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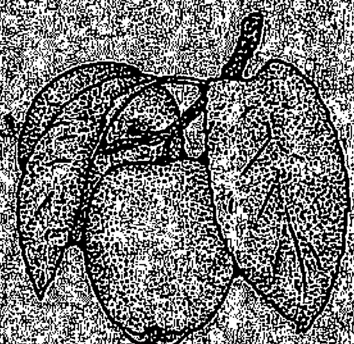
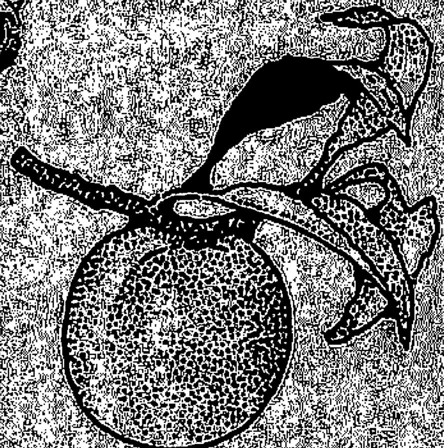
PROCEEDINGS

70TH Cumberland-Shenandoah Fruit Workers Conference





November 17-18, 1994
Winchester, Virginia

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PLANT PATHOLOGY

ENTOMOLOGY

CUMBERLAND-SHENANDOAH FRUIT WORKERS CONFERENCE PROGRAM HIGHLIGHTS

The 70th meeting of the Cumberland-Shenandoah Fruit Workers Conference was hosted by New Jersey and South Carolina at the Holiday Inn in Winchester, VA. The meeting was held on Thursday and Friday, November 17-18, 1994 with 52 registered participants and presented papers. Dean Polk was the General Chair, William Tietjen was the Secretary/Treasurer and Chair of the Horticulture Session, Walker Miller was Chair of the Plant Pathology Session, and Clyde Gorsuch was Chair of the Entomology Session.

Officers nominated for the 1995 meeting were Ross Byers, General Chair, John Barden, Horticulture Chair, Keith Yoder, Plant Pathology Chair and Doug Pfeiffer, Entomology Chair.

The Thursday morning session started with a "Call of the States", consisting of brief reports of crop conditions, weather abnormalities, and pest summaries for the 1994 season. The General Session began with a review of the status of regionalization of fruit research and extension efforts by CSFWC representatives named at the 1993 annual meeting.

Ed Rajotte introduced a subject for consideration at Friday's business meeting, i.e., inviting consultants and others involved in the fruit industry to future meetings of the CSFWC. The General Session concluded with a presentation by Tim Warman of the American Farmland Trust. His talk included insights into the political process concerning pest management in the future.

Following the General Session, three concurrent sessions were held on Thursday afternoon and only the Entomology Session was held on Friday morning following the business meeting. The Plant Pathologists/and some Horticulturists had their own round table session on topics of mutual interest.

70TH CUMBERLAND-SHENANDOAH FRUIT WORKERS CONFERENCE
MINUTES OF BUSINESS MEETING

Dean Polk, General Chair, welcomed CSFWC participants to the annual business meeting.

Old Business:

The general consensus of CSFWC participants was to hold the 1995 meeting at the Winchester Holiday Inn or at another facility. Specific site was left up to the host state.

Host state for the next conference is Virginia. The nominating committee for the 71st conference selected the following officers for the 1995 meeting: Ross Byers, General Chair; John Barden, Horticulture Session Chair, Keith Yoder, Plant Pathology Session Chair and Doug Pfeiffer Entomology Session Chair. A Secretary/Treasurer was not designated.

Secretary/Treasurer, Bill Tietjen, reported that 54 individuals registered for the 1994 meeting and that the current treasury balance was $936.55. After paying the Holiday Inn and preparing and mailing the proceedings, the final balance will be forwarded to Virginia for the 1995 meeting.

Section Chairpersons, Bill Tietjen (Horticulture), Walker Miller (Plant Pathology) and Clyde Gorsuch (Entomology) gave reports on the concurrent sessions (individual papers in proceedings).

New Business:

A lengthy discussion ensued regarding reasons for the low attendance and methods to increase attendance, and inviting fruit consultants to future meetings of the CSFWC. Mark Brown reported that fruit consultants attend the New York, New England, and Canadian Pest Management Conference and participate fully in the meeting and provide practical information concerning fruit production problems.

Stephen Miller reminded the group of our Mission Statement which was approved at the 69th Annual Meeting. Ken Hickey pointed that the Extension numbers are not growing. Ken Hickey made a motion to consider inviting Private Crop Consultants that do not sell chemicals. Yes - 20 Opposed - 1

Finally Larry Hull moved and Rob Crassweller seconded that:

Independent private crop consultants be invited to future meetings of the CSFWC. Yes - 23 Opposed - 3

Who to invite? Each state will send a list of independent private crop consultants to the General Chair of the 1995 meeting.

Win Cowgill and Clyde Gorsuch updated the group on the internet discussion groups.

There was general agreement that the topic for the 1995 General Session should be Calcium and Fruit Quality.

In addition the secretary will draft a list of the attendees and will send the list to each state for review. New Jersey did not receive a master mail list. Some individuals were apparently missed.

The meeting was adjourned.

FUTURE MEETINGS AND HOST STATES
1995 - Virginia
1996 - Maryland and Delaware
1997 - North Carolina
1998 - USDA
1999 - Pennsylvania (75th Anniversary)
2000 - West Virginia
2001 - New Jersey and South Carolina

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1994 New Jersey Tree Fruit Crop Report

The 1994 growing and harvest season is now complete. Most of the apples in storage are for processing into juice, or for local market sales. Very few apples are packed in NJ for shipment to distant markets.

The 1993-94 winter varied around the state. In the southern part of the state it was generally decent, while in the northern half of the state temperatures reached -36F at several locations. A heavy snow cover, coupled with melting ice followed by freezing, resulted in storage and barn damage around the state. Approximately 3% of the state. However, this reflects 85-90% loss of peach buds in northern New Jersey. Several growers in the same area lost approximately 10-20% of their peach trees. Also, in northern New Jersey approximately 5% of the apple trees were damaged. The apple crop in New Jersey was reduced due to drought conditions the year before resulting in low return bloom. Soil temperatures remained low with frozen soil well into early April.

It was obvious in May that significant tree injury in peaches was experienced. After close examination, it appeared that most was due to root injury caused by the frozen, water saturated soil, coupled with mold fungi infection. Some blocks were also observed with significant peach tree borer infection.

Peach full bloom was normal, while apple bloom was about 3 days earlier than normal.

In northern New Jersey the peach crop resulted in the loss of approximately 20,000 bushels of fresh market stone fruit.

The growing season was unusual due to the occurrence of many violent storms throughout the state Four of these storms in southern New Jersey were hail storms resulting in the loss of about 300,00 boxes of peaches and a reduction of fresh marked apples to juice quality apples. Several farms lost 100% of their crop. In northern New Jersey, various hailstorms hit 5 large apple orchards in July and August reducing excellent fresh market apples to cider apples. Peach harvest was relatively normal with good movement throughout the season to distant markets. Large (2 1/2"+) peaches of yellow fleshed varieties are still preferred. Prices were strong, $13 to $18 per 38lb box of large fruit. Most 2 1/4" fruit was also moved profitably for $10 to $13 per box. The mid-season Loring movement was still a problem. New markets were found for non-packed fruit to some outlets in the mid-Atlantic area.

Some sensational new white fleshed peaches were available for wholesale movement. In northern New Jersey, acreage of white peaches is growing as demanded and acceptance of them is growing

Peach harvest was approximately, 1,850,000 boxes. Peach volume continues to decline slightly. Apple harvest data is currently unavailable. Although there are some nice, new planting of Gala and Fugi, which are all sold quickly and at good prices. Except for approximately 150 acres of pears, other tree and small fruit (except cranberries and blueberries) acreage is insignificant.

Nectarine movement was sluggish throughout the year. It is obvious that we must spend more time and energy convincing chain store buyers that eastern nectarines are available in quantity and quality comparable to California.

The tree fruit acreage continues to decline in southern New Jersey. High regulatory and labor costs, the loss of good pesticides, and real estate pressure have resulted in increasing pressure on the wholesale fruit industry in the southern part of the state. Our 1993 Fruit Survey indicates there are more fruit orchards in northern New Jersey then in the southern part of the state. Ninety percent of this acreage is dedicated to direct market sales. New orchards in this area continue to be planted with apple acreage of specialty varieties increasing including the scab resistant cultivars Liberty, Enterprise, and Goldrush. Pressure from regulatory agencies on right to farm issues continues but growers are persisting.

Call of the States--Virginia

The peach crop was virtually wiped out in the Northern Virginia Valley area by low temperatures of -11F to -15F in January 1994. Some limbs and a few older trees died during the summer. One peach pruning test was set up at the USDA to evaluate time and extent of pruning on tree recovery and survival.

The 1994 apple crop was 60 to 70% of normal. The poor crop was the result of a poor return bloom in 1994. The 1993 apple crop was larger than normal due to low temperatures during the chemical thinning period and thus the poor thinning resulted in a poor return bloom for 1994. The reduced crop was not related to the cold January temperatures, since trees that were adequately thinned in 1993 set heavy crops in 1994. Unfortunately temperatures were again cold during the 8 to 12 mm stage of fruit development; and thinning was poor. We expect a poor return bloom in 1995 on trees inadequately thinned. Temperatures during petal fall were 10F to 15F higher than at the 8 mm to 12 mm stage of fruit development. Better thinning was obtained at petal fall than at later stages of fruit development.

Fruit size was poor in 1994 on over cropped of trees (due to poor thinning results). A drought in May and June also contributed to reduced fruit size. In late August maturity of Red and Golden Delicious appeared normal with higher than average fruit firmness, soluble solids and color.

Environmental conditions were ideal for fireblight for the late blooming varieties (York & Rome) and blight was severe in some poorly protected orchards. Alternaria leaf blotch was severe in some orchards in southern Virginia, but the spread from infected orchards in 1993 was not great in 1994.

Tufted apple bud moth leaf rollers were high in orchards that had organophosphate -resistant populations. Teniform leaf miner populations were high in some orchards and mite populations were generally low.

Temperatures in excess of -20°F on January 19 and 21 eliminated the 1994 peach crop. Drought conditions during the summer of 1993 contributed to a poor return bloom in apples in 1994, resulting in about 60 percent of a normal crop. June was abnormally hot and dry, with only 1.35 inches of rainfall, whereas August was cooler and very wet, with almost 8 inches of rain. As many as three hail events occurred in some area orchards, with the first on May 25 being the most damaging and widespread. Eight apple scab infection periods occurred during the period from April 10 (half-inch green) through May 25 (first cover). The first scab lesions were observed the week of May 2, and the level of scab was generally light, due in part to the extended dry period from May 8 through June 16. Fire blight was severe in many locations, especially on the cultivar 'York', but also on 'Jonathan' and other susceptible cultivars. A series of four blight infection periods in five days at the end of April were preceded by warm temperatures that were favorable for the buildup of the pathogen on blossoms. Fifteen additional wet periods occurred from early June through mid-August, providing favorable conditions for the summer disease complex. Sooty blotch and fly speck were observed in late July in unsprayed blocks. 'Golden Delicious' necrotic leaf blotch was present in many locations, but was not severe. The cold temperatures in January apparently impacted survival of overwintering eggs of European red mite as populations were very low in most orchards. Some loads of apples were rejected at the processor because of codling moth injury due to reduced spray programs because of the light crop and/or hail damage.

NORTH CAROLINA

The 1994 growing season was characterized by a relatively cool spring, and cool and very wet summer. Abundant rainfall from early June through August contributed to conditions favorable for fruit diseases. However, losses to diseases on peaches and apples were kept to a minimum as growers shortened their fungicide application intervals. The exception, however, was a high level of Alternaria blotch severity, which contributed to many 'Delicious' orchards in Henderson County experiencing >50% defoliation by early August. Mite populations were relatively high early in the season (May and June), but decreased with the rains in July. Damage to apples by first generation tufted apple was high in Henderson County, while in other production regions second and third generation codling moth damage was unusually high. The apple crop matured considerably earlier than normal, with Red Delicious and Rome harvest beginning the third week of August and early September, respectively. In general, peach and apple growers experienced a good crop (ca. 75% of a full crop) with average to slightly higher than average prices.

Horticulture

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Apple Cultural Management: Notes, Observations, and Open Discussion on Several Studies in 1994

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<u>Low-Rate Ethephon for Enhanced Color Development</u> - Red color is an important criteria for consumer selection in apples. A number of the new apple cultivars develop poor or marginal red color when grown under mid-Atlantic conditions. Ethephon is a registered plant growth regulator (PGR) used to stimulate red color development in red apple cultivars. Label recommendations to stimulate red color are for a single dilute ethephon spray at 1.25 l/1000 l (1 pt/100 gal= 300 ppm) applied 2 to 3 weeks before normal harvest. A stop-drop material such as NAA must be added to control preharvest drop. This application will also hasten fruit maturity and force the grower to harvest and market ethephon treated fruit in a timely manner to avoid fruit losses. Multiple low-rate applications of ethephon for shoot growth control in apple were observed to improve color development with no apparent effect on fruit softening (personal communication, Ross Byers, VPI&SU). In preliminary studies at AFRS in 1991, 'Hardibrite Delicious' treated at weekly intervals beginning 5 weeks before harvest with dilute sprays of 100 ppm ethephon had more red color at harvest, higher soluble solids, and lower starch levels than untreated fruit. Fruit firmness did not differ from untreated fruit. This study suggested that multiple low-rate ethephon may enhance fruit quality without the fruit softening effects associated with the current label recommended treatment.

Eight-year-old Empire/M.9/MM.106 and 5-year-old Fuji/EMLA.7 were selected for treatment in early August, 1994 to confirm these observations. Individual limbs at least 15 cm in circumference and with a minimum of 25 fruits were selected and tagged for spray treatments. Treatments on Empire were replicated 8 times; Fuji had 4 replications per treatment. Based on previous fruit maturity records, the anticipated date of harvest for Empire was September 22 and for Fuji October 13. The following treatments were applied with a hand-pump backpack sprayer:

> Empire: 1) <u>weekly</u> (Wk) 100 ppm ethephon beginning 5 weeks before (August 18) anticipated harvest; 2) same as treatment No. 1 + 0.1% Regulaid (v/v); 3) <u>bi-weekly</u> (Bi-Wk) 125 ppm ethephon beginning 7 weeks before (August 4) anticipated harvest (total of 4 sprays); 4) same as treatment No. 3 + 0.1% Regulaid; 5) <u>Wk</u> 0.1% Regulaid beginning August 18; 6) <u>Bi-Wk</u> 0.1% Regulaid beginning August 4; and 7) no spray control.

Fuji: same treatments as Empire except treatments No. 3 and 4, Bi-Wk, had 5 sprays of 100 ppm ethephon applied.

All sprays were applied to the point of drip from leaves. Two weeks and then one week before the anticipated harvest date and on the anticipated harvest date, samples of 10 fruit were collected from each treatment replication for analysis. If the sample date coincided with a spray treatment date, fruit samples were collected before treatments were applied. An NAA stop-drop spray at 10 ppm was applied to all trees, including controls (simulates conditions experienced in a grower's orchard), 10 days before the anticipated harvest date (September 12 for Empire; October 3 for Fuji). Fruit drops were counted at weekly intervals beginning August 25. Fruits were evaluated in the lab for average weight; length/diameter ratio; % surface red (pink for Fuji) color; color intensity on a scale of 1 to 5 with 1 = very light, 3 = medium, and 5 = very dark; flesh firmness (mounted McCormick FT327 penetrometer); soluble solids concentration (SSC)(Atago PR-100 refractometer); and starch index (SI) on a 1 to 9 scale with 1 = fully immature and 9 = fully over-mature. Treatment means were analyzed using AOV with mean separation according to Duncan's Multiple Range Test, P=0.05.

Two weeks before the anticipated harvest date, Empire apples treated with 3-100 ppm dilute ethephon sprays at Wk intervals or 3-125 ppm ethephon sprays at Bi-Wk intervals had more surface red color, higher SSC, and lower starch levels than untreated fruit (Table 1). Although fruit SSC and SI suggested advanced maturity, flesh firmness of treated fruit did not differ from controls; generally, softening is associated with advanced maturity. The addition of 0.1% Regulaid, a non-ionic spreader activator, had no effect on ethephon response. This was contrary to expected since previous studies with ethephon showed enhanced activity with the addition of similar materials. Color intensity was enhanced on fruit harvested 2 weeks before the anticipated harvest by 3-100 ppm Wk ethephon sprays. Both Wk and Bi-Wk ethephon sprays increased color intensity compared to control fruit at 1 week before the anticipated harvest date and at harvest. Wk low-rate (3-100 ppm) ethephon sprays increased preharvest fruit drop (Fig. 1). Application of NAA as a recommended stop-drop treatment reduced fruit drop on Wk and Wk+Reg ethephon treated trees to near that for control trees at harvest. Fruit drop on Bi-Wk sprayed trees did not differ from controls throughout the study except Bi-Wk Reg trees at harvest had fewer drops per tree than the controls or the Wk ethephon treatments.

