents when it was tested, however, more testing, stressing the use of lower volumes of water is needed. Based on the reduction of leaf water potential on 5 July, the use of the system for evaporative cooling also offers promise. Postharvest differences were not detectable, but this may be due to the lack of sufficiently hot weather in 1990 to test the system. The system offers further potential for injection of nutrients and pesticides, and will be tested for these in 1991.

Literature cited

Duffy, P.S. 1984. Artificial buds as sensors for microcomputer control of pulsed overhead sprinklers for frost protection. M.S. thesis, Pennsylvania State University. 91 pp.

Gerber , J.F., and D.S. Harrison. 1964. Sprinkler irrigation for cold protection of citrus. Trans. ASAE 7:464-468

Goulart, B.L., E.G. Rajotte, J.W. Travis, and C.H. Collison. 1989. Small fruit production and pest management guide 1989-90. Ext. Pub., Penn State Univ., Univ. Park, Pa.

Goulart, B.L. and J.F. Gardner. 1987. Design and Implementation of a Microprocessor-Driven Overhead Trickle Irrigation System for Evaporative Cooling and Chemical Injection. Proc. 64th Cumberland/Shenendoah Fruit Workers Conference. Harper's Ferry, W.Va. 6 pp.

Heinemann, P.H., C.T. Morrow, T. Stombaugh, B. Goulart and R. Crassweller. 1989. An integrated irrigation system for the environmental modification for fruit crops. Proc. International Winter Meeting, ASAE microfiche no. 89-7573.

Heinemann, P.H. and C.T. Morrow. 1986. An artificial apple bud for frost temperature sensing. Trans. of the ASAE. 29(5): 1338-1341.

Perry, K.B., J.D. Martsolf, and C.T. Morrow. 1980. Conserving water in sprinkling for frost protection by intermittent application. J. Amer. Soc. Hort. Sci. 105(5): 657-660.

Phillips, J.R. 1982. Microcomputer control of a pulsed irrigation system for frost protection of apple buds. M.S. thesis, Pennsylvania State University. 134 pp.

DO CHEMICAL THINNING RECOMMENDATIONS REFLECT THE REAL WORLD?

R. M. Crassweller and G. M. Greene II
Department of Horticulture
Penn State University
102 Tyson Building
University Park, PA 16802

Chemical thinning of apples is still one of the most misunderstood practices growers perform; but errors can have drastic economic effects. To understand the current confusion we need to consider a brief history of the orchard conditions when chemical thinners came into usage. In the early '60's when chemical thinners were first developed most fruit trees were on standard rootstocks and typically 25 to 40 feet tall. Pesticide applications were done on an every row basis typically using 300 - 400 gallons of water per acre. Therefore, all the research upon which NAA rates were based upon was using high volumes of water in a dilute spray. The recommendations developed (and still listed on the label) were to apply thinners based on fruit size and the dosage with a suggested rate of 5 to 22 ppm of NAA.

Since then many advances in chemical applications have been made in apple orchards. Probably the greatest change that has had an impact upon the application of chemical thinners is the reduction in gallonage of water applied per acre. With reduced tree size and improved machinery the carrier volume has been reduced to 50 to 150 gallons of water per acre. Unfortunately this reduction in water per acre has not always been in a proportional manner to maintain thinning applications on a dilute basis.

A further complication has been the misunderstanding of what parts per million (ppm) means. In all other chemicals applied in the orchard we are applying an amount per acre. For example you might apply 6 ounces per acre of benomyl or 1 lb per acre of Guthion. Typically the manner in which growers determine how much material to add to the tank is to calibrate the sprayer to determine how many gallons of water per acre they are applying. Once this is known growers determine how many acres they can spray with the gallonage in your sprayer. Therefore if they have a 500 gallon sprayer tank and are applying 100 gallons per acre at a given tractor speed they know that they can spray 5 acres per tank. Multiplying the desired rate per acre by 5 to gives the amount of material to add to the tank.

The research in chemical thinning however, was not developed on a per acre basis but rather a concentration basis. Therefore, in chemical thinning we are **NOT** applying an amount per acre. When applying NAA growers should be mixing up a solution of a certain concentration. and then applying the solution in a large enough volume to thoroughly wet the trees. The amount of water needed will vary depending upon the size of the trees. For small trees 50 to 100 gallons may be enough water, while in larger trees it may be necessary to apply up to 200 gallons.

Unfortunately, since the majority of pesticides are applied on a per acre basis at low volumes of water, few growers will recalibrate their sprayer to higher volumes needed for chemical thinners. The end result is poorer distribution of chemical thinners and inconsistent results.

Fortunately the chemical thinning problem is not as serious as it sounds for all growers. Many growers through knowledge, experience, experimentation, and old fashioned luck have adjusted their application methods to achieve adequate results.

What we suspect that has happened is that growers are actually mixing higher concentrations (>20 ppm) in their spray tanks, but because they are applying less water per acre they are achieving adequate results. Preliminary data that has been gathered from the attached survey (Figure 1) has shown that some growers are mixing solutions in excess of 80 ppm. They are reporting satisfactory results with their program.

The purpose of this small survey was to record what growers are doing for chemical thinning. The second, goal is to take this information and revise our recommendations to reflect what is happening in the real world. The survey was distributed at spring twilight fruit meetings and published in the Pennsylvania Fruit News. The response to date has not been overwhelming. We would however, gladly cooperate with other extension and researchers in other states to see if the confusion has a wider spread.

Table 1. Sample responses of three growers to chemical thinning survey in 1990.

	Tree Age	Trees per Acre	Height (ft)	Vigor (L,M,H)	Frt. Size (mm)	Amt to Tank	Desired Conc.	Actual. Conc.	Gal/A	Response*
Golden	25	66	18	H	10	7.5lb	20	99	50	VT
Rome	15	100	15	H	12.7	0.75lb	15	30	200	CT
Rome	15	181	12	H	12	2.5lb	**	40	75	UT

*Response to thinning; VT = variable thinning; UT = underthinned; CT = correct thinning; OT = over thinned
** Grower indicated that he applies an amount of material per acre

Table 2. Selected response of Pennsylvania grower to chemical thinning survey in 1990

	Tree Age	Trees per Acre	Height (ft)	Vigor (L,M,H)	Frt. Size	Amt to Tank*	Desired Conc.	Surfact.	Amt	GPA	Response
Golden	34	45	20	H	0.5	8.3lb	15	Tween20	3gal	30	UT
Golden	23	71	20	H	0.5	8.3lb	15	Tween20	3gal	30	UT
Golden	7	90	16	H	0.4	8.3lb	15	Tween20	3gal	20	CT
Golden	12	96	16	H	0.4	6.6lb	10	Tween20	2.5gal	20	CT

* Amt added to 400 gallon tank; translates to the following ppm concentrations; 8.3 lb = 83 ppm; 6.6 lb = 66 ppm

Figure 1. Chemical Thinning Survey - 1990 given to growers.

In order to improve our chemical thinning recommendations we are conducting a survey of current usage patterns for thinning apples. Enter the requested information for three main cultivars. We would like you to fill out this questionaire as much as possible. Your responses will be kept confidential.

Name	Orchard Name	Address	City	Zip	County

GENERAL BACKGROUND (Assumes using the same sprayer in all blocks)

Airblast Sprayer Tank Size:______________________ gallons

CULTIVAR/BLOCK SPECIFIC INFORMATION

Culivar or Variety	Tree Information: Age (years)	No/ Acre	Height (feet)	Vigor[1] (LMH)	Date of (mo/day): Full Bloom	Thinner Applic.	Fruit Size[2]	Chemical Information: Material (name)	Amt added added to tank	Desired Conc.(ppm)	Gal. of Water / A	Surfactant (name)	Surfactant Rate	Thinning Response[3] (OT-CT-UT)

[1] Tree Vigor; L = Low , M = Medium, H = High

[2] Fruit Size at time of application - specify average size and units, i.e., 9/16 inches

[3] Specify Thinning Response; OT = Over thinned; CT = Correct Thinning; UT = Under thinned

Not for Citation

DETERMINING APPLE PACKOUT LOSSES AND IMPACT ON PROFITABILITY

T. A. Baugher, H. W. Hogmire, Jr.,
G. W. Lightner and M. Ingle
WVU and USDA-AFRS Cooperating
Kearneysville, WV 25430

Fruit growers have had to make a number of changes in their operations over the past decade in order to maintain profitability. Economic forecasts for the 1990's indicate that the business environment will become even more competitive and that growers will need to intensively use crop records to improve management and marketing decision-making.

Fruit quality is a key component affecting the prosperity of commercial apple orchards. High quality fruit brings higher returns in the market place and increases profit to the grower. More growers are adopting the Integrated Orchard Management (IOM) approach in order to improve fruit quality and reduce production costs. As new IOM strategies are introduced, they must be evaluated to determine how they impact apple packout and economic returns. This requires the development and evaluation of a sampling strategy whereby packout losses can be identified as part of a cost/benefit analysis of the IOM program. With this information, growers should be able to better allocate resources, thereby increasing profits.

Orchardists and their crop consultants often look at the cull bin in order to determine factors responsible for apple packout losses. Monitoring fruit quality after it has been graded provides important feedback to field operations, but there are some limitations. Loss data based only on downgraded fruit, rather than fruit examined before grading, are subject to variability that is influenced by the number and efficiency of the inspectors on the grading line and the marketing intention of the grower. In addition, losses due to the difference in return between extra fancy and lower grades are not accounted for by limiting evaluation to culled fruit. A scheme is needed for sampling fruit and assessing defects just prior to grading. Such an evaluation will facilitate improved marketing if fruit packout can be determined simultaneously.

Proposed Sampling Plan and Grading Scheme. To facilitate better marketing decision-making, it would be advantageous if growers could predict fruit packout for a given block prior to placement in storage, and without the expense involved of operating the grading line. By utilizing U. S. grading standards and inspection procedures, the factors affecting fruit quality were organized into a chart format for use in determining packout and for assessing how management decisions impact on the market grade of fruit (scheme modified after Russo and Rajotte, 1983). In a study conducted in 1987, a sampling plan was developed in which samples of 100 fruit were collected from random bins at the submersion tank. Apple packout was predicted to within 10% by sampling 5 bins and packout loss factors were predicted to within 5% by sampling 4 bins.

Packout Losses and Impact on Returns. 'Red Delicious' apple packout losses were determined from samples collected from nine packinghouses during 1987-1988 and 1988-1989. The submersion tank collection technique and modified Russo/Rajotte grading scheme chart were utilized, and defects and grades were simultaneously determined. Common defects found in 100% of the lots in both years were inferior color, bruising and small size (Figures 1 and 2). An IOM cost/benefit analysis, or audit, conducted on each lot of fruit revealed that total losses in returns from defects ranged from $673 to $4247 per hectare ($272 to $1719 per acre), indicating differences in management as well as microclimate. The cost of a defect such as hail, scald, small size or tufted apple budmoth injury was generally higher than bruising or poor color because the fruit was downgraded to a greater extent. Regression analyses relating orchard data to defect data indicated that a packout audit could be used to provide valuable feedback to field operations.

For further information, request a copy of Extension Bulletin OM 105, "Determining Apple Packout Losses and Impact on Profitability".

Figure 1. Percentage of fruit downgraded compared to loss in revenue for each defect (average from nine packinghouses in 1987-1988).

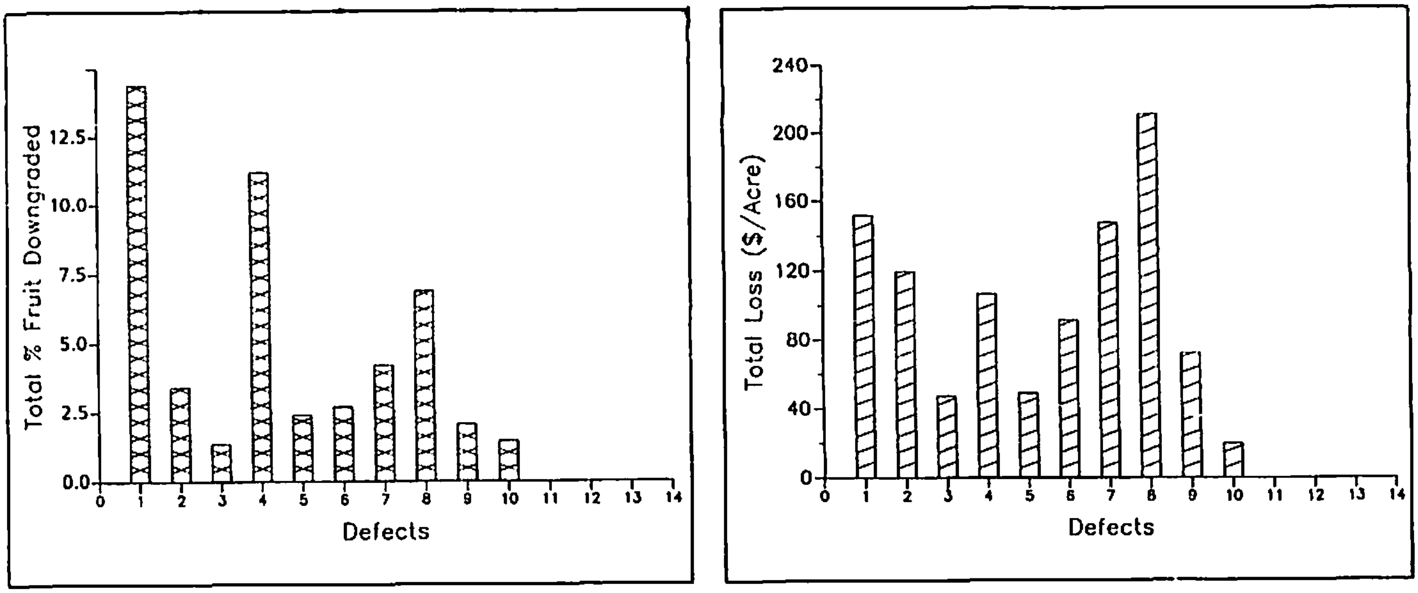
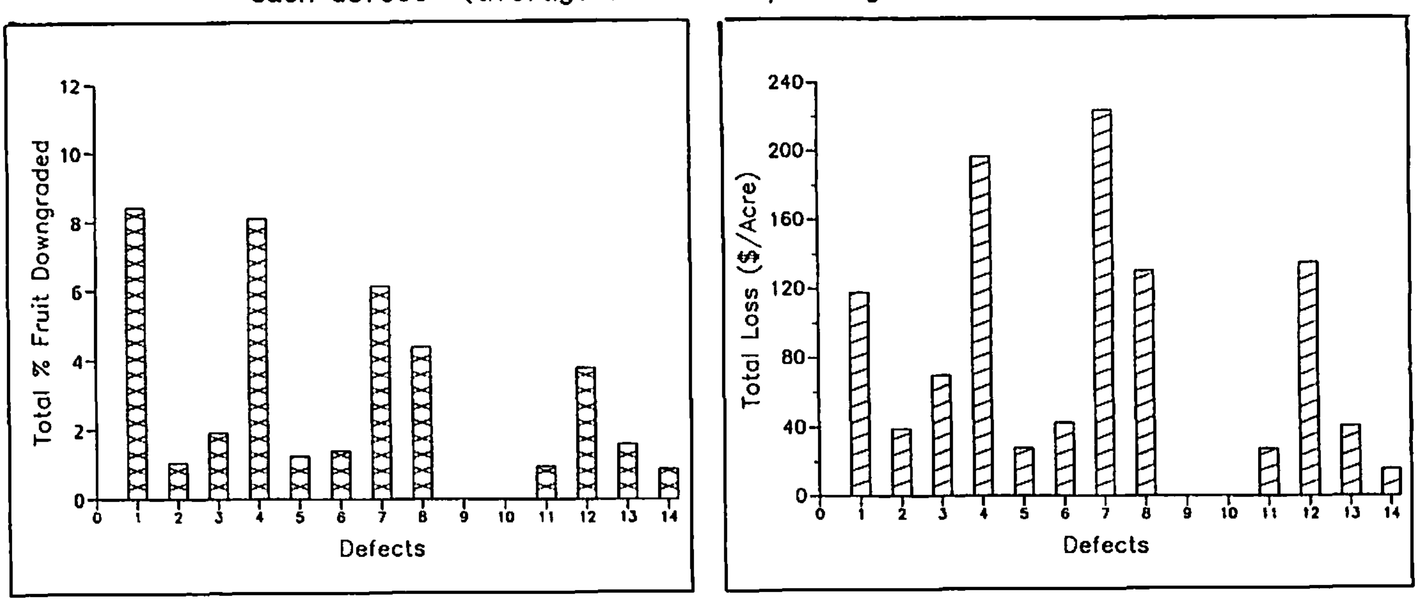


Figure 2. Percentage of fruit downgraded compared to loss in revenue for each defect (average from nine packinghouses in 1988-1989).



DEFECTS / Legend for Figures 1 and 2

1 Poor Color
2 Scald
3 Cuts, Punctures
4 Bruises
5 Limb Rubs
6 Tufted Apple Budmoth
7 Undersized
8 Other
9 Bitter Pit
10 Cork Spot
11 Russeting
12 Hail
13 Chemical Injury
14 Sooty Blotch Fly Speck

Not for Citation

GROWTH REGULATION FOR THE CONTROL OF NECTARINE POX

T. A. Baugher, S. S. Miller, D. W. Leach,
S. Walter, V. L. Crim and J. Eldridge
WVU and USDA-AFRS, Cooperating
Kearneysville, WV 25430

According to the 1987 West Virginia Fruit Tree Survey, there were approximately 200 acres of nectarines grown in the state. Interest in nectarines has increased in recent years.

A disorder which reduces nectarine packout is "nectarine pox", which is characterized by superficial warty outgrowths. The disorder has been observed in other nectarine growing regions in the country, and various causal agents have been suggested, such as virus or low levels of boron. The expression of the disorder follows a trend similar to that of cork spot on apple. It is not observed every year in an orchard but it tends to be most severe when the crop load is light, shoot growth is excessive, and nitrogen, potassium or magnesium levels are excessive and calcium or boron levels are low.

A study was initiated in 1985 in a commercial block of 'Firebrite' nectarines where nectarine pox was present on 20-50% of the fruit in some years. Tissue analyses (foliar and fruit) indicated that the disorder was associated with high levels of nitrogen, potassium and magnesium and low to moderate levels of calcium and boron. Initial studies were established to test the effect of soil-or foliar-applied boron, but nectarine pox was not consistently reduced. Subsequent studies were designed to test the effect of treatments which reduced tree vigor. Treatments were applied to 8 single-tree replicates in a randomized block design. Root pruning was found to significantly reduce the incidence of nectarine pox (Table 1). Percentage red color was significantly increased by all growth regulation treatments. Trunk cross-sectional area was unaffected by treatments; however, shoot length was reduced by growth regulation treatments.

Table 1. Influence of growth regulation treatments on 'Firebrite' color, fruit size and incidence of nectarine pox.

Treatment	Red color (%)[z]	Fruit diameter (cm)[y]	Nectarine pox (%)[x]	Shoot length[w] vertical (cm)	Shoot length[w] horizontal (cm)
Root pruning on two sides of trunk at distance of 90 cm and depth of 25 cm (5/2/89)	79 ab[v]	6.8 a	5.5 a	82 ab	32 a
Root pruning on two sides of trunk at distance of 60 cm and depth of 25 cm (4/19/88)	84 a	6.8 a	4.4 a	87 bc	32 a
Cultar, with handgun to run-off (Applications of 250 ppm on 5/9,24/89 and 6/8,22/89)	80 ab	6.9 a	8.1 ab	78 a	31 a
Girdling 2 weeks prior to pit hardening, "S" cut around each scaffold limb (5/26/89)	76 b	7.0 a	10.8 b	95 c	37 b
Untreated control	70 c	6.9 a	11.5 b	105 d	38 b

[z]Visually estimated on 20 fruit per each of 8 single-tree replicates, day of second harvest picking (7/25/89).

[y]Measured 20 fruit per replicate (7/25/89).

[x]Based on inspection of 100 fruit per replicate (7/25/89).

[w]Measured 10 vertical and 5 horizontal shoots per replicate (11/13/89).

[v]Means, within columns, followed by the same letter are not significantly different according to DMRT, 5% level.

Apple Disease Control Options for the 90's: Getting by with Less

D. A. Rosenberger, F. W. Meyer, and P. J. Jentsch
New York State (Geneva) Agricultural Experiment Station
Hudson Valley Lab, Box 727, Highland, NY 12528

INTRODUCTION: During the past decade, at least 10 apple fungicides have been withdrawn from the market, and legal uses for some of the remaining fungicides have been reduced. Only three new fungicides registered during the past 10 years have proven widely useful for controlling foliar and fruit diseases on apples. Development of new fungicides has slowed because federal and state pesticide policies have increasingly made registration of new compounds economically unfeasible for minor crops. This is especially true for apples because apples are grown on a relatively limited acreage and have high visibility with anti-pesticide activist groups. Biological studies and development of biocontrols may contribute new options for apple disease control in the next century, but they are unlikely to have major impacts in the immediate future.

Apple disease control options for the next decade will most likely be based on fungicides currently registered for use. Thus, it appears likely that we will be forced to get through the 1990's with fewer apple fungicide options than we had in the 1970's and early 1980's. Improvements in disease-control strategies during the next decade will likely depend on refinements in application technology and improved understanding of pest biology and fungicide mode of action. We may need to "re-invent the wheel" and learn how to use some of our older fungicides to best advantage.

Three fungicide trials conducted in the Hudson Valley during 1990 year involved re-evaluations of old or registered fungicides. In the first trial, low rates of Rubigan and Nova were compared to determine what constitutes comparable scab control dosages for these two SI fungicides. In the second trial, we evaluated registered contact fungicides applied with and without Benlate to determine their effectiveness against summer diseases. Summer applications of copper fungicides were evaluated in our third trial.

METHODS: In all trials, sprays were applied to run-off using a handgun with pressure adjusted to approximately 300 psi.

Nova/Rubigan trial: This trial was conducted in a 12-yr-old block of McIntosh, Cortland, and Rome on M.26 rootstock. Treatments were replicated four times in plots containing one tree of each cultivar except that the control was replicated only 3 times. Sprays were applied April 24 (tight cluster), May 3 (bloom), 12 (petal fall), 23, June 6, and 20. Captan was included in all treatments on June 20. Additional sprays of captan or Benlate plus captan were applied on July 4, 26, and August 15, but the summer treatments do not impact on results reported here. April was dry, but major scab infection periods occurred May 4, 10, 13, 16, 21, and 29. Treatments were evaluated by observing all leaves on 25 McIntosh clusters per tree on June 6, 25 terminals per tree on McIntosh June 26 and on Cortland July 5, and 100 fruit per tree from Cortland in mid-September and from Rome in late-September.

Summer fungicide trial: Treatments involving contact fungicides with and without Benlate were replicated four times in 2-tree plots containing a McIntosh and a Golden Delicious. The orchard had a history of severe summer disease problems, was located in a pocket with poor air drainage, and was surrounded by woods on three sides. All plots were sprayed with Nova 40W 1.5 oz/100 gal on April 26, May 7, 18, 31 to control apple scab. Summer fungicide treatments were applied June 8, 30, and July 20. An additional treatment was applied to Golden Delicious only on August 14. Weather during July and August favored disease development. Fruit evaluations were made from 100 McIntosh fruit per tree harvested Sept 4-5 and 100 Golden Delicious fruit harvest Sept 28.

Copper fungicide trial: Experimental copper treatments were replicated six times using 5-tree plots in a 1987 planting of Liberty on M.9 with trees spaced 3 feet by 10 feet. Sprays were applied to run-off using a handgun with pressure adjusted to approximately 300 psi. The experiment was designed with the intention of making two or three applications at monthly intervals beginning either in July or in June. (We assumed treatments initiated in July would be less likely to cause phytotoxicity because fruit would be less sensitive to injury as they matured.) However, fruit injury on all plots was so severe in early August that we eliminated the August treatment in all the previously sprayed plots. Instead a single August application was made in an additional plot that had been previously unsprayed. Fruit evaluations were made following harvest in late-September by evaluating 50 fruit per plot selected at random from the center three trees in each plot.

RESULTS AND DISCUSSION:

Nova/Rubigan trial: The low rates of Rubigan and Nova that we tested are not appropriate for commercial orchards, but the treatments provide useful new information on the comparative effectiveness of these fungicides. Nova 40W applied at 0.5 oz/100 gallons dilute spray was more effective against leaf scab than 1 fl oz of Rubigan, but fruit scab control with these two treatments was comparable (Table 1). The summer decays observed in Cortland were primarily black rot and were adequately controlled only where captan was included in the treatments.

The Rubigan/Captan and Nova/Captan treatments were comparable to commonly used commercial rates and provided excellent control of apple scab. However, we have observed several control failures during the past two years in commercial orchards where Rubigan was applied at 6 fl oz per acre in combination with 3 lb captan per acre. In many cases, the causes of the failures can be attributed to poor coverage due to spraying under windy conditions, spraying alternate rows, or spraying large, poorly pruned trees. Although Rubigan failures can usually be attributed to some kind of applicator misjudgment, the number of problems reported are an indication that 6 fl oz per acre is a marginal rate for Rubigan. Nova is commonly used at 4.5 to 6 oz per acre. If 2 fl oz of Rubigan equal 1 oz of Nova, then the commercial rate of Nova is the equivalent of 9-12 oz per acre of Rubigan. To avoid problems in future years,we believe growers should consider 9 oz per acre of Rubigan to be a minimum rate for orchards where trees are more than 12 feet tall.