Results confirm preliminary tests and support a label for multiple low-rate ethephon to enhance fruit color and fruit quality without the adverse effect of fruit softening. A registration would benefit apple growers in the mid-Atlantic region as well as other areas where climatic conditions do not favor good color development.

Shoot Growth Control - Control of excess shoot growth is a major problem on many apple cultivars grown in the eastern U.S. and particularly in the Appalachian region. Past observations and studies indicate that climatic and edaphic factors in this region encourage vigorous vegetative growth at the expense of fruiting wood. Vigorous vegetative growth results in canopy shading which reduces fruiting and fruit quality. Excess growth must be dormant-pruned which adds to production costs. Daminozide, an effective growth retardant, was removed from the market in 1989. Paclobutrazol, a very effective triazole PGR with growth controlling properties, was not labeled for use on tree fruits in the U.S. despite extensive testing which supported its use. Interest continues among researchers and fruit growers for an effective chemical growth controlling PGR.

A new chemical from BASF with apparent growth controlling properties was evaluated on vigorous Mercier Redchief Delicious/MM.106 for its effect on shoot growth, fruit quality, and phytotoxicity. Results from preliminary replicated trials look promising. No phytotoxicity was observed. Under agreement with BASF, data cannot be published at this time; however, results were briefly discussed with interested researchers assembled at the meeting.

Apple Fruit Maturity, 1994 - Open Discussion - The expected harvest (or maturity) date for apple is influenced by a number of factors not all of which are well-understood or known. Historical date and number of days from full bloom have long been used to calculate the expected date for maturity and harvest. More recently it has been suggested that full bloom date and temperatures during June, July and August applied in optimal harvest date equations may be a better predicator for maturity (Abeles and Lightner, 1984, HortSci. 19:427).

The degree to which fruit obtain good red color is dependent on many factors during the growing season, especially available sunlight and temperatures in August and September. Cool nights (temperatures below 15.5 C) and warm sunny days (temperatures between 24 and 27 C) promote red color development. Fruit harvested in 1992 at the Appalachian Fruit Research Station (AFRS), Kearneysville, WV was highly colored. Fruit from nearby commercial orchards also exhibited good color. The opposite was true in 1993. Delicious and other red cultivars developed very poor color, except several cultivars like Stayman which developed exceptionally good color and Fuji which had good color. In 1994, Delicious developed fair to good color but other red cultivars, such as

TABLE 1. EFFECT OF MULTIPLE LOW-RATE ETHEPHON ON COLOR AND FRUIT QUALITY IN EMPIRE APPLES, 1994. USDA-ARS, AFRS, S. MILLER

Treatment	Color Intensity	Surface Red Color	Flesh Firmness	SSC	Starch Index
	(1-5)[z]	(%)	(lbs.)	(%)	(1-9)[y]
		------ 2 weeks before harvest[x] -----			
Weekly(Wk)	4.0 a[w]	79 a	16.9 b	11.8 ab	4.8 ab
Wk+Regulaid(Reg)	3.6 abc	76 ab	17.0 b	11.4 abc	4.5 bc
Bi-Weekly(Bi-Wk)	3.8 ab	75 ab	16.9 b	11.9 a	5.0 ab
Bi-Wk+Reg	3.6 abc	70 bc	17.1 b	11.6 abc	5.2 a
Reg, Wk	3.1 c	66 c	18.2 a	11.3 abc	4.0 cd
Reg, Bi-Wk	3.2 c	66 c	16.8 b	11.2 bc	3.9 cd
Control	3.3 bc	65 c	17.1 b	11.0 c	3.7 d
		------ 1 week before harvest[v] ------			
Weekly(Wk)	4.0 a	81 a	16.5 ab	12.2 a	7.6 a
Wk+Regulaid(Reg)	3.7 a	77 a	16.2 b	11.9 ab	7.3 a
Bi-Weekly(Bi-Wk)	3.9 a	79 a	16.3 b	12.1 a	7.3 a
Bi-Wk+Reg	3.6 a	79 a	17.1 a	12.2 a	7.3 a
Reg, Wk	3.1 b	72 b	16.7 ab	11.8 ab	6.3 b
Reg, Bi-Wk	3.1 b	72 b	16.8 ab	11.9 ab	6.7 b
Control	3.1 b	70 b	16.8 ab	11.5 b	6.4 b
		------ anticipated harvest date[u] ------			
Weekly(Wk)	3.8 ab	82 a	16.0 a	12.6 ab	8.8 a
Wk+Regulaid(Reg)	3.9 a	82 a	15.2 a	13.1 a	8.1 b
Bi-Weekly(Bi-Wk)	3.8 ab	80 ab	15.3 a	12.7 ab	8.2 ab
Bi-Wk+Reg	3.4 bc	77 bc	15.6 a	11.8 c	8.1 b
Reg, Wk	3.0 c	75 bc	16.2 a	12.2 bc	8.0 b
Reg, Bi-Wk	3.4 bc	76 bc	15.1 a	11.2 c	7.6 b
Control	3.1 c	74 c	15.8 a	11.7 c	7.8 b

z 1= very light; 3= medium; 5= very dark
y 1= fully immature; 4-6= mature; 9= fully over-mature
x Wk= 3-100 ppm sprays @ 7 day intervals; Bi-Wk= 3-125 ppm sprays @ 14 day intervals
w Mean separation, DMRT, P = 0.05
v Wk= 4-100 ppm sprays; Bi-Wk= 3-125 ppm sprays
u Wk= 5-100 ppm sprays; Bi-Wk= 4-125 ppm sprays

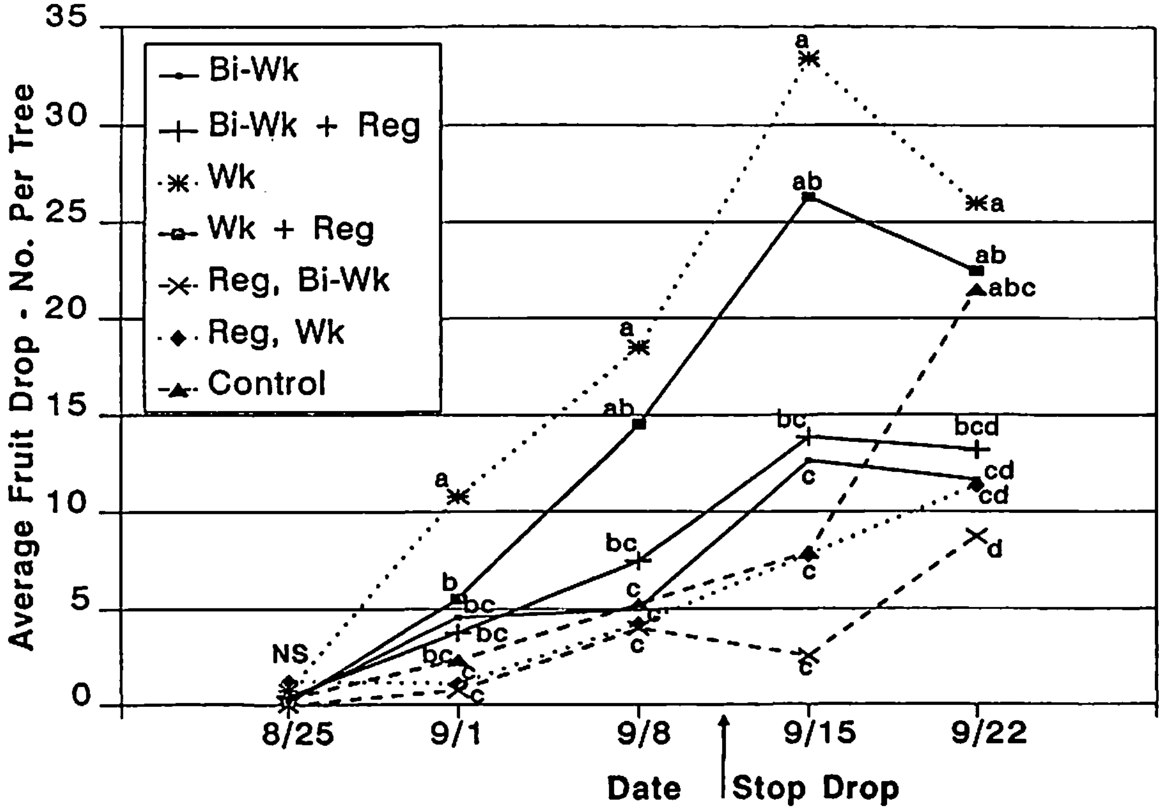

FIGURE 1. EFFECT OF MULTIPLE LOW-RATE ETHEPHON ON FRUIT DROP IN EMPIRE APPLES, 1994. USDA-ARA, AFRS, S. MILLER

Stayman, Royal Gala, and Fuji, had marginal to very poor color. In 1994, fruit at AFRS and from commercial orchards in the West Virginia eastern panhandle generally matured 10 to 14 days ahead of the historical date and at least 7 days ahead of the date calculated from full bloom. Fruit softening was significantly advanced and flesh firmness rapidly declined below the normal level for a given stage of fruit maturity in most cultivars. Some comparisons of fruit quality data for selected cultivars at harvest from 1992 to 1994 revealed the following:

Cultivar	Full Bloom Date	Harvest Date	Flesh Firmness(lbs)	SSC(%)	Starch Index
Kidd's Gala	4/28/92	9/1/92	19.5	11.0	2.2
	5/2/93	8/30/93	18.0	10.6	4.1
	4/20/94	8/29/94	13.3	10.0	6.8
Empire	4/27/92	9/25/92	20.2	11.8	4.4
	4/30/93	9/24/93	19.8	10.6	4.0
	4/20/94	9/19/94	14.3	10.9	6.4

Ideally, fruit firmness for Gala and Empire is 16 pounds or greater at harvest with a SI between 3 and 4. The data illustrate the advanced maturity and fruit softening characteristic of many cultivars in 1994. About 25 miles south of AFRS at the VPI&SU Fruit Research Lab, Winchester, VA fruit matured near the historical date for the cultivar in 1994 (personal communication, R. Byers). Several hundred miles south at Blacksburg, VA and about 70 miles northeast at the PSU Fruit Research Lab, Biglerville, PA advanced fruit maturity and rapid fruit softening were observed similar to that found at AFRS in 1994. The question arises, what growing conditions led to the advanced fruit maturity, rapid fruit softening, and generally poor fruit color observed in 1994?

The number of growing degree hours (GDHs) above 12.7 C calculated on a monthly basis may provide some clue to the differences observed (Table 2). The total number of GDHs accumulated in 1993 and 1994 was about 23% more than accumulated in 1992, a year in which fruit matured and softened as expected. A close comparison between 1992 and 1994 shows a much greater accumulation of GDHs from April 1 through July 31 in 1994 with the majority of the difference occuring in June (205 GDHs). Does this unusual "spike" in heat units trigger a fruit softening mechanism?

TABLE 2. GROWING DEGREE HOURS (GDH)[z], JANUARY THRU SEPTEMBER, APPALACHIAN FRUIT RESEARCH STATION, KEARNEYSVILLE, WV

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Total
1992	3	7	22	100	184	356	589	402	297	1960
1993	7	9	7	89	299	439	663	589	357	2459
1994	0	4	23	184	191	561	646	467	284	2360

z Hours above 12.7 C calculated monthly

An examination of average maximum temperatures from April thru September for the years 1992 to 1994 shows maximum temperatures for 1993 and 1994 were above those for 1992. The greatest differences were observed between 1992 and 1994 and these differences occured in April and June and averaged about 5 C higher in 1994. Less difference was noted between average minimum temperatures, but again, average minimum temperatures were generally greater in 1993 and 1994 compared to 1992 particularly for the months April through July. Temperatures in August and September showed less differences between the three years, however, both maximum and minimum temperatures were slightly elevated during this period in 1993, a year characterized by poor coloring but expected maturity and softening.

Precipitation has generally not been linked to maturity and softening, certainly not to the extent that temperature is known to affect these factors. However, an examination of precipitation data for the months April through September, 1992 to 1994 may be of interest. Total precipitation was recorded as: 68.14 cm, 1992; 65.04 cm, 1993; and 66.11 cm in 1994. Obviously there were no real differences in total precipitation between the three years. Monthly deviation was greatest in 1994 (high, 20.01 cm, August and low 3.43 cm, June) and least in 1992 (high, 14.35 cm, April and low, 8.25 cm , June). Calculating the average daily precipitation per month for each year and the deviation from the three-year average daily precipitation reveals the greatest negative deviation in precipitation occured in April (-1.8 mm) and June (-1.5 mm) 1994, and May (-1.5 mm) 1993. Low precipiation was generally associated with high temperatures in 1994 and to some extent in 1993.

Solar radiation or photosynthetically active radiation (PAR) data were not available at the time this report was prepared, but they do play a role in fruit maturity and possibly softening through effects on fruit hormones (ethylene).

The data above were presented to those assembled in the Horticulture Section of the Cumberland-Shenandoah Fruit Workers meeting to generate open discussion on factors affecting fruit maturity and softening and how these and other factors may contribute to a model of fruit maturity in the Appalachian region.

Title: Evaluation of Conventional June Bearing Strawberries with Annual Plastic Culture for 1994 Planting Season

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Objectives: Evaluation of Chandler strawberry plants grown on plastic to determine the ideal planting window for plastic culture, annual strawberry production and its economic feasibility under Maryland conditions in comparison to conventional strawberry production.

Treatments: A September 23, 1993 planting of Chandler plug plants and bare rooted Chandlers were made with both conventional and organic fertility programs. Row spacing double row 12" x 12" in raised beds on 6' centers 14,500 plants per acre.

A comparison planting of conventional June-bearers was made in April 1993 at the Wye and WMREC. Thirteen June bearing varieties were planted on a 52" x 24" row spacing at the Wye and on a 48" x 24" row spacing at WMREC. The 1994 harvests are as follows:

WYE

Annual Strawberry	Oz. Per Plant	Picking Dates	Lbs. Yield/Acre
Chandler conventional fertility, bare rooted no row cover	4.4	5/13-6/15	3,990
Chandler conventional fertility, bare rooted, row cover	7.1	5/13-6/15	6,430
Chandler organic fertility, bare rooted, row cover	5.7	5/13-6/15	5,170
Chandler conventional fertility, plug plants, row cover	12.5	5/13-6/17	11,330a
Chandler organic, fertility, plug plants, row cover	12.5	5/13-6/17	11,330a
Sweet Charlie conventional fertility, plug plants, row cover	5.4	*5/06-6/17	4,890

*Birds had first picking

13 June Bearing Varieties and Their Picking Dates

Variety	Picking Dates	Comments	Lbs. Yield/Acre
MoHawk	5/20-6/1	M.D. US Release Dr. G. Galletta	14,980bc

Variety	Picking Dates	Comments	Lbs. Yield/Acre
5084	5/30-6/10	M.D. US Dr. G. Galletta	12,690bcde
5069	5/27-6/8	M.D. US Dr. G. Galletta	15,860b
Allstar	5/27-6/15	Grower Standard	19,370a
Cavendish	5/20-6/13	Canadian Variety, white shoulder problem	20,770a
Delmarvel	5/23-6/3	M.D. US Release Dr. G. Galletta	11,540de
Annapolis	5/20-6/1	Canadian Variety	13,430bcde
Seneca	5/27-6/8	New York Release	12,620bcde
Jewel	5/27-6/10	New York Release	12,470cde
Glooscap	5/27-6/3	Canadian Variety	14,040bcd
Earliglow	5/20-6/1	Grower Standard Best Flavor	10,460def
Lateglow	5/27-6/8	Grower Standard	7,140f
Blomidon	6/1-6/8	Canadian Variety, yellows problem	11,280de

WMREC

Variety	Picking Dates	Comments	Lbs. Yield/Acre
MoHawk	5/31-6/10	M.D. US Release Dr. G. Galletta	7,570d
5084	5/31-6/17	M.D. US Dr. G. Galletta	10,450c
5069	6/03-6/21	M.D. US Dr. G. Galletta	18,890a
Allstar	6/07-6/21	Grower Standard	13,460b
Cavendish	5/31-6/17	Canadian Variety	13,370b
Delmarvel	6/03-6/17	M.D. US Release Dr. G. Galletta	9,480cd
Annapolis	5/31-6/14	Canadian Variety	14,300b
Seneca	6/03-6/17	New York Release	4,290e
Jewel	6/03-6/21	New York Release	13,970b
Glooscap	6/03-6/17	Canadian Variety	13,170b
Earliglow	5/31-6/10	Grower Standard Best Flavor	9,220cd
Lateglow	6/07-6/21	Grower Standard	9,440cd
Blomidon	6/03-6/14	Canadian Variety, yellows problem	7,310d

BERRY WEIGHT KG PER 100 FRUIT AT MID HARVEST

Variety	Wye	WMREC
MoHawk	1.46de	1.15 bcd
5084	1.57bed	1.04def
5069	1.65bcd	1.04def

Variety	Wye	WMREC
Allstar	1.51cde	1.21bc
Cavendish	1.73ab	1.40a
Delmarvel	1.64bcd	1.03def
Annapolis	1.58bcd	1.26ab
Seneca	1.86a	.93ef
Jewel	1.50de	1.14bcd
Glooscap	1.38e	1.06de
Earliglow	1.35e	1.10cd
Lateglow	1.35e	.92f
Blomidon	1.69abc	1.03def

FALL BED EVALUATION $\overline{X}$

	WYE			WMREC		
Variety	Width Inches	% Plants Missing	Stand Rating	Width Inches	% Plants Missing	Stand* Rating
Glooscap	22	13	3.9	27	4	5.5
5084	23	9	4.5	29	2	6.2
Jewel	17	33	2.0	24	25	3.7
Blomidon	25	14	4.0	29	4	6.0
MoHawk	32	0	9.0	31	4	7.5
Earliglow	27	3	6.4	29	1	6.0
Delmarvel	26	4	5.6	24	6	4.7
Annapolis	21	5	4.1	25	13	4.2
Lateglow	28	4	6.5	31	1	7.7
Seneca	14	56	1.0	17	60	1.7
Cavendish	19	23	2.5	23	15	4.7
5069	24	9	5.1	29	3	6.7
Allstar	23	10	3.9	21	49	2.5

* Too Many Plants	Ideal	No Plants
10	5	0

June was an extremely hot month at the Wye Research and Education Center. Some varieties did not recover well from renovation and this is reflected in the percent of plants missing and stand rating at both sites. This is one year data and should be taken as such. The real proof with June-bearers is how they do over three seasons.

Special thnaks to the Maryland Horticultural Society for Support Funding, Dr. Gene Galletta, U.S.D.A., and Brittingham Plant Farms for June Bearing Varieties.

Leaf Expansion in Peach cv Loring Under Non-Flowering Conditions

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Abstract:

Leaf expansion in peach (Prunus persica cv Loring) was measured by the increase in blade length as a function of leaf position and time after vegetative bud break. Measurements were made on a total of 20 apical shoots (2 trees) in the late spring and early summer of 1994, a season in which the trees were essentially vegetative with less than one flower observed per tree. Although leaf development was asynchronous, general trends in expansion of the shoot could be detected. On the average, leaves 1 through 5 (numbered acropetally) ceased expansion around 30 days after bud break, whereas leaves 6 through 9 continued expanding up to 52 days after bud break. For the most part, leaves 13 through 22 were still expanding at the last measurement taken. The basal three leaves of each shoot were noticeably smaller at full expansion than leaves 4 through 12 and most showed visible signs of senescence by 30 days after bud break. By 63 days after bud break, most of the shoot tips (12 out of 20) had ceased producing new leaves. Information from this study will be used for comparison with leaf expansion under flowering conditions.

Acknowledgements:

The author wishes to thank Deanna Fishel for her expert technical assistance in collecting data for this study.

Introduction:

Vegetative growth in plants is critical to survival, since leaves as the primary organs of photosynthesis provide carbon to the whole plant. During reproduction, the synthesis and distribution of photosynthate is crucial to flower production and subsequent fruit or seed development. In peaches, fruit formation is positively correlated with shoot growth vigor, except when growth is excessive (Dorsey, 1935). For example, fruit bud initiation takes place early in shoot development and continues as long as shoot elongation occurs. However, when shoot growth becomes excessive, fruit bud formation can be reduced by the formation of 'blind' nodes, laterals or by the suppression of further fruit bud development. Shoot growth is also correlated with root growth and vigor. Williamson and Coston (1989) demonstrated that seasonal increases in white root length in 'Redhaven' correlated with periods of rapid shoot elongation in non-fruiting trees. In addition, shoot development was shown to be related to root restriction in high-density orchards of 'Redhaven' (Williamson et al., 1992). Because of the importance of vegetative growth to overall plant health and survival, the present study was undertaken to examine more closely shoot growth as a function of individual leaf expansion.

Materials and Methods:

Peach trees (Prunus persica cv Loring) planted in 1980 in AFRS Orchard No. 3 were used for this study. Two trees in one row were selected, and 10 branches on each tree were tagged. Length measurements were made of individual leaves on the apical shoots of each branch beginning April 25, 1994 until June 14, 1994. A clear, plastic ruler was used to measure the length down the mid-rib of each leaf from the base of the blade to its tip. The number of leaves/shoot was estimated on each measurement date counting acropetally to the last leaf visible without mechanically damaging the shoot tip. Less that one flower/tree was observed during the 1994 season; vegetative bud break for this cultivar was estimated to be on April 5, 1994. Statistical analysis of the data was done using Duncan's Multiple Range Test. There were no significant differences between trees or between branches ($P = 0.05$) on each of the sampling dates. The coefficient of variation was high for most measurements due in large part to the asynchronous development of the leaves.

Results:

The total number of leaves on each shoot was estimated at each time of measurement. As shown in Table 1 there was a general increase in the number of leaves per shoot from an average of approx. 9 leaves/shoot 20 days after bud break to a maximum of approx. 14 reached 63 days after bud break.

In general, leaf length increased as a function of days from bud break, as illustrated in Figure 1. Leaves at the base of the shoot had already reached full expansion by the time measurements began, whereas leaves at the top of the shoot were still in the linear phase of expansion at the last sampling date (data not shown). Leaf length also increased as a function of leaf position, increasing acropetally to a maximum, then decreasing at the tops of the shoots where the leaves were still developing (Fig. 2). The final length attained at full expansion gradually increased from the base of the shoot to a maximum at leaf position 7 or 8 (numbered acropetally; Table 2).

Discussion:

In most studies of peaches, vegetative growth is monitored by measuring shoot elongation and/or increasing shoot diameter or by monitoring morphologic changes during leaf unfolding (Williamson and Coston, 1989; Williamson et al., 1992; Haun and Coston, 1983). The present study was undertaken to examine vegetative growth as a function of elongation at the level of the individual leaf in order to document growth and development under non-flowering conditions. Leaf development in most higher plants is primarily a function of position. Newly emerging leaves develop from the base of the stem or shoot to the tip, progressing from oldest to youngest. Data obtained on non-flowering peach trees from late April until mid-June indicated that similar patterns were evident in the field-grown material. The primary leaf development pattern can be roughly divided into three stages: older leaves showing signs of senescence, very young leaves in the early stages of expansion, and mature leaves in the later stages of expansion. Not surprisingly, leaves classified as mature were at the same position on the shoot where previous measurements in 'Elberta' and Lovell' had determined maximum stomatal development and diffusive resistance (Horton and Edwards, 1976). Also of interest is the observation that most of the 'Loring' shoot tips no longer had newly emergent leaves by 63 days after bud break (June 7th sampling). This observation is consistent with the precipitous decline in shoot growth rate (leaves/week) determined for non-fruiting 'Redhaven' in mid-June, 1985 and at the end of April, 1986 (Williamson and Coston, 1989). Future studies with 'Loring' will focus on measurements of leaf elongation during flowering and will determine whether or not leaf emergence resumes after a period of decline in rate. This information will be used to compare individual leaf development under full flowering conditions to examine the influence of sink organs on leaf development.

References:

1. Dorsey, MJ (1935). Nodal development of the peach shoot as related to fruit bud formation. Proc Amer Soc Hort Sci 33:245-257.

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4. Williamson, JG and Coston, DC (1989). The relationship among root growth, shoot growth, and fruit growth of peach. J Amer Soc Hort Sci 114:180-183.

5. Williamson, JG, Coston, DC and Cornell, JA (1992). Root restriction affects shoot development of peach in a high-density orchard. J Amer Soc Hort Sci 117:362-367.

Table 1. Estimated number of leaves on sampling date[1].

	Days From Bud Break					
	20	30	38	52	63	70
Total Leaves	>9.1	>10.6	>12.3	>13.6	>14.3	>14.4

[1]only emergent leaves were scored for fear of damaging the shoot apex.

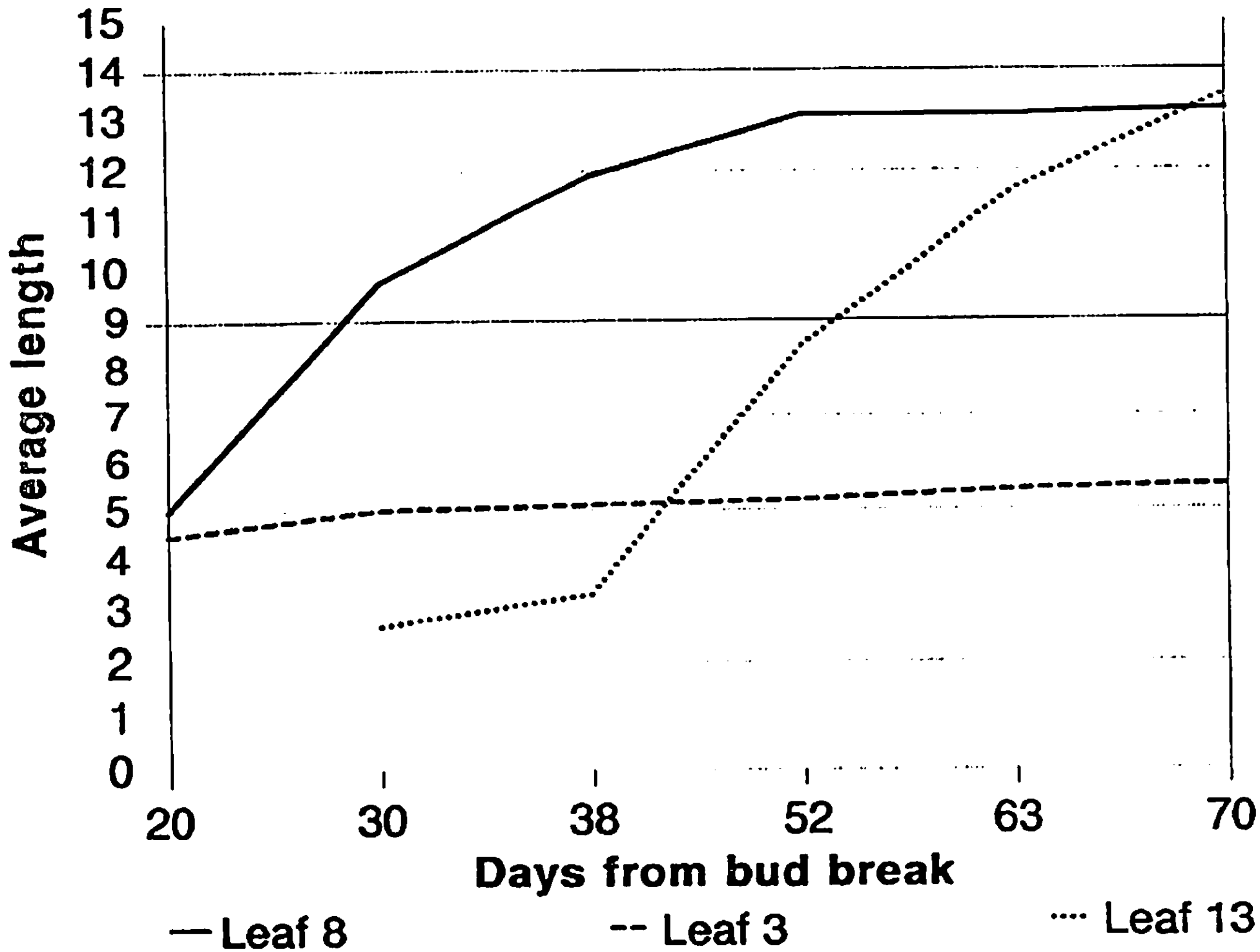

Figure 1. Leaf expansion as a function of age.

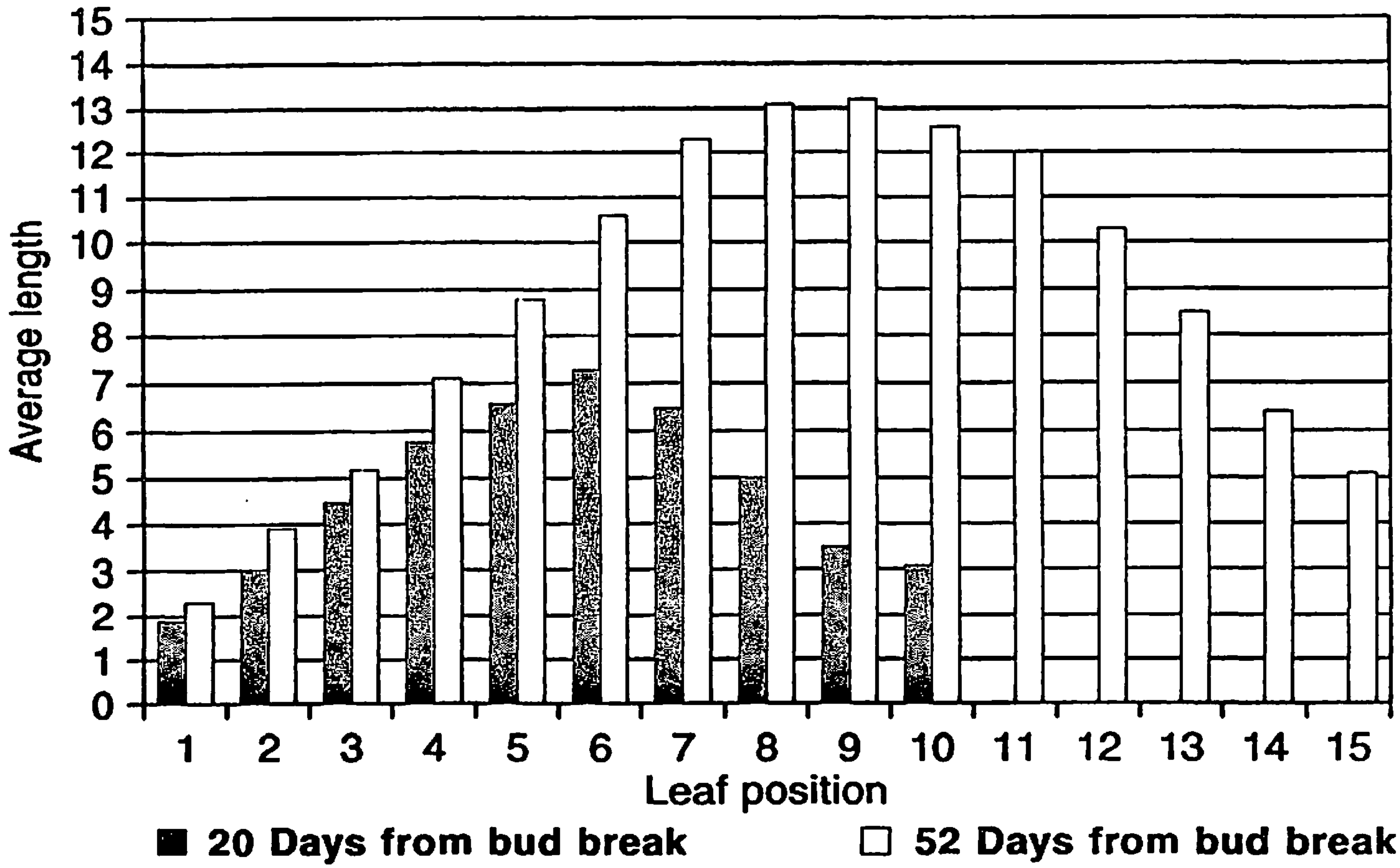

Figure 2. Leaf expansion as a function of position.

Table 2. Date and final length of full expansion as a function of leaf position.

Leaf Position No.	Date of Full Expansion (From Days After Bud Break)	Average Length at Full Expansion (cm)
1	30	2.6
2	30	4.1
3	30	5.5
4	30	7.1
5	30	8.8
6	52	10.7
7	52	12.3
8	52	13.2
9	52	13.6
10	63	13.3
11	63	13.5
12	70	12.9

Title: Observations of Apple and Peach Culture in Nova Scotia - What Can We Learn?