Summer fungicide trial: Captan and ferbam (Carbamate) provided better control of sooty blotch and fly speck than did thiram or ziram. Ferbam left a black residue on fruit. On Golden Delicious, the stains from the Ferbam could not be removed by wiping with a damp cloth. Fruit treated with Benlate plus captan, thiram, or ziram generally had less disease than fruit treated with the respective contact fungicide used alone. The Benlate combinations with captan, thiram, and ziram were all comparable, presumably because of the excellent residual activity of Benlate masked the differences noted when the contact fungicides were used alone.

Most fungicide treatments appeared less effective on McIntosh than on Golden Delicious because the Golden Delicious received an extra spray in August. The interval from the last spray to harvest was 45-46 days for both cultivars, but McIntosh fruit were exposed to higher temperatures and relative humidities between the last spray and harvest. These environmental conditions favored rapid development of sooty blotch and fly speck on McIntosh during August.

Copper fungicide trial: All copper treatments caused some injury to fruit. The injury appeared as raised black specks, generally less than 1 mm in diameter, over lenticels on the exposed sides of the fruit. These blackened lenticels were especially evident on green fruit, but the damage became less obvious as fruit turned red. Where only one or a few lenticels were affected, the damage was very difficult to spot on mature fruit. Thus, most consumers would not accept fruit which we rated as severely damaged, but they probably would not have noticed the occasional black lenticel on red fruit.

The low rate of Champ Flowable applied in June and July controlled summer diseases as well as captan applied at the same interval (Table 3). The proportion of fruit with severe injury was much greater for fruit sprayed in June and July than for fruit sprayed only in July (Table 4). Because of our experimental design, we cannot determine if the greater severity of injury noted with copper treatments applied in June and July is attributable to a greater susceptibility of fruit to injury in June or to an additive effect from the two applications. Champ Flowable caused less severe copper injury than Kocide 101 or COCS when all three compounds were applied at comparable rates in mid-July.

No copper sprays are currently labeled for use on apples after petal fall, and the problems with copper injury make summer sprays of copper undesirable for most commercial growers as long as effective alternatives such as captan and benzimidazole fungicides are available.. However, summer sprays of copper would provide an effective means for organic farmers to control summer diseases on apples. More research is needed to determine if injury from copper sprays could be further reduced by applying sprays in low volumes of water with an airblast sprayer. The effect of lenticel injury on storageability of the fruit should also be investigated.

Table 1. Early-season disease control with low rates of Rubigan and Nova.

Materials and rate per 100 gal	% leaves with apple scab: McIntosh cluster lvs.	% leaves with apple scab: terminal leaves McIntosh	% leaves with apple scab: terminal leaves Cortland	% fruit at harvest with scab: Grand mn* for McIntosh, Cortland, & Rome	% fruit at harvest with summer rots Cortland
Control	15.5 d	78.9 e	78.1 d	97.0 f	21.9 d
Captan 50W 1 lb	2.2 c	18.3 d	12.0 c	5.1 bc	2.0 a
Rubigan 1EC 1 fl oz ...	1.4 bc	16.8 d	12.9 c	13.3 e	7.2 bc
Rubigan 1EC 2 fl oz ...	0.7 abc	5.1 c	10.1 c	6.8 cd	6.5 bc
Rubigan 1EC 2 fl oz + Captan 50 W 1 lb.	0.2 ab	0.9 ab	0.1 a	0.1 a	4.7 ab
Nova 40W 0.5 oz	0.3 ab	2.8 bc	2.7 b	11.9 de	10.1 c
Nova 40W 1.0 oz	0.0 a	0.3 a	0.8 ab	2.1 b	10.4 c
Nova 40W 1.5 oz + Captan 50W 1 lb**	0.4 abc	0.4 ab	<0.1 a	<0.1 a	3.2 ab

Mean separations were determined using LSD (P=0.05) if the F-test indicated significant differences existed between treatments. The arcsin transformation was used for statistical analyses. *Grand means are for split-plot analyses of three cultivars. **Captan was not included in the tight cluster (April 24) and pink (May 3) applications.

Table 2. Effectiveness of summer fungicides for controlling sooty blotch and fly speck.

Material and rate per 100 gal	% McIntosh fruit with no disease	% McIntosh fruit with fly speck	% McIntosh fruit with sooty blotch	% Golden Delicious fruit with no disease	% Golden Delicious fruit with fly speck	% Golden Delicious fruit with sooty blotch
Control	0.1 e	92.9 e	88.6 c	0.0 e	100.0 c	100.0 d
Captan 50W 1 lb	64.1 bcd	26.3 cd	14.0 b	92.6 ab	3.1 a	1.9 a
Thiram 75WDG 1 lb.....	51.1 d	37.4 d	16.3 b	72.2 cd	12.5 b	12.8 c
Ziram 75WDG 1 lb	56.8 cd	31.5 d	12.4 ab	61.8 d	23.1 b	18.9 c
Carbamate 75 WDG 1 lb	67.6 bc	16.6 bc	11.4 ab	85.3 bc	3.4 a	10.6 bc
Captan 50W 1 lb +Benlate 50DF 2 oz ...	87.9 a	7.0 a	2.6 a	99.4 a	0.3 a	0.1 a
Thiram 75WDG 1 lb +Benlate 50DF 2 oz ...	83.7 a	10.1 ab	2.4 a	94.1 ab	2.1 a	2.0 ab
Ziram 76WDG 1 lb +Benlate 50DF 2 oz ...	75.2 ab	11.3 ab	7.0 ab	96.5 ab	0.7 a	1.4 a

Mean separations were determined using LSD (P=0.05) if the F-test indicated significant differences existed between treatments. The arcsin transformation was used for statistical analyses.

Table 3. Incidence of fly speck and sooty blotch on Liberty apples sprayed at various times throughout the summer with various formulations and rates of copper.

Material and rate per 100 gal	Spray dates	% clean fruit (no SBFS)	% fruit with fly speck	% fruit with sooty blotch
1. Control		4.8 e	92.2 e	45.5 c
2. Captan 50W 1.5 lb	June 15, July 13	58.0 b	35.7 b	3.1 a
3. Champ Flowable** 3 pt	June 15, July 13	83.7 a	9.7 a	2.8 a
4. Champ Flowable 1.5 pt	June 15, July 13	56.8 b	34.8 b	10.4 b
5. Champ Flowable 3 pt	July 13	61.1 b	28.2 b	10.8 b
6. Champ Flowable 1.5 pt	July 13	41.6 cd	49.1 cd	12.3 b
7. COCS** 9 oz	July 13	39.7 d	52.2 d	15.1 b
8. Kocide 101*** 9 oz	July 13	31.9 d	59.1 d	12.9 b
9. Champ Flowable 1.5 pt	Aug 14	51.5 bc	36.5 bc	12.8 b

Mean separations were determined using LSD (P=0.05) if the F-test indicated significant differences existed between treatments. The arcsin transformation was used for statistical analyses.

*Champ Flowable Copper contains 2.3 lb copper hydroxide per gallon (= 1.5 lb metallic copper).

**COCS contains 50% metallic copper equivalent with copper in the form of basic sulfates and chlorides (9 oz COCS = 1.5 pt Champ Flowable).

***Kocide 101 contains 77% copper hydroxide (= 50% metalic copper equivalent; 9 oz Kocide 101 = 1.5 pint Champ Flowable).

Table 4. Incidence of copper injury on Liberty apples sprayed at various times throughout the summer with various formulations and rates of copper.

Material and rate per 100 gal	Spray dates	% fruit with copper injury* severe	% fruit with copper injury* any visible injury
1. Control		0.0 a	0.0 a
2. Captan 50W 1.5 lb	June 15, July 13	0.0 a	0.0 a
3. Champ Flowable3 pt	June 15, July 13	94.9 d	100.0 d
4. Champ Flowable1.5 pt	June 15, July 13	95.6 d	100.0 d
5. Champ Flowable3 pt	July 13	46.5 c	98.6 c
6. Champ Flowable1.5 pt	July 13	31.0 b	96.1 c
7. COCS 9 oz	July 13	47.2 c	95.9 c
8. Kocide 101 9 oz	July 13	58.3 c	97.8 c
9. Champ Flowable 1.5 pt	Aug 14	25.0 b	63.8 b

*Injury was considered severe if it was immediately evident when fruit were viewed at arm's length. Data for percent fruit with any visible injury includes both fruit with severe injury and fruit with only inconspicuous injury. The latter, fruit with only one or several blackened lenticels, might have been packed as US Extra Fancy whereas severely injury fruit would have been down-graded.

K. D. Hickey, J. May, and G. McGlaughlin
PSU Fruit Research Laboratory
Biglerville, PA 17307-0309

APPLE (*Malus domestica* 'Rome Beauty', 'Golden Delicious', 'Delicious', 'Stayman', 'Cortland')
Apple scab; *Venturia inaequalis*

POST-INFECTION CONTROL OF APPLE SCAB WITH MBI FUNGICIDES, 1990: Sterol demethylation inhibitor fungicides (MBI) were evaluated for post-infection (PI) control of apple scab when applied 72-127 hours following scab infection periods (Mill's modified chart) during the primary scab infection period. Treatments consisting of eight PI applications were compared with treatments receiving the same PI sprays plus a second "follow-up" application which followed 5-7 days after each of the PI applications. The experiment was conducted under heavy disease pressure in a five-year old semi-dwarf orchard. The experimental design was a randomized complete block with four replicates. Experimental plots consisted of one tree of each of five cultivars planted 3 m apart in sequence along the row separated by a 15 m space between plots. Spacing between trees was 9 m which allowed for a minimum of spray drift. The fungicide suspensions were applied to the point of run-off at 5.0 L/tree (935 L/ha). Applications were made with a high pressure sprayer operated at 2758 kPa (400 psi) and equipped with a 7-nozzle boom. The youngest unfolded leaf on each terminal observed was marked at various times forming time zones during which scab infections (L,M,S) occurred and post-infection (PI) applications were applied as follows: 'Stayman' and 'G. Del' - leaves 1-9 - infections on 15-16 Mar (L), 29 Mar-1 Apr (S), 10-11 Apr (L), 14-15 Apr (L), 20 Apr-1 May (S), 3-5 May (S), - post-infection (PI) and additional protective (PI + P) applications were made on 3 Apr (106 hr), 14 Apr (88 hr), 19 Apr (PI + 5 da P), 2 May (72 hr), 9 May (PI + 7 da P); leaves 10-14 - infections on 9-10 May (M), 13 May (M), and 15-16 May (M) - post-infection applications (PI) on 14 May (114 hr) and 19 May (70 hr) and additional protective applications on 19 May (PI + 5 da P) and 24 May (PI + 5 da P); leaves 15-23 - infections on 25 May (M), 8 Jun (S), and 18 Jun (S) - post-infection (PI) applications on 31 May (127 hr), 12 Jun (85 hr), and 22 Jun (82 hr) and additional protective applications on 5 Jun (PI + 5 da P), and 18 Jun (PI + 5 da P); 'Cortland' - similar to 'Stayman' and 'G. Del', except the three counts were as follows: leaves 1-14 (from 15 Mar to 14 May); leaves 15-18 (15 May to 25 May), and leaves 19-24 (26 May to 22 Jun). Incidence of scab infection on leaves was determined by observing all leaves on each marked section of 10 vegetative terminals/single-tree replicate on 30 May-1 Jun (leaves 1-14) and 16 Jul (leaves 15-23). Scab incidence on fruit was determined at harvest by observing 100 fruits/tree (25-30 on 'Del' trees). Data were analyzed by analysis of variance using appropriate transformation and significance among means was determined by the Duncan's Multiple Range Test (P = 0.05).

Scab incidence on the untreated check was high during each of the terminal time zones associated with 3-6 infection periods. Leaf infections on the check among the five cultivars ranged between 58-78% and on fruit between 80-100%. Each of the DMI fungicides provided near complete control of scab when the PI applications were followed by a second application 5-7 days later. Only small differences occur among the treatments receiving only the PI applications, with the exception of Rubigan on 'Del' and 'Stayman'. The results obtained are in agreement with previous results with DMI fungicides when the application interval was no more than 6-8 days. No phytotoxicity to leaves or fruit was observed among the treatments.

1990 PRIMARY APPLE SCAB INFECTIONS AND SPRAY APPLICATIONS TIMED AS POST-INFECTION OR PROTECTIVE SPRAYS ON 'ROME BEAUTY'. PSU FRUIT RESEARCH LAB 5-C NORTH BLOCK.

Fig. 1. 15 March- 4 April, 1990.

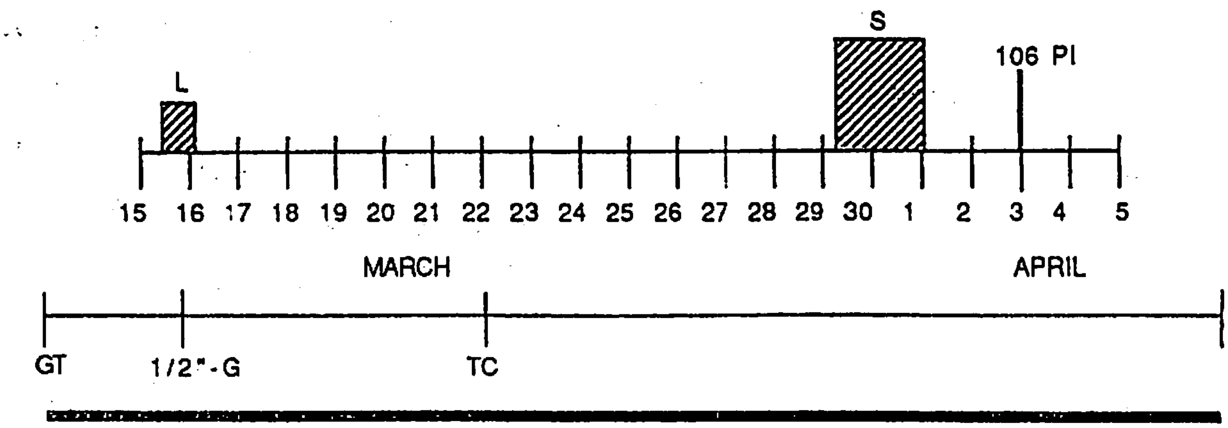


Fig. 2. 5-25 April, 1990.

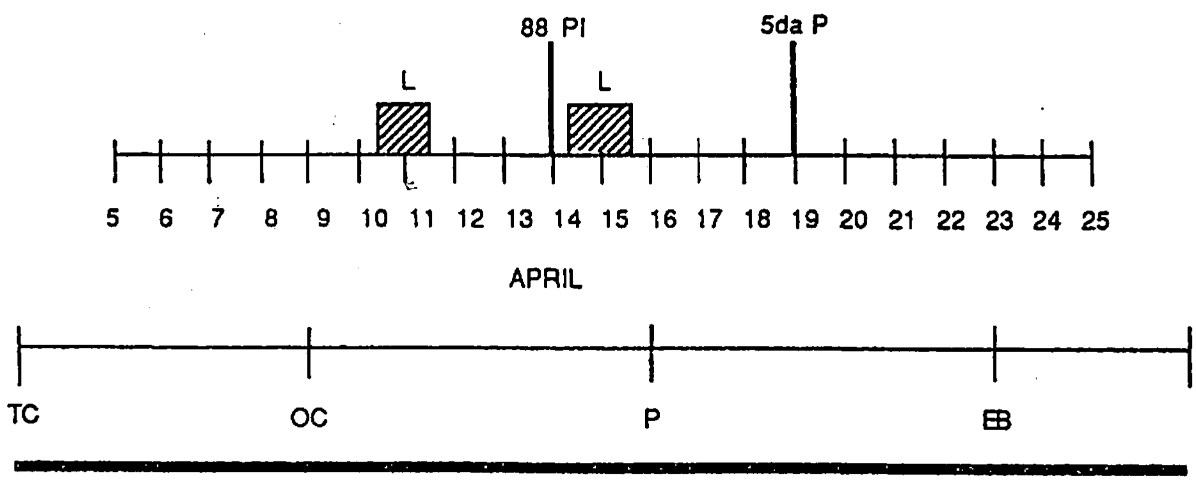


Fig. 3. 26 April- 20 May, 1990.

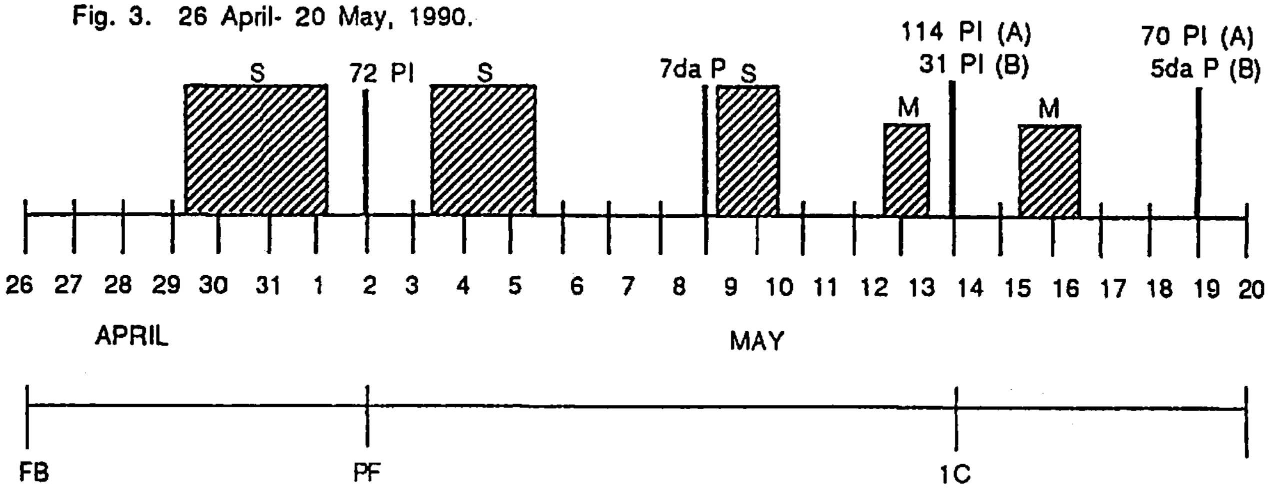


Fig. 4. 21 May- 10 June, 1990.

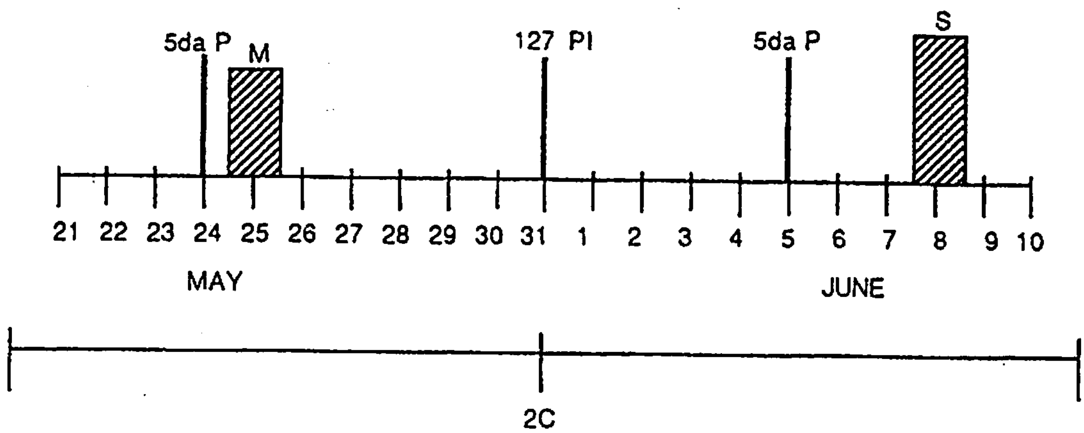


Fig. 5. 11-30 June, 1990.

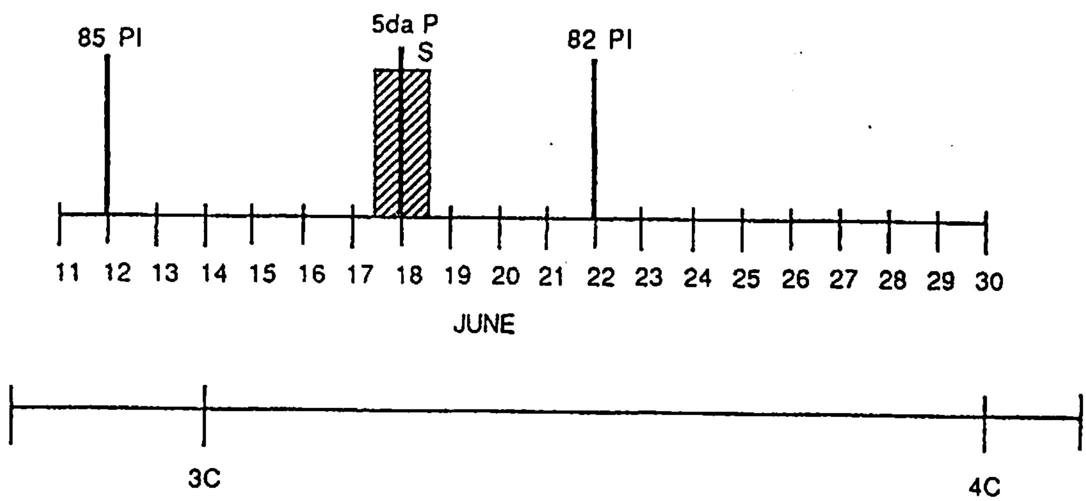


Table 1. Apple Scab Incidence on 'Delicious' and 'Rome Beauty' Treated with Dilute Post-Infection Sprays in 1990. PSU Fruit Research Lab 5-C North.

Fungicide and Rate mg ai/L (Form/100 Gal)	Percent Leaves Infected[1] — Leaf Position on Vegetative Terminal[2]											
	1-10		11-13		14-17		18-20		21-23		1-23	
	PI	PI + P[3]	PI	PI + P[3]	PI	PI + P[3]	PI	PI + P[3]	PI	PI + P[3]	PI	PI+& P[3]
'<u>Delicious</u>'												
1. Elite 45DF 67 (2.0 oz)	0.7cd[4]	0.0b	3.3c	0.0b	3.8bc	0.0b	0.0c	0.0c	3.1cd	1.3b	1.7cd	0.2c
2. Nustar 20DF 15 (1.0 oz)	0.5c	0.0b	3.2c	0.0b	4.8bc	0.0b	6.5b	0.0c	9.6b	2.4b	4.4c	0.4bc
3. Nustar 20DF 60 (2.0 oz)	0.8d	0.0b	0.0d	0.8b	0.0c	0.0b	0.0c	0.0c	0.0d	0.8b	0.3d	0.2c
4. Rubigan 1E 37 (4.0 fl oz)	1.4b	0.3b	12.3b	0.7b	11.0b	1.8b	8.4b	5.6b	21.2b	7.7b	8.6b	2.9b
5. Untreated	58.8a	52.9a	99.2a	93.7a	96.3a	93.8a	82.8a	77.5a	62.4a	63.1a	74.5a	71.6a
'<u>Rome Beauty</u>'												
1. Elite 45DF 67 (2.0 oz)	0.2b	0.0b	0.0c	0.0b	1.4b	0.0b	3.6b	0.0b	0.0b	0.7b	0.8b	0.1b
2. Nustar 20DF 15 (1.0 oz)	0.0b	0.0b	0.0c	0.0b	0.6b	0.0b	2.3b	0.0b	1.9b	0.0b	0.7b	0.0b
3. Nustar 20DF 60 (2.0 oz)	0.0b	0.0b	0.0c	0.0b	0.0b	0.0b	0.0b	0.0b	0.0b	0.0b	0.0b	0.0b
4. Rubigan 1E 37 (4.0 fl oz)	0.2b	0.0b	3.6b	1.1b	0.8b	0.0b	0.0b	0.8b	0.0b	1.3b	0.7b	0.4b
5. Untreated	42.7a	58.9a	95.4a	95.5a	74.8a	84.4a	97.2a	97.9a	92.3a	95.6a	64.6a	73.8a

1 Percent leaves infected was determined by observing all leaves on each marked section of 10 vegetative terminals per single-tree replicate (4 reps) on 30 May-1 Jun (leaves 1-13) and 16 Jul (leaves 14-23).

Additional footnotes - next page

Additional Footnotes 'Delicious' and 'Rome Beauty'

2 The youngest unfolded leaf on each terminal observed was marked at various times forming times zones during which scab infections (L,M,S) occurred and post-infection (PI) applications were applied as follows: leaves 1-10 - infections on 15-16 Mar (L), 29 Mar-1 Apr (S), 10-11 Apr (L), 14-15 Apr (L), 20 Apr-1 May (S), 3-5 May (S), - post-infection (PI) and additional protective (PI + P) applications were made on 3 Apr (106 hr), 14 Apr (88 hr), 19 Apr (PI + 5 da P), 2 May (72 hr), 9 May (PI + 7 da P); leaves 11-13 - infections on 9-10 May (M), 13 May (M), - post-infection (PI) application on 14 May (114 hr) and additional protective application on 19 May (PI + 5 da P); leaves 14-17 - infection on 15-16 May (M) - post infection (PI) applications on 19 May (70 hr) and additional protective application on 24 May (PI + P 5 da); leaves 18-20 - infection on 25 May (M), - post-infection (PI) application on 31 May (127 hr) and additional protective application on 5 Jun (PI + P 5 da); leaves 21-23 - infections on 8 Jun (S) and 18 Jun (S) - post-infection (PI) applications on 12 Jun (85 hr) and 22 Jun (82 hr) and additional protective application on 18 Jun (PI + P 5 da).