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During the summer of 1994 I spent a four month sabbatical leave at the Ag Canada Research Station in Kentville, Nova Scotia. I studied several areas of tree fruit culture with Charlie Embree, research horticulturist at the station. Nova Scotia is a large province that is relatively sparsely populated. When you think of Nova Scotia perhaps you think of picturesque fishing villages, foggy seacoast scenes, and antiquated big old apple trees. However, I found the people friendly, the agriculture competitive and the scenery delightful. Nova Scotia's location gives it a relatively moderate winter climate. In most areas summers are cool and short. However, in the Annapolis Valley the summer climate is different with an earlier spring and a warmer summer. There is a diversity of fruit and vegetable crops grown in the valley and the intensity of this production rivals Lancaster County, Pennsylvania.

In 1994 the apple flower density was much higher than is normally seen in south central Pennsylvania. Tree size for comparable cultivars and rootstocks was much smaller than in the mid-Atlantic area. The fruit industry is served by a highly competent federal staff at the Research Station and by excellent provincial extension personnel located at the same facility. A whole host of spring and summer educational meetings, IPM schools and grower tours insures that the industry stays current. The majority of the apple industry is located within eight to ten miles of the station. Approximately three million bushels are produced on about eight thousand acres.

On a trip to New Brunswick an orchard experiencing tree decline from winter injury was visited. A grower meeting was held with a full compliment of research and extension personnel present. Some trees were dying outright but many more were showing slow decline, poor productivity and eventual death. Root injury appeared to be the main culprit with the injury being much more severe in areas of the orchard with poor internal soil drainage. Thus, the importance of deep well drained soils for maximum winter hardiness was reinforced.

One of the main peach growers has a unique production system. Trees are grown in wooden pots that are two by three feet by three feet deep. Tree size is nearly normal and the trees are constantly fed nutrients and water by trickle irrigation. The trees are over-wintered in a plastic greenhouse to prevent low temperatures. Trees are moved outside when the fruit are about a half inch in diameter. During the summer the greenhouse was used for vegetable production. No evidence of cytospora canker was seen on the trees. On my return trip a peach tree was observed in Pemiquid, Maine that was located only two hundred feet from the ocean. Apparently this tree also escaped winter injury since no cytospora canker was observed.

Economic evaluations of several apple production systems were started. Several analogies were seen between these systems and some forestry harvesting methods. In addition, the comparison of medium and high density apple production systems appears to have similarities to the comparison of low and high bush blueberry production. Thus, some lower investment, lower intensity business can remain competitive if costs per unit can be controlled.

Eleven blossom thinning trials were conducted on various apple cultivars and on Clapps Favorite pears. In addition, Charlie Embree conducted several cytological experiments on pollen tube growth as influenced by blossom thinners.

Results of 1994 Chemical Apple Thinning Tests

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Introduction:

Apple growers in different regions obtain different responses from chemical thinning treatments that may be due to differences in climate, cultural practices, rootstocks, tree age, etc. In 1994, a federal registration was obtained by Abbott Labs for Accel (6-BA + low rate of GA_{4+7}) and a Virginia State registration was obtained by Dupont for Vydate for thinning apples. In addition, considerable interest in pollination and fertilization inhibitors has developed due to the cancellation of Elgetol in the Northwestern U.S.A.

Materials and Methods

All trees were selected for uniform flowering at bloom and were blocked according to row and terrain into six blocks for the number of treatments listed in each table. Specific information about tree size, spray application dates, chemical rates, and stage of development are reported in each table.

Results and Discussion:

Table 1. Redchief Delicious (difficult to thin)—Accel applied at 8 mm fruit diameter did not cause fruit thinning (trt # 2,3,4), but did when applied at petal fall (trt 16). Comparison of trt # 13 vs trt # 8 and trt #4 and #16 indicated that more thinning occurred with the PF treatments than at 8 mm. Combinations of Sevin + Oil + Accel at 8 mm (trt # 8) or Seven + Accel (trt # 5, 6, 7) or Vydate + Accel (trt # 12) did not cause fruit thinning. Average 2 day temperatures at PF were: High 85F and Low 59F, and at 8 mm were High 70F and Low 45F. The 15F higher temperature at PF could account for the difference in thinning and not the timing of the sprays.

Table 2. York (moderate to thin)--Accel applied at 8 mm fruit diameter did not cause fruit thinning (trt 2,3,4), but did when applied at petal fall trt (#16) Comparison of trt #8 vs trt #13 and trt #5 and #16 indicated that more thinning occurred with the PF treatments than at 8 mm. Accel applied at 8 mm caused significant seed abortion, but this did not affect fruit diameter (storability of this fruit and return bloom of these trees will be followed). Combinations of Sevin + Oil + Accel at 8 mm (trt # 8) resulted in good thinning but the same treatment at petal fall almost defruited the trees (trt 16). Seven + Accel (trt # 5, 6, 7) or Vydate + Accel (trt # 12) caused thinning but only slightly more that Sevin or Vydate alone (trt 9, 11). Two

applications of Sevin was better than one (trt # 15). Average 2 day temperatures at PF were: High 63F and Low 37F; and at 8 mm were: High 53F and Low 45F. The 10 F higher temperature at PF could account for the difference in thinning and not the timing of the sprays.

Table 3, 4, 5, 6, 7. Pollination and fertilization inhibitors caused some fruit thinning at the highest rates and multiple applications. The MYX4801 caused more thinning and more injury to fruit than other materials. Endothall gave good thinning without fruit injury. Willthin (GWN-6592) did cause some thinning but fruit injury was a problem in one experiment. Two applications of Captan or Funginex did not reduce fruit set when applied with an airblast sprayer during bloom. Fruit loss after chemical thinning counts (12 May) was greatest when trees were poorly thinned by the bloom thinner (fruit recounted 31 May), since greater competition would exist with heavier crop loads. Treatments that caused the most thinning caused the greatest fruit size increase.

Table 8. NAA caused thinning of Golden Delicious fruit at 8 mm fruit diameter. The addition of Regulaid or Guthion, Captan, Carzol, Imidan, Polyram, Lorsban, Omite or Lannate had no affect on NAA efficacy.

Table 9. York/M.26 trees were hand thinned at 0, 7, 14, 21, 28, 35, 61 days AFB. There was a small but negative relationship between time of thinning and fruit size, but no statistical difference in yield between thinning treatments. The return bloom and yields for the next season will be followed. The non-thinned control had the highest one year yield and lowest average fruit diameter.

Table 10. Golden Delicious/M.26 trees were hand thinned at 0, 7, 14, 21, 28 35, 61 days AFB. There was a small but negative relationship between time of thinning and fruit diameter, but no statistical difference between yield and thinning treatment. The return bloom and yields for the next season will be followed. The non-thinned control had the highest one year yield and lowest average fruit diameter.

Table 11. An analysis of daytime high temperatures for the 10-year period from 1984 to 1993 indicates that in the 21 days AFB in 7 of 10 years there were 3 days or more above 85F, but only 3 days above 85F during the 15-21 days AFB when fruit are usually 8 to 12 mm in fruit diameter. In the 15-21 days AFB the high temperature was only 75F for 7 out of 10 years. Thus, it is possible that a grower would have to choose temperatures 10 degrees lower if he were to spray thin during the warmest 3 days during the period when fruit are 8 to 12 mm in fruit diameter. For this reason we would suggest that a grower begin his chemical spray thinning soon after full bloom when temperatures are adequate.

Table 1. Effect of Accel on fruit set of 'Campbell Redchief Delicious' /MM 111 (1994).

No.	Color	Treatment[zy]	Rate ai/A/100gal	Rate /25 gal	Spray timing	Fruit/cm^2 cross sectional area limb (13 Jun)	Fruit diameter (cm) (30 Aug)	Length/ diameter ratio
1.	W	Control				11.4 a[x]	5.87 cdef	1.000 a
2	R	Accel	20 g	264 ml	8 mm	10.9 ab	5.84 def	1.013 a
3	B	Accel	30 g	396 ml	8 mm	11.0 ab	5.73 f	1.014 a
4	HP	Accel	40 g	528 ml	8 mm	10.4 abc	5.73 f	1.010 a
5	FO	Accel	20 g	264 ml	8 mm	9.2 abc	5.73 f	1.023 a
		+ Sevin XLR	0.75 lb	177 ml				
6	LG	Accel	30 g	396 ml	8 mm	11.4 a	5.98 bcde	0.992 a
		+ Sevin XLR	0.75 lb	177 ml				
7	BK	Accel	40 g	528 ml	8 mm	10.0 abc	5.92 bcdef	1.001 a
		+ Sevin XLR	0.75 lb	177 ml				
8	Y	Accel	40 g	528 ml	8 mm	10.2 abc	5.92 bcdef	0.997 a
		+ Sevin XLR	0.75 lb	177 ml				
		+ Oil 0.5%	4 pt	473 ml				
9	PBKS	Sevin XLR	0.75 lb	177 ml	8 mm	9.3 abc	5.93 bcdef	1.017 a
10	OBKS	Sevin XLR	0.75 lb	177 ml	8 mm	9.0 bc	6.07 bc	1.009 a
		+ Oil 0.5%	4 pt	473 ml				
11	YBKS	Vydate	4 pt	473 ml	8 mm	10.6 abc	6.04 bcd	0.999 a
12	YS	Vydate	4 pt	473 ml	8 mm	9.6 abc	5.78 ef	1.000 a
		+ Accel	40 g	528 ml	8 mm			
13	RS	Accel	40 g	528 ml	PF	3.4 e	6.77 a	1.016
		+ Sevin XLR	0.75 lb	177 ml	PF			
		+ Oil 0.5%	4 pt	473 ml	PF			
14	BS	Sevin XLR	0.75 lb	177 ml	PF	9.9 abc	6.12 b	1.010
15	RD	Sevin XLR	0.75 lb	177 ml	PF + 8 mm	8.4 c	6.02 bcd	1.002
16	BD	Accel	40 g	528 ml	PF	5.7 d	6.13 b	1.004

[z]Full bloom occurred 21 April 1994.

[y]Treatments were applied at PF on 26 Apr 94 and on 3 May 94 when fruit size was 7.9 ± 0.441. Airblast sprayer was calibrated for 100 gal/acre (trees were 24 feet between rows, tree wideth was 11 feet, and tree height was 15 ft (50% TRV). Average 2 day temperatures at PF were: High 63 and Low 37 and at 8 mm were High 53 and Low 45.

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

Table 2. Effect of Accel on fruit set of 'York' /MM 111 (1994).

No.	Color	Treatment[zy]	Rate ai/A/100gal	Rate /25 gal	Spray timing	Fruit/cm^2 cross sectional area limb (10 Jun)	Fruit diameter (cm) (6 Sep)	Seeds/ fruit	Length/ diameter ratio	Side russet rating[x]
1	W	Control				14.9 a[w]	6.99 cd	6.30 a	0.777 ab	0.950 cd
2	R	Accel	20 g	264 ml	8 mm	14.4 ab	7.09 bcd	6.38 a	0.763 b	1.250 bcd
3	B	Accel	30 g	396 ml	8 mm	14.4 ab	6.91 d	5.85 abc	0.778 ab	0.933 cd
4	HP	Accel	40 g	528 ml	8 mm	12.9 abc	6.99 cd	4.94 bcde	0.806 ab	0.892 d
5	BS	Accel	20 g	264 ml	8 mm	10.1 cde	7.18 bcd	4.27 def	0.810 ab	1.067 bcd
		+ Sevin XLR	0.75 lb	177 ml						
6	LG	Accel	30 g	396 ml	8 mm	11.2 bcd	7.01 cd	4.68 cde	0.790 ab	1.050 bcd
		+ Sevin XLR	0.75 lb	177 ml						
7	BK	Accel	40 g	528 ml	8 mm	10.7 cd	6.99 cd	3.77 ef	0.785 ab	1.025 cd
		+ Sevin XLR	0.75 lb	177 ml						
8	Y	Accel	40 g	528 ml	8 mm	6.9 e	7.20 bcd	1.60 g	0.780 ab	1.183 bcd
		+ Sevin XLR	0.75 lb	177 ml						
		+ Oil 0.5%	4 pt	473 ml						
9	PBKS	Sevin XLR	0.75 lb	177 ml	8 mm	11.9 abcd	7.07 bcd	5.13 abcd	0.818 a	1.108 bcd
10	RD	Sevin XLR	0.75 lb	177 ml	8 mm	6.9 e	7.37 b	4.15 def	0.771 ab	1.408 b
		+ Oil 0.5%	4 pt	473 ml						
11	YBKS	Vydate	4 pt	1 pt 473 ml	8 mm	10.7 cd	7.28 bc	5.38 abcd	0.776 ab	1.842 a
12	BD	Vydate	4 pt	1 pt 473 ml	8 mm	9.2 de	7.19 bcd	3.13 f	0.763 b	1.802 a
		+ Accel	40 g	528 ml	8 mm					
13	FO	Accel	40 g	528 ml	PF	1.7 f	8.03 a	6.45 a	0.819 ab	1.875 a
		+ Sevin XLR	0.75 lb	177 ml						
		+ Oil 0.5%	4 pt	473 ml						
14	YS	Sevin XLR	0.75 lb	177 ml	PF	15.2 a	7.21 bcd	6.03 ab	0.776 ab	1.225 bcd
15	RS	Sevin XLR	0.75 lb	177 ml	PF + 8 mm	9.3 de	7.28 bc	5.57 abc	0.781 ab	1.150 bcd
16	OBKS	Accel	40 g	528 ml	PF	10.0 cde	7.29 bc	6.40 a	0.778 ab	1.292 bc
17	OS	NAA 5 ppm	36.5 ml	9 ml		12.2 abcd	7.00 cd	5.93 abc	0.813 ab	1.100 bcd
		+ Regulaid	1 pt	118 ml	8 mm					

[z]Full bloom occurred 26 April 1994.

[y]Treatments were applied at PF on 28 April and on 11 May 94 when fruit size was 8.2 ± 0.37. Airblast sprayer was calibrated for 100 gal/acre (trees were 24 feet between rows, tree width was 11 feet, and tree height was 15 ft (50% TRV). Average 2 day temperatures at PF were: High 85 and Low 59 and at 8 mm were High 70 and Low 45.

[x]Side-russet rating: 0 = no lenticel development; 1 = lenticel enlargement; 2 = lenticel enlargement and some russet between lenticels; 3 = lenticel enlargement and raised to touch and moderate russet between lenticels; 4 = lenticel enlargement and raised to touch with heavy russet between lenticels; 5 = lenticel enlargement and raised to touch with very heavy russet between lenticels.

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

Table 3. Effect of pollenation inhibitors on 'Ace Red Delicious'/MM 111 fruit set (1994).

No.	Color	Treatment[zy]	Rate /25gal	Rate /100 gal	Spray timing % Flowers open Apr20 + Apr 22 + Apr 24	Fruit/cm^2 cross sectional area limb (12 May)	Fruit/cm^2 cross sectional area limb (31 May)	% fruit lost between counting dates	Petal burn rating (0 to 10)	Fruit diameter (1 Sep)	Length/ diameter ratio	Net fruit russet rating[x]
1	W	Control				14.1 abc[w]	9.5 ab	26 ab	0.2 d	7.19 bcd	0.973 ab	0.63 c
2	FO	Endothal 0.4 EC	236.5	2 pt	90% FB	12.7 abcd	8.8 abcde	25 ab	0.5 d	7.07 bcd	0.979 ab	0.61 c
3	BS	Endothal 0.4 EC	177	1.5 pt	90% FB	13.4 abc	9.8 ab	24 ab	0.3 d	7.05 d	0.977 ab	0.59 c
4	HP	Endothal 0.4 EC	177	1.5 pt	30% + 60% + 90% FB	8.7 de	6.4 cde	22 ab	0.3 d	7.14 bcd	0.953 bcd	0.63 c
5	PBKS	Endothal 0.4 EC	118	1 pt	90% FB	10.5 cde	7.4 bcde	24 ab	0.0 d	7.06 cd	0.942 cd	0.63 c
6	BK	GWN-6592	1419	12 pt	90% FB	10.7 cde	8.5 abcde	17 bc	2.3 bc	7.05 bcd	0.980 a	0.58 c
		+ Regulaid	118	1 pt								
7	OBKS	GWN-6592	1419	12 pt	90% FB	11.1 bcde	8.0 abcde	21 b	2.0 c	7.20 bcd	0.975 ab	0.63 c
		+ Regulaid	118	1 pt								
		+ Sevin	177	0.75 lbs	+ 8.2 mm							
		+ Oil	473	4 pt								
8	LG	GWN-6592	946	8 pt	90% FB	13.0 abcd	9.7 ab	18 bc	2.3 bc	7.24 bcd	0.975 ab	0.63 c
		+ Regulaid	118	1 pt								
9	R	GWN-6592	946	8 pt	30% + 60% + 90% FB	10.5 cde	7.7 bcde	25 ab	2.9 b	7.35 bc	0.962 abc	0.69 c
		+ Regulaid	118	1 pt								
10	YS	MYX4801	946	8 pt	90% FB	7.2 e	6.3 e	11 bc	6.0 a	7.36 b	0.962 abc	0.94 b
		+ Regulaid	118	1 pt								
11	B	MYX4801	946	8 pt	30% + 60% + 90% FB	7.0 e	6.3 de	5 c	6.2 a	7.61 a	0.933 d	1.63 a
		+ Regulaid	118	1 pt								
12	YBKS	MYX4801	710	6 pt	90% FB	10.1 cde	7.4 bcde	21 b	5.5 a	7.12 bcd	0.987 a	0.68 c
		+ Regulaid	118	1 pt								
13	RS	MYX4801	473	4 pt	90% FB	11.7 abcd	9.0 abc	21 b	1.8 c	7.17 bcd	0.976 ab	0.57 c
		+ Regulaid	118	1 pt								
14	RD	Sevin	177	0.75 lbs	+ 8.2 mm	15.7 a	8.9 abcd	37 a	0.2 d	7.14 bcd	0.984 a	0.59 c
		+ Oil	473	4 pt								
15	BD	Dormex	473	4 pt	90% FB	15.1 ab	10.4 a	27 ab	0.6 d	7.12 bcd	0.982 a	0.56 c

[z]Full bloom occurred 24 April 1994.

[y]Treatments were applied at 30% (20 Apr), 60% (22 Apr) and 90% (24 Apr) open flowers, and 5 May when fruit size was 8.2 ± 0.37. Airblast sprayer was calibrated for 160 gal/acre (trees were 16 feet between rows, tree width was 7 feet, and tree height was 10 ft (33% TRV--130 gal/A + 30 gal/A for drift).

[x]Side russet rating: 1 = very little net side russet; 5 = heavy net russet.

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

(Percent fruit set on 200 stigmas cut off on 25 April 94 was--10%, and 25% natural set on the non-cut stigmas.)

Table 4. Effect of two sprays of a pollenation inhibitor on 'Stayman'/Mark fruit set (1994).

No.	Color	Treatment[zy]	Rate /100 gal	Spray timing % Flowers open Apr20 + Apr 22	Fruit/cm^2 cross sectional area limb (12 May)	Fruit/cm^2 cross sectional area limb (1 June)	% Fruit lost between counting dates	Fruit diameter (cm) 7 Sep	Length/ diameter ratio	Net fruit russet rating[x]
1	W	Control			20.0 a[w]	13.6 a	32 a	6.56 a	0.869 a	0.965 a
2	R	Wilthin + Regulaid	12 pt 1 pt	40% + 90%	16.6 b	11.9 a	28 a	6.51 a	0.864 a	1.030 a

[z]Full bloom occurred 22 April 1994.
[y]Treatments were applied at 40% (20 Apr) and 90% (22 Apr) open flowers. Airblast sprayer was calibrated for 160 gal/acre (trees were 16 feet between rows, tree width was 7 feet, and tree height was 10 ft (33% TRV--130 gal/A + 30 gal/A for drift).
[x]Side russet rating: 1 = very little net side russet; 5 = heavy net russet.
[w]Mean separation within columns by t test, 5% level.

Table 5. Effect of two sprays of pollenation inhibitors on `Stayman'/MM 111 fruit set (1994).

No.	Color	Treatment[zy]	Rate /100 gal	Spray timing % Flowers open Apr20 + Apr 22	Fruit/cm^2 cross sectional area limb (12 May)	Fruit/cm^2 cross sectional area limb (1 June)	% Fruit lost between counting dates	Fruit Diameter (cm)(Sep 6)	Length/ diameter ratio	Net fruit russet rating[x]
1	W	Control			17.6 a[w]	12.6 a	28 a	6.75 a	0.878 a	1.267 a
2	HP	Endothall	1.5 pt + 1.5 pt	40% + 90%	11.1 b	8.0 b	24 a	6.42 b	0.852 a	1.160 a

[z]Full bloom occurred 22 April 1994.
[y]Treatments were applied at 40% (20 Apr) and 90% (22 Apr) open flowers. Airblast sprayer was calibrated for 110 gal/acre (trees were 24 feet between rows, tree width was 11 feet, and tree height was 15 ft (50% TRV--but only 110 gal/A was applied).
[x]Side russet rating: 1 = very little net side russet; 5 = heavy net russet.
[w]Mean separation within columns by t test, 5% level.

Table 6. Effect of pollenation inhibitors on 'Starkrimson'/Mark fruit set (1994).

No.	Color	Treatment[zy]	Rate /100 gal	Spray timing % Flowers open Apr20 + Apr 22	Fruit/cm^2 cross sectional area of limb (11 May)	Fruit/cm^2 cross sectional area of limb (1 June)	% fruit lost between counting dates	Fruit diameter (cm) (1 Sep)	Length/ diameter ratio	Net fruit russet rating[x]
1	W	Control			19.3 a[w]	9.8 a	44.4 a	6.71 a	0.952 a	0.76 a
2	R	Wilthin	12 pt	40% + 90% FB	20.3 a	9.0 ab	43.7 a	6.96 a	0.953 a	0.72 a
		+ Regulaid	1 pt							
3	B	MYX 4801	8 pt	40% + 90% FB	14.0 ab	9.1 ab	25.7 ab	7.11 a	0.944 a	1.06 a
		+ Regulaid	1 pt							
4	HP	Endothall	1.5 pt	40% + 90% FB	7.0 b	5.6 ab	17.6 b	6.93 a	0.936 a	1.05 a
5	FO	ATS	3 gal	40% + 90% FB	14.8 ab	9.1 b	25.6 ab	6.99 a	0.927 a	0.91 a
		+ Regulaid	1 pt							

[z]Full bloom occurred 22 April 1994.
[y]Treatments were applied at 40% (20 Apr) and 90% (22 Apr). Airblast sprayer was calibrated for 160 gal/acre (trees were 16 feet between rows tree, wideth was 7 feet, and tree height was 10 ft (33% TRV--130 gal/A + 30 gal/A for drift).
[x]Side russet rating: 1 = very little net side russet; 5 = heavy net russet.
[w]Mean separation within columns by Duncan's multiple range test, 5% level.

Table 7. Effect of two sprays of pollenation inhibitors on Starkrimson/MM.106 & MM.111 fruit set (1994).

No.	Color	Treatment[zy]	Rate /100 gal	Spray timing % Flowers open Apr20 + Apr 22	Fruit/cm^2 cross sectional area limb (11 May)	Fruit/cm^2 cross sectional area limb (1 June)	% fruit lost between counting dates	Fruit diameter (cm) (31 Aug)	Length/ diameter ratio	Net fruit russet rating[x]
1	W	Control			11.6 a[w]	8.0 a	30 a	6.84 c	0.942 a	1.11 a
2	LG	Captan	2 lb	40% + 90%	12.8 a	8.4 a	31 a	6.88 c	0.914 ab	1.02 a
3	PBKS	Funginex	10 oz	40% + 90%	11.7 a	8.2 a	26 ab	6.84 c	0.926 ab	1.16 a
4	R	Wilthin	12 pt	40% + 90%	7.6 bc	6.7 a	10 b	7.20 ab	0.927 ab	1.41 a
		+ Regulaid	1 pt							
5	B	MYX 4801	8 pt	40% + 90%	5.3 c	3.8 b	19 ab	7.33 a	0.897 b	1.59 a
		+ Regulaid	1 pt							
6	HP	Endothall	1.5 pt	40% + 90%	6.9 c	5.7 ab	15 ab	7.02 bc	0.905 ab	1.17 a
7	FO	ATS	3 gal	40% + 90%	10.9 ab	7.3 a	22 ab	7.30 ab	0.910 ab	1.16 a
		+ Regulaid	1 pt							

[z]Full bloom occurred 24 April 1994.
[y]Treatments were applied at 40% (20 Apr) and 90% (22 Apr) open flowers. Airblast sprayer was calibrated for 160 gal/acre (trees were 16 feet between rows, tree width was 7 feet, and tree height was 10 ft (33% TRV--130 gal/A + 30 gal/A for Drift).
[x]Side russet rating: 1 = very little net side russet; 5 = heavy net russet.
[w]Mean separation within columns by Duncan's multiple range test, 5% level.

Table 8. Effect of NAA and combinations of other pesticides on fruit set of 'Golden Delicious'/M.26 (1994).

No.	Color	Treatment[z,y]	Rate /100 gal	Rate /12.5 gal	Spray timing 13 May	Fruit/cm² sectional area limb (14 June)
1	W	Control				13.6 a[x]
2	B	NAA 7.5 ppm	55 ml	6.8 ml	8 mm	8.5 c
3	OS	NAA 7.5 ppm	55 ml	6.8 ml	8 mm	8.9 bc
		+ Regulaid	473 ml	59 ml		
4	HP	NAA 7.5 ppm	55 ml	6.8 ml	8 mm	10.9 b
		+ Guthion 50W	2 lb	113.5 g		
5	FO	NAA 7.5 ppm	55 ml	6.8 ml	8 mm	10.2 bc
		+ Captan 50W	2 lb	113.5 g		
6	LG	NAA 7.5 ppm	55 ml	6.8 ml	8 mm	9.1 bc
		+ Carzol 92 SP	1.5 lb	85 g		
7	Y	NAA 7.5 ppm	55 ml	6.8 ml	8 mm	9.6 bc
		+ Imidan 70 W	1 lb	57 g		
8	BK	NAA 7.5 ppm	55 ml	6.8 ml	8 mm	10.1 bc
		+ Polyram 80 DF	1 lb	57 g		
9	YS	NAA 7.5 ppm	55 ml	6.8 ml	8 mm	8.6 c
		+ Lorsban 50 W	1 lb	57 g		
10	BD	NAA 7.5 ppm	55 ml	6.8 ml	8 mm	8.3 c
		+ Omite 6 E	8 oz	30 ml		
11	RD	NAA 7.5 ppm	55 ml	6.8 ml	8 mm	8.1 c
		+ Lannate 90 SP	4 oz 118 ml	15 ml		

[z]Full bloom occurred 24 April 1994.
[y]Treatments were applied with a hand gun on 13 May 1994 when fruit size was 9.2 ± 0.5.
[x]Mean separation within columns by Duncan's multiple range test, 5% level.

Table 9. Effect of time of hand thinning on 'York'/M.26 fruit size (1994).

No.	Color	Treatment[z]	Timing	Fruit/cm² cross sectional area limb	Fruit/cm² cross sectional area limb (after thinning)	Yield/cm² cross sectional area trunk (Sep 20)	Fruit diameter (inches)				Increment increase in fruit diameter (inches)			
							Jul 1	Aug1	Sep 1	Oct 3	Jul1-Aug1	Aug1-Sep1	Sep1-Oct3	Jul1-Oct3
1	W	Control	0	14.69 a[y]	14.69 a	4.70 a	1.64 d	2.02 e	2.38 d	2.59 d	0.378 c	0.362 c	0.207 a	0.947 c
2	R	Hand Thinning	FB	7.47 b	7.47 b	3.73 b	1.85 a	2.35 a	2.79 a	3.02 a	0.507 a	0.438 a	0.230 a	1.175 a
3	B	Hand Thinning	FB + 7	7.34 b	7.34 b	3.91 b	1.78 b	2.26 bc	2.68 ab	2.91 ab	0.482 ab	0.418 ab	0.232 a	1.132 ab
4	HP	Hand Thinning	FB + 14	7.96 b	7.54 b	4.06 b	1.74 bc	2.18 cd	2.59 bc	2.79 bc	0.447 b	0.407 abc	0.203 a	1.057 abc
5	FO	Hand Thinning	FB + 21	8.20 b	7.72 b	4.09 b	1.76 bc	2.24 bcd	2.66 bc	2.88 abc	0.480 ab	0.423 ab	0.220 a	1.123 ab
6	LG	Hand Thinning	FB + 28	8.09 b	7.72 b	3.72 b	1.74 bc	2.19 cd	2.60 bc	2.82 bc	0.453 b	0.407 abc	0.220 a	1.080 ab
7	Y	Hand Thinning	FB + 35	7.16 b	7.16 b	3.73 b	1.79 ab	2.29 ab	2.71 ab	2.94 ab	0.492 ab	0.428 ab	0.223 a	1.143 ab
8	BK	Hand Thinning	FB + 61	13.20 a	7.72 b	3.52 b	1.69 cd	2.16 d	2.54 c	2.73 c	0.468 ab	0.378 bc	0.194 a	1.040 bc

[z]Full bloom occurred April 25, 1994.
[y]Mean separation within columns by Duncan's range test, 5% level.

Table 10. Effect of time of hand thinning on 'Golden Delicious'/M. 26 fruit size (1994).

No.	Color	Treatment[z]	Timing	Fruit/cm² cross sectional area limb	Fruit/cm² cross sectional area limb (after hand thinning adjustment)[y]	Yield/cm² cross sectional area trunk Sep 20	Fruit diameter (inches)				Increment increase in fruit diameter (inches)			
							Jul 1	Aug1	Sep 1	Sep 19	Jul 1-Aug1	Aug1-Sep1	Sep1-Sep19	July1-Sep19
1.	W	Control	0	13.6 a	13.6 a[x]	3.99 a	1.62 c	2.02 c	2.38 c	2.49 c	0.404 b	0.359 a	0.111 b	0.870 b
2	R	Hand Thinning	FB	9.4 b	7.4 b	2.97 b	1.74 a	2.31 a	2.68 a	2.81 a	0.562 a	0.372 a	0.132 ab	1.066 a
3	B	Hand Thinning	FB + 7	8.0 b	6.4 b	3.05 b	1.76 a	2.32 a	2.67 a	2.81 a	0.560 a	0.352 a	0.135 a	1.053 a
4	HP	Hand Thinning	FB + 14	8.1 b	7.0 b	3.22 b	1.74 a	2.30 a	2.66 ab	2.80 ab	0.551 a	0.360 a	0.141 a	1.046 a
5	FO	Hand Thinning	FB + 21	8.9 b	7.2 b	3.06 b	1.71 ab	2.24 ab	2.59 ab	2.72 ab	0.530 a	0.352 a	0.132 ab	1.013 a
6	LG	Hand Thinning	FB + 28	9.3 b	7.7 b	3.03 b	1.73 ab	2.27 ab	2.62 ab	2.75 ab	0.539 a	0.349 a	0.133 ab	1.020 a
7	Y	Hand Thinning	FB + 35	7.5 b	6.8 b	3.06 b	1.72 ab	2.26 ab	2.60 ab	2.73 ab	0.533 a	0.341 a	0.130 ab	1.004 a
8	BK	Hand Thinning	FB + 61	12.1 a	7.7 b	3.38 b	1.65 bc	2.17 b	2.54 b	2.66 b	0.516 a	0.367 a	0.123 ab	1.006 a

[z]Full Bloom occurred April 25, 1994.
[y]Sixty one days after FB, all treatments except trt#1 was further thinned to adjust the crop load to similar levels.
[x]Mean separation within columns by Duncan's range test, 5% level.

Table 11. Day time temperatures above a designated temperature for 21 days and 7 days AFB for the ten-year period 1984 to 1993.

Day time high temperatures above	1984 May 5	1985 Apr 21	1986 Apr 22	1987 May 1	1988 Apr 22	1989 Apr 25	1990 Apr 25	1991 Apr 24	1992 May 1	1993 May 3	Years with 3 days above temp / total number of years
	Full Bloom Date										
	Day 1-21										
90	1	2	1	1	0	0	2	3	0	1	1/10
85	4	6	5	5	0	0	4	3	1	3	7/10
80	6	12	10	8	2	1	7	13	4	7	8/10
75	11	16	14	13	6	4	12	16	9	12	10/10
70	16	19	18	17	10	8	16	20	15	17	10/10
65	17	20	18	18	12	13	20	21	15	21	10/10
60	19	20	20	20	17	17	21	21	17	21	10/10
55	20	20	20	21	21	18	21	21	21	21	10/10
50	21	21	21	21	21	21	21	21	21	21	10/10

Day time high temperatures above	1984 May 5	1985 Apr 21	1986 Apr 22	1987 May 1	1988 Apr 22	1989 Apr 25	1990 Apr 25	1991 Apr 24	1992 May 1	1993 May 3	Years with 3 days above temp / total number of years
	Full Bloom Date										
	Day 15-21										
90	1	0	1	1	0	0	0	3	0	0	1/10
85	4	0	3	2	0	0	0	3	0	0	3/10
80	6	4	3	4	2	0	1	7	1	0	5/10
75	7	7	6	5	5	0	4	7	2	0	7/10
70	7	7	7	5	6	1	5	7	6	3	9/10
65	7	7	7	5	6	3	7	7	6	7	10/10
60	7	7	7	6	6	4	7	7	7	7	10/10
55	7	7	7	7	7	5	7	7	7	7	10/10
50	7	7	7	7	7	7	7	7	7	7	10/10

Mystery Spot of 'Enterprise' Apple

W.H. Tietjen, D.F. Polk, W.P. Cowgill, Jr., K.S. Petersen, and E. F.Rizio, Jr.
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'Enterprise' is the ninth apple cultivar developed by the Purdue-Rutgers-Illinois cooperative breeding program. Fruiting of 'Enterprise' has been observed for 2 to 3 years at widely separated locations in New Jersey.