3 An application was made to a separate plot of trees at 5-7 days following each post-infection spray.

4 Means within columns followed by the same letter(s) do not differ significantly, DMRT (P = 0.05)

** Not for Publication **

Table 2. Incidence of Apple Scab on Leaves and Fruit of Five Cultivars Treated with Dilute Post-Infection Fungicide Sprays in 1990. PSU Fruit Research Lab 5-C North Block.

Fungicide and Rate mg ai/L (Form/100 Gal)	Percent Apple Scab			
	Terminal Leaves[1]		Fruit[2]	
	PI[3]	PI + P[4]	PI[3]	PI + P[4]
'*Delicious*'				
1. Elite 45DF 67 (2.0 oz)	1.7cd[5]	0.2c	7.7b	0.0c
2. Nustar 20DF 15 (1.0 oz)	4.4c	0.4c	9.9b	0.9c
3. Nustar 20DF 60 (2.0 oz)	0.3d	0.2c	2.3b	0.0c
4. Rubigan 1E 37 (4.0 fl oz)	8.6b	2.9b	5.0b	3.9b
5. Untreated	74.5a	71.6a	96.7a	100.0a
'*Rome Beauty*'				
1. Elite 45DF 67 (2.0 oz)	0.8b	0.1b	6.0b	4.5bc
2. Nustar 20DF 15 (1.0 oz)	0.7b	0.0b	1.0d	2.3cd
3. Nustar 20DF 60 (2.0 oz)	0.0b	0.0b	1.5cd	1.5d
4. Rubigan 1E 37 (4.0 fl oz)	0.4b	0.4b	3.3bc	8.2b
5. Untreated	73.8a	73.8a	80.3a	93.5a
'*Stayman*'				
1. Elite 45DF 67 (2.0 oz)	1.3c	0.7b	7.7bc	3.8bc
2. Nustar 20DF 15 (1.0 oz)	2.1c	0.0b	4.0cd	1.5c
3. Nustar 20DF 60 (2.0 oz)	0.6c	0.2b	1.6d	1.3c
4. Rubigan 1E 37 (4.0 fl oz)	8.8b	0.3b	10.2b	6.3b
5. Untreated	64.4a	70.9a	99.6a	99.4a

Continuation of Table 2 - next page

Table 2 - continued

Fungicide and Rate mg ai/L (Form/100 Gal)	Percent Apple Scab			
	Terminal Leaves[1]		Fruit[2]	
	PI[3]	PI + P[4]	PI[3]	PI + P[4]
'Golden Delicious'				
1. Elite 45DF 67 (2.0 oz)	1.4b	0.4b	1.5c	0.5b
2. Nustar 20DF 15 (1.0 oz)	0.4c	0.1b	1.0c	0.5b
3. Nustar 20DF 60 (2.0 oz)	0.0c	0.0b	0.3c	2.3b
4. Rubigan 1E 37 (4.0 fl oz)	1.1b	0.4b	7.0b	2.0b
5. Untreated	57.5a	67.9a	91.8a	97.0a
'Cortland'				
1. Elite 45DF 67 (2.0 oz)	2.2b	1.6bc	9.0b	2.5b
2. Nustar 20DF 15 (1.0 oz)	0.6b	1.3c	1.8c	2.3b
3. Nustar 20DF 60 (2.0 oz)	1.2b	0.2c	1.8c	1.0b
4. Rubigan 1E 37 (4.0 fl oz)	1.7b	1.8b	7.5b	1.4b
5. Untreated	73.5a	78.0a	92.6a	96.0a

1 Percent leaves infected was determined by observing all leaves on each of 10 vegetative terminals per single-tree replicate (4 reps).

2 Percent fruit infected was determined by observing 100 fruits (Mean 25 and 30 in 'Delicious' Block A (PI) & B (PI + P) and a few trees of other cultivars) per single-tree replicate (4 reps).

3 Data represent seasonal incidence of scab on leaves and fruit on trees treated with 8 post-infection applications timed 70-127 hours after the beginning of scab infection periods between 15 Mar and 18 Jun (12 infection periods, application interval was 10-12 days, except one 5-day interval).

4 Data represent seasonal incidence of scab on leaves and fruit on trees treated with 8 post-infection applications plus additional protective sprays timed 5-7 days after each post-infection application (6 additional protective sprays applied between 14 Apr and 18 Jun.

5 Means within columns followed by the same letter(s) do not differ significantly, DMRT ($P = 0.05$).

K. D. Hickey, J. May and G. McGlaughlin
PSU Fruit Research Laboratory
Biglerville, PA 17307-0309

APPLE (Malus domestica 'Golden Delicious', 'Red Delicious', 'Rome Beauty')
Scab; Venturia inaequalis
Powdery mildew; Podosphaera leucotricha
Cedar-apple rust; Gymnosporangium juniperi-virginianae
Sooty blotch; Gloeodes pomigena
Flyspeck; Zygophiala jamaicensis
Fruit russet

EVALUATION OF PROTECTIVE FUNGICIDES FOR APPLE DISEASE CONTROL, 1990: Protective fungicides used alone or in combination with Rubigan were evaluated for control of early- and late- season diseases of apple. Environmental conditions were highly favorable for disease development, except for powdery mildew, in the test orchard where inoculum levels were moderate to high. The experiment was conducted in a mature block of trees planted 9 X 11 m and well pruned to a height of 4.5 m. Each tree was grafted to each of three cultivars which composed approximately 1/3 of the tree. Treatments were arranged in a randomized complete block design with four single-tree replicates (each with the three cultivars). The fungicide treatments were applied as dilute sprays to the point of run-off using 8.0 L/tree (1720 L/ha). Sprays were applied with a high pressure sprayer operated at 2758 kPa (400 psi) equipped with a 9-nozzle boom. Applications were made on the following dates and phenological tree stages: 9 Apr (1/2" green), 16 Apr (tight-cluster), 27 Apr (bloom), 9 May (petal-fall), first through seventh cover sprays 22 May, 5, 21 Jun, 3, 17, 30 Jul, and 14 Aug, respectively. Standard insecticides necessary for insect and mite control were applied in standard schedules with an airblast sprayer. Disease incidence on leaves and fruit was recorded. The youngest unfolded leaf on each of 10 terminals/single-tree replicate was marked on 22 May and 19 Jun forming two time zones on each terminal as follows: leaves 1-14, 3 Apr-22 May; leaves 15-18, 23 May-19 Jun. Disease incidence on fruit at harvest was recorded by observing 100 fruits/replicate and severity on fruit was determined by observing all lesions on the five most severely infected fruit/tree. Fruit finish on 'Golden Delicious' was determined by the Horsfall Barratt rating scale with units transformed to percent surface affected with russet. The data obtained were subjected to an analysis of variance using an appropriate transformation and the significance between means was determined by the Duncan's Multiple Range Test ($P = 0.05$).

Favorable conditions for scab development occurred with 12 primary apple scab infection periods resulting in 67-73% leaf infection and near 100% fruit infection on untreated checks. Mildew and apple rust incidence was low in this test. Sooty blotch and flyspeck on 'Golden Delicious' fruit was 100% with a moderate severity rating. The protectant fungicides ziram, thiram, captan, and sulfur used alone provided poor control of scab and the summer diseases. Performance against these diseases was not improved by the combination of these fungicides with Rubigan except with the captan/Rubigan combination which was significantly better than other combinations. Scab control with the Nova/Dithane M-45/sulfur standard was poor, probably due to the high disease pressure during the early cover sprays when only the sulfur was used. The Benlate/captan combination used in the fifth, sixth, and seventh cover spray period provided only fair control of sooty blotch and flyspeck, but was significantly better than other treatments except the Rubigan/captan mixture. Sooty blotch severity was low to moderate on all treatments except the Super Six Sulfur treatment. There was no phytotoxicity to leaves or fruit among the treatments.

Table 3. Percent Leaves Infected with Apple Scab, Powdery Mildew, and Apple Rust when Dilute Protective Fungicide Sprays were Applied in 1990. PSU Fruit Research Lab, Grafted Block.

Fungicide and Rate mg ai/L (Form/100 Gal)	Application Timing	Percent scab on leaves — Leaf position on vegetative terminal — Rome Beauty 1-14	Rome Beauty 15-18	Rome Beauty 1-18	G. Del. 1-18	Del. 1-20	% Disease on Rome — P. mildew	A. rust
1. Untreated	---	66.8a*	99.1a	72.6a	66.5a	71.7a	18.7a	23.0a
2. Ziram 76WDG 1820 (2.0 lb)	1/2" G - 7C	31.7b	96.8ab	45.7ab	30.0b	27.8c	16.5a	0.0b
3. Thiram 76WDG 1820 (2.0 lb)	1/2" G - 7C	27.0b	97.5abc	39.4abc	27.4b	18.4cd	14.7a	0.1b
4. Captan 50W 1200 (2.0 lb)	1/2" G - 7C	14.5bc	56.9de	21.8de	24.8bc	6.1f	19.8a	8.5a
5. Super Six Sulfur 52L 1800 (32.0 fl oz) Super Six Sulfur 52L 1350 (24.0 fl oz)	1/2" G - PF 1C - 7C	62.2a	69.4b-e	54.0b-e	54.5a	42.6b	2.4b	19.7a
6. Rubigan 1E 28 (3.0 fl oz) + Super Six Sulfur 52L 900 (16.0 fl oz) Super Six Sulfur 52L 1800 (32.0 fl oz)	 1/2" G -2C 3C - 7C	9.6bc	75.0b-e	24.5b-e	12.6de	16.0de	1.9b	0.4b
7. Rubigan 1E 28 (3.0 fl oz) + Ziram 76WDG 910 (1.0 lb) Ziram 76WDG 1820 (2.0 lb)	 1/2" G - 2C 3C - 7C	6.2c	89.1a-d	24.4b-e	15.8cde	15.1de	4.5b	0.1b
8. Rubigan 1E 28 (3.0 fl oz) + Thiram 76WDG 910 (1.0 lb) Thiram 76WDG 1820 (2.0 lb)	 1'2" G - 2C 3C - 7C	6.2c	66.6de	21.4de	7.9ef	9.6ef	2.0b	0.1b
9. Rubigan 1E 28 (3.0 fl oz) + Captan 50W 600 (1.0 lb) Captan 50W 1200 (2.0 lb)	 1/2" G - 2C 3C - 7C	1.9c	39.7e	9.3e	3.0f	5.4f	3.7b	0.0b
10. Nova 40W 37 (1.25 oz) + Dithane M-45 80W 960 (1.0 lb) Super Six Sulfur 52L 1800 (32.0 fl oz) Benlate 50W 75 (2.0 oz) + Captan 50W 600 (1.0 lb)	 1/2" G - PF 1C - 4C 5C - 7C	5.5c	68.8cde	18.3cde	17.5bcd	11.5def	3.2b	0.1b

* Means within columns followed by the same letter(s) do not differ significantly, DMRT (P = 0.05).

Table 4. **Percent Fruit Infected with Scab, Sooty blotch, and Fly speck and Surface Russeted when Dilute Protective Fungicide Sprays were Applied in 1990. PSU Fruit Research Lab, Grafted Block.**

Fungicide and Rate mg ai/L (Form/100 Gal)	Application Timing	Percent Fruit Infected: Apple Scab 'Rome'	Apple Scab 'G. Del'	Apple Scab 'Del'	S. blotch 'G. Del'	Fly speck 'G. Del'	% Surface Affected: S. blotch	% Surface Affected: Russet
1. Untreated	--	99.5a*	98.0a	99.8a	100.0a	91.5a	54.6a	8.1a
2. Ziram 76WDG 1820 (2.0 lb)	1/2"G-7C	83.5ab	42.3bc	79.1ab	54.3c	38.0de	2.0e	7.4a
3. Thiram 76WDG 1820 (2.0 lb)	1/2"G-7C	84.0ab	51.8bc	83.4a	75.3bc	64.0abc	6.5bcd	7.2a
4. Captan 50W 1200 (2.0 lb)	1/2"G-7C	10.0d	29.8c	58.2b	53.8c	32.0e	8.8bc	6.7a
5. Super Six Sulfur 52L 1800 (32.0 fl oz) Super Six Sulfur 52L 1350 (24.0 fl oz)	1/2"G-PF 1C-7C	94.0a	94.5a	99.3a	100.0a	76.0ab	38.3a	7.4a
6. Rubigan 1E 28 (3.0 fl oz) + Super Six Sulfur 52L 900 (16.0 fl oz) Super Six Sulfur 52L 1800 (32.0 fl oz)	1/2"G-2C 3C-7C	95.0a	57.8ab	95.8a	100.0a	41.0cde	12.9b	8.8a
7. Rubigan 1E 28 (3.0 fl oz) + Ziram 76WDG 910 (1.0 lb) Ziram 76WDG 1820 (2.0 lb)	1/2"G-2C 3C-7C	51.0abc	33.8bc	83.8a	64.0bc	50.5b-e	2.6de	6.5a
8. Rubigan 1E 28 (3.0 fl oz) + Thiram 76WDG 910 (1.0 lb) Thiram 76WDG 1820 (2.0 lb)	1'2"G-2C 3C-7C	45.0abc	16.8d	72.5ab	70.3bc	54.5bcd	4.1cde	6.8a
9. Rubigan 1E 28 (3.0 fl oz) + Captan 50W 600 (1.0 lb) Captan 50W 1200 (2.0 lb)	1/2"G-2C 3C-7C	29.0c	14.0d	39.5c	25.3d	19.0f	2.1e	8.5a
10. Nova 40W 37 (1.25 oz) + Dithane M-45 80W 960 (1.0 lb) Super Six Sulfur 52L 1800 (32.0 fl oz) Benlate 50W 75 (2.0 oz) + Captan 50W 600 (1.0 lb)	1/2"G-PF 1C-4C 5C-7C	37.0bc	46.3bc	80.3ab	22.0d	13.8f	1.5e	9.0a

* Means within columns followed by the same letter(s) do not differ significantly, DMRT (P = 0.05).

K. D. Hickey, J. May, and
G. McGlaughlin
PSU Fruit Research Laboratory
Biglerville, PA 17307-0309

APPLE (Malus domestica 'Rome Beauty')
Apple scab; Venturia inaequalis
Powdery mildew; Podosphaera leucotricha
Cedar apple rust; Gymnosporangium juniperi-virginianae

INCIDENCE OF SCAB, RUST, AND POWDERY MILDEW ON APPLE SPRAYED SEASONALLY WITH CONCENTRATE FUNGICIDE TREATMENTS, 1990: The objective of this test was to evaluate the efficacy of DMI (sterol demethylation inhibitor) fungicides for scab control when used alone in four applications (1/2" green - petal-fall) followed by their combination with Captan in the second and third cover sprays. The experimental orchard used was a mature block of well pruned trees planted 9 X 12 m and pruned to a height of 5 m. Scab inoculum level in the orchard was high and favorable environmental conditions which resulted in 12 primary apple scab infections highly favored scab development. Inoculum level and environmental conditions were only moderately favorable for the development of powdery mildew and cedar apple rust. The fungicide treatments were arranged in a randomized complete block design with four replicates consisting of two-tree plots bordered by untreated rows between parallel plots. The treatments were applied as concentrate sprays at 50 gal/A (467 L/ha) with a commercial orchard airblast sprayer (Metters 36-inch fan) operated at 2.5 mph (4.0 km/hr) and a manifold pressure of 1380 kPa (200 psi). Applications were applied under steel air to low breeze conditions as protective sprays at 9-15 day intervals. Commercially used insecticides were applied separately as needed to maintain control of insects and mites in the orchard. Disease incidence on leaves was determined by observing on 25-26 Jun all leaves on each of two sections of 10 terminals/double-tree replicate. The youngest unfolded leaf on each terminal observed was marked as follows: leaves 1-14, (3 Apr-21 May); leaves 15-21 (22 May-20 Jun). Scab incidence at harvest was determined by observing 50 fruits/tree (100 fruits/replicate). Scab severity on fruit was determined by observing all lesions on the five most severely infected fruit/replicate. Data were analyzed by analysis of variance using appropriate transformations and the Duncan's Multiple Range Test (P = 0.05) for significance among treatments.

Incidence of apple scab on untreated leaves and fruit was 76 and 99%, respectively. Nine apple scab infection periods occurred between 3 Apr (1/2" green) and 21 May (first cover) during which five sprays were applied at 9-14 day intervals. Under these conditions Rubigan 1E used alone at 9.0 oz/A was less effective than when used at 6.0 oz/A in combination with Captan 4.0 lb/A. RH-7592 and Nustar provided excellent control of scab and Nustar was benefited only slightly by the combination with Captan during the early sprays. All treatments provided good control of apple rust. Nova provided significantly better control of mildew than other treatments.

Table 5. Percent Scab, Rust, and Powdery Mildew Infection on 'Rome Beauty' Apple Treated with Concentrate Fungicide Treatments Applied in Complete Sprays with an Airblast Sprayer in 1990.

Fungicide and Rate g ai/ha (Form/A)	Application Timing	Percent terminal leaves infected: Scab on Leaf Position 1-14	15-21	1-21	Apple rust	Powdery mildew	Percent fruit inf. scab
1. Untreated	---	67.0a*	97.9a	76.0a	30.5a	46.9a	98.3a
2. Rubigan 1E 52.5 (6.0 fl oz) + Captan 50W 2241 (4.0 lb)	1/2" G-2C						
Captan 50W 2241 (4.0 lb)	3C-7C	12.0cd	8.6cd	10.9cde	7.5b	25.3bc	2.5cd
3. Rubigan 1E 52.5 (6.0 fl oz) + Ziram 76 WDG 3406 (4.0 lb)	1/2" G-2C						
Ziram 76WDG 3406 (4.0 lb)	3C-7C	16.9bc	59.3b	30.0b	0.4d	26.7b	7.5b
4. Rubigan 1E 79 (9.0 fl oz)	1/2" G-PF						
Rubigan 1E 52.5 (6.0 fl oz) + Captec 4F 1680 (48.0 fl oz)	1C-2C						
Captec 4F 2240 (64.0 fl oz)	3C-7C	23.2b	15.7c	20.8c	6.7b	19.8c	7.5b
5. Nova 40W 126 (4.5 oz)	1/2" G-PF						
Nova 40W 126 (4.5 oz) + Captan 50W 1680 (3.0 lb)	1C-2C						
Captan 50W 2241 (4.0 lb)	3C-7C	17.6bc	9.6cd	15.0cd	0.3d	7.6d	5.5bc
6. RH-7592 2F 105 (6.0 fl oz) + Triton B-1956 (12.0 fl oz)	1/2" G-PF						
RH-7592 2F 105 (6.0 fl oz) + Triton B-1956 (12.0 fl oz) + Captan 50W 1680 (3.0 lb)	1C-3C						
Captan 50W 2241 (4.0 lb)	3C-7C	2.0de	2.7d	2.3e	1.7c	22.3bc	0.8d

Continuation of Table 5 - page 13

Table 5 - continued

Fungicide and Rate g ai/ha (Form/A)	Application Timing	Percent terminal leaves infected: Scab on Leaf Position 1-14	15-21	1-21	Apple Rust	Powdery mildew	Percent fruit inf scab
7. Nustar 20DF 42 (3.0 oz)	1/2" G-PF						
Nustar 20DF 42 (3.0 oz) + Captan 50W 1680 (3.0 lb)	1C-2C						
Captan 50W 2241 (4.0 lb)	3C-7C	0.9e	5.2d	2.2de	2.9c	19.7c	0.8d
8. Nustar 20DF 42 (3.0 oz) + Captan 50W 1680 (3.0 lb)	1/2" G-2C						
Captan 50W 2241 (4.0 lb)	3C-7C	3.9de	4.4d	3.9de	1.3cd	18.8c	0.8d

* Means within columns followed by the same letter(s) do not differ significantly, DMRT (P = 0.05).

K. D. Hickey, J. May, and G. McGlaughlin
PSU Fruit Research Laboratory
Biglerville, Pa 17307-0309

APPLE (*Malus domestica* 'Red Del', G. Del', 'Rome Beauty')
Scab; *Venturia inaequalis*
Powdery mildew; *Podosphaera leucotricha*
Cedar-apple rust; *Gymnosporangium junniperi-virginianae*
Sooty blotch; *Gloeodes pomigena*
Flyspeck; *Zygophiala jamaicensis*
Fruit russet

EFFICACY OF LIME SULFUR SPRAYS FOR CONTROL OF APPLE DISEASES, 1990: Dilute sprays of lime sulfur applied in a single or multi-spray schedule were evaluated for efficacy against early-season and summer diseases of apple. A specific objective was to determine the value of a single-application (full-rate) at half-inch green stage followed by a reduced-rate in two or ten applications on control of sooty blotch and flyspeck. The test was conducted in a block of 15 year-old semi-dwarf trees planted 3 X 11 m and pruned to a height of 3 m. Experimental plots consisted of one tree each of three cultivars planted in sequence along the row (four groups/replicate). The experimental design was a randomized complete block with four replicates. Treatments were applied as dilute sprays to the point of run-off at 8.0 L/tree (2465 L/ha) with a high pressure sprayer equipped with a 9-nozzle boom and operated at 2758 kPa (400 psi). Applications were made on the following dates and phenological tree stages: 26 Mar (1/2" green), 24 Apr (pink), 27 Apr (bloom), 16 May (petal-fall), and first through seventh cover spray on 16, 25 May, 8, 29 Jun, 16, 27 Jul, 10 and 24 Aug, respectively. Incidence of leaf infection with scab, rust, and mildew was recorded on 30 Jul by observing all leaves on 10 vegetative terminals collected from 2 trees/replicated plot. The percent fruit infected was determined by observing at harvest 100 fruits collected from 2 trees/replicate. Fruit finish on 'Golden Del' was determined by the Horsfall-Barratt rating scale with units transformed to percent surface affected with russet. The same method was used to assess the severity of sooty blotch. The data obtained were subjected to an analysis of variance using appropriate transformations and significance among means was determined by the Duncan's Multiple Range Test ($P = 0.05$).

Environmental conditions were highly favorable for disease development with 12 primary scab infection periods occurring between 15 Mar and 18 Jun; two apple rust infection periods on 29 Apr and 16 May; but only limited favorable conditions for mildew after bloom. Incidence of scab, rust, and mildew on leaves of the no fungicide check was severe (86-98%), moderate (35%), and light (26%), respectively. Continued rain periods during the summer favored the development of sooty blotch, flyspeck, and secondary scab on fruit. Lime sulfur applied in 11 seasonal applications provided very poor control of apple scab and sooty blotch, but provided very good control of flyspeck. On leaves, powdery mildew control was moderate to good while rust control was poor. The lime sulfur 5.0 gal/100 gal treatment applied at 1/2" green followed by two applications at pink and early bloom at 1.5 gal/100 gal had no apparent effect on sooty blotch control. Nova plus Captec applied in the first, second, and third cover sprays followed by Benlate in the fourth through seventh cover sprays provided 95% control of sooty blotch and a very low severity rating. Phytotoxicity to leaves caused by lime sulfur was light and consisted of a somewhat lighter green color. Fruit russeting was light but unsightly visible residue was evident on fruit treated throughout the entire season.

Table 6. Incidence of Apple Scab, Apple Rust, and Powdery Mildew on Trees Treated with Dilute Fungicide Applications in 1990. Fruit Research Lab. University Drive Block.

Fungicide and Rate mg ai/L (Form/100 Gal)	Application Timing	Percent Terminal Leaves Diseased[1]				
		Apple Scab			A. rust	P. mildew
		'G. Del'	'Del'	'Rome'	'Rome'	'Rome'
1. Lime Sulfur 29% Sol (5.0 Gal)	1/2"-Green					
Nova 40W 30 (1.0 oz) + Captec 4F 600 (16.0 fl oz)	1C-3C					
Benlate 50DF 100 (2.0 oz)	4C-7C	35.1c[2]	37.6c	60.7c	37.8a	1.4c
2. Lime Sulfur 20% Sol (5.0 Gal)	1/2"-Green					
Lime Sulfur 20% Sol (1.5 Gal)	P, EB	61.0b	77.3b	89.1b	29.4ab	13.2b
3. Lime Sulfur 20% Sol (5.0 Gal)	1/2"-Green					
Lime Sulfur 20% Sol (1.5 Gal)	P, B, PF, 1C-7C	31.6c	33.0c	67.7c	23.2b	10.8b
4. Untreated	--	86.1a	92.8a	97.8a	35.1a	25.8a

[1] Percent leaves infected was determined by observing on 30 Jul all leaves on 10 vegetative terminals per double-tree replicate (4 reps) per treatment.

[2] Means within columns followed by the same letter(s) do not differ significantly, DMRT (P= 0.05).

Table 6. Incidence of Apple Scab, Sooty blotch, Fly speck, and Fruit russet on Trees Treated with Dilute Fungicide Applications in 1990. Fruit Research Lab. University Drive Block.