A disorder, resembling Brooks Fruit Spot, has been observed at three locations in New Jersey; Rutgers-NJAES Snyder Research Farm (SNY), Pittstown, Rutgers-NJAES Fruit Research Center, Cream Ridge (CR), and at a grower planting in Hardingville (HAR). The disorder has not been reported at other locations in North America and Europe. (Table 1)

The circular, slightly sunken spots are associated with lenticels and are variably colored (usually green to black). Corky tissue extends a short distance into the flesh. The spots appear just prior to harvest and also develop during storage. The disorder varies from a single spot to numerous spots. The spots occur less frequently on the stem end than on other areas.

In 1993, visually sound fruit was selected at harvest for a storage study. After nearly 5 months of storage, fruit held in air developed spots on 40.8% of the stored apples versus 10.8% spotted fruit held under CA. (Table 2)

The Rutgers Plant Diagnostic Laboratory reported that the disorder resembles Jonathan Spot. No pathogenic agent was identified. Secondary invaders were isolated and included. Alternaria, Penicillium, Botrytis and Aureobasidium.

(Preliminary Report)

Table 1. Incidence (%) of Enterprise 'Mystery Spot'

Location	Rootstock	Fungicide	'92	'93	'94
SNY	M26	+	_	59.3	
		-		52.0	
CR	Mark	+	22.2	3.1	_
		-	22.9	0.0	
	M7	+	2.3	25.0	5.7
		-	5.4	31.7	17.0
HAR	MM111	+	41.0	_	26.0

Table 2. Development of 'Mystery Spot' During Cold andCA Storage of Enterprise

Treatment	S/S	Pressure	Mystery Spot (%)
CA	15.6a	14a	10.8
Air	15.1b	12.6b	40.8

*Fruit Harvested 10/26/93
*Air and CA Storage started 10/29/93
*CA Storage (2° C, 2.0% O_2, 2.0% Co_2)
*Air Storage (2° C, vent with pure O_2)
*Removed from Storage 03/24/94

Update on Apple Crop Mg
the Internet Discussion Group on Apple Production

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The Apple Crop Production Mail Group, **apple-crop-mg**, was formed a year ago to allow pomologists to better communicate on all aspects of apple production, marketing and related topics.

The goal of this discussion group is to provide a forum which will foster the exchange of information between University Researchers, Extension Agents and Specialists, students, apple farmers, wholesalers/brokers, retailers and direct marketers of apples.

The apple-crop-mg discussion forum has the potential to strengthen communications between commercial producers of apples and the scientific and education community. Discussion relating to all aspects of apple production from cultivar selection, tree growth and performance, rootstock development and testing to the development of sustainable production systems is welcome. Initially this group has focused on the horticultural aspects of apple production including ICM and pest control. This may change as the group evolves. I would welcome more discussion on marketing. Research briefs and abstracts are welcome along with new technology developments. News articles are invited, particularly local items from your region.

The use of electronic mail over the Internet, via the apple-crop-mg, has provided an inexpensive, rapid means of communication. Lively on-line chatter this past year has ensued on numerous topics from tree row volume calculations, seeding rates of hard fescues for orchard sod middles to the ongoing discussion of the Mark Rootstock.

The group now has over 200 participants from all over North America. On-line discussion seems to happen in spurts when a topic of interest is posted. Your input is always welcome. I have been pleased with the activity on Apple-Crop-Mg but any tool of communication is only as good as the participants make it. We have room for more participants and I would encourage you to get active on e-mail and join the group. If you are already a member let us hear what you are up to. We encourage the posting of preliminary research results and any topic of interest or concern to you.

To subscribe to Apple-Crop-Mg, send an E-mail message to:
almanac@esusda.gov
In the body of the message type:
Subscribe apple-crop-mg@esusda.gov
Then send/exit the message.

To un-subscribe to Apple-Crop-Mg, send an E-mail message to:
almanac@esusda.gov
In the body of the message type the command: unsubscribe apple-crop-mg
Then send/exit the message.

Preliminary Performance of Six Scab Resistant Apple Cultivars in Northwest New Jersey

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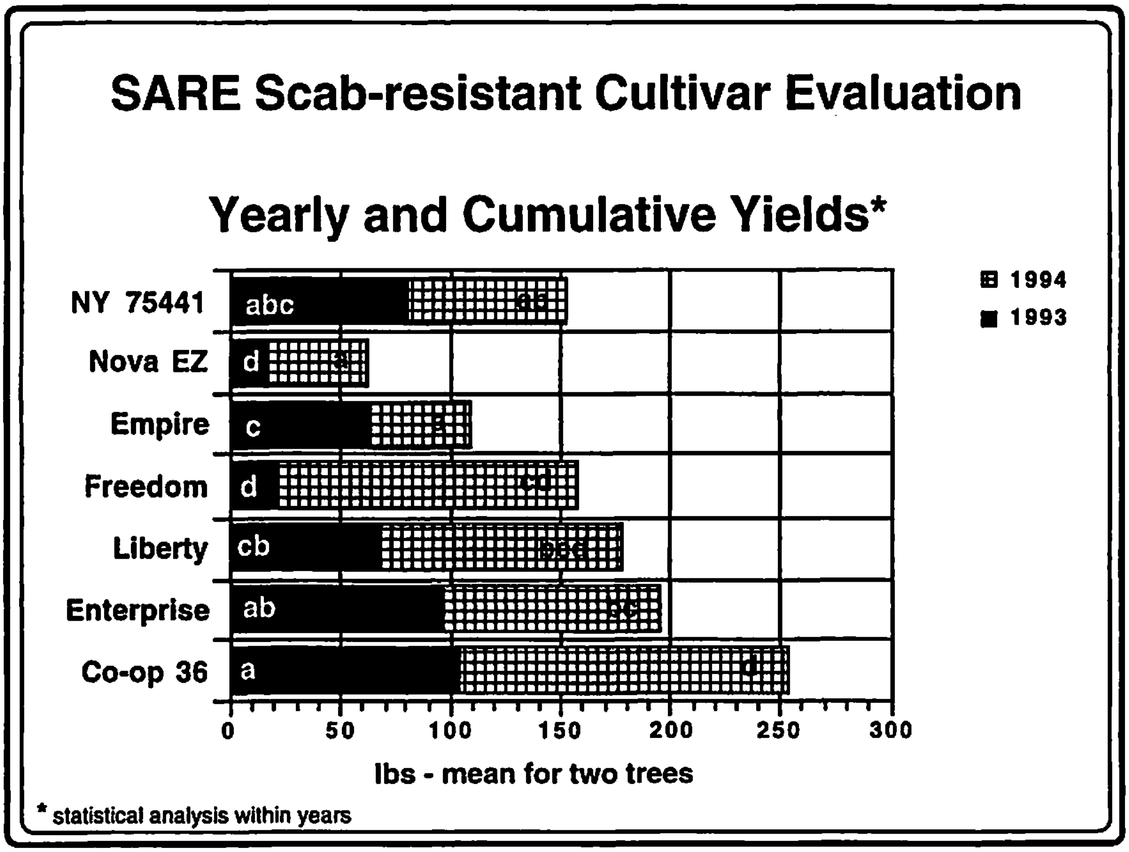
Six scab resistant apple cultivars, Enterprise (CO-OP 30), CO-OP 36, Liberty, Freedom, Nova-Ez-Grow, NY-754 were propagated on M.26 EMLA. Trees were planted in 1990 in a randomized complete block design with six replications, five trees per replication. Empire/M.26 EMLA was the control cultivar. Tree spacing was 3M apart in the row and 6M between rows. Trees were individually staked and trained to a modified spindle bush. Precocity, bloom counts, tree height and width, TCA, cumulative yield efficiency and fruit quality have been determined annually. CO-OP 36, Enterprise and Liberty had significantly higher cumulative yields in 1993-94 than the other cultivars. The same three also had significantly superior fruit quality characteristics. Liberty was the most precocious of the scab resistant cultivars, very similar to Empire. Liberty was also the weakest growing cultivar followed by Empire.



1994 Apple Thinning Trials With Accell

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Location of Trial: Melick Farms
Oldwick, New Jersey

Objective: Thinning efficacy of Accel: rate with and without Sevin

Crop: Apple

Variety: Red Delicious 'Red Chief'

Materials: Accel™
Sevin XLR™

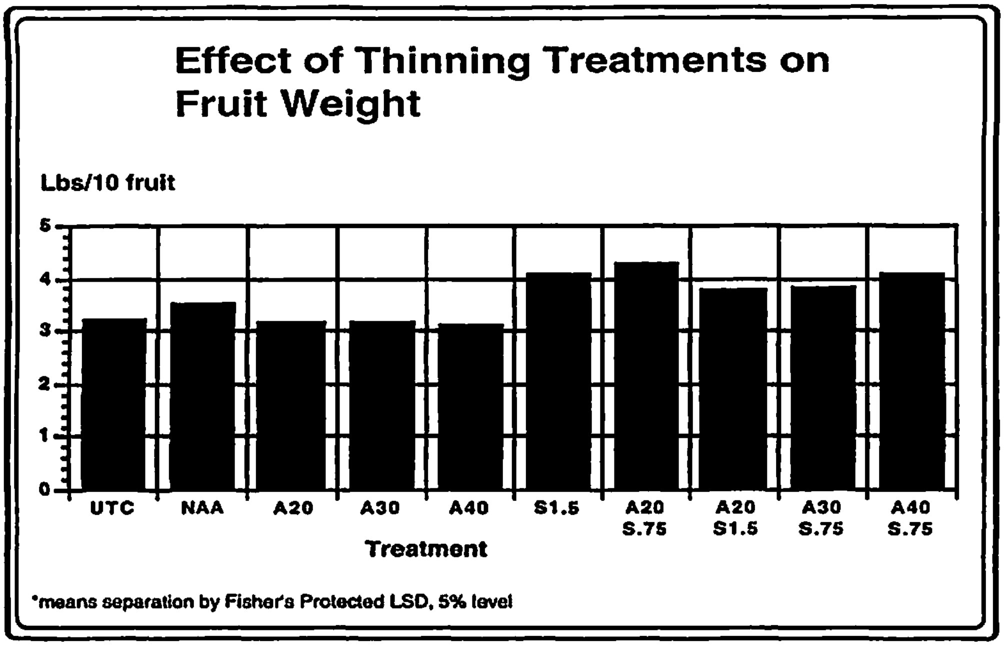
Application: Backpack power sprayer; 100 gal/acre; applied at 10mm

Design: two limbs Single factor, completely randomized design; five single tree replications/ per tree

Treatments:
1 - untreated check
2 - NAA 5 ppm
3 - Accel 20 gm ai/acre
4 - Accel 30 gm ai/acre
5 - Accel 40 gm ai/acre
6 - Sevin 1.5 lb/acre
7 - Accel 20 gm ai/acre
8 - Accl 20 gm ai/acre
9 - Accel 30 gm ai/acre
10 - Accel 40 gm ai/gm

Materials and Methods: Two limbs for treatment were selected for uniformity of size and flower cluster density. Treatments were applied on.5, 1995.Flower clusters on selected limbs were counted on and fruit were counted on July 19 and on September 16. Because of unexpected fruit losses at this grower site, only counts from July are reported. On September 20 all fruit from treated limbs were harvested. A sample of ten fruit from each limb were evaluated utilizing the University of Vermont apple fruit testing protocol. Data from the two limbs in each replication were averaged prior to analysis of variance and means testing.

Results and Discussion:



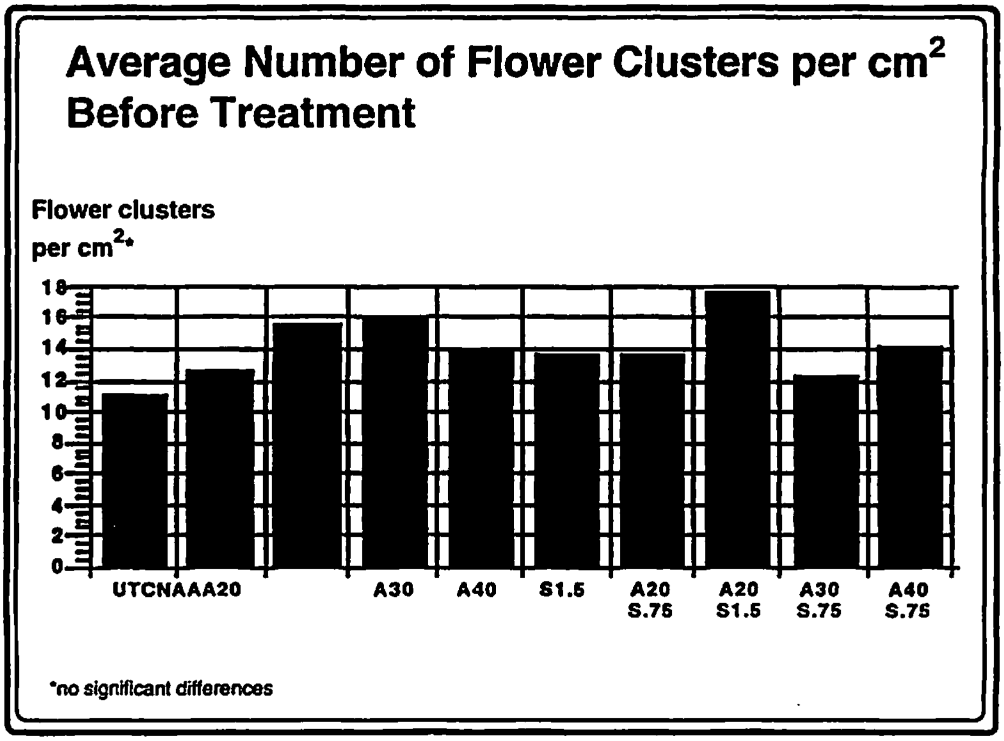


Table 1. Effect of thinning treatments on fruit number.

treatment	number flower clusters per cm2 TCSA	number fruit per cm2 TCSA
untreated control	11.1	14.5 bcd*
NAA 5 ppm	12.6	14.0 bcd
Accel 20 gm ai/acre	15.6	15.7 d
Accel 30 gm ai/acre	16	15.2 bcd
Accel 40 gm ai/acre	13.8	15.0 bcd
Sevin 1.5 lb/acre	13.7	11.5 abc
Accel 20 gm ai + Sevin 0.75lb/acre	13.7	11.1 ab
Accel 20 gm ai + Sevin 1.5 lb/acre	17.6	8.2 a
Accel 30 gm ai + Sevin 0.75lb/acre	12.3	13.1 bcd
Accel 40 gm ai + Sevin 0.75 lb/acre	14.2	12.7 bcd

*means separation in columns by Fisher's LSD, 5% level

Table 2. Effect of fruit thinning treatments on weight, soluble solids, starch-iodine index, seed count and lenght-diameter ratio.

treatment	average fruit weight - grams	soluble solids percent	starch-iodine index	seed count average /fruit	length:diameter average/10fruit
untreated control	3.2a*	8.88a	2.85	7.3	.918a
NAA 5 ppm	3.52 ab	9.58 abc	2.68	6.84	.927 ab
Accel 20 gm ai/acre	3.14 a	9.28 ab	2.79	7.70	.973 c
Accel 30 gm ai/acre	3.19 a	9.32 ab	3.00	7.20	.950 abc
Accel 40 gm ai/acre	3.11 a	9.58 abc	2.76	6.98	.951 bc
Sevin 1.5 lb/acre	4.08 cd	9.36 ab	2.98	7.04	.947 abc
Accel 20 gm ai + Sevin 0.75lb/acre	4.27 d	9.98 bc	2.86	6.78	.954 bc
Accel 20 gm ai + Sevin 1.5 lb/acre	3.77 bc	10.18 c	2.74	6.58	.945 abc
Accel 30 gm ai + Sevin 0.75lb/acre	3.82 bc	10.10 c	2.72	6.10	.957 bc
Accel 40 gm ai + Sevin 0.75 lb/acre	4.05 cd	9.94 bc	2.72	5.86	.970 c

*means separation in columns by Fisher's LSD, 5% level

Plant Pathology

STUDIES OF FIRE BLIGHT RESISTANCE TO STREPTOMYCIN

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Fire blight was severe on apple in 1994. The disease increased rapidly following hailstorms in Van Buren and Kent counties; or following blossom blight infections in Allegan county. Some growers experienced losses similar to those recorded in the 1991 epidemic. Losses were particularly common in young orchards and in high density planting of Gala, Fuji, Idared, Jonathan, and Rome.