Fungicide and Rate mg ai/L (Form/100 Gal)	Application Timing	Percent Fruit Infected					% Surface Affected
		Apple Scab			S. blotch	Fly speck	
		'Del'	'Rome'	'G. Del'	'G. Del'	'G. Del'	Russet
1. Lime Sulfur 29% Sol (5.0 Gal)	1/2"-Green						
Nova 40W 30 (1.0 oz) + Captec 4F 600 (16.0 fl oz)	1C-3C						
Benlate 50DF 100 (2.0 oz)	4C-7C	68.5c	26.3b	32.0c	4.8c	4.8b	7.5a
2. Lime Sulfur 20% Sol (5.0 Gal)	1/2"-Green						
Lime Sulfur 20% Sol (1.5 Gal)	P, EB	100.0a	97.0a	97.3a	99.8a	81.8a	5.8a
3. Lime Sulfur 20% Sol (5.0 Gal)	1/2"-Green						
Lime Sulfur 20% Sol (1.5 Gal)	P, B, PF, 1C-7C	82.5b	36.8b	47.3b	63.8b	4.5b	6.1a
4. Untreated	--	99.0a	97.5a	100.0a	100.0a	87.3a	5.8a

1 Percent fruit infected was determined by observing at harvest time 100 fruits per double-tree replicate (4 reps) per treatment.

2 Means within columns followed by the same letter(s) do not differ significantly, DMRT (P= 0.05).

K. D. Hickey, J. May, and G. McGlaughlin
PSU Fruit Research Laboratory
Biglerville, PA 17307-0309

APPLE (Malus domestica 'Rome Beauty','Golden Delicious', 'Red Delicious')
Scab; Venturia inaequalis
Cedar-apple rust; Gymnosporangium juniperi-virginianae
Sooty blotch; Gloeodes pomigena
Flyspeck; Zygophiala jamaicensis
Powdery mildew; Podosphaera leucotricha
Fruit russet

EFFICACY OF EXPERIMENTAL FUNGICIDES FOR CONTROL OF APPLE DISEASES, 1990: Experimental fungicides applied as dilute protective sprays were evaluated for control of five apple diseases. The test block used was a mature block of semi-dwarf trees planted 9 X 11 m and pruned to a height of 4 m. Each plot consisted of three trees, one of each cultivar, planted in a group at each tree site. The fungicide treatments were arranged in a randomized complete block design with four replicates for each cultivar. The inoculum level for apple scab was high from heavy infections which occurred in 1989. Inoculum of the cedar rust fungus in the form of 3-4 cedar apple galls was placed in wire baskets 30 cm above the center of each group of trees on 29 Apr and 16 May. Environmental conditions were highly favorable for development of all of the diseases except powdery mildew which was moderate to light. The fungicide treatments were applied as dilute sprays to the point of "complete wetness" with a high pressure sprayer operated at 2758 kPa (400 psi) equipped with a 9-nozzle boom which delivered 8.0 L/tree (2457 L/ha). Applications were made at 9-12 day intervals from 1/2"-green through second cover and at 14-day intervals during the summer. Dates of applications and phenological stages were as follows: 2 Apr (1/2"-green), 14 Apr (open-cluster), 23 Apr (pink), 27 Apr (full-bloom), 2 May (late-bloom), 12 May (petal-fall), first through the seventh cover spray on 7, 21 Jun, 5, 19, 30 Jul, and 16 Aug, respectively. Fungicide performance during specific times during the early season was determined by marking the youngest unfolded leaf on each terminal observed forming two time zones on each terminal as follows: leaves 1-11, 2 Apr-23 May; leaves 12-21, 24 May-4 Jun. Disease incidence on leaves during these periods was recorded by observing all leaves on each marked terminal on 4 Jun (leaves 1-11) and 20 Jul (leaves 12-21). Incidence of scab, sooty blotch, and flyspeck on fruit was determined at harvest by observing 100 fruit/replicate (each of three cultivars). Fruit finish and sooty blotch severity on 'Golden Delicious' was determined by the Horsfall-Barratt rating scale with units transformed to percent surface affected with russet. The data obtained were analyzed by analysis of variance using appropriate transformations and significance between means was determined by the Duncan's Multiple Range test (P = 0.05).

Apple scab incidence was severe resulting from 12 primary infection periods. Five apple rust infection periods in May resulted in 34% leaf infection on the untreated check of 'Rome Beauty'. Continued rain during the summer months also highly favored the development of sooty blotch and flyspeck. Nova 40W used alone from 1/2"-green through petal-fall followed by its combination with Captan 50W in the first and second cover sprays then followed by the combination of Captan 50W plus Benlate 50DF in the third through seventh cover sprays served as a standard and provided very good control of scab, rust, and mildew, but only fair control of sooty blotch and flyspeck. Captan 50W 2.0 lb/100 gal also served as a standard for protective type fungicides and provided fair control of scab, sooty blotch, and flyspeck. ASC 66811 and SN 597265 are MBI fungicides which provided very good control of scab, rust, and mildew. The lower rate of ASC 66811 was somewhat weaker against scab on fruit. These compounds provided some control of sooty blotch and flyspeck with SN 597265 providing better control and each performed better at the higher rate. MON-18833 is a new protective type fungicide which provided scab control equal to the Captan standard but inferior to the Nova standard. It was not effective against powdery mildew or cedar apple rust. Its performance against sooty blotch and flyspeck was fair to poor, similar to the Captan standard. Ziram F-4 provided poor control of scab, moderate control of apple rust, and poor to fair control of sooty blotch and flyspeck. The combination of Ziram plus microthiol sulfur performed about the same or slightly better than Ziram alone. The microthiol used alone (Ziram substituted in the pre-bloom sprays) provided only fair to poor control of the diseases present except mildew which was well controlled. Phytotoxicity to leaves was not observed for any of the fungicide treatments and only small differences was apparent in fruit russet ratings.

Table 8. Percent Leaves Infected with Apple Scab, Apple Rust, and Powdery Mildew on Apple Trees Sprayed with Fungicide Treatments Applied as Protectants in 1990. PSU Fruit Research Lab. 3-C Block.

Fungicide and Rate mg ai/L (Form/100 Gal)	Application Timing	Percent scab on leaves: Leaf position on vegetative terminals: 'Rome Beauty' 1-11	'Rome Beauty' 12-21	'Rome Beauty' 1-21	'G. Del.' 1-20	'Del.' 1-23	Percent Disease 'Rome': P. mildew	'Rome' A. rust
Untreated	--	35.6a**	100.0a	66.2a	60.3a	60.8a	27.5a	34.4a
Nova 40W 52 (1.75 oz)	1/2"G - PF							
Nova 40W 37 (1.25 oz) + Captan 50W 600 (16.0 oz)	1C - 2C							
Captan 50W 600 (16.0 oz) + Benlate 50DF 75 (2.0 oz)	3C - 7C	0.5d	16.2efg	8.4de	1.2f	0.9g	3.8def	0.0d
Captan 50W 1200 (2.0 lb)	1/2"G - 7C	6.4bc	43.0cde	23.0c	7.5de	5.4ef	27.9a	2.0d
ASC 66811 10%EC 16.0 (2.0 fl oz)	1/2"G - 7C	1.4cd	35.1def	17.3cd	2.3f	2.0fg	0.1h	0.0d
ASC 66811 10%EC 27.0 (3.5 fl oz)	1/2"G - 7C	0.0d	20.9efg	10.4de	1.3f	0.6g	1.2fgh	0.0d
SN 597265 25W 37 (2.0 oz)	1/2"G - 7C	0.3d	9.2fg	4.8ef	4.0ef	1.5fg	1.0fgh	0.0d
SN 597265 25W 75 (4.0 oz)	1/2"G - 7C	0.0d	1.6g	0.8f	2.1f	1.9fg	0.6gh	0.0d
MON-18833 40W 180 (6.0 oz)	1/2"G - 7C	4.3bcd	52.0bcd	18.6cd	8.5de	11.6de	9.0cd	17.8bc
MON-18833 40W 240 (8.0 oz)	1/2"G - 7C	11.0bc	25.4ef	17.8cd	9.3de	16.1d	18.3ab	27.1a
Ziram F-4 1198 (32.0 fl oz)	1/2"G - 7C	16.4b	79.5b	47.7b	19.7c	48.3ab	21.7ab	10.2c
Microthiol 80DF 1438 (1.5 lb)* + Ziram F-4 1198 (32.0 fl oz)	1/2"G - 7C	16.4b	70.6bc	44.4b	23.9c	34.4c	15.3bc	8.9c
Microthiol 80DF 2996 (2.5 lb)*	Bloom - 7C	16.2b	77.1b	46.0b	38.1b	47.4b	7.0de	24.5ab

* First applied in bloom on 27 Apr. Sprayed with Ziram F-4 32.0 fl oz on 2, 14, and 23 Apr.
** Means within columns followed by the same letter(s) do not differ significantly, DMRT (P= 0.05)

Table 9. Percent Fruit Infected with Apple scab, Sooty blotch, and Fly speck and Surface Russeted on Apple Trees Sprayed with Fungicide Treatments Applied as Protectants in 1990. PSU Fruit Research Lab. 3-C Block.

Fungicide and Rate mg ai/L (Form/100 Gal)	Application Timing	Percent Fruit Infected: Apple Scab 'Del'	Apple Scab 'Rome'	Apple Scab 'G. Del'	S. blotch 'G. Del'	F. speck 'G. Del'	% Surface Affected: S. blotch	% Surface Affected: Russet
Untreated	--	99.0a**	99.5a	98.3a	100.0a	95.5a	91.8a	11.8ab
Nova 40W 52 (1.75 oz)	1/2"G - PF							
Nova 40W 37 (1.25 oz) + Captan 50W 600 (16.0 oz)	1C - 2C							
Captan 50W 600 (16.0 oz) + Benlate 50DF 75 (2.0 oz)	3C - 7C	2.8de	3.3de	1.8d	26.3cd	15.8de	0.7d	8.8ab
Captan 50W 1200 (2.0 lb)	1/2"G - 7C	12.0cde	2.3de	0.5d	68.8b	32.0bcd	4.1d	7.2b
ASC 66811 10%EC 16.0 (2.0 fl oz)	1/2"G - 7C	13.0cde	18.3bc	5.3d	99.5a	54.3b	34.4b	9.0ab
ASC 66811 10%EC 27.0 (3.5 fl oz)	1/2"G - 7C	8.8cde	6.8cde	2.0d	86.8ab	32.0bcd	36.7b	13.0ab
SN 597265 25W 37 (2.0 oz)	1/2"G - 7C	3.5de	0.5e	0.5d	42.3c	13.0de	2.6d	7.5b
SN 597265 25W 75 (4.0 oz)	1/2"G - 7C	0.3e	0.8e	0.3d	11.5d	3.0e	0.6d	9.7ab
MON-18833 40W 180 (6.0 oz)	1/2"G - 7C	21.0c	12.5cd	6.8cd	76.8ab	26.5cd	29.7bc	10.7ab
MON-18833 40W 240 (8.0 oz)	1/2"G - 7C	14.3cd	7.8cde	1.5d	41.0c	15.0de	4.1d	8.7ab
Ziram F-4 1198 (32.0 fl oz)	1/2"G - 7C	61.8b	29.5b	17.5c	69.5b	41.3bc	2.4d	13.5a
Microthiol 80DF 1438 (1.5 lb)* + Ziram F-4 1198 (32.0 fl oz)	1/2"G - 7C	46.0b	33.5b	8.0cd	71.5b	31.0bcd	3.5d	9.6ab
Microthiol 80DF 2996 (2.5 lb)*	Bloom - 7C	86.8a	39.8b	46.8b	99.3a	49.8bc	39.6b	10.5ab

* First applied in bloom on 27 Apr. Sprayed with Ziram F-4 32.0 fl oz on 2, 14, and 23 Apr.

** Means within columns followed by the same letter(s) do not differ significantly, DMRT (P = 0.05).

K. D. Hickey, J. May, and G. McGlaughlin
PSU Fruit Research Laboratory
Biglerville, PA 17307-0309

APPLE (Malus domestica 'Golden Delicious'
Sooty blotch; Gloeodes pomigena
Fly speck; Zygophiala jamaicensis
Fruit Russet

SOOTY BLOTCH AND FLY SPECK INCIDENCE ON APPLE TREATED WITH VARIOUS FUNGICIDE SPRAY PROGRAMS, 1990: The efficacy of various fungicide spray programs applied with a commercial airblast sprayer for control of sooty blotch and flyspeck was measured in a semi-dwarf experimental orchard. The orchard consisted of 10 one-half acre plots of five tree-training systems (two replicates of each system) each randomly planted in a completely randomized experimental design. Fungicide treatments were applied to each tree plot and were not replicated. The trees were well-pruned and the orchard floor vegetation well-managed. The major objectives were: 1) to determine the efficacy of a single spray of copper or lime-sulphur applied at the half-green stage on incidence of sooty blotch and flyspeck, presumably initiated from inoculum on the tree; 2) to determine the protectiveness of captan, thiram, or ziram applied during the summer cover sprays against these diseases. The treatments were applied as concentrate sprays at 50 gal/A (467 L/ha) with a commercial orchard airblast sprayer (Metters 36-inch fan) operated at 2.5 mph (4.0 km/hr) and a manifold pressure of 200 psi (1,380 kPa). Nozzle output was adjusted for differences in tree row spacing among the half-acre plots to provide for equal amounts of spray volume per acre. To allow for direct comparisons of specific treatments (copper vs lime sulfur, etc.) blocks of the same tree training system and spacing were selected. Applications were applied under calm air to low breeze conditions at 13-16 day intervals during the summer cover sprays. Insecticides were applied separately as needed to maintain control of insects and mites in the orchard. Sooty blotch and flyspeck incidence and severity was determined at harvest on 2 Oct (49 days after the last fungicide application) by observing 200 fruits collected from 10 trees throughout each of the sprayed plots. Sooty blotch severity and fruit russeting was determined on each of 20 fruits/treated plot by the Horsfall-Barratt rating scale with units transformed to percent surface affected.

Incidence of sooty blotch and flyspeck was 98% and 54%, respectively on the untreated check. Fungicide spray programs applied at 7-13 day intervals between half-inch green and second cover sprays had little effect on the control of sooty blotch and flyspeck. Except for the Rubigan plus Polyram/Captec treatment, disease incidence among these treatments was similar to the untreated check. The Rubigan combination treatment provided 54% and 73% control of sooty blotch and flyspeck, while the Nova combination provided only 17% and 30% control of these diseases, respectively. Captan, thiram, and ziram treatments applied from the third through the seventh cover sprays at 13-16 day intervals gave fair to good control of both diseases. Ziram was somewhat less effective while Captan and thiram were near equal in their performance. Sooty blotch severity in the test orchard was rated low with only 9% of the surface affected on the untreated check. About 5% of the surface was affected on fungicide treatments which allowed high incidence, while on fruit receiving effective treatments the severity was limited to a few lesions per infected fruit. There was no observable phytotoxicity to leaves and fruit russeting was about equal among treatments.

Table 10. Sooty blotch and Flyspeck on 'Golden Delicious' Apple Treated Seasonally with Fungicides Applied Concentrate in 1990. PSU Fruit Research Lab, USDA Block.

Fungicide and Amt g ai/ha (Formulation/A)	Application Timing	Percent Fruit Infected: Sooty blotch Incidence	Sooty blotch Surface Affected	Flyspeck
1. Untreated	---	97.5	9.4	54.0
2. Rubigan 1EC 52.5 (6.0 fl oz) + Polyram 80W 2689 (3.0 lb) Captec 4F 1400 (40.0 fl oz)	1/2"G-PF 1C, 2C	45.0	0.5	14.5
3. Nova 40W 112 (4.0 oz) + Polyram 80W 2689 (3.0 lb) Captec 4F 1400 (40.0 fl oz)	1/2"G-PF 1C, 2C	81.0	4.7	38.0
4. Kocide 101 77W 5602 (10.0 lb) Rubigan 1EC 52.5 (6.0 fl oz) + Polyram 80W 2689 (3.0 lb) Captec 4F 1400 (40.0 fl oz)	1/2"-G P,B,PF 1C,2C	81.5	4.7	53.5
5. Lime Sulfur 29% Sol 13 Kg (5.0 gal) Rubigan 1EC 52.5 (6.0 fl oz) + Polyram 80W 2689 (3.0 lb) Captec 4F 1400 (40.0 fl oz)	1/2"-G P,B,PF 1C,2C	94.0	4.7	55.0
6. Kocide 101 77W 5602 (10.0 lb) Rubigan + Polyram/Captec* Captan 50W 1681 (3.0 lb) Captan 50W 2241 (4.0 lb)	1/2"-G P-2C 3C,4C,5C 6C,7C	11.0	0.2	2.0
7. Kocide 101 77W 5602 (10.0 lb) Rubigan + Polyram/Captec* Thiram 76WDG 2555 (3.0 lb) Thiram 76WDG 3406 (4.0 lb)	1/2"-G P-2C 3C,4C,5C 6C,7C	6.0	0.2	1.5
8. Kocide 101 77W 5602 (10.0 lb) Rubigan + Polyram/Captec* Ziram 76WDG 2555 (3.0 lb) Ziram 76WDG 3406 (4.0 lb)	1/2"-G P-2C 3C,4C,5C 6C,7C	17.5	0.5	13.0
9. Lime Sulfur 29% Sol 13 Kg (5.0 gal) Rubigan + Polyram/Captec* Captan 50W 1681 (3.0 lb) Captan 50W 2241 (4.0 lb)	1/2"-G P-2C 3C,4C,5C 6C,7C	0.0	0.0	0.0
10. Lime Sulfur 29% Sol 13 Kg (5.0 gal) Rubigan + Polyram/Captec* Thiram 76WDG 2555 (3.0 lb) Thiram 76WDG 3406 (4.0 lb)	1/2"-G P-2C 3C,4C,5C 6C,7C	4.0	0.1	1.0
11. Lime Sulfur 29% Sol 13 Kg (5.0 gal) Rubigan + Polyram/Captec* Ziram 76WDG 2555 (3.0 lb) Ziram 76WDG 3406 (4.0 lb)	1/2"-G P-2C 3C,4C,5C 6C,7C	17.0	0.5	5.0

* Applied combination of Rubigan 1EC 6.0 fl oz + Polyram 80W 3.0 lb/A at pink, bloom, and petal-fall stages; Rubigan 1EC 6.0 fl oz + Captec 4F 40 fl oz at first and second cover sprays.

K. D. Hickey, J. May, and G. McGlaughlin
PSU Fruit Research Lab
Biglerville, PA 17307-0309

APPLE (Malus domestica 'Golden Delicious', 'Nittany', 'York Imperial' and 'Rome Beauty')
Scab; Venturia inaequalis
Sooty Blotch; Gloeodes pomigena
Flyspeck; Zygophiala jamaicensis

COMPARISON OF EARLY- AND FULL-SEASON SPRAY PROGRAMS ON INCIDENCE OF APPLE SCAB, SOOTY BLOTCH, AND FLYSPECK, 1990: The fungicide spray programs were evaluated in a 10-year old well-pruned and managed experimental orchard. Trees were grown on MM106 rootstock, planted at 5 X 8 m, pruned to a height of 3 m, and consisted of Golden Delicious, York Imperial, Nittany, and Rome Beauty cultivars. The experimental design was a randomized complete block with four replicates. Each plot consisted of six trees of the same cultivar planted consecutively in each replicated block. The fungicide treatments were each applied to a single-tree on either side of two untreated trees located in the center of each plot. Applications were made as dilute sprays to the point of "complete wetness" using 8.0 L/tree (1,720 L/ha). Sprays were applied with a high pressure sprayer operated at 400 psi (2,758 kPa) equipped with a 9-nozzle boom. Applications were made on the following dates and phenological stages: 22 Mar, 1/2"-green (G. Del); 9 Apr, 1/2"-green (York, Nittany, Rome), tight-cluster (G. Del); 26 Apr, early-bloom; 16 May, petal-fall; 23 May, first cover; 6 Jun, second cover; 19 Jun, third cover; 2 Aug, sixth cover; and 15 Aug, seventh cover. Insecticides were applied separately with an airblast sprayer as needed to maintain control of insects and mites. Disease incidence on fruit at harvest (27 Sep, G. Del and 24-27 Oct, Nittany, Rome, York) was recorded by observing 100 fruit/replicated tree and scab severity on fruit was determined by observing all lesions on the five most severely infected fruits/sample. Sooty blotch severity and fruit finish on 'G. Delicious' was determined by the Horsfall-Barratt rating scale with units transformed to percent surface affected. Severity on other cultivars was made using a 1-5 scale with each increment equaling 20% of surface affected. The data were subjected to an analysis of variance using an appropriate transformation and the significance between means was determined by the Duncan's Multiple Range Test (P = 0.05).

Disease development was highly favored by moderate to high rainfall during the entire growing season. Frequent rain periods during the spring resulted in 12 primary apple scab infection periods. Above normal rainfall in Aug and Sep was favorable for the development of sooty blotch and flyspeck. Scab incidence on untreated fruit of the four cultivars ranged between 94% and 99% infected; sooty blotch between 73% and 99%; and flyspeck between 50% and 79%. All fungicide treatments allowed some scab development on fruit (5%-20%) but differences were small and generally not significant. Four moderate (1) to severe (3) infection periods between bloom and first cover, a 20-day interval when no applications were applied, probably contributed significantly to the amount of scab present on treated fruit. Spray programs containing copper or lime sulfur in the half-inch green spray followed by five applications of Nova plus Captec in the tight-cluster through third cover period, then followed by either a combination of Captec plus Benlate or Benlate alone in the sixth and seventh cover sprays gave excellent control of sooty blotch and very good control of flyspeck. There was 3% to 7% more flyspeck on 'Nittany' and 'York' than on 'Rome' or 'Golden Delicious' on trees treated full-season, but no apparent difference in sooty blotch incidence among these cultivars. The early season sprays applied through the third cover and containing copper and lime sulfur had little affect on flyspeck incidence. Control of sooty blotch with these treatments were poor, but was significantly better than the untreated on 'Rome', 'York', and 'Nittany'. Treatments containing lime sulfur was not significantly better than Kocide 101 except on 'Rome Beauty'. In this experiment sprays were omitted between 19 Jun and 2 Aug (44 day interval) because of low rainfall which measured 4.7 inches (4.4 between 10-22 Jul) resulting mostly from heavy thunder showers. This omission of sprays presumably had little effect on sooty blotch and flyspeck incidence during this period as evidence by very good to excellent control by treatments applied during the last two cover sprays. Sooty blotch severity was light in all treatments including the untreated check. There was no apparent effect on fruit russet or finish by any of the treatments.

Table 11. Incidence of Scab, Sooty blotch and Flyspeck on 'Golden Delicious' Apple Treated With Fungicide Spray Programs in 1990. PSU Fruit Res. Lab. 8-C Block.

Fungicide and Rate mg ai/L (Formulation/100 gal)	Applic. Timing	% Fruit Infected or Surface Affected: Sooty blotch Inc.	Sooty blotch Sev.	Fly-speck	Apple Scab Inc.	Apple Scab Lesions/ fruit
1) Untreated	--	98.5a*	30.0a	76.5a	99.3a	50.0a
2) Lime Sulfur 29% Sol 14.5 g (5.0 gal)	1/2"-G					
Nova 40W 15 (0.5 oz) + Captac 4F 600 (16.0 fl oz)	TC-3C	84.5a	15.0a	68.0a	13.5b	7.7b
3) Kocide 101 77W 2768 (3.0 lb)	1/2"-G					
Nova 40W 15 (0.5 oz) + Captec 4F 600 (16.0 fl oz)	TC-3C	83.3a	7.0b	62.3a	8.8b	3.4b
4) Lime Sulfur 29% Sol 14.5g (5.0 gal)	1/2"-G					
Nova 40W 15 (0.5 oz) + Captec 4F 600 (16.0 fl oz)	TC-3C					
Captec 4F 600 (16.0 fl oz) + Benlate 5CW 150 (4.0 oz)	6C,7C	0.3b	0.0b	1.3b	10.3b	8.8b
5) Kocide 101 77W 2768 (3.0 lb)	1/2"-G					
Nova 40W 15 (0.5 oz) + Captec 4F 600 (16.0 fl oz)	TC-3C					
Benlate 50W 300 (8.0 oz)	6C,7C	1.8b	0.0b	1.8b	5.5b	3.8b

Table 12. Incidence of Scab, Sooty blotch and Flyspeck on 'Rome Beauty' Apple Treated With Fungicide Spray Programs in 1990. PSU Fruit Res. Lab. 8-C Block.

Fungicide and Rate mg ai/L (Formulation/100 gal)	Applic. Timing	% Fruit Infected or Surface Affected: Sooty blotch Inc.	Sooty blotch Sev.	Fly-speck	Apple Scab Inc.	Apple Scab Lesions/ fruit
1) Untreated	--	73.3a	40.0a	50.3a	97.8a	50.0a
2) Lime Sulfur 29% Sol 14.5 g (5.0 gal)	1/2"-G					
Nova 40W 15 (0.5 oz) + Captac 4F 600 (16.0 fl oz)	TC-3C	22.5c	20.0b	26.8b	9.8b	9.1b
3) Kocide 101 77W 2768 (3.0 lb)	1/2"-G					
Nova 40W 15 (0.5 oz) + Captec 4F 500 (16.0 fl oz)	TC-3C	52.8b	25.0b	42.5a	13.3b	8.9b
4) Lime Sulfur 29% Sol 14.5g (5.0 gal)	1/2"-G					
Nova 40W 15 (0.5 oz) + Captec 4F 600 (16.0 fl oz)	TC-3C					
Captec 4F 600 (16.0 fl oz) + Benlate 50W 150 (4.0 oz)	6C,7C	0.0d	0.0c	1.5c	7.8b	16.1b
5) Kocide 101 77W 2768 (3.0 lb)	1/2"-G					
Nova 40W 15 (0.5 oz) + Captec 4F 600 (16.0 fl oz)	TC-3C					
Benlate 50W 300 (8.0 oz)	6C,7C	0.0d	0.0c	0.3c	8.8b	6.0b

* Means within columns followed by the same letter(s) do not differ significantly, (DMRT, P=0.05).