This article summarizes the progress of recent research in Michigan on the distribution of streptomycin-resistant *Erwinia amylovora*; the basis for resistance in strains with high-level resistance to streptomycin; and new methods for detecting cells of *E. amylovora* in symptomless plant tissue.

Distribution of Streptomycin Resistance in 1994

Streptomycin-resistant strains of *E. amylovora* were detected at one orchard in Michigan in 1990 and at 14 of 63 apple orchards surveyed during 1991-1993. Orchards with resistance were located in Van Buren, Kent, and Newaygo counties.

In 1994, about 1,000 samples were collected from 35 apple orchards and 1 pear orchard and tested for the presence of resistant strains (Table 1). As in previous surveys, most orchards contain only streptomycin-sensitive strains. Resistance was detected in 8 additional orchards in Van Buren county in 1994, for a total of 17 orchards with resistance in Van Buren county and 22 orchards statewide.

These results and those obtained previously clearly show that streptomycin resistance is increasing in apple orchards in Van Buren county, but not in orchards in Kent and Newaygo counties. Because resistance is now widespread in Van Buren county, streptomycin is no longer effective for fire blight control in this county.

Mechanism of High-Level Resistance

In the United States, streptomycin-resistant *E. amylovora* became a serious problem in the West about 20 years before it became serious in the East (early 1970s versus early 1990s). Bacteria cope with streptomycin by acquiring genes from other bacteria for streptomycin-modifying enzymes or through mutations that affect the ribosomal target site for streptomycin. Resistance in *E. amylovora* from most Michigan apple orchards was mediated by enzymes encoded by two genes (*strA* and *strB*) carried by the transferable plasmid pEa34 and transposon Tn*5393*. In medically important bacteria, resistance can arise from mutations in the *rpsL* gene, which alters ribosomal protein S12, or in the 16S rRNA gene; both mutations reduce the sensitivity of the ribosome to streptomycin. The objective of this study was to determine if these same mutations were responsible for high-level resistance in field strains of *E. amylovora* and whether strains from Michigan and the West had identical mutations.

Streptomycin-resistant and -sensitive strains of *E. amylovora* from Michigan, Washington, Oregon, California, Idaho, and New Zealand were compared on streptomycin-amended and myomycin-amended media. Strains with high-level resistance (HR strains) were insensitive to the streptomycin-related antibiotic myomycin; strains with medium resistance (MR) or sensitivity (S) to streptomycin were sensitive to myomycin. Thus, myomycin proved useful as a tool for identifying HR strains.

Standard molecular techniques were used to examine S, MR, and HR strains for mutations in the chromosomal *rpsL* gene (Table 2). All HR strains contained a single mutation in codon 43 of their *rpsL* gene that resulted in an amino acid substitution in ribosomal protein S12. Except for six strains from Oregon, all contained the same mutation regardless of their geographic origin. A possible explanation for this result is that the same mutation for streptomycin resistance has occurred independently in several locations. It is also possible that a streptomycin-resistance mutant was distributed widely on nursery stock, but this appears less likely because strains from New Zealand were probably local strains.

Other molecular techniques were used to prove that the mutations detected in the *rpsL* gene were responsible for the resistance to streptomycin. Sensitivity to streptomycin and myomycin was restored to HR strains with a plasmid carrying the normal *E. amylovora rpsL* gene. Resistance to streptomycin and insensitivity to myomycin in S strains was restored only when the plasmid carried a mutant *rpsL* gene. Thus, mutations in a single codon of gene *rpsL* have resulted in high-level streptomycin resistance in *E. amylovora*.

Table 1. Results of monitoring for streptomycin-resistant *Erwinia amylovora,* the cause of fire blight, in Michigan apple orchards in 1994.

County	Orchard	Ratio Resistant/total	Resistant (%)
Berrien	1	0/38	0
	2	0/36	0
Van Buren	1*	9/14	64
	2	19/36	53
	3	8/35	23
	4	0/17	0
	5	0/27	0
	6	0/24	0
	7	0/17	0
	8	0/30	0
	9*	6/37	16
	10	23/24	96
	11	14/15	93
	12	27/27	100
	13	16/32	50
	14	27/46	58
	15	8/25	32
Allegan	1	0/33	0
	2	0/23	0
	3	0/41	0
	4	0/32	0
Ottawa	1	0/26	0
	2	0/36	0
	3	0/45	0
Kent	1	0/27	0
	2	0/16	0
Montcalm	1	0/28	0
Newaygo	1*	16/24	67
	2*	0/24	0
Oceana	1	0/10	0
	2	0/15	0
Mason	1(pear)	0/15	0
	2	0/18	0
	3	0/30	0
Grand Traverse	1	0/32	0
	2	0/28	0

*Resistance detected previously in this orchard.

Previously, it was determined that resistance in MR strains from Michigan was due to plasmid-borne genes. Therefore, two mechanisms of streptomycin resistance have now been characterized in *E. amylovora*; the genetic mechanism determines the level of streptomycin resistance and expression of myomycin resistance; the presence and relative importance of the two mechanisms differ among geographic regions. The chromosomal type is widespread; the plasmid-borne type is in Michigan only.

Table 2. Analysis of chromosomal DNA from highly-resistant *Erwinia amylovora* from various geographic regions for a mutation in the *rpsL* gene for resistance to streptomycin.

Origin of strain	Strains (total no.)	Mutated strains (no.)
Michigan	12	12
California	5	5
Idaho	1	1
Oregon	29	23*
Washington	42	42
New Zealand	13	13

*All except six strains from Oregon with identical mutations; all strains with a mutation at position 43 of the *rpsL* gene.

Effects of Tank Mixing ATS and Fungicides on Peach
-- Results After Two Years --

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1994 Objective:

Determine if ammonium thiosulfate (ATS) can be tank mixed with bloom-applied fungicides without adversely affecting chemical activity of either ATS or fungicide, and without excessive phytotoxicity to blooms or shoots of peach trees.

Justification:

Growers apply fungicides to peach orchards during bloom in order to reduce blossom blight (*Monilinia fructicola* [Wint.] Honey) incidence when disease history and impending weather indicate that disease risk is high (Bost, et al., 1993; Ritchie et al., 1993; Travis, 1993). Spray application of ammonium thiosulfate (ATS) at bloom is also important for bloom nitrogen fertilization and fruit thinning (Byers and Lyons, 1984, 1985; Havis, 1962).

Efficiency of application and timing would be increased if growers could safely apply ATS as a tank mix with fungicides without risk of adverse effects. However, interactive effects are not known.

Previous work:

Observations made in 1993 in commercial peach orchards suggested that dieback of young shoots occurred in some cases where ATS and fungicides had been tank mixed by the grower. No injury occurred under similar conditions when ATS and the same fungicides were applied in separate sprays. We therefore felt it important to conduct controlled studies to test effects of ATS and fungicides applied separately and in tank mixed combinations.

In 1993, we conducted a factorial field study with two levels of ATS (0 and 2%) combined with ten fungicide treatments (water, benomyl, chlorothalonil, captan, triforine, propiconazole, vinclozolin, iprodione, sulfur, and thiophanate-methyl) applied to a "Redhaven' orchard. The 20 treatment combinations were replicated over four blocks of 20 trees each in a randomized block design (whole-tree plots).

1993 results indicated that there were no ATS x fungicide interactions on final fruit load/tree and no interactive effects on fungicide control of blossom blight. Fruit load (number of fruit per tree) was affected only by ATS and blossom blight cankers/tree were affected only by fungicide main effects. Blossom blight did occur in the orchard, but at a low frequency. However, phytotoxicity to blooms and 1-year-old shoots differed among ATS x fungicide combinations. No fungicide was phytotoxic when applied alone but blossom burn due to ATS was reduced when combined with some fungicides, and shoot burn appeared to be increased when combined with other fungicides.

Results from 1993 indicated that further tests should be conducted, especially to evaluate risk of ATS x fungicide combinations on phytotoxicity symptoms, and under conditions of airblast application methods used in commercial peach production. The 1994 project was designed to address these concerns.

1994 Orchard Experiment:

The 1994 study site was in a commercial peach orchard located in Spartanburg County, South Carolina. Trees were Redhaven on Lovell rootstock, planted 16 by 22 feet, trained to standard open centers, approximately 10 years old.

Individual plot size for each replication of each treatment (experimental unit) was 5 rows wide by 9 trees long (45 trees per plot), so that normal row overlap effects of airblast application were included in this study. Data was collected from the middle row of each plot. Treatments were replicated over five blocks in a randomized complete block design, with blocks oriented perpendicular to the direction of slope (Rep 1 = bottom of hill; Rep 5 = top of hill). Outer guard rows were in common between plots. Thus, there were approximately 900 trees in the study over an area of 8.2 acres.

Five treatments were applied at 80% full bloom with a 500 gallon capacity air blast sprayer. Treatments were applied on March 23, 1994. Conditions were warm and sunny, good drying conditions. Mid-day temperature was approximately 70°F, with slight wind, gusts to 15 mph.

The five treatments tested in 1994 were selected to compare untreated controls with ATS alone and ATS tank mixed with fungicides representing different modes of fungicide action. All treatments were applied in 150 gal/acre, based on recommended application volume for ATS. Fungicides were evaluated only in combination with ATS because the purpose of this study was to evaluate ATS x fungicide interactions effects. Efficacy of the fungicides themselves is well documented from other fungicide evaluation trials. Treatment used in this study are described in Table 1.

All plots were evaluated for shoot phytotoxicity, blossom blight cankers, fruit number per shoot (30 tagged shoots per plot), fruit number per shoot length (30 shoots per plot), and total fruit per tree. Data evaluations were made prior to fruit drop on April 20 (4 weeks after treatment), and after fruit drop on May 31 (10 weeks after treatment).

1994 Results and Conclusions:

A late spring frost occurred after treatment application and created a marked gradient in crop load from top to bottom of the hill. At the top of the hill Rep 3 had 10% of a crop, Rep 4 30% of a crop, and Rep 5 a full crop. Reps 1 and 2 (bottom of hill) had zero to slight crop.

Treatments applied in 1994 caused no problems of shoot phytotoxicity and there were no significant interactive effects of fungicide on ATS activity. Results from this year do not indicate any problem with tank mixing ATS with fungicides.

Treatment effects on blossom blight could not be evaluated. No blossom blight lesions were detected in any treatment. Conditions were not favorable for development of this disease in this orchard in 1994.

There was some indication that the nitrogen content of ATS may have a beneficial effect on flower frost hardiness. In the frosted reps (Rep 1, 2, 3) lower on the hill there was an apparent increase in fruit set associated with ATS (Table 2). At the top of the hill (Rep 3, 4, 5) apparent fruit thinning was associated with ATS, as expected (Table 2). However, these trends were not statistically significant.

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Table 1. 1994 Treatments applied

Treatment	Chemical formulation	Treatment Application Rates: Amount of formulation per acre	Amount of formulation per 350 gal. tank
A: Control	(no treatment	-----	-----
B: ATS*	60% ai w/w	2% (= 3 gal/acre)	7.0 gal
C: ATS + Bravo 270	6 lb ai/gal (= 54% ai w/w)	5.5 pint	1.6 gal
D: ATS + Orbit	41.8% ai w/w	4 oz	9.3 oz (fluid)
E: ATS + Rovral 50W	50.0% ai w/w	2.74 lb**	6.4 lb**

*All ATS applications were 2% ATS formulation in 150 gal/acre.
**Rovral rate is high, field error. Intended Rovral rate was: 2 lb/acre. Rate applied higher than this by 1.37 X.

Table 2. Treatment effects on fruit load.

Treatment	Crop essentially lost area (Rep 1,2, 3): Final total fruit per tree	Frost damaged area (Rep 3, 4, 5): Final fruit/m shoot as relative difference from control (% difference)	Frost damaged area (Rep 3, 4, 5): Final fruit/m shoot relative to initial fruit/m %
Control	10	0%	10.0%
ATS	23	-28%	7.1%
ATS + Bravo	32	-51%	3.4%
ATS + Orbit	16	-60%	4.8%
ATS + Rovral	17	-33%	9.0%
Overall ATS	22	-43%	6.0%

LACK OF ADEQUATE CONTROL OF PEACH SCAB WITH IPRODIONE

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Research reports of Rhone Poulenc suggested that their fungicide iprodione (Rovral) controlled peach scab (*Cladosporium carpohilum* Thum. (Keitt 1917)). They placed a recommendation for scab control on the label. Field experience in planned demonstrations of the senior author and the observations of several researchers did not support this action. Many southeastern states did not include the use of iprodione in their spray guide recommendations for scab and some made specific recommendations against its use in various news releases and at winter grower meetings.

Iprodione belongs to a family of fungicides known as the dicarboximides. Application of oil in close proximity in time or with captan, another member of the dicarboximide group, results in toxic uptake of captan. It was hypothesized that application of oil with iprodione may increase the efficacy for scab control

The objective of this research was to determine the efficacy of iprodione for control of peach scab and determine the effect of various rates of superior type oil on that control

Methods and materials: Six treatments were replicated four times as single tree applications in a completely randomized block design. Statistical procedures included Analysis of Variance and mean separation at the 95% confidence level. The treatments were the untreated control; Captan at 2 lb ai per acre, as a 50 % WP, first and second cover with Propiconazole (Orbit) at 50 grams ai per acre applied in bloom and preharvest; and iprodione (Rovral 4 F) at 1 lb ai per acre in combination by volume with either 0.125% 80-20 surfactant(Farm World), 0.125%, 0.5% or 1.0% superior type 70 second oil (Omni Oil) applied on April 7 (bloom), April 25 (shuck off), May 6 (second cover) and June 24, 1994 (preharvest). All treatments were applied by handgun to the point of run off and at full foliage required 2 gallons per tree. For rate calculation purposes 200 gallons per acre was considered the water rate for all treatments for all applications.

The treatments were applied to 9 year old Redhaven trees either on Lovell rootstock or their own roots. The plot was located at the Clemson University Musser Fruit Farm on Oconee Point a peninsula on Lake Hartwell in Anderson County South Carolina. Generally there were buffer trees between all treatment trees.

Eighty fruit were examined at harvest using the Barret-Horsfall rating system enabling both an incidence rating and percent surface area impacted. They were stored for 7 days at room temperature and rated for brown rot (Monilinia fruticola, *Rhizopus* and *Gilbertella* as a complex and anthracnose). These data are not analyzed and are just provided as background information (Table 1).

The weather was normally wet through mid-April and then turned dry till the 7th of June, 1994. The weather was then wet through harvest on July 3. Disease pressure was considered light even though the orchard had not been sprayed for scab control the previous season. Such practice means an increase in initial inoculum load.

Results: Results are presented in Figures 1 through 4. Based on percent fruit infected iprodione significantly reduced scab incidence but was significantly greater than the captan grower standard (figure 1). When examined by the percent surface area infected iprodione significantly reduced scab incidence and although 8 fold greater than captan was not significantly different than the captan standard (Figure 2). Although increasing oil rates were not significantly different regression analysis indicates a trend towards increasing control with increasing oil rates (Figures 3 and 4). When the percent surface area is considered the 0.5% and 1.0 % were not significantly different from the captan grower standard (Figure 2). No oil injury was observed to either fruit or foliage. Oil reduced foaming in the spray tank.

Conclusions: Rovral does control peach scab when applied in cover sprays but not adequately within the 2 application practical label limit (one bloom, two cover and 2 preharvest) during the cover spray period. There is a trend towards increase control with increasing oil concentration up to 1%. No injury from oil was observed and oil decreased foaming in the tank. Unfortunately no oil or surfactant controls were included therefore it is possible that the observed control was due to the oil or surfactant and not the Rovral.