Table 13. Incidence of Scab, Sooty blotch and Flyspeck on 'York Imperial' Apple Treated With Fungicide Spray Programs in 1990. PSU Fruit Res. Lab. 8-C Block.

Fungicide and Rate mg ai/L (Formulation/100 gal)	Applic. Timing	% Fruit Infected or Surface Affected: Sooty blotch Inc.	Sooty blotch Sev.	Fly-speck	Apple Scab Inc.	Apple Scab Lesions/fruit
1) Untreated	--	81.8a	30.0a	78.5a	97.0a	50.0a
2) Lime Sulfur 29% Sol 14.5 g (5.0 gal)	1/2"-G					
Nova 40W 15 (0.5 oz) + Captac 4F 600 (16.0 fl oz)	TC-3C	49.5b	20.0ab	62.5a	4.5c	2.0c
3) Kocide 101 77W 2768 (3.0 lb)	1/2"-G					
Nova 40W 15 (0.5 oz) + Captec 4F 600 (16.0 fl oz)	TC-3C	61.8b	20.0ab	78.5a	14.3b	6.7b
4) Lime Sulfur 29% Sol 14.5g (5.0 gal)	1/2"-G					
Nova 40W 15 (0.5 oz) + Captec 4F 600 (16.0 fl oz)	TC-3C					
Captec 4F 600 (16.0 fl oz) + Benlate 50W 150 (4.0 oz)	6C,7C	1.5c	10.0c	9.5b	10.5b	4.6bc
5) Kocide 101 77W 2768 (3.0 lb)	1/2"-G					
Nova 40W 15 (0.5 oz) + Captec 4F 600 (16.0 fl oz)	TC-3C					
Benlate 50W 300 (8.0 oz)	6C,7C	2.5c	15.0c	4.8b	11.8b	6.5b

Table 14. Incidence of Scab, Sooty blotch and Flyspeck on 'Nittany' Apple Treated With Fungicide Spray Programs in 1990. PSU Fruit Res. 8-C Block.

Fungicide and Rate mg ai/L (Formulation/100 gal)	Applic. Timing	% Fruit Infected or Surface Affected: Sooty blotch Inc.	Sooty blotch Sev.	Fly-speck	Apple Scab Inc.	Apple Scab Lesions/fruit
1) Untreated	--	89.8a	20.0a	78.3a	94.0a	50.0a
2) Lime Sulfur 29% Sol 14.5 g (5.0 gal)	1/2"-G					
Nova 40W 15 (0.5 oz) + Captac 4F 600 (16.0 fl oz)	TC-3C	64.8b	20.0a	76.5a	20.0b	8.2b
3) Kocide 101 77W 2768 (3.0 lb)	1/2"-G					
Nova 40W 15 (0.5 oz) + Captec 4F 600 (16.0 fl oz)	TC-3C	58.3b	20.0a	59.0a	11.8c	3.4d
4) Lime Sulfur 29% Sol 14.5g (5.0 gal)	1/2"-G					
Nova 40W 15 (0.5 oz) + Captec 4F 600 (16.0 fl oz)	TC-3C					
Captec 4F 600 (16.0 fl oz) + Benlate 50W 150 (4.0 oz)	6C,7C	0.5c	5.0b	6.8b	17.3bc	7.4bc
5) Kocide 101 77W 2768 (3.0 lb)	1/2"-G					
Nova 40W 15 (0.5 oz) + Captec 4F 600 (16.0 fl oz)	TC-3C					
Benlate 50W 300 (8.0 oz)	6C,7C	0.0c	0.0b	3.3b	9.3c	5.3cd

* Means within columns followed by the same letter(s) do not differ significantly, (DMRT, P=0.05).

K. D. Hickey, J. May, and G. McGlaughlin
PSU Fruit Research Laboratory
Biglerville, PA 17307-0309

PEACH (*Prunus persica* 'Redhaven', 'Loring')
Brown rot; *Monilinia fructicola*

INCIDENCE OF BROWN ROT ON PEACH FRUIT TREATED WITH FUNGICIDES AS SEASONAL SPRAYS OR POST-HARVEST DIPS, 1990: Three experiments were conducted to evaluate efficacy of seasonal fungicide sprays or a single post-harvest dip for control of brown rot on fruit. In Experiment 1, seasonal fungicide applications were evaluated in a block of four-year old well-pruned 'Redhaven' trees planted in rows 9 m apart. The same treatments were applied as a single post-harvest one-minute dip to 'Loring' fruit which previously received no fungicide treatment (Experiment 2). In Experiment 3, treatments were applied as sprays in two pre-harvest applications made 8 and 0 days before harvest. The fungicide sprays were applied dilute to the point of "complete wetness" using 8.0 L/tree (1,976 L/ha) with a high pressure sprayer equipped with a 9-nozzle boom and operated at 2,758 kPa (400 psi). Application dates in the 'Redhaven' block (Experiment 1) and phenological stages were made as follows: 9 Apr (pink), 14 Apr (full-bloom), 1 May (petal-fall), 14 May (shuck-fall), 24 Jul (14 da pre-harvest interval) (PHI), 30 Jul (7 da PHI), and 7 Aug (0 da PHI). The orchard block used in Experiment 3 contained mature well-pruned trees which bore a full crop. Incidence of brown rot on fruit in all three experiments was determined by observing 20 uniformly selected fruit/replicate collected 1-2 hours after final sprays. Fruits used were harvested at a "firm-ripe" stage which showed slight yellowing of the "green ground color". Fruits were placed stem-end down on packing trays and inoculated by uniformly itemizing with a conidial suspension of *Monilinia fructicola* (120,000 conidia/ml on 'Redhaven' and 200,000 conidia/ml on 'Loring'). Inoculated fruit were incubated for three to ten days at 20°-29° C and 90-100% RH under polyethylene tarp before disease incidence was determined. The data was subjected to analysis of variance using appropriate transformations and the significance among means was determined by the Duncan's Multiple Range Test (P = 0.05).

Brown rot incidence was light to moderate in the test blocks. No blossom blight occurred and only an occasional decayed fruit was found at harvest in the test blocks. Untreated 'Redhaven' fruit which were inoculated had 44% infection after three days at room temperature (20°-29° C). RH-7592 and Rovral provided significantly better control than CGA-455. All treatments provided better control when used in the dip treatment on 'Loring'. RH-7592 provided near complete control up to 10 days after treatment on fruit held without refrigeration. Uninoculated fruit in the dip treatment showed only an occasional infected fruit. In Experiment 3, decay was 65% on the uninoculated check after four days incubation. RH-7592, Rovral, and captan provided significantly better control than the check when used in only two pre-harvest applications. Three applications of either RH-7592 or Rovral provided better disease control than two applications but the results were not highly significant. Control with Super Six Sulphur or Microthiol was not significantly better than the untreated check. All treatments gave poor control when fruit were incubated for six days.

Table 15. Percent Brown Rot Infection on Peach Fruit Treated with Fungicides Applied as Seasonal Dilute Sprays or Post-harvest Dips in 1990. Fruit Research Lab, 3-C Peach/ Nectarine Block.

Fungicide and Rate mg ai/L (Form/100 Gal)*	Percent Brown Rot Infection				
	'Redhaven' (sprayed)		'Loring' (dipped)		
	Days after inoculation				
	3	6	5	7	10
1. Untreated	43.8a**	93.8a	33.8a	66.3a	75.0a
2. CGA-455 50W 37 (1.0 oz)	27.5bc	86.3ab	12.5b	35.5b	58.8ab
3. CGA-455 50W 75 (2.0 oz)	35.0ab	95.0a	8.8bc	23.8bc	50.0b
4. RH-7592 2F 45 (2.4 fl oz) + Triton B-1956 (4.0 fl oz)	16.3c	73.8b	0.0d	0.0d	1.3c
5. Rovral 4SC 600 (16.0 fl oz) + Triton CS-7 (4.0 fl oz)	15.0c	70.0b	2.5cd	3.8cd	8.8c

* 'Redhaven' - Treated with 7 seasonal sprays. 'Loring - Untreated until dipped in the fungicide suspension at harvest on 17 Aug.

** Means within columns followed by the same letter(s) do not differ significantly, DMRT (P = 0.05).

Table 16. Incidence of Brown Rot on 'Loring' Peach Fruit Treated with Dilute Pre-harvest Fungicide Sprays in 1990. Fruit Res. Lab, 'Loring' Block.

Fungicide and Amt mg ai/L (Form/100 Gal)	No. Applic.	Percent Brown Rot Days after Inoculation 4	6
1. Topsin-M 85WDG 254 (4.0 oz) + Captan 50W 600 (16.0 oz)	2*	33.8abc***	61.3abc
2. RH-7592 2F 45 (2.4 oz) + Triton B-1956 (4.0 fl oz)	3**	20.0bc	33.8cd
3. RH-7592 2F 45 (2.4 oz) + Triton B-1956 (4.0 fl oz)	2	13.8c	25.0d
4. Rovral 4SC 600 (16.0 fl oz) + Triton CS-7 (4.0 fl oz)	3	7.5c	32.5cd
5. Rovral 4SC 600 (16.0 fl oz) + Triton CS-7 (4.0 fl oz)	2	22.5bc	43.8bcd
6. Captan 50W 1200 (32.0 oz)	2	15.0c	50.0bcd
7. Captec 4F 1200 (32.0 fl oz)	2	20.0bc	55.0bc
8. Super Six Sulfur 52L 900 (32.0 fl oz)	2	35.0ab	70.0ab
9. Microthiol Sulfur 80DF 1917 (32.0 oz)	2	50.0ab	68.8ab
10. Untreated	0	65.0a	88.8a

* Applied on 1 Aug (8 da PHI) and 9 Aug (0 da PHI).

** Applied at 14, 8, and 0 da PHI.

*** Means within columns followed by the same letter(s) do not differ significantly, DMRT (P = 0.05).

K. D. Hickey, J. May, and
G. McGlaughlin
PSU Fruit Research Laboratory
Biglerville, PA 17307-0309

CHERRY (RED TART) (Prunus ceraus 'Montmorency')
Brown rot; Monilinia fructicola
Cherry leaf spot; Coccomyces hiemalis

BROWN ROT AND LEAF SPOT CONTROL WITH DILUTE FUNGICIDE SPRAYS, 1990: A block of 11-year old trees planted 9 X 9 m and 3.5 m high was used to evaluate efficacy of fungicide treatments applied as protective seasonal dilute sprays. Environmental conditions were highly favorable for leaf spot development but marginal for brown rot. The treatments were arranged in a randomized complete block design with four single-tree replicates. The fungicides were applied to the point of "complete wetness" with a high pressure sprayer operated at 2,758 kPa (400 psi) equipped with a 9-nozzle boom which delivered 8.0 L/tree (1,720 L/ha). Applications were made on the following dates and phenological stages: 25 Apr (full-bloom), 1 May (petal-fall), 9 May (shuck-fall), first through fourth cover sprays applied on 24 May, 8 and 25 Jun, and 10 Jul, respectively. The Kocide 101 plus spray lime used in the standard treatment was applied post-harvest on 16 Jul. Incidence of brown rot was determined by observing 100 fruits/replicate collected one hour after application of the harvest spray on 10 Jul. Fruits were inoculated with a conidial suspension of Monilinia fructicola (650,000 spores/ml) and incubated at 20°-29° C and 85-100% RH for five and ten days before observation. Cherry leaf spot incidence was determined by observing all leaves on each of 10 terminals/tree on six dates between 21 Jun and 30 Aug. The percent soluble solids in fruit juice taken from a 50 fruit sample/tree was determined with a Chemtrix hand refracto-meter. The data were subjected to an analysis of variance using appropriate transformations and significance between means was determined using Duncan's Multiple Range Test ($P = 0.05$).

Brown rot development on inoculated untreated fruit was 36% and 82% after 5- and 10- days incubation, respectively. Nova 40W 1.5 oz/100 gal did not provide significant reduction of brown rot. The 2.0 oz rate provided a significant reduction, but not as good as other treatments. Rovral, Elite, RH-7592, and the Benlate plus Captec standard all provided excellent control of brown rot for five days after inoculation, while only RH-7592 provided good control for 10 ten days. Conditions were highly favorable for leaf spot development with 70% of the leaves infected on the untreated check by 21 Jun and 97% by 30 Aug. Elite, RH-7592, and Nova 40W 2.0 oz controlled leaf spot equal to the Benlate plus Captec standard and significantly better than Rovral, Nova 40W 1.5 oz, or the combination of Nova plus Captec. Fruit soluble solids levels were equal among fungicide treatments and all were significantly higher than the untreated check. The Nova and Elite treatments significantly reduced fruit size, an effect not previously observed.

Table 18. Fruit Quality and Incidence of Brown Rot and Leaf Spot on Montmorency Cherry Sprayed with Dilute Fungicide Treatments in 1990. PSU Fruit Research Lab, Tart Cherry Block.

Fungicide and Rate mg ai/L (Form/100 Gal)	# fruit/ kilogram	% soluble solids	% Brown Rot		Percent Leaf Spot				
			5-day	10-day	21 Jun	3 Jul	17 Jul	14 Aug	30 Aug
1. Untreated	197b**	12.9b	36.0a	81.8a	70.1a	89.0a	90.2a	96.5a	96.6a
2. Rovral 4SC 600 (16.0 fl oz) + Triton CS-7 (4.0 fl oz)	206b	15.1a	1.0c	23.8b	34.4b	55.2b	64.9b	98.5a	98.5a
3. Elite 45DF 67 (2.0 oz)	216ab	15.2a	1.0c	27.5b	0.8c	8.0c	21.0c	35.2c	46.1d
4. RH-7592 2F 45 (2.4 fl oz) + Triton B-1956 (4.0 fl oz)	207b	14.2a	1.0c	9.5b	1.5c	12.6c	30.0c	56.1bc	73.3bc
5. Nova 40W 60 (2.0 oz)	229a	15.3a	16.5b	60.3a	3.4c	22.2c	31.8c	52.0bc	64.6cd
6. Nova 40W 45 (1.5 oz)	220a	14.4a	32.4a	87.8a	29.1b	54.3b	71.2a	90.9a	96.6a
7. Nova 40W 30 (1.0 oz) + Captec 4F 1200 (32.0 fl oz)	217a	14.5a	7.0b	31.8b	10.2b	22.0c	38.0bb	46.5b	92.4a
8. Benlate 50DF 150 (4.0 oz) + Captec 4F 600 (16.0 fl oz) Kocide 101 77W 1845 (2.0 lb) + Hydrated Spray Lime (2.0 lb)*	200b	14.9a	3.3c	19.5b	1.6c	17.7c	19.7c	74.6ab	86.7ab

* Apply only in a single post-harvest application.
** Means within columns followed by the sam letter(s) do not differ significantly, (DMRT, P = 0.05).

Apple (Malus domestica 'Golden Delicious')
Bitter rot; Glomerella cingulata
White rot; Botryosphaeria dothidea
Sooty blotch; Gloeodes pomigena
Flyspeck; Zygophiala jamaicensis

Eldon I. Zehr, G. W. Kirby and A. M. Kelly, Dept. of Plant Pathology & Physiology, Clemson University, Clemson, SC

Summer disease control on apples in 1990. Summer disease control was tested with certain fungicides at the Clemson University Simpson Experiment Station. Scab and rust were controlled on all trees by early-season sprays of captan plus Nova at 7-14-day intervals through first cover, and captan 50W, 2 lb per 100 gallons, at second cover (7 May). Sprays for summer disease control began at third cover (21 May) and were renewed on 4 and 18 June, 9 and 23 July, and 7 and 20 August. Imidan, 1 lb per 100 gallons, was applied separately by airblast sprayer on 16 May; Penncap M, 2 pt per 100 gallons, on 1 and 13 June, and 6 and 20 July; and Sevin 50W, 2 lb per 100 gallons, on 3 and 17 August. Treatments were replicated four times in a randomized complete block design. Sprays were applied to runoff at 200 psi with a handgun. At maturity (30 August), up to 100 fruits per tree were harvested and examined for rot, sooty blotch, and flyspeck. (Some trees had less than 100 fruit because late frosts reduced the crop.) Russet on 25 fruits per tree was estimated visually.

Rainfall for the season was less than normal -- 1.85 in. in May, 0.52 in June, 4.02 in July, and 4.94 in August. The frequency of summer diseases was relatively light. Bitter rot was not significantly suppressed by any treatment, whereas the captan/Benlate standard appeared best for white rot control. All fungicides suppressed sooty blotch and flyspeck, but sulfur appeared to be less effective than the others. Sulfur sprays resulted in the best fruit finish, but the captan/Benlate standard and MON 18833 at the highest rate aggravated russet problems.

Table 1.

Treatment and rate per 100 gallons	% fruit infected ± std. deviation				% fruit surface russeted
	Bitter rot	White rot	Sooty blotch	flyspeck	
MON 18833 40W 10 oz	1.8 ± 2.2	1.8 ± 1.7	0.0	0.0	20 ± 4.8
MON 18833 40W 15 oz	1.5 ± 0.6	1.8 ± 1.2	0.0	0.0	16 ± 2.4
MON 18833 40W 20 oz	1.5 ± 1.3	3.2 ± 3.4	0.0	0.0	31 ± 9.3
Microthiol sulfur 3.5 lb	7.0 ± 8.2	3.0 ± 0.8	0.8	16.5	14 ± 2.6
Thiram 65W 2.0 lb	2.2 ± 2.6	5.8 ± 6.4	0.0	0.0	19 ± 1.5
Ziram 4F 1.3 pt	2.3 ± 1.5	1.7 ± 0.6	0.0	0.0	17 ± 4.0
Captan 50W 2.9 lb + Benlate 50DF 4.0 oz	2.3 ± 0.6	0.3 ± 0.6	0.0	0.0	24 ± 5.7
Control	3.5 ± 1.7	3.5 ± 2.6	89.2	35.5	16 ± 3.7
L.S.D. .05	N.S.	N.S.	----	----	7.2

Nectarine (*Prunus persica* var. *nusipersica*)
Scab; *Cladosporium carpophilum*

Eldon I. Zehr, G. W. Kirby and A. M. Kelly, Dept. of Plant Pathology and Physiology, Clemson University, Clemson, SC

Five-year-old Redgold nectarine trees were sprayed using cover sprays with experimental fungicides to control scab. Sprays began at shuck fall (11 April), and were applied again on 24 April, 8 and 22 May, and on 5 June. Applications were made to runoff via handgun. Each treatment was replicated four times in a randomized complete block design. Captan, 2 lb/100 gallons, was applied to all trees including controls at shuck split (4 April); Penncap M, 16 oz/100 gallons, was applied to all trees by airblast sprayer on 4 and 18 April and 1 and 13 June; and Imidan, 1 lb/100 gallons, was applied on 1 and 16 May. At maturity, up to 100 fruits per tree were harvested and examined for scab lesions. A single, well-defined lesion on a fruit was counted as an infected fruit.

A series of late spring freezes decimated the crop, and many replicates had insufficient fruit for evaluation. Data were collected from trees having more than 10 fruits. Dry weather during the season contributed to a low incidence of scab even on unsprayed fruit. All fungicides tested controlled scab satisfactorily. Because the numbers of usable replicates was small, no conclusions as to relative effectiveness can be made. Ferbam applications resulted in an undesirable black residue on fruit at harvest.

Table 1. Scab frequency on nectarine fruit as affected by fungicide application.

Treatment and rate per 100 gallons	# replicates	% scab
Ziram 4F 4.0 pt	1	3.0
Microthiol sulfur 5.0 lb	2	1.0
Microthiol sulfur 2.5 lb + Ziram 4F 2.0 pt	3	0.3
Wettable sulfur 5.0 lb	1	1.0
Thiram 65W 2.0 lb	3	3.3
Ferbam 76 WDG 2.0 lb	3	0.0
Control	3	36.3

Apple (Malus x domestica, 'Golden Delicious')
Sooty blotch; Gloeodes pomigena
Flyspeck; Zygophiala jamaicensis
Bitter rot; Glomerella cingulata
White rot; Botryosphaeria dothidea

T. B. Sutton and L. R. Pope
Dept. of Plant Pathology
NC State University
Raleigh, NC 27695

SUMMER DISEASE CONTROL, 1990. Treatments were applied to two five-tree blocks of 11-year-old Golden Delicious trees with an airblast sprayer at the Central Crops Research Station, Clayton, NC. Trees were sprayed to drip at 207 gpa. Treatments were applied on 17 Apr (petal fall), 1, 15, and 29 May, 12 and 26 Jun, 10 and 24 Jul, and 7 Aug. The second and fourth trees within each block were used as record trees. Due to a late-season frost, the crop was light; consequently some fruit for harvest samples were collected from trees adjacent to the record trees. Sooty blotch and flyspeck incidence and severity were determined from a sample of 25 fruit per replicate collected arbitrarily at harvest on 27 Aug. Bitter rot and white rot incidence in the sample were determined at harvest and following storage of all symptomless fruit for 2 wk at 20-25 C.

Sooty blotch and flyspeck incidence and severity were light due to extended dry periods in Jun and early Jul. Rainfall amounts for May-August were 4.99, 2.36, 4.68, and 6.53 in, respectively. All treatments except captan 50W 2.0 lb, Ziram F4 1 qt, and Dithianon 4.2 SC 3.8 oz, provided satisfactory sooty blotch and flyspeck control. The addition of Benlate 50DF or Topsin M 85DF to dialkyldithiocarbamate fungicides generally improved sooty blotch and flyspeck control. Bitter rot control was poorest with MON 18833 40W 20 oz. No distinct differences were evident among other treatments for bitter rot control. Variation among replications obscured differences among treatments for white rot control; however, treatments containing captan generally provided better control than those containing Ziram or Thiram. Fruit finish was poorest with Carbamate 76W 2 lb; fruit in this treatment also were covered with a sooty residue.

Treatment and rate/100	% fruit affected: Sooty blotch	% fruit affected: Flyspeck	Sooty blotch and flyspeck severity*	% fruit affected: Bitter rot	% fruit affected: White rot	Russet (0-10)
Captan 50W 2.0 lb	14.0 bc**	20.0 c**	1.2 b**	9.3 bc**	12.0 ab**	1.5 de**
Mancozeb 75DF 2.0 lb	1.3 d	0.0 d	0.7 b	1.0 bc	6.0 ab	1.7 cde
Captan 50W 2.0 lb + Benlate 50DF 2.0 oz	0.0 d	4.0 d	0.5 b	6.0 bc	11.0 ab	1.7 cde
Captan 50W 1.0 lb + Benlate 50DF 2.0 oz	0.0 d	2.0 d	0.5 b	8.0 bc	10.0 ab	2.3 bcde
Mancozeb 75DF 2.0 lb + Benlate 50DF 2.0 oz	4.0 cd	0.0 d	0.5 b	3.0 bc	5.0 b	2.9 ab
Thiram 65W 2.0 lb	2.0 d	4.0 d	0.5 b	7.2 bc	10.9 ab	2.1 bcde
Ziram F4 1 qt	2.0 d	24.0 c	1.3 b	6.0 bc	20.0 ab	2.2 bcde
Carbamate 76WDG 2.0 lb	6.0 cd	6.0 d	1.0 b	1.0 bc	10.0 ab	3.7 a
Thiram 65W 2.0 lb + Topsin M 85DF 1.65 oz	0.0 d	0.0 d	0.0 b	0.0 c	16.0 ab	2.1 bcde
Ziram F4 1 qt + Topsin M 85DF 1.65 oz	0.0 d	6.0 d	1.0 b	8.0 bc	22.0 a	2.6 abcd
Carbamate 76WDG 2.0 lb + Topsin M 85DF 1.65 oz	10.0 cd	8.0 d	1.5 b	0.0 bc	12.5 ab	2.7 abc
Dithianon 4.2 SC 3.0 oz	22.0 b	38.0 b	1.5 b	2.0 bc	17.0 ab	1.9 bcde
MON 18833 40W 40 oz	0.0 d	0.0 d	0.0 b	11.0 bc	7.0 ab	1.9 bcde
MON 18833 40W 20 oz	0.0 d	0.0 d	0.0 b	33.0 a	12.0 ab	2.2 bcde
Ziram F4 1 pt + Topsin M 85DF 2.08 oz	0.0 d	2.0 d	0.5 b	5.0 bc	7.0 ab	2.2 bcde
Thiram 76W 1.0 lb + Topsin M 85DF 2.08 oz	2.0 d	2.0 d	1.0 b	12.0 abc	17.0 ab	1.5 de
Control	93.2 a	95.4 a	7.9 a	22.1 ab	19.3 ab	1.8 bcde

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

Apple (Malus x domestica 'Golden Delicious')
Sooty blotch; Gloeodes pomigena
Flyspeck; Zygophiala jamaicensis
Bitter rot; Glomerella cingulata
White rot; Botryosphaeria dothidea

T. B. Sutton and L. R. Pope
Dept. of Plant Pathology
North Carolina State Univ.
Raleigh, NC 27695

SUMMER DISEASE CONTROL WITH INORGANIC FUNGICIDES AND ORGANIC STANDARDS, 1990. Fungicides were applied to rows (20-30 trees each) of 23-yr-old Golden Delicious apples at the Sandhills Research Station, Jackson Springs, NC. Treatments were applied with an airblast sprayer to the drip point at 207 gpa. Funginex 1.8 EC was applied to all plots on 21 and 25 Mar and 4, 10 and 16 Apr. Treatments were initiated on 19 Apr (petal fall) and subsequently applied on 2, 16, and 30 May, 13 and 27 Jun, 11 and 25 Jul, and 11 and 22 Aug. Four trees within each row were arbitrarily chosen as sample trees and 25 fruit/sample tree were selected arbitrarily at harvest on 30 Aug for determining sooty blotch and flyspeck incidence and severity and russet. If 25 fruit were not available on a sample tree, fruit from an adjacent tree were selected. Russet was scored on a subsample of 10 fruit/replicate on a scale of 0-10 where 0 = no russet, 1 = russet in stem cavity, 2 = lenticels prominent, 3 = 10-30% surface russetted, 4 = 30-40% russet, and 10=100% fruit surface russetted. Bitter rot and white rot incidences were determined in the harvest sample and after storing all symptomless fruit in the samples for 2 wk at 20-25C.

Disease incidence and severity was light in 1990 as a result of dry weather in Jun, Jul and Aug with only 0.74, 2.75, and 2.96 in rainfall, respectively. Sooty blotch and flyspeck control was good in all treatments. Bitter rot control was significantly better than the control in all treatments; there were no significant differences among treatments. None of the treatments provided satisfactory white rot control; best control was achieved in the 8-8-100 Bordeaux treatment. Fruit finish was poor in the two Bordeaux treatments.

Treatment/Rate per 100 gal	% fruit affected Sooty blotch	Flyspeck	Sooty blotch and flyspeck severity*	Bitter rot	White rot	Russet
Captan 50W 2.0 lb	0.0 b**	2.0 b**	0.5 b**	7.0 b**	30.8 b**	2.3 a**
Captan 50W 1.0 lb + Benlate 50DF 3.0 oz	0.0 b	0.0 b	0.0 b	2.0 b	16.0 ab	2.3 a
Captan 50W 2.0 lb + Benlate 50DF 3.0 oz	0.0 b	0.0 b	0.0 b	8.0 b	21.0 ab	2.6 a
Mancozeb 75DF 2.0 lb + Benlate 50DF 3.0 oz	1.0 b	0.0 b	0.3 b	3.0 b	16.0 ab	2.2 a
Sulfur 6 lb + hydrated lime 3 lb pf; $CuSO_4$ 3 lb + hydrated lime 6 lb 1C-8C	0.0 b	0.0 b	0.0 b	1.0 b	16.0 b	4.5 b
Liquid lime sulfur 2.5 gal pf; $CuSO_4$ 4 lb + hydrated lime 8 lb 1C-3C; $CuSO_4$ 8 lb + hydrated lime 8 lb 4C-8C	1.0 b	0.0 b	0.5 b	1.0 b	13.0 b	4.2 b
Check (insecticide only)	77.0 a	87.0 a	5.0 a	20.0 a	39.0 a	2.4 a

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

Apple (<u>Malus</u> x <u>domestica</u> 'Rome Beauty')
Scab; <u>Venturia</u> <u>inaequalis</u>
Powdery mildew; <u>Podosphaera</u> <u>leucotricha</u>
Brooks spot; <u>Mycosphaerella</u> <u>pomi</u>
Sooty blotch; <u>Gloeodes</u> <u>pomigena</u>
Flyspeck; <u>Zygophiala</u> <u>jamaicensis</u>
White rot; <u>Botryosphaeria</u> <u>dothidea</u>
Black rot, frogeye leafspot; <u>Botryosphaeria</u> <u>obtusa</u>

T. B. Sutton and E. M. Brown
Dept. of Plant Pathology
NC State University
Raleigh, NC 27695

DISEASE CONTROL ON ROME BEAUTY, 1990. Treatments were applied to 4 to 6 tree plots of 28-yr-old Rome Beauty trees at the Mountain Horticultural Crops Research Station, Fletcher, NC to the drip point with an airblast sprayer at 295 gpa. 23 Mar (gt), 2, 16 (pink), and 26 (petal fall) Apr, 5 and 23 May, 6 and 19 Jun, 6 and 17 Jul, and 3, 16, and 31 Aug. Three trees were arbitrarily selected within each plot for data collection. The incidence of scab, powdery mildew, and frogeye leafspot was determine on 5 Jun by recording the number of leaves and number of leaves with symptoms of each disease on 10 terminals selected arbitrarily on each replicate. The percent fruit affected with scab and Brooks spot were determined at harvest on 24 Sep by examining 100 fruit arbitrarily picked from each replicate. Sooty blotch and flyspeck incidence and severity were determined from a subsample of 25 of the 100-fruit sample. The incidence of white rot and black rot were determined by examining drops during the season and fruit on the tree at harvest. White rot and black rot are reported collectively because of the difficulty in separating them based on macroscopic symptoms.

Primary apple scab infection was light. Mills' infection periods prior to first cover occurred on 29-31 Mar (moderate), 9-11 (moderate), and 25-28 (moderate) Apr; 2-3 (moderate), 4 (moderate), and 9-10 (moderate) May. First primary scab was observed during the third wk of May. Little secondary scab developed prior to the onset of hot weather because of dry weather from 1 Jun - 9 Jul (0.95 in rain). Consequently, scab control in all treatments was good with no differences among fungicide treatments. Similarly, all treatments provided good Brooks spot control. Sooty blotch and flyspeck control was poorest in treatments with captan 50W 2.0 lb alone in the cover sprays. There was no difference between Thiram and Ziram treatments. The incidence of white rot and black rot was significantly less in all treatments than the control; there were no differences among treatments.

Treatment and rate/100 gal	% leaves affected: Powdery mildew	% leaves affected: Frogeye leafspot	% fruit affected: Scab	% fruit affected: Brooks spot	% fruit affected: Sooty blotch	% fruit affected: Flyspeck	Sooty blotch and flyspeck severity*	% fruit affected with black rot and white rot
Captan 50W 2.0 lb gt-9C	12.6 cd**	4.7 ab**	0.0 b**	1.0 b**	94.0 a**	88.0 ab**	12.4 b**	5.7 b**
Cyprex 65W 0.5 lb gt-1C; Bayleton 50DF 0.5 oz tc-2C; Captan 50W 2.0 lb 2C; Captan 50W 2.0 lb + Benlate 50DF 2.0 oz 3C	6.4 e	1.0 c	0.0 b	0.3 b	4.0 d	6.7 f	0.7 d	5.0 b
Ziram 76WDG 2.0 lb, gt-9C	14.5 c	4.5 ab	0.3 b	0.3 b	22.7 c	16.0 ef	3.4 cd	5.0 b
Nova 40W 1.25 oz gt-2C; Captan 50W 2.0 lb pf-9C	0.0 f	0.7 c	0.3 b	0.3 b	85.3 a	81.3 a	7.8 cd	5.1 b
Rubigan 1E 3.0 oz + Captan 50W 1.0 lb gt-2C; Captan 50W 2.0 lb 3-9C	76.8 ef	1.8 bc	0.3 b	0.7 b	53.3 b	58.7 c	6.1 cd	2.7 b
Rubigan 1E 3.0 oz + Thiram 65W 1.0 lb gt-2C; Thiram 65W 2.0 lb 3-9C.	73.2 ef	2.2 bc	0.3 b	0.3 b	16.0 cd	10.7 ef	1.5 d	3.6 b
Thiram 65W 2.0 lb gt-9C	24.0 b	5.0 ab	0.7 b	0.3 b	32.0 c	21.3 f	3.3 cd	6.5 b
Rubigan 1E 3.0 lb + Ziram 76 WDG 1.0 lb gt-2C; Ziram 76WDG 2.0 lb 3-9C	0.3 f	0.5 c	0.7 b	1.0 b	25.3 c	40.0 d	1.9 d	3.5 b
Control	32.2 a	7.2 a	18.0 a	15.0 a	100.0 a	100.0 a	44.6 a	25.4 a

*% Surface area covered.

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

PROGRESS REPORT

MARYBLYT

A predictive program for forecasting apple fire blight

Paul W. Steiner, *Botany Department, The University of Maryland, College Park, MD, and* **Gary Lightner,** *USDA Appalachian Fruit Research Station, Kearneysville, WV*

MARYBLYT is an empirically derived, comprehensive model for fire blight disease management in apples that anticipates and identifies infection periods and predicts symptom appearance for four distinct phases of fire blight on apples: blossom, canker, shoot and trauma blight. Growers in western Maryland who scheduled streptomycin treatments based on the *MARYBLYT* system have obtained excellent control of the destructive blossom blight phase and significantly reduced the incidence of shoot blight in 1988, 1989 and 1990. Similar success with the program has been reported from other fruit production areas throughout the U.S.

A computer program for *MARYBLYT* has been developed to compile relevant data, to compute blight risk status and to identify specific infections, the symptoms of which can be predicted with an overall accuracy of ca. $\pm$ 1 day. The program requires data inputs of daily minimum and maximum temperatures, rainfall, and several phenological benchmarks. The system will track up to 10 separate blossom infection periods (from infection to symptom appearance) simultaneously, signal when the bacteria begin invading new bark tissue at canker margins, and when the first incidence of shoot blight is likely to occur. Of considerable value for deciding if and when to apply protective treatments is a predictive analysis for any number of days based on weather forecasts. A new version will also signal the user with an audible tone when treatment should be considered based on the number of conditions required for infection that exist and when any previous treatment was made. An audible tone will also sound when all conditions for infection exist and damage is likely.

The program displays data entries, blossom blight risk status, and a predictive index (as percent of activity threshold) for the four blight types in an easy to read spread sheet format. The average daily temperature and the progress of various infections toward symptom appearance can also be displayed graphically so that a visual extrapolation of various predictions can be made easily based on the slope of the plotted line and its anticipated intercept with the activity threshold. The software is designed to run on most IBM compatible personal computers, including lap tops. Data files can be downloaded to a printer and the printed files show additional calculations of accumulated degree days and degree hours relevant to the program's operation. The latest version also includes an optional graphics screen which allows the plotted data to be captured clearly via some wordprocessing programs (e.g., WordPerfect).

Work is in progress to develop a reliable farm weather station that will collect all data relevant to the operation of *MARYBLYT* for fire blight as well as for apple scab programs developed elsewhere and will include several ports for additional instruments or programs a grower might wish to include (e.g., frost warning system, soil moisture, soil temperature, etc.). Our plans are to design software that will allow all pertinent weather information to be downloaded directly or on command into the *MARYBLYT* file.

We anticipate that the *MARYBLYT* program and, possibly, the weather station will be available commercially by the 1992 season.

PATTERNS IN THE DEVELOPMENT OF FIRE BLIGHT ON APPLES IN MARYLAND IN 1990

Paul W. Steiner and Patrice Suleman
Botany Department, The University of Maryland, College Park, MD 20742

Fire blight, caused by *Erwinia amylovora*, seldom causes significant damage in the well managed, commercial orchards of central and eastern Maryland, although the incidence of severe blight is not uncommon on poorly managed backyard trees and small orchards. Most of what fire blight damage does occur in commercial orchards here is associated with small outbreaks of late shoot blight which cause little overall economic loss. Because of this experience, growers in central and eastern Maryland tend to employ only the most conventional cultural practices for blight control (good dormant pruning and steps to limit excessive vegetative growth). In western Maryland, by contrast, destructive blossom blight or shoot blight epidemics are not uncommon so that rigorous control programs must be followed every season, including special antibiotic sprays during bloom.

Since the general weather conditions, cultivars grown and orchard management practices in both western and central\eastern areas are similar, the major difference between them seems to be in the number of inoculum sources available within orchards and the distances between orchards. In western Maryland, for example, many different orchard operations are concentrated in a limited area such that poor fire blight management in any one location can affect the risks for infection in many other operations. In central Maryland, commercial orchards under the management of one individual are usually separated by >20 miles. In the latter situation, good general orchard management practice and the sporadic nature of fire blight appear to have allowed most growers to "escape" serious fire blight epidemics for years at a time. In 1990, special conditions allowed the development of moderate to severe epidemics of fire blight throughout the state, *except in western Maryland*. Observations made through the course of the season coupled with an analysis of weather and orchard conditions using the *MARYBLYT* fire blight forecasting model developed at The University of Maryland (1,2,3) offer some explanations for why the disease occurred the way it did in 1990.

The stage was set early...

The 1990 season began nearly two weeks earlier than usual with apples reaching green tip phenophase March 13-15. Cold temperatures $\leq$ 24F° during the late green tip to early tight cluster stage on March 27-28 (18-24°F), at tight cluster to pink on April 8-10 (25-29°F) and again during early bloom on April 13-14 (22-24°F) killed or damaged many of the primary blossom buds. As a result, secondary buds were stimulated, extending the flowering period over 3-4 weeks instead of the usual 10-12 days. The bulk of this secondary bloom occurred in the upper half of the trees.

The plot developed slowly...

Generally cool temperatures after full pink kept the risk of blossom infection low to moderate through most of the primary bloom period. During the week of 22 April, however, warmer temperatures increased the inoculum potential so that, by 25-26 April, the minimum threshold of ≥198 cumulative degree hours ≥65 F° (CDH>65) needed to support an epidemic of blossom blight was reached and, by 29 April, the CDH>65 had increased 5-fold. This was at or near the end of primary bloom, but a substantial amount of secondary bloom was still available. CDH>65 is an indirect measure of the relative epiphytic inoculum potential (EIP) and reflects the proportion of open blooms colonized by the pathogen, not necessarily the bacterial population per flower. At the CDH>65 threshold of 198, it is estimated that 3-5% of open flowers are colonized [see FIGURE 1]. Because the increase in inoculum potential is logarithmic, the 1,000+ CDH>65 reached here meant that virtually all flowers that were open on 26 April were probably colonized and were, therefore, potential infection sites should rain occur when the average temperature was ≥60F°, which is exactly what occurred.

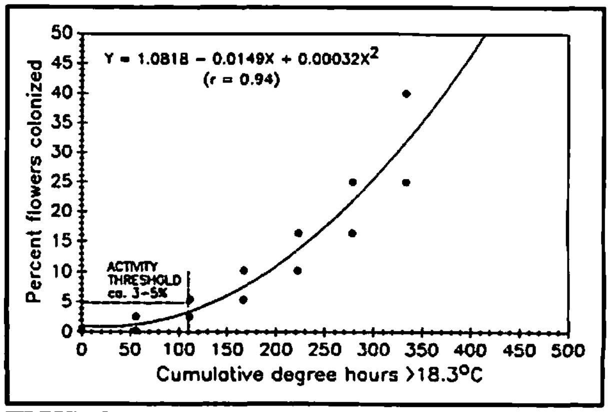
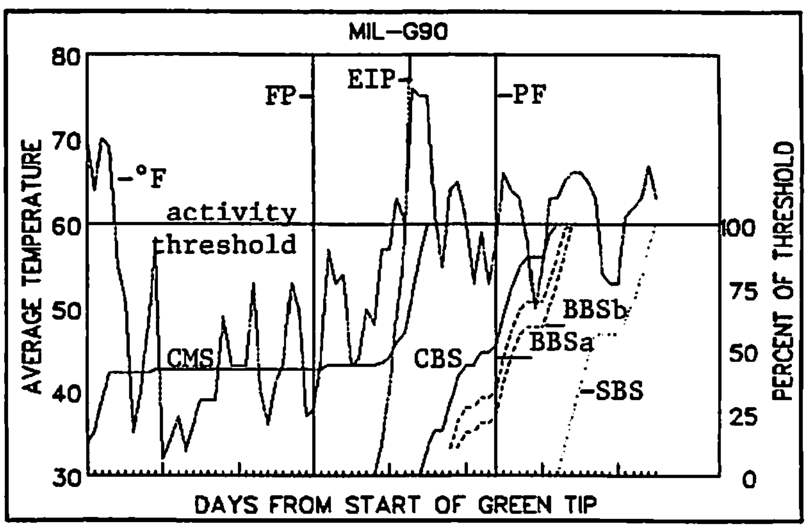


FIGURE 1. Relative epiphytic inoculum potential for *E. amylovora* [data from Zoller & Sisevich (1979), Phytopathology 69:1050 Abstr.]

The second act quickened the pace...

Blossom infections occurred throughout the state between 27 and 30 April, depending on location and were linked to rain periods. In at least one instance, we suspect some additional infections were initiated in an eastern Maryland Gala orchard following relatively high volume (100 gpa) fungicide application made to small trees with an airblast sprayer (BBSb in Figure 2). Moderately cool weather following these infections delayed symptom development for at least 2 weeks in most locations (May 11 in western MD, May 17 in eastern MD). We believe this unusually late development of blossom blight symptoms contributed to the subsequent extensive and very rapid invasion of fruiting wood proximal (pathogenic isolates of *Erwinia amylovora*

FIGURE 2. *MARYBLYT* graphic of fire blight epidemic in an eastern Maryland orchard of Gala\M26 apples in 1990. Green tip was 14 March, full pink [FP (= first bloom)] was 13 April and petal fall [PF] was 6 May. °F = average daily temperature, CMS = canker margin symptom development, CBS = canker blight symptoms, EIP = relative epiphytic inoculum potential, BBSa,b = two blossom blight infection events, SBS = primary shoot blight symptoms. Accuracy of intercept of plotted predictions with observed symptoms = ±1 day.



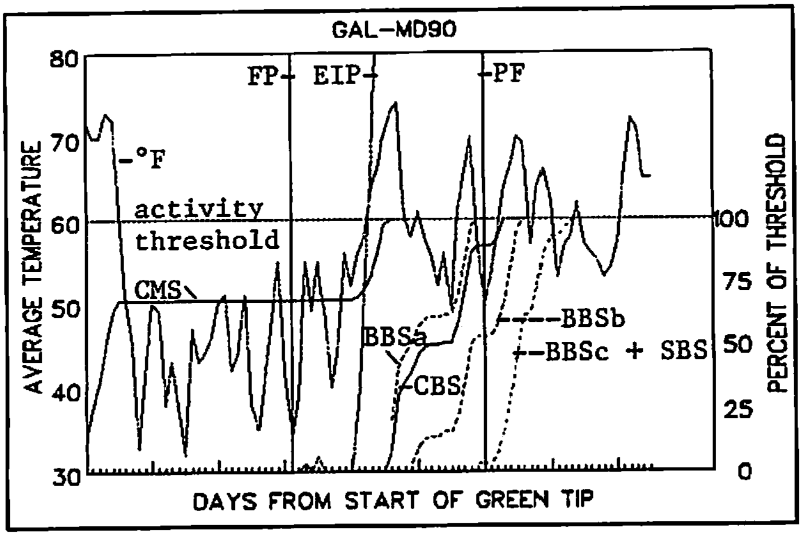


FIGURE 3. *MARYBLYT* graphic of fire blight epidemic in a western Maryland orchard of Gala\M26 apples in 1990. Green tip was 13 March, full pink [FP (= first bloom)] was 13 April and petal fall [PF] was 11 May. °F = average daily temperature, CMS = canker margin symptom development, CBS = canker blight symptoms, EIP = relative epiphytic inoculum potential, BBSa,b,c = three blossom blight infection events, SBS = primary shoot blight symptoms (coincident with BBSc). Accuracy of intercept of plotted predictions with observed symptoms = ±1 day.

were recovered from >90 cm into healthy bark cortex beyond lower visible canker margin in June) and distal to infected spurs in 1990.

Work in progress now suggests that the rate of symptom development in apple tissues is indirectly proportional to the content of stored photosynthates in those tissues which, in turn, is indirectly proportional to the demands for carbohydrate reserves created by strong vegetative growth. Thus, under normal conditions wood invasion following early blossom infections is often slow or limited compared with that seen later in early shoot blight. Here, however, vegetative shoot development had been underway for nearly 5 weeks when blossom spurs and the supporting limbs were invaded by the pathogen. The situation worsened in that since the majority of blossom infections developed on secondary flowers in the tops of trees, several substantial rains during the latter part of May carried inoculum down through the tree canopies, giving rise to many secondary infections of young shoot tips which advanced quickly into lower scaffold branches and, from there, into the main trunk stems.

Since 1989, the regional fruit specialist for the western Maryland area, has made recommendations on the timing of streptomycin treatments based on the *MARYBLYT* forecasting system available via a telephone tape system. This year, much like last year, grower compliance with those recommendations was nearly 100% in Washington County (2 sprays recommended, ca. 26 April and 1 May). As a result, we had a difficult time locating blossom blight symptoms in that area, except at our WMREC research block where the forecasting system was not used and, for the first time since the orchard was planted 8 years ago, fire blight occurred much as described above. A *MARYBLYT* alert system has not been available elsewhere in the state because of equipment limitations and lack of grower interest (past experience above noted).

The third act was a killer...

An additional factor contributing to severe tree loss in some situations appears related to the increasingly popular use in our area of fire blight susceptible cultivars on the highly susceptible M26 rootstock. Some trees showed evidence of bacterial ooze below the graft union on the M26 rootstock by 30 June (pathogenic isolates *E. amylovora* were recovered from internal bark tissues). Many more trees exhibited rootstock cankering by the end of August and into early September. None of these trees showed evidence of possible direct invasion of the rootstock via infections progressing through root suckers or inoculations such as might be associated with insect wounds. By mid-September, trees with partial to complete girdling of the rootstock showed early reddening of the foliage (also partial to complete, coincident with canker zones). Tree losses in an eastern MD Gala\M26 orchard (5-7 years) where collar rot was also present were estimated at >30%, while those in a central MD Gala\26 + Jonee\M26 orchard (4-5 years) where collar rot was not a factor were estimated at ca. 10%.

Our evidence is still incomplete, but it appears that the bacteria migrate rapidly from infection sites in the canopy via the intercellular spaces of healthy scion bark cortex into those of the rootstock in the early summer. At this point the bacteria appear to remain latent (with respect to symptom development) until later in the summer when the physiological status of the M26 rootstock bark cortex changes sufficiently to support bacterial growth and ooze production. At this time we are speculating that the nature of this physiological change is associated with osmotic potentials between intercellular spaces and cortical parenchyma cells relative to changes in the composition or concentration various carbohydrates.

References:

1. **Lightner, G. and P.W. Steiner** (1990). Computerization of a blossom blight prediction model. Proceedings Vth I.S.H.S. International Workshop on Fire Blight, 19-22 June 1989, Diepenbeek, Belgium, *In* Acta Horticulturae, No. 273: 159-162
2. **Steiner, P.W.** (1990a). Predicting apple blossom infections by *Erwinia amylovora* using the Maryblyt model.*Ibid.* pp 139-148.
3. **Steiner, P.W.** (1990b). Predicting canker, shoot and trauma blight phases of apple fire blight epidemics using the Maryblyt model. *Ibid.* pp 149-158.
4. **Zoller, B.G. and J. Sisevich** (1979). Blossom populations of *Erwinia amylovora* in pear orchards vs accumulated degree hours over 18.3C (65F), 1972-1976. Phytopathology 69: 1050 Abstr.

APPLE (*Malus domestica*
'Red Delicious', 'Golden Delicious',
'Rome Beauty)
Scab; *Venturia inaequalis*
Powdery mildew; *Podosphaera leucotricha*
Cedar-apple rust;
Gymnosporangium juniperi-virginianae
Sooty blotch; *Gloeodes pomigena*
Flyspeck; *Zygophiala jamaicensis*
Fruit rots
Fruit finish

K. S. Yoder, A. E. Cochran II,
W. S. Royston, A. E. Ellis,
J. R. Warren
Virginia Agricultural Experiment
Station -Winchester
Virginia Polytechnic Institute
and State University
2500 Valley Avenue
Winchester, VA 22601

EVALUATION OF EXPERIMENTAL FUNGICIDES ON THREE APPLE CULTIVARS, 1990: Experimental and standard treatments were compared for early season and summer disease control and fruit finish on an 18-yr-old block of semi-dwarf trees planted in groups with one tree of each cultivar per group. The test was conducted in a randomized block design with four replicate groups per treatment. Treatments were applied as dilute sprays to the runoff point with a single nozzle handgun at 500 psi as follows: 26 Mar (Rome 1/2" green, 1/2" G; G. Del. tight cluster, TC; R. Del., pink); 6 Apr (Rome 1/2" G; G. Del. open cluster, OC; R. Del., pink to 10% bloom; 13 Apr (Rome, 1/2"G-TC; G. Del., OC-pink; R. Del., bloom); 23 Apr (Rome, OC-pink; G. Del., bloom; R. Del, petal fall, PF); 2 May (Rome, bloom; G. Del., PF; R. Del. fruit set); first through 6th cover sprays were applied 15 May, 31 May, 14 Jun, 3 Jul, 24 Jul and 31 Aug. Other materials applied separately to the entire test block with an airblast sprayer included Supracide + oil, Dipel, streptomycin, and Guthion + Lannate L. To assure high inoculum potential, cedar galls, bramble canes infected with the sooty blotch and flyspeck fungi, and apple shoot sections colonized by fruit rot fungi were placed in baskets over each test tree. Scab and powdery mildew developed from natural inoculum in the test area. Foliar data represent averages of ten terminal shoots from each replicate tree 11 Jul (G. Del.) or 17 Jul (Rome). Twenty-five fruit/replicate were harvested 24 Sep (R. Del. and G. Del.) or 10 Oct and rated after 3 wk (Rome) or 6 wk (R.Del. and G.Del.) storage at 2C.

Weather and inoculum conditions provided a strong test situation for early and late season diseases. The earliest scab infection period on record occurred 16-17 Mar (open cluster, R.Del.). Most treatments protected the fruit from the heavy scab infection which developed during the summer on untreated fruit. All treatments except MON-18833 gave adequate protection from cedar rust. MON-18833 was also relatively ineffective for mildew control. A range in effectiveness was evident among treatments for control of summer diseases which were favored by two 4-day wetting periods in mid-July and late August. SN 597265 gave excellent control of sooty blotch, flyspeck and fruit rots at the highest test rate and good control at the lowest rate. MON-18833 also showed good potential for summer disease control. Several other treatments suppressed sooty blotch, flyspeck and the rots as good as the captan and Benlate + captan standards. Although significant fruit finish differences were evident among treatments, no treatment was significantly deleterious compared to untreated fruit (p = 0.05). Several treatments significantly reduced russetting of Golden Delicious. Fruit finish data for Red Delicious are not reported because of interference from frost injury following unusually early bud development of this cultivar.

Table 1. Early season disease control and fruit finish with experimental fungicides

Treatment and rate/100 gal*	Scab (%)					Cedar rust (%)			Mildew, Rome		Fruit finish*		
	leaves		fruit			leaves		Rome	%	% lf.	russet		Rome
	Rome	G.Del.	Rome	G.Del.	R.Del.	Rome	G.Del.	fruit	leaves	area	G.Del.	Rome	opalescence
No fungicide	8.4 b	4.6 bc	85 c	86 b	67 b	31.6 c	33.2 d	25 b	21.1 f	9.3 c	2.9 d	1.8 a-d	1.5 ab
MON-18833 40W 10 oz	1.2 a	0.5 a	1 a	2 a	1 a	30.4 c	18.7 c	6 a	16.0 ef	5.4 b	2.2 abc	1.9 bcd	1.8 ab
MON-18833 40W 15 oz	0.3 a	0.3 a	2 a	1 a	0 a	22.6 b	17.4 bc	3 a	12.1 cde	3.6 ab	1.7 ab	1.8 a-d	1.6 ab
MON-18833 40W 20 oz	0.3 a	0.5 a	0 a	0 a	0 a	25.9 bc	16.1 bc	3 a	11.1 b-e	3.6 ab	1.7 ab	1.7 a-d	2.0 b
SN 597265 25W 2 oz	0.7 a	0.6 a	1 a	0 a	0 a	5.4 a	0.1 a	1 a	6.5 a-d	2.0 ab	2.2 abc	1.3 a	1.2 ab
SN 597265 25W 4 oz	0.0 a	0.0 a	0 a	0 a	0 a	0.0 a	0.4 a	0 a	2.6 abc	1.0 a	2.0 abc	1.5 abc	1.2 ab
SN 597265 25W 8 oz	0.0 a	0.0 a	0 a	0 a	0 a	0.1 a	0.0 a	0 a	3.5 abc	1.0 a	2.0 abc	1.6 a-d	1.6 ab
Exp 10064B 1.67SC 42.6 ml	0.0 a	0.0 a	2 a	0 a	0 a	0.2 a	0.0 a	0 a	2.8 abc	1.1 a	1.6 a	1.6 a-d	1.2 ab
Exp 10064B 1.67SC 56.8 ml	0.1 a	0.3 a	2 a	0 a	2 a	1.0 a	0.1 a	2 a	5.7 abc	1.9 ab	2.4 bcd	1.5 a-d	1.3 ab
Aliette 80W 6 oz	2.4 a	2.1 ab	17 ab	4 a	6 a	8.1 a	6.1 ab	3 a	8.4 a-e	2.4 ab	2.0 abc	2.2 d	1.8 ab
Nova 40W 1.25 oz + Aliette 80W 8 oz	0.3 a	1.0 a	3 a	0 a	0 a	1.6 a	0.0 a	0 a	2.7 abc	1.0 a	2.4 bcd	2.0 cd	1.4 ab
Nova 40W 1.25 oz	0.7 a	1.8 ab	8 ab	2 a	3 a	0.0 a	0.0 a	0 a	0.9 a	0.4 a	2.2 abc	1.6 a-d	1.1 ab
Nova 40W 1.75 oz to 2nd C; Benlate 50DF 2 oz + Captan 50W 2 lb from 3rd C	0.4 a	0.8 a	4 a	0 a	1 a	0.1 a	0.0 a	0 a	4.4 abc	1.4 ab	2.0 abc	1.3 ab	1.4 ab
Captan 50W 2 lb	2.3 a	6.4 c	14 ab	5 a	3 a	1.0 a	1.9 a	1 a	15.6 def	3.9 ab	2.1 abc	1.8 a-d	1.3 ab
ASC-66811 10XEC 2.5 fl oz	0.8 a	2.9 ab	11 ab	1 a	3 a	0.4 a	0.1 a	0 a	1.6 ab	0.5 a	2.1 abc	1.8 a-d	1.1 a
ASC-66811 10XEC 5.0 fl oz (1st and 2nd applications); ASC-66811 10XEC 1.25 fl oz from TC	1.0 a	1.1 a	23 b	10 a	4 a	0.0 a	0.0 a	0 a	1.7 ab	0.5 a	2.6 cd	1.6 a-d	1.1 a

Averages of 10 terminal shoots or 25 fruit from each of four single-tree replicates.
Mean separation by Duncan's Multiple Range Test (p = 0.05).

Table 2. Control of summer diseases with experimental fungicides

Treatment and rate/100 gal*	Sooty blotch (%) Rome fruit	Sooty blotch (%) Rome area	Sooty blotch (%) G.Delicious fruit	Sooty blotch (%) G.Delicious area	Sooty blotch (%) R.Del. fruit	Flyspeck (% fruit) Rome	Flyspeck (% fruit) G.Del.	Flyspeck (% fruit) R.Del.	Fruit with rots (%) Rome	Fruit with rots (%) G.Del.	Fruit with rots (%) R.Del.
No fungicide	100 g	46 e	100 h	54 c	89 d	95 e	100 e	76 f	25 c	67 c	16 b
MON-18833 40W 10 oz.........	22 abc	4 abc	34 a-e	12 ab	8 ab	18 abc	32 abc	19 abc	8 ab	14 a	9 ab
MON-18833 40W 15 oz.........	18 ab	1 a	20 abc	1 ab	1 a	22 abc	10 ab	9 ab	5 ab	6 a	9 ab
MON-18833 40W 20 oz.........	4 a	0.2 a	6 a	0.4 a	0 a	10 ab	2 a	6 a	15 bc	3 a	8 ab
SN 597265 25W 2 oz..........	3 a	0.2 a	13 ab	1 a	0 a	4 ab	5 a	2 a	3 ab	6 a	9 ab
SN 597265 25W 4 oz..........	0 a	0 a	8 a	1 a	3 a	0 a	1 a	4 a	6 ab	5 a	1 a
SN 597265 25W 8 oz..........	1 a	0 a	0 a	0 a	0 a	0 a	0 a	0 a	2 a	3 a	0 a
Exp 10064B 1.67SC 42.6 ml...	16 ab	2 ab	36 a-d	6 ab	27 abc	18 abc	24 ab	21 a-d	8 ab	6 a	7 ab
Exp 10064B 1.67SC 56.8 ml...	56 de	10 bcd	82 efg	14 ab	49 c	53 d	42 bcd	44 de	7 ab	20 a	0 a
Aliette 80W 8 oz............	46 cd	5 abc	62 c-f	13 ab	32 bc	38 bcd	34 ab	31 bcd	11 ab	7 a	1 a
Nova 40W 1.25 oz + ... Aliette 80W 8 oz	59 de	6 abc	75 def	12 ab	27 abc	37 bcd	25 ab	20 abc	6 ab	20 a	6 ab
Nova 40W 1.25 oz............	36 bcd	3 ab	71 def	12 ab	17 ab	20 abc	34 ab	17 abc	5 ab	17 a	4 ab
Nova 40W 1.75 oz to 2nd C Benlate 50DF 2 oz + Captan 50W 2 lb from 3rd C..	7 a	0.4 a	26 a-d	4 ab	8 abc	17 abc	21 ab	12 abc	7 ab	6 a	2 a
Captan 50W 2 lb.............	40 bcd	5 abc	57 b-f	13 ab	11 ab	45 cd	44 bcd	36 cde	4 ab	10 a	0 a
ASC-66811 10%EC 2.5 fl oz...	71 ef	12 cd	83 fg	16 b	32 bc	54 d	65 cd	25 a-d	10 ab	21 a	11 a
ASC-66811 10%EC 5.0 fl oz (1st and 2nd applications) ASC-66811 10%EC 1.25 fl oz from TC..............	85 f	16 d	99 gh	44 c	77 d	55 d	70 d	53 e	8 ab	46 b	1 a

Mean separation by Duncan's Multiple Range Test (p = 0.05).
Averages of 25 fruit from four single-tree replicates.

APPLE (*Malus domestica* 'Golden Delicious')
Scab; *Venturia inaequalis*
Cedar-apple rust; *Gymnosporangium juniperi-virginianae*
Powdery mildew; *Podosphaera leucotricha*
Sooty blotch; *Gloeodes pomigena*
Flyspeck; *Zygophiala jamaicensis*
Fruit rots
Fruit russet

K. S. Yoder, A. E. Cochran II, W. S. Royston, A. E. Ellis, J. R. Warren
Virginia Agricultural Experiment Station -Winchester
Virginia Polytechnic Institute and State University
2500 Valley Avenue
Winchester, VA 22601

COMPARISON OF EBDC FUNGICIDE ALTERNATIVES ON GOLDEN DELICIOUS APPLE, 1990: Fungicide mixtures and possible alternatives to EBDC fungicides were compared for early and late season disease control and fruit finish effects on an 18-yr-old block of trees at the VPI and SU Research Farm near Winchester, VA. 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. Treatments were applied to both sides of the tree on each application date with a Swanson Model DA-400 airblast sprayer at 100 gal/A as follows: 2 Apr (tight cluster); 13 Apr (pink); 27 Apr (bloom); first through fifth covers (8 May, 25 May, 8 Jun, 28 Jun, and 19 Jul). During the test period other materials applied separately to the entire test block included Guthion 35W + Lannate L (15 May, 1 Jun, 15 Jun, 28 Jun, 16 Jul, 30 Jul, and 17 Aug); streptomycin (27 Apr and 2 May) and Amid-Thin (21 May). To assure high inoculum potential cedar galls, bramble canes infected with the sooty blotch and flyspeck fungi, and apple shoot sections colonized by fruit rot fungi were placed in baskets over each test tree. Scab and powdery mildew developed from natural inoculum in the test area. Fruit were harvested 20 Sep and rated after 5 wks storage at 2C.

Weather and inoculum conditions provided a strong test situation for early and late season diseases. Six early infection periods allowed scab to become established before heavier secondary periods 3-5 May and 25-27 May. All treatments gave adequate control of scab on foliage. Fruit scab incidence was variable among the replicates of several treatments and significant differences ($p = 0.05$) were not detected. Seven rust infection periods occurred from 21 Apr through 27 May resulting in a strong comparison treatments for cedar rust control on mid-terminal leaves. Ferbam (Carbamate) and Nova + Captan gave good rust control. The reduced rate of ferbam + Rubigan was significantly less effective for rust control than the higher ferbam rate. Nova + Captan gave significantly better mildew control than Rubigan + captan. Rubigan combinations with ziram, thiram and ferbam were acceptable for mildew control. Summer disease development was favored by two 4-day wetting periods in mid-July and late August. The treatment series was stopped after 19 Jul to test for differences in residual activity. Ferbam, captan, and the higher rate of ziram gave the best reduction in sooty blotch and flyspeck severity. Fruit rot incidence was variable and significant differences were not detected ($p = 0.05$). No treatment significantly increased fruit russetting compared to untreated fruit, however, the ferbam treatments resulted in significantly poorer finish than captan, ziram and thiram.

Table 3. Comparison of EBDC alternatives for early season disease control on Golden Delicious apple

	Treatment and rate/A*	Scab % leaves	Scab lesions/ inf leaf	Scab % fruit	Rust % leaves	Rust lesions/ inf leaf	Mildew % leaves	Mildew % area	Fruit finish rating
0	Untreated	18.7 b	7.1 c	77 b	28.8 f	6.1 c	30.9 d	4.9 c	2.95 abc
1	Nova 40W 5 oz + ... Captan 50W 3.25 lb to 2nd C Captan 50W 6.5 lb from 3rd C	0.5 a	0.8 ab	1 a	2.9 ab	2.2 ab	5.9 a	1.4 a	2.18 a
2	Rubigan 1E 6 fl oz + ... Captan 50W 3.25 lb to 2nd C Captan 50W 6.5 lb from 3rd C	0.1 a	0.2 a	9 a	16.7 e	3.9 b	13.5 bc	2.5 ab	2.70 abc
3	Rubigan 1E 9.0 fl oz to 2nd C... Captan 50W 6.5 lb from 3rd C	1.5 a	1.1 ab	4 a	8.0 bcd	3.1 ab	7.9 ab	1.8 ab	2.55 ab
4	Rubigan 1E 6 fl oz + ... Ziram 76WDG 3.25 lb to 2nd C Ziram 76WDG 6.5 lb from 3rd C	1.6 a	1.2 ab	10 a	5.6 abc	2.4 ab	7.1 ab	1.6 ab	2.73 abc
5	Rubigan 1E 6 fl oz + ... Thiram 65W 3.25 lb to 2nd C Thiram 65W 6.5 lb from 3rd C	0.4 a	1.0 ab	3 a	8.1 bcd	3.3 ab	9.1 ab	1.8 ab	2.28 a
6	Rubigan 1E 6 fl oz + ... Carbamate 76WDG 3.25 lb to 2nd C Carbamate 76WDG 6.5 lb from 3rd C	0.6 a	0.7 ab	3 a	10.4 cd	2.4 ab	7.6 ab	1.4 a	3.33 bc
7	Rubigan 1E 6 fl oz + ... Syllit 65W 1 lb to 2nd C Captan 50W 6.5 lb from 3rd C	1.9 a	2.5 b	14 a	9.9 cd	3.3 ab	11.6 abc	2.1 ab	2.45 a
8	Ziram 76WDG 6.5 lb..............	2.9 a	1.9 ab	14 a	6.8 a-d	2.2 ab	10.7 abc	2.1 ab	2.48 a
9	Ziram 76WDG 10 lb	1.5 a	1.2 ab	4 a	5.5 abc	2.4 ab	12.8 abc	2.4 ab	2.35 a
10	Thiram 65W 6.5 lb	4.5 a	1.3 ab	18 a	7.9 a-d	1.9 a	16.6 c	2.8 ab	2.45 a
11	Captan 50W 6.5 lb	2.4 a	1.4 ab	10 a	12.6 de	2.9 ab	12.9 abc	2.5 ab	2.13 a
12	Carbamate 76WDG 6.5 lb..........	1.8 a	1.0 ab	12 a	2.1 a	1.6 a	11.8 abc	2.2 ab	3.48 c

Averages of ten terminal shoots from each of four single-tree replicates, 25 Jun, or 25 fruit/rep 24 Oct. Mean separation by Duncan's Multiple Range Test ($p = 0.05$).

Table 4. Comparison of EBDC alternatives for summer disease control, Winchester, VA, 1990

Treatment and rate/A	Scab % fruit	Sooty blotch % fruit	Sooty blotch % area	Fly speck % fruit	Fly speck % area	Rots % fruit	Russet rating (0-5)*
0 Untreated	77 a	100 c	50.0 c	100 e	13.3 d	55 b	2.95 abc
1 Nova 40W 5 oz + Captan 50W 3.25 lb to 2nd C Captan 50W 6.5 lb from 3rd C	1 b	91 bc	20.5 ab	59 bc	2.9 ab	21 a	2.18 a
2 Rubigan 1E 6 fl oz + Captan 50W 3.25 lb to 2nd C Captan 50W 6.5 lb from 3rd C	9 b	93 bc	22.9 ab	63 bcd	5.2 b	22 a	2.70 abc
3 Rubigan 1E 9.0 fl oz to 2nd C Captan 50W 6.5 lb from 3rd C	4 b	92 bc	23.6 ab	67 bcd	4.1 ab	16 a	2.55 ab
4 Rubigan 1E 6 fl oz + Ziram 76WDG 3.25 lb to 2nd C Ziram 76WDG 6.5 lb from 3rd C ...	10 b	95 bc	22.3 ab	81 d	4.9 b	17 a	2.73 abc
5 Rubigan 1E 6 fl oz + Thiram 65W 3.25 lb to 2nd C Thiram 65W 6.5 lb from 3rd C	3 b	95 bc	30.8 b	63 bcd	4.3 ab	21 a	2.28 a
6 Rubigan 1E 6 fl oz + Carbamate 76WDG 3.25 lb to 2nd C Carbamate 76WDG 6.5 lb from 3rd C	3 b	63 a	14.3 a	49 ab	3.4 ab	13 a	3.33 bc
7 Rubigan 1E 6 fl oz + Syllit 65W 1 lb to 2nd C Captan 50W 6.5 lb from 3rd C	14 b	88 bc	24.0 ab	48 ab	2.5 ab	14 a	2.45 a
8 Ziram 76WDG 6.5 lb	14 b	92 bc	32.8 b	79 cd	8.4 c	25 a	2.48 a
9 Ziram 76WDG 10 lb	4 b	83 ab	13.3 a	57 bc	3.2 ab	13 a	2.35 a
10 Thiram 65W 6.5 lb	18 b	92 bc	23.2 ab	79 d	4.0 ab	17 a	2.45 a
11 Captan 50W 6.5 lb	10 b	76 ab	15.3 a	59 bc	2.5 ab	17 a	2.13 a
12 Carbamate 76WDG 6.5 lb	12 b	85 ab	23.3 ab	30 a	1.1 ab	18 a	3.48 c

Mean separation by Duncan's Multiple Range Test ($p = 0.05$).
Averages of 25 fruit from each of four single-tree replicates.
*Rated on a scale of 0-5 (0 = perfect finish; 5 = severe russet).

APPLE (*Malus domestica*
'Golden Delicious'
Scab; *Venturia inaequalis*
Sooty blotch; *Gloeodes pomigena*
Fly speck; *Zygophiala jamaicensis*

K. S. Yoder, A. E. Cochran II,
W. S. Royston
Virginia Agr. Exp. Sta.-Winchester
Virginia Polytechnic Inst. & St. Univ.
2500 Valley Avenue
Winchester, VA 22601

EVALUATION OF LORSBAN AND DIPEL FOR SUMMER DISEASE CONTROL ON GOLDEN DELICIOUS APPLES, 1990: Semi-dwarf, 18-yr-old trees which had not been treated with fungicides through mid-season were used to test the effect of selected insecticides on late season disease development. The test was conducted in a randomized block design with four single-tree replicates. Treatments were applied to both sides of the test row 6 Jul and 3 Aug with a Swanson Model DA-400 airblast sprayer calibrated to deliver 100 gal per acre. The regular season insecticides, Guthion 35W 2 lb/A + Lannate L 3 pt/A, were applied to the entire test row with the same equipment 15 May, 1 Jun, 15 Jun, 28 Jun, 16 Jul, 30 Jul, and 17 Aug. Fruit were harvested 20 Sep and evaluated after 18 days' storage at 2C.

Early season weather favored the development of scab which was evident on leaves and some fruit prior to the first test application. Dry weather in June was unfavorable to scab infection or sooty blotch and fly speck development. Considering the strong treatment effect and the time of appearance of secondary scab on fruit in mid-August, it is likely that the protective action of captan and Lorsban against scab occurred during a long wetting period 11-15 Jul. Ten additional significant wetting periods from mid-July through August, including a 4-day period 21-24 Aug, increased summer disease pressure during the test period. The two applications of captan and Lorsban significantly reduced fly speck incidence and severity of sooty blotch and fly speck. Sooty blotch incidence was high and rot incidence was too variable to show a significant treatment effect (p = 0.05).

Treatment and formulated rate/A	Scab		Sooty blotch		Fly speck		Rots
	% fruit	lesions per fruit	% fruit	% area	% fruit	% area	% fruit
No fungicide	88 b	4.1 bc	100 a	39 b	98 b	11 b	56 a
Captan 50W 6.5 lb...	26 a	0.5 a	80 a	13 a	56 a	3 a	26 a
Lorsban 50W 3.0 lb..	44 a	1.7 ab	87 a	13 a	72 a	3 a	36 a
Dipel 2X 1.5 lb.....	79 b	5.7 c	93 a	23 ab	91 b	8 b	43 a

Mean separation by Duncan's Multiple Range Test (p = 0.05).
Averages of 25 fruit from each of four single-tree replications.

APPLE (*Malus domestica* 'Golden Delicious')
Blue mold; *Penicillium expansum*

K. S. Yoder, A. E. Cochran II,
W. S. Royston
Virginia Agr. Exp. Sta.-Winchester
Virginia Polytechnic Inst. & St. Univ.
2500 Valley Avenue
Winchester, VA 22601

POSTHARVEST DIP TREATMENT FOR CONTROL OF PENICILLIUM BLUE MOLD, 1990: Fruit from a commercial orchard were selected for uniform size, firmness, and maturity and randomized into four 25-fruit replicates for each treatment. Each fruit was inoculated in two locations by dipping the point of a 4 mm diameter nail in a suspension containing 10^4 benzimidazole-sensitive conidia per ml and uniformly piercing the fruit skin with the nail point to a depth of 5 mm. Following inoculation, fruit were dipped 30 sec in the fungicide suspension, placed on fiber trays in polyethylene bags and incubated at 15C.

Treatments involving Topsin-M or Mertect gave excellent control of benzimidazole-sensitive *Penicillium.* Rovral + Triton CS-7 was more effective than captan. Aliette + Triton CS-7 was ineffective, but Aliette greatly enhanced the effectiveness of the Rovral + Triton CS-7 combination. Experimental compounds ASC 66811 and MON-18833 did not effectively control Penicillium blue mold under these test conditions.

Treatment and formulated rate per 100 gal	Blue mold incidence (%) after indicated days' incubation at 15C		
	5 days	8 days	12 days
Untreated	98 f	98 e	98 e
Aliette 80W 4.5 LB + Triton CS-7 16.0 fl oz	90 e	97 e	97 e
Aliette 80W 4.5 lb + Rovral 4SC 8 fl oz + Triton CS-7 16 fl oz	1 a	3 a	6 ab
Rovral 4SC 8 fl oz + Triton CS-7 16 fl oz	17 b	20 b	22 c
Rovral 4SC 16 fl oz + Triton CS-7 16 fl oz	6 ab	14 ab	19 bc
Topsin-M 85WDG 10 oz + Captan 50W 16 oz	0 a	0 a	0 a
Captan 50W 2.0 lb	35 c	60 c	65 c
Topsin-M 85WDG 10 oz	0 a	0 a	0 a
Mertect 340-F 16 fl oz	0 a	0 a	1 a
Mertect 340-F 16 fl oz + Captan 50W 16 oz	0 a	0 a	0 a
ASC 66811 10%EC 2.5 fl oz	61 d	86 d	88 d
MON-18833 40W 20 oz	86 e	86 d	89 d

Mean separation by Duncan's Multiple Range Test ($p = 0.05$).

PEACH (*Prunus persica* 'Loring')
Leafcurl; *Taphrina deformans*
Scab; *Cladosporium carpophilum*
Brown rot; *Monilinia fructicola*
Rhizopus rot; *Rhizopus* spp.

K. S. Yoder, A. E. Cochran II,
W. S. Royston, A. E. Ellis
Virginia Agr. Exp. Station-Winchester
Virginia Polytechnic Inst. & St. Univ.
2500 Valley Avenue
Winchester, VA 22601

EVALUATION OF EXPERIMENTAL FUNGICIDES ON LORING PEACH, 1990: Experimental fungicides were evaluated for disease control and phytotoxicity on 11-yr-old trees at the VPI and SU Research Farm. The trees had not been treated with fungicides in 1989. Natural carry-over brown rot inoculum was adjusted to three mummified fruit per tree in early March. Dilute treatments were applied to the point of run-off with a single nozzle handgun at 500 psi in a randomized block design with three or four single-tree replicates as follows: 5 Mar (bud swell); 15 Mar (pink, P); 26 Mar (bloom, Bl); 9 Apr (petal fall, PF); 23 Apr (shuck split, SS); 1st-5th covers 15 May, 31 May, 14 Jun, 3 Jul and 17 Jul and two pre-harvest (2PH) sprays 31 Jul and 7 Aug. Fruit were harvested 9 Aug; 10 to 20 apparently rot-free fruit per replication were selected for uniform ripeness, placed on fiber trays and incubated in polyethylene bags at 21C for the indicated interval.

Weather conditions were favorable for the development of leaf curl, scab, and fruit rots. Although buds had swollen by 5 Mar, leaf curl infection did not occur until 16-17 Mar. All treatments gave adequate leaf curl control including five treatments which were not applied until pink stage, 15 Mar. Many treatments received captan which gave good scab control during the critical scab period. Ziram, RH-7592 and the higher rate of CGA 455 also gave acceptable scab control under these conditions. Rovral, applied pre-harvest, gave good control of brown rot on the tree and after harvest. Several other treatments gave fair to good brown rot control on the tree, but were significantly weaker than Rovral shortly after harvest. No phytotoxic effects were observed.

Table 6. Evaluation of experimental fungicides on Loring peach

Treatment and rate per 100 gal*	Timing	% shoots with leaf curl 23 May	Scab 9 Aug	Brown rot incidence (%) on tree 8 Aug	Brown rot incidence (%) after indicated days post harvest** 2	4	6	% Rhizopus 6 days after harvest
0 Untreated	---	28.8 b	25 b	23 b	84 d	92 b	100 b	31 ab
1 Carbamate 76WDG 1.5 lb Captan 50W 2 lb	Bud swell Pink⟶	0.0 a	0 a	20 ab	23 ab	56 ab	88 ab	27 ab
2 Ziram F-4 36.5 fl oz	Bud swell⟶	0.0 a	1 a	19 ab	68 cd	90 b	100 b	26 ab
3 Ziram 76WDG 1.5 lb	Bud swell⟶	0.0 a	8 a	18 ab	65 c	83 ab	100 b	19 ab
4 Kocide 101 77W 2 lb Kocide 101 77W 4 oz Captec 4L 1 qt	Bud swell Pink Bloom⟶	0.0 a	2 a	4 a	32 ab	58 ab	88 b	18 ab
5 GX 241 40DF 2 lb GX 241 40DF 4 oz Captec 4L 1 qt	Bud swell Pink Bloom⟶	0.0 a	6 a	14 ab	39 abc	74 ab	94 b	39 b
6 CGA 455 50W 1 oz	Bud swell⟶	0.3 a	21 b	17 ab	52 bc	69 ab	92 b	21 ab
7 CGA 455 50W 2 oz	Bud swell⟶	0.4 a	5 a	4 a	45 abc	63 ab	90 b	16 ab
8 RH 7592 2F 56.8 ml + Triton B-1956 4 fl oz	Pink⟶	0.1 a	5 a	5 ab	51 bc	73 ab	96 b	24 ab
9 Elite 45DF 1.5 fl oz Captan 50W 2 lb	P,Bl,PF,2PH SS-5th C	0.0 a	2 a	9 ab	28 ab	50 ab	76 ab	12 a
10 Elite 45DF 2 oz Captan 50W 2 lb	P,Bl,PF,2PH SS-5th C	0.1 a	5 a	9 ab	22 ab	38 a	84 ab	21 ab
11 Rovral 4SC 8 fl oz + Triton CS-7 1 pt Captan 50W 2 lb	P,Bl,PF,2PH SS-5th C	0.3 a	1 a	5 ab	14 a	26 a	55 a	9 a
12 Bravo 720 33.1 fl oz + Rovral 4SC 8 fl oz + Triton CS-7 1 pt Captan 50W 2 lb Rovral 4SC 8 fl oz + Triton CS-7 1 pt	P,Bl,PF SS-5th C 2PH	0.0 a	0 a	3 a	12 a	37 a	83 ab	13 a

Averages of three or four replications. Mean separation by Duncan's Multiple Range Test ($p = 0.05$).

* Formulated material per 100 gal dilute. Applied to runoff with a single nozzle handgun at 500 psi as indicated: 5 Mar (bud swell); 15 Mar (pink); 26 Mar (bloom); 9 Apr (petal fall); 23 Apr (shuck split, SS); 15 May, 31 May, 14 Jun, 3 Jul, 17 Jul (1st -5th covers). All treatments received two pre-harvest sprays 31 Jul and 7 Aug.

**Fruit harvested 9 Aug; 10-20 apparently rot-free fruit/rep selected for uniform ripeness, placed on fiber trays and incubated in polyethylene bags at 21 C for indicated interval.

Title: Effects of Nemacur and Clandosan on Nematode Biocontrol Agents

Author: James Kotcon
Division of Plant and Soil Sciences
West Virginia University
P. O. Box 6057
Morgantown, WV 26506-6057

Introduction

Nematicides registered for use on deciduous tree fruit have been under increasing regulatory scrutiny and the number of materials registered for nematode control on fruit has declined in recent years. Most nematicides are not target-specific; however their impacts on nontarget organisms has not been adequately quantified. Thus, while population reductions of plant-parasitic nematodes have been associated with nematicide usage, the lack of data on nontarget nematode biocontrol agents makes it difficult to evaluate the long-term impacts of nematicides on target pests. Severe impacts on the predators and parasites of plant-parasitic nematodes may prevent normal development of biological control agents which would mitigate plant-parasitic nematode populations; thus use of these chemicals could make growers "dependent" on perpetual use of nematicides.

A new product, Clandosan (a chitin-urea soil amendment), has been registered as a soil amendment to provide natural biocontrol of nematodes. The high chitin content of Clandosan is believed to promote the proliferation of chitin-degrading microorganisms in soil, thereby increasing natural populations of nematode biocontrol agents. An alternative hypothesis suggests that chitin degradation releases substantial quantities of ammonia and other nitrogenous compounds that are directly toxic to nematodes. The impact of Clandosan on nematode biocontrol agents and their activity in soil has not been evaluated in orchard soils.

In these studies, field and laboratory experiments evaluated the impacts of two nematicides, Nemacur (fenamiphos) and Clandosan, on population dynamics of predatory nematodes. A laboratory assay was also used to quantify overall nematode biocontrol agent (NBA) activity.

Materials and Methods:

Laboratory Trials

A new procedure to quantify NBA activity in soil was developed. This procedure is based on the premise that nematode mortality is higher in untreated field soil than in soil sterilized to remove microorganisms active in biological control of nematodes. Known quantities of *Pratylenchus penetrans* were added to 100-cc samples of untreated and sterilized silt loam peach orchard soil from a site adjacent to Location B. Trials were conducted to evaluate nematode survival after incubation for periods from 1 to 21 days, inoculum densities of 50 to 500 P. penetrans, and soil moisture contents from 13 to 30 % (dry to saturated). NBA activity was calculated as the difference in the percentage of nematodes surviving in raw versus sterile soil.

The assay was used to quantify the initial impact of Clandosan on survival of P. penetrans. Untreated and sterilized soils were amended with 0 or 11.5 g Clandosan/kg soil. Soils were incubated at 16.5 % moisture at 25 C for 5 to 6 weeks in a sealed plastic bag. Four 100-g aliquots of each soil were then inoculated with a known number of P. penetrans and incubated an additional 14 days at 25 C. The number of predatory nematodes and dead and surviving P. penetrans recovered was determined. The experiment was repeated twice.

Orchard Trials

Nematode population dynamics were monitored in three long-term field trials for three field seasons. Location A was located in Berkeley Co. WV and was infested with *Pratylenchus crenatus*, *P. neglectus*, *Xiphinema americanum*, *X. rivesi*, and *Meloidogyne hapla* as well as three Mononchid predators, *Mononchus papillatus*, *Mylonchulus obliquus*, and an unidentified *Iotonchus* sp. Five replicate plots of eight trees each were treated with Nemacur at 18 lb ai./acre in spring 1987, in fall 1987, with a split application of 9 lb ai./acre in both spring and fall, or were left untreated. Trees planted at this site in 1987 were removed in 1988 after bloom because blossom characters had indicated a mixed-cultivar stand. New Redhaven trees on Halford rootstocks were planted in April 1988 on the same sites as the 1987 nematicide trial, resulting in significant differences in initial nematode population densities among treatments (Table 1). The spring and the split applications were repeated annually. Nematode population densities were monitored in soil samples taken from the tree root system. Predators were counted using a stereomicroscope at 40-120 X and representative specimens were identified using a compound microscope at 1000 X.

At Location B, located in Jefferson Co., WV, annual broadcast applications of Nemacur were compared with applications through drip irrigation systems. Plot design and nematode species were similar to Location A but *P. penetrans* and *Criconemella ornata* were also present. Treatments applied to peach cv. Blake were: 1) Nemacur applied at 18 lb. ai. per acre via broadcast spray, 2) Nemacur applied via drip irrigation at 18 lb. per acre each spring, 3) Nemacur applied via drip irrigation at 9 lb each spring and an additional 9 lb each fall, and 4) an untreated control. Drip applications assumed nematicide treatment throughout a 4-foot diameter wetted zone underneath drip emitters placed on two sides of each tree. Nematode population densities were monitored in soil samples from irrigated and nonirrigated portions of the tree root system.

At Location C, located in Monongalia Co., WV, Nemacur was compared to Clandosan treatment in single tree plots. Soil in

25-ft[2] plots around two-year old apple trees, cvs Empire, Northern Spy, and York Imperial on EMLA-7A rootstocks, was treated with 3T/A Clandosan annually, 1T/A Clandosan annually, 1T/A Clandosan (1988 only), 18 lb ai. Nemacur/A annually, 600 lb NH_4NO_3/acre annually (nitrogen equivalent to 1 T/A Clandosan), or was untreated. Treatments were incorporated into the soil using hand tilling. Soil samples were collected from the treated portion of the tree root zone.

NBA Assays

The NBA assay was used to evaluate biocontrol activity in Nemacur- and Clandosan-treated and untreated soil from the experimental plots after two or three consecutive years of application. At Location B, soil samples were collected from plots Nov. 11, 1988 (187 days after the previous application). Samples were again collected May 2, 1990 (343 days after the previous application). NBA activity was assayed in soil from Location C collected on Nov. 15, 1989 and on April 24, 1990 (160 and 320 days after the previous application).

A 100-cc sample of soil from each plot was autoclaved. This and another 100-cc sample (raw) were moistened to field capacity (20 %) and inoculated with a pre-counted number of *P. penetrans* from greenhouse *Zea mays* cultures. Samples were sealed in plastic bags and incubated for 14 days at 25 C. An uninoculated replicate was also incubated and extracted to determine the indigenous population of *P. penetrans*. Percent nematode survival and biocontrol activity were calculated after correcting for the indigenous population density.

Results and Discussion

Laboratory Trials

Survival of *P. penetrans* in sterile soil did not differ from that in raw soil until 14 days after inoculation and differences in per cent survival in raw and sterile soil were greatest with soil at or above 20 % soil moisture and with inoculum densities of 200 *P. penetrans* (data not shown). Assays incubated for 14 days at 20 % soil moisture (approximately field capacity) produced estimates of NBA activity between 7 and 19 % in six out of seven trials using this soil. In other words, between 7 and 19 % more nematodes survived the 14-day incubation in sterile than in raw soil. This approach to quantifying biocontrol activity was shown to be useful for addressing a variety of important questions dealing with nematode biocontrol; however, it is labor intensive and requires skilled operators and a highly efficient and reliable extraction procedure to achieve the precision necessary for statistically significant results. The procedure may not be appropriate for routine diagnostic work because of the need for adequate replication of treatments and a high level of technical expertize. Nevertheless, it is the first technique for the quantitative assessment of nematode biological control activity. The soil used in developing this procedure was taken from an orchard site that had negligible indigenous population densities of P. penetrans. As such, it may have a high level of NBA activity against P. penetrans which would be ideal for development of this technique. Furthermore, it avoided the problem of distinguishing indigenous P. penetrans from those added as inoculum, thereby avoiding the need to process additional uninoculated samples.

In each of three laboratory assays, Clandosan incubated in sterile and untreated (raw) orchard soil for 5 to 6 weeks reduced survival of Pratylenchus penetrans incubated for an additional 2 weeks (Table 2). The reduction in nematode survival attributed to Clandosan was similar in raw and sterile soils in each of the three replicated trials. These data suggest that Clandosan acts through release of ammonia rather than by stimulating nematode biocontrol activity in soil. This hypothesis was further substantiated by observations of numerous dead, but undecomposed, P. penetrans after 14-days incubation in Clandosan-amended soils. Proliferation of biocontrol agents should have resulted in the decomposition of nematode corpses during this period. Furthermore, the population density of predatory nematodes was significantly reduced by Clandosan in these short-term laboratory assays (data not shown).

Orchard Trials

At Location A, nematicide treatment in fall 1987 reduced population densities of Pratylenchus for two years; however population densities of Xiphinema and Mononchids rebounded within two seasons to levels not significantly different from untreated plots (Table 1). This suggests that nematicide applications are needed annually to control Xiphinema but may be applied less frequently to control Pratylenchus on peach.

At Location B, population densities of Xiphinema, Pratylenchus, and Mononchids were reduced by the third season, in portions of the root system where the nematicide had been applied (Table 3). Population densities were reduced in the nonirrigated portion of the root system only in the broadcast application treatment. Substantial tree mortality was observed during the 1989 and 1990 seasons. Of 40 trees per treatment, 17, 9, 15, and 22 trees died in the broadcast, 18 lb drip, 9+9 lb drip, and untreated plots, respectively. While substantial injury from peach tree borer was observed on most dead trees, Peach Stem Pitting symptoms were observed in 10, 3, 1, and 10 trees of these treatments.

At Location C, reductions in population density of Pratylenchus, but not Xiphinema or Mononchids were observed in Clandosan treated plots in 1988 (Figure 1). No significant reductions in Xiphinema population densitites were observed with any treatment at any sample date over the three years of this trial. Nemacur lowered population densities of Pratylenchus, but

Mononchid population densities were not significantly different from those in untreated plots. York Imperial trees treated with Clandosan exhibited more fire blight than trees in other treatments, but other cultivars did not exhibit fire blight symptoms.

NBA Assays

When biocontrol activity of Nemacur-treated and nontreated soil from Location B was compared, survival of *Pratylenchus* was similar in sterile and raw soil from untreated plots (Table 4). Since the *P. penetrans* recovered from raw soil included both indigenous and inoculated nematodes, data were adjusted to account for the estimated indigenous population density. Survival was reduced in raw soil from Nemacur-treated plots compared to that from sterilized soil from treated plots. The data suggest that little biocontrol activity was measured in this orchard. Furthermore, annual fenamiphos applications did not reduce this activity and may have increased it, although too much variability exist in this trial for the trends to be statistically significant.

At Location C, NBA activity in Nemacur and Clandosan treated soils was significantly greater than that in untreated soil in the first trial; however, these differences were largely due to enhanced survival in sterilized soil. Trends were reversed in the second trial from Location C; however differences were not statistically significant.

Conclusions

Nemacur provided significant control of plant-parasitic nematodes in the three orchard trials; however annual applications may be necessary for good dagger nematode control. Clandosan was only marginally effective for control of *Pratylenchus* and was ineffective for *Xiphinema*, even after annual applications at the maximum labelled rate.

Reductions in population densities of predatory nematodes was observed with Nemacur treatments, however Clandosan generally did not influence predatory nematode densities over the three year trial. Other biocontrol agents in soil may have increased their activity in response to Nemacur application because the NBA assay indicated no reduction in activity in spite of the reduction in predator densities observed. There is not strong evidence of any increase in NBA activity in Clandosan treated plots, providing further evidence that Clandosan's mode of action is dominated by release of toxic breakdown products rather than a proliferation of biocontrol microorganisms. The assays used do not provide any direct measure of activity against sedentary stages such as eggs. Nontarget effects of pesticides against these stages may also be important.

Table 1. Nematode population densities at location A from 1987 to 1989 with trees replanted in early April 1988.

Nematode & Treatment	1987 4/24	1987 6/4	1987 9/24	1987 11/18	1988 4/28	1988 6/24	1988 9/27	1989 6/13	1989 7/10
Xiphinema									
Untreated	25	20	23 a	29 b	5	12 b	31 b	28 ab	22ab
18 lb-spring	20	21	6 b	7 a	2	2 a	5 a	7 a	8 a
9 lb-spr&fall	21	12	5 b	6 a	3	2 a	6 a	13 ab	9 a
18 lb-fall-87	18	27	21 a	26 b	5	9 ab	30 b	48 b	58 b
Pratylenchus									
Untreated	46	25	20 a	13 b	31 b	34 b	25 c	41 b	23 b
18 lb-spring	27	19	6 b	4 a	2 a	1 a	0 a	2 a	3 a
9 lb-spr&fall	52	37	8 b	6 ab	4 a	3 a	1 a	2 a	4 a
18 lb-fall-87	33	20	25 a	10 ab	3 a	1 a	4 b	2 a	6 a
Mononchids									
Untreated	6	8	5 a	3 b	2	14 b	3 b	13 c	9 c
18 lb-spring	3	6	1 c	1 ab	1	1 a	0 a	1 b	0 a
9 lb-spr&fall	6	3	2 b	0 a	1	1 a	0 a	0 a	0 a
18 lb-fall-87	5	6	9 a	2 b	1	1 a	1 a	8 c	2 b

Table 2. Mean percent recovery of 200-300 *Pratylenchus penetrans* added to raw (R) and sterilized (S) soils, amended with 0 (-) or 11.5g Clandosan/kg soil (+) after 14 days incubation (INC) in open or sealed containers.

TREATMENT SOIL	TREATMENT CLANDOSAN	SEALED INC TRIAL ONE	SEALED INC TRIAL TWO	OPEN INC TRIAL THREE	
R	+	0 c	0 d	0 d	1 c
R	-	17 b	17 b	16 a	9 b
S	+	16 b	8 c	1 cd	0 d
S	-	33 a	25 a	20 a	22 a

Means of four replicates (six replicates in Trial two). Means in the same trial followed by the same letters are not significantly different (P=0.05) according to Duncan's New Multiple Range Test.

Table 3. Nematode population densities and stem cross-sectional area at location B from 1987 to 1989.

Nematode & Treatment	Irrig.	1987 6/4	1987 9/24	1988 5/4	1988 9/22	1989 5/22	1989 7/10
Xiphinema							
Broadcast	-	21	6 abc	5 ab	1 ab	1 a	0 a
(18 lb)	+	5	8 bcd	6 abc	0 a	4 ab	1 ab
18 lb-drip	-	9	17 cd	3 a	10 d	12 b	25 d
	+	14	2 a	3 a	2 abc	2 a	4 bc
9 lb-spr&fall	-	10	19 cd	5 ab	5 cd	3 ab	10 cd
drip	+	20	4 ab	3 a	3 bcd	4 ab	2 ab
Untreated	-	32	30 d	19 bc	5 cd	10 b	18 cd
	+	24	14 bcd	23 c	9 d	13 b	17 cd
Pratylenchus							
Broadcast	-	19	9 b	26 cd	7 a	2 a	1 a
(18 lb)	+	11	7 ab	21 bc	2 a	3 a	1 a
18 lb-drip	-	11	3 a	7 ab	30 bcd	62 b	50 c
	+	13	27 c	55 cde	8 ab	4 a	3 ab
9 lb-spr&fall	-	17	7 ab	6 a	33 cd	54 b	44 c
drip	+	19	34 c	46 cde	11 abc	2 a	6 b
Untreated	-	10	31 c	64 de	54 d	72 b	40 c
	+	24	38 c	84 e	40 cd	48 b	42 c
Mononchids							
Broadcast	-	0.9	0.5	0.5 ab	0.0 a	0.0 a	0.2 a
(18 lb)	+	0.6	0.6	0.8 ab	0.0 a	0.6 ab	0.7 a
18 lb-drip	-	0.3	2.0	1.6 b	0.9 ab	10.0 d	11.1 b
	+	1.4	0.6	1.0 ab	1.5 ab	2.6 bc	0.7 a
9 lb-spr&fall	-	1.2	1.1	0.6 ab	1.3 ab	3.0 cd	4.9 b
drip	+	1.5	0.8	0.1 a	0.9 ab	0.5 ab	0.4 a
Untreated	-	0.3	0.6	0.5 ab	1.5 ab	4.7 cd	5.4 b
	+	1.4	2.3	2.2 b	3.7 b	4.5 cd	7.1 b
Stem area (cm2)							
Broadcast	- -	0.6 b	-	-	-	2.4 b -	4.1 b
18 lb-drip	- -	0.6 b	-	-	-	2.2 ab -	3.9ab
9 lb-spr&fall	- -	0.4 a	-	-	-	1.8 a -	3.7ab
Untreated	- -	0.5ab	-	-	-	1.8 a -	2.9 a

Table 4. Nematode biocontrol activity in Nemacur-treated, Clandosan-treated, and untreated soil from experimental field plots.

Treatment	Recovery of *Pratylenchus* Raw (Corrected)	Sterile	NBA Activity (Corrected)
LOCATION B Trial 1 18 lb a.i./acre Broadcast	(38)	54	(16%)
Untreated	(46)	51	(5%)
LSD 0.05	-------12.4-------		22% (ns)
LOCATION B trial 2 18 lb a.i./acre Broadcast	2	8	6 %
Untreated	3	10	7 %
LSD 0.05	---------6.5------		8 ns
LOCATION C Trial 1 18 lb a.i. Nemacur/A Broadcast	12	70 ab	58 a
3 T Clandosan/A	13	76 a	63 a
Untreated	17	53 b	36 b
LSD 0.05	7 (ns)	18	18
LOCATION C trial 2 18 lb a.i. Nemacur/A Broadcast	9	25	16
3 T Clandosan/A	10	33	23
Untreated	7	35	28
LSD 0.05	7 (ns)	10 (ns)	12 (ns)

Means of ten (nine replicates at Location C) replicate soil samples. Corrected data are estimates of nematode biocontrol activity corrected for indigenous nematodes.

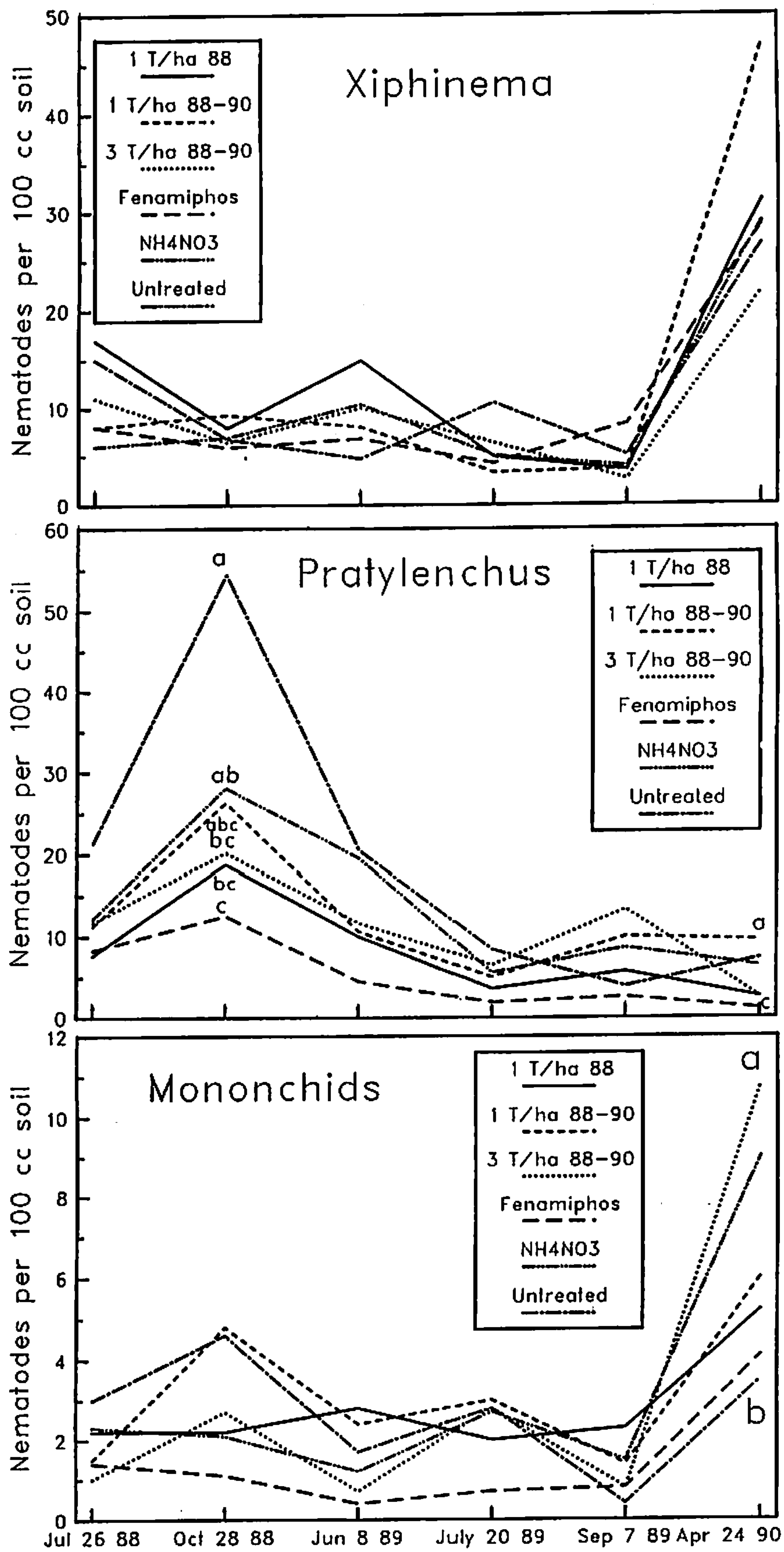


Figure 1. Nematode population densities on apple after three years treatment with Nemacur (fenamiphos) or Clandosan.