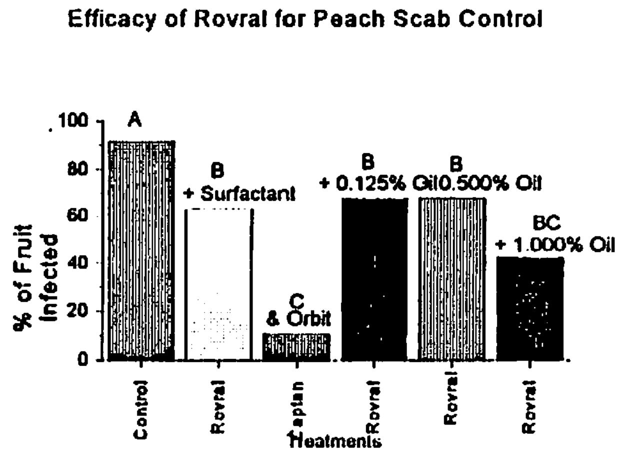

Figure 1. Percent incidence of peach scab when Rovral is applied with various rates of Superior type oil or surfactant compared to the grower standard of captan or no treatment at all.

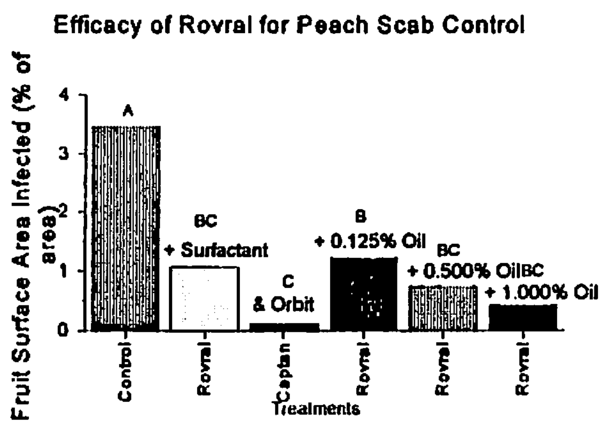

Figure 2. Percent surface area of the peach fruit infected with peach scab when Rovral is applied with various rates of Superior type oil or surfactant compared to the grower standard of captan or no treatment at all.

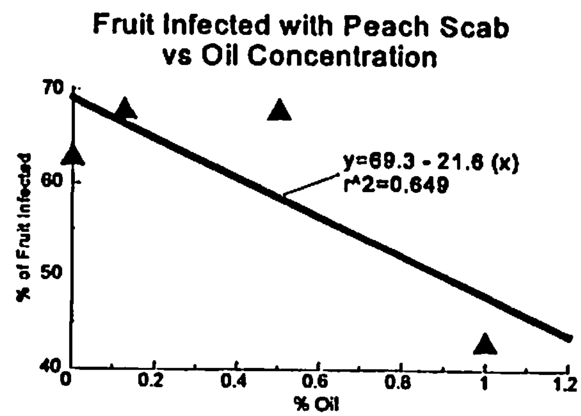

Figure 3. Regression of the percent incidence of peach scab against oil concentrations of 0.0, 0.125, 0.5, and 1.0 percent by volume when applied with Rovral.

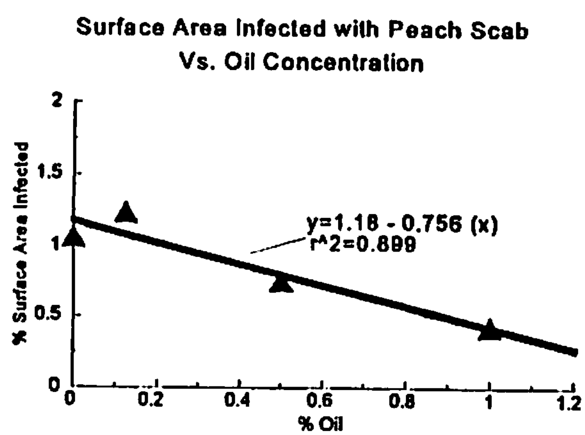

Figure 4. Regression of the percent surface area of peach fruit infected with peach scab against oil concentrations of 0.0, 0.125, 0.5, and 1.0 percent by volume when applied with Rovral.

Table 1. The incidence of brown rot, mucors (*Rhizopus* and *Gilbertella*) and anthracnose 7 days after harvest in Redhaven peaches when sprayed with Rovral and varying rates of oil, surfactant, or the grower standard Captan.

Treatment	Percent Disease incidence		
	brown rot	mucors	anthracnose
control	68.8	8.1	0.9
Rovral + surfactant	6.3	4.4	4.7
Captan & Orbit	9.4	12.5	1.9
Rovral + oil 0.125%	11.3	4.1	0.6
Rovral + oil 0.5%	20.6	10.0	2.5
Rovral + oil 1.0%	14.0	7.5	2.8

Title: Latent Infections in Apple Fruit Detected with the Herbicide Paraquat

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Abstract: This research was conducted to assess the effect of paraquat on the breakdown of apple fruit in the pre- and postharvest setting, to observe and identify the fungi recovered from paraquat-treated fruit, and to determine the potential use of paraquat for screening apples prior to or at harvest in order to develop a rapid quantitative measure of the pathogenic component of fruit storability. In 1992, approximately 13% of paraquat-treated apples developed acervuli of Colletotrichum acutatum, 36% of fruit showed conidia of Alternaria alternata, and 18% exhibited pycnidia of Botryosphaeria dothidea. Surface-sterilized control fruit exhibited fungal activity, with 14% of fruit showing acervuli of C. acutatum and 20% of fruit showing conidia of A. alternata. The incidence of A. alternata and B. dothidea, but not C. acutatum, was significantly greater in the paraquat-treated fruit when compared to the control fruit. In 1993, fungi observed on both cultivars were C. acutatum, B. dothidea, Phoma spp., Phyllosticta solitaria, Penicillium expansum, and A. alternata. Treatment of asymptomatic fruit sections with paraquat facilitated the detection of B. dothidea, Phoma spp., and P. solitaria on Golden Delicious fruit. There were no significant differences among treatments for any of the other fungi. Exposure of Nittany fruit to paraquat facilitated the detection of several fruit pathogens, including B. dothidea, P. expansum, Phoma spp, and P. solitaria. No significant differences were observed for C. acutatum or A. alternata on Nittany. For Golden Delicious fruit that had been inoculated with B. dothidea or C. acutatum, but which were still asymptomatic, those treated with paraquat yielded 80% and 20% infection, respectively, compared to 6.7% and 0%, respectively, for the controls. Following exposure to paraquat, naturally-infected symptomatic Golden Delicious fruit exhibited signs of B. dothidea, P. expansum, A. alternata, Phoma spp., and P. solitaria. The incidence of C. acutatum from paraquat-treated fruit was positively correlated with the incidence after storage (r = 0.98) and after storage plus incubation at 22 ± 2 C (r = 0.79). For B. dothidea, incidence from paraquat-treated fruit was not correlated with incidence after storage; however, there was a positive correlation after fruit removed from storage had incubated for 4 weeks (r = 0.95). The incidences of P. expansum and A. alternata after paraquat treatment were correlated with their incidences after storage (r = 0.81 and r = 0.85, respectively), but was not correlated after fruit had incubated for 4 weeks at 22 ± 2 C. For Phoma spp. and P. solitaria, the incidences of these fungi from paraquat-treated fruit was not correlated with their respective incidences after storage nor after storage plus 4 weeks incubation at 22 ± 2 C.

Introduction

In the combined Mid-Atlantic region of Pennsylvania, Virginia, West Virginia,

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and Maryland, apples are grown on approximately 28,000 ha and command a market worthabout $124.3 million annually. West Virginia has approximately 6,120 ha of apples currently in production with 'Delicious' being the leading cultivar, and 'York' and 'Golden Delicious' ranking second and third, respectively. With the increased consumer awareness of food safety issues and the probable loss or withdrawal of fungicide materials for postharvest use on fruits and vegetables in the United States, the influences of preharvest management programs on crops in the postharvest environment must be better understood. Storability of apples following harvest is a major concern of the industry in the Mid-Atlantic region.

Storage quality is defined broadly by measuring parameters that include fruit firmness and acid content (measured as titratability), and incidence and severity of superficial scald and decay. One aspect of rating fruit for decay that is not generally practiced is the identification of the fungal decay organisms established in the preharvest period. These data may be essential to the improved postharvest management of pathogens because the identity of the decay species reflects on the preharvest program and provides the information needed to make changes in the program in order to achieve optimum storage time.

Studies to determine the incidence of decay in postharvest fruit require storage periods of 3 to 6 months to allow decay fungi to develop. Shortening the period in which assessment of postharvest pathogens could be conducted to 7 to 21 days would be an important improvement in such studies. In addition, the development of such a technique could provide a means to screen lots of fruit destined for storage for the incidence of postharvest pathogens, thus providing the opportunity to make informed decisions on the proper storage time and conditions for a particular lot of fruit. Isolation of fruit pieces onto agar media could be used to screen fruit for fungal organisms; however, a major drawback to this approach is that not all fungi grow and sporulate on one agar medium, thus limiting the population of fungi that can be identified if only one medium is used, or, alternatively, increasing the labor and expense of using multiple media. Hastening the breakdown of fruit with the herbicide paraquat may hold promise for accelerating the appearance of decay fungi and their fruiting structures.

Paraquat was first used to detect latent colonization by Colletotrichum truncatum, Phomopsis phaseoli, and Cercospora kicuchii in field-grown soybean stem and pod tissues (3). Later, it was used in a field study of the effect of environmental conditions on infection and latent colonization of soybean plants by Phomopsis longicolla (11) and in studies of the epidemiology and latent colonization in soybean and weed tissues by Colletotrichum spp. (6,7,8), and by Phomopsis leptostromiformis in lupin in western Australia (4). The herbicide also enhanced the recovery of Cercospora canescens from bean tissue in Brazil (5) and Monilinia fructicola in symptomless plum fruits following severe blossom blight (9).

Paraquat was first used on apple in our laboratory to determine the occurrence of latent infections on Nittany apple fruit by Alternaria alternata, a serious pre- and postharvest disease causing significant losses in this cultivar (1). During the course of these studies, latent infections due to other fungi were detected. Of particular interest was the occurrence of bitter rot, caused by Colletotrichum spp. and white rot, caused by Botryosphaeria dothidea. The objectives of this to determine its potential use in screening apples prior to or at harvest in order to develop a rapid quantitative measure of the pathogenic component of fruit storability.

Materials and Methods

Studies with asymptomatic and symptomatic whole fruit, preharvest and postharvest. In 1992, Nittany apple fruit at various stages of maturity (see below) were selected and brought into the laboratory. The cultivar Nittany is highly susceptible to bitter rot, caused by Colletotrichum gloeosporioides and C. acutatum, and Alternaria rot, caused by Alternaria alternata. Fruit selected for treatment had received biweekly fungicide sprays of captan + benzimidazole at standard rates. Fruit were observed for any pathological symptoms, which were marked with an indelible pen, washed in tap water, dipped in 70% ethanol for 2 min., in 0.5% NaOCl (10% Chlorox) for 7 min, and then rinsed in sterile distilled water for 1 min. Whole, surface-sterilized fruit were then dipped for 1 min. in 2900 μg/ml paraquat (1,1'-dimethyl-4,4'--bipyridinium dichloride in sterile distilled water and filter sterilized), and placed on autoclaved paper trays enclosed in plastic ziplock bags with moistened paper towels (autoclaved) to provide high humidity conditions. Fruit were incubated at room temperature (22 C) under diurnal light conditions and were observed after 1, 2, 3, and 6 weeks for rate of breakdown and appearance of fungi. After fungi appeared, they were transferred aseptically to 2% potato dextrose agar (PDA, Difco) poured into 9-cm-diameter plastic Petri dishes. Control fruit received no paraquat and were either surface sterilized with ethanol and 0.5% NaOCl or received no treatment. Control fruit were incubated and observed concomitant with the paraquat-treated fruit. Fruit were observed weekly until the fruit could no longer be manipulated (6 weeks usually). The experiment was conducted five times with groups of 20 replicate fruit per treatment collected at 6-wk preharvest, 4-wk preharvest, harvest maturity, 4-wk postharvest (from refrigerated storage), and 8-wk postharvest (from refrigerated storage).

Studies with asymptomatic fruit sections and assessment of the predictive capability of the paraquat test results. In 1993, symptomless Golden Delicious and Nittany apple fruit (160 of each) were selected and brought into the laboratory. Fruit selected for receiving the treatments described below had received no fungicide sprays after second cover (mid-June). Sixty fruit were washed in tap water, dipped in 70% ethanol for 2 min., then in 0.5% NaOCl (10% Chlorox) for 7 min, then rinsed in sterile distilled water for 1 min. Thirty fruit were cored and sliced with a sterile metal template, and single fruit section from each was dipped for 1 min. in 6000 μg/ml paraquat, and placed in sterile 1-pint Mason jars with filter paper lids (Whatman No. 4). Jars were then placed within ziplock storage bags that had a 7-mm-diam hole punched near the top to provide air exchange. Fruit were incubated in the dark at 22 $\pm$ 2 C for 5 days, then hydrated with 1 ml of sterile distilled water applied to the filter paper lid, moved into the light (constant fluorescent), and observed weekly for 3 weeks for rate of breakdown (90% fruit surface with necrotic, water-soaked appearance) and signs of fungi.

Control fruit sections from the same fruit as above were treated identically as above except for the paraquat dip. The second set of 30 fruit from each cultivar was incubated at 22 $\pm$ 2 C to observe the natural development of symptoms. The third set consisting of 100 fruit was placed in refrigerated storage (2 C ± 1 C) to provide data that was used to assess the predictive capability of the paraquat test results. Fruit were assessed visually for signs and symptoms of rots after refrigerated storage for 3 and 5 months. After 5 months, fruit were incubated at 22 C and assessed after 2 and 4 weeks. The experiment was repeated five times with Golden Delicious fruit and four times with Nittany fruit at varying stages of maturity. For Golden Delicious, fruit were used at Julian dates 215, 228, 243, 264, and 284 (7-, 5-, and 3-weeks before maturity, optimum harvest maturity, and 3-weeks post-optimum maturity, respectively). For Nittany, fruit were used at Julian dates 228, 264, 284, and 299 (8- and 3-weeks preharvest, optimum harvest maturity, and 2-weeks post-optimum maturity, respectively). Optimum harvest maturity was determined with the starch-iodine test.

Studies with naturally infected symptomatic fruit and asymptomatic, inoculated fruit. In 1993, attached fruit were inoculated with conidia (1 x 10^3, 1 x 10^4, or 1 x 10^5 conidia/ml) of either C. acutatum or B. dothidea. Cultures of both fungi were maintained on PDA. Sporulating cultures were flooded with sterile, distilled water and scraped with a rubber spatula. The suspension of conidia and mycelial fragments was passed through three layers of cheesecloth, resulting in the removal of the majority of mycelial fragments. Concentration of conidia was determined with a hemocytometer and then adjusted to the desired level. For inoculation, 2.5-cm-wide strips of autoclaved cheesecloth, three layers thick, were dipped in the conidial suspensions, these were then wrapped and attached around the intact fruit, and then the fruit were wrapped completely with aluminum foil for 7 to 12 days. Control fruit for the inoculations were prepared as above except the inoculum was excluded from the cheesecloth wrap. Approximately 15 days after inoculation, symptomless fruit were collected, treated with paraquat, and incubated as described above. Controls for the paraquat procedure included fruit that were surface-sterilized but not exposed to paraquat, and whole fruit allowed to incubate at room temperature. The experiment was conducted three times with Golden Delicious and once with Nittany. For Golden Delicious, samples of fruit exhibiting small (≤ 3 mm), red superficial lesions, often around lenticels, were collected at Julian date 284 and treated with paraquat or allowed to incubate at room temperature.

Data analysis. Data were analyzed for each cultivar separately with the general linear models procedure, using type I sums of squares for balanced data and type IV sums of squares for unbalanced data (SAS Institute, Cary, NC). For Golden Delicious, noninoculated, asymptomatic fruit were analyzed separately (with type I sums of squares) from the symptomatic fruit and the inoculated, asymptomatic fruit, which were analyzed together (with type IV sums of squares). For Nittany, all fruit were analyzed together using type IV sums of squares. Means were separated with the Waller-Duncan Bayesian k-ratio t-test. Contrast comparisons also were made for each cultivar among treatment pairs to determine the utility of the paraquat treatment to detect latent pathogens. Correlation analysis was conducted on the incidences of the various fungi from the paraquat-treated fruit sections with their respective incidences after 5 to 6 months of refrigerated storage, and again after an additional 4 weeks at 22 C.

Results

Studies with asymptomatic and symptomatic whole fruit, preharvest and

postharvest. In 1992, whole Nittany apples dipped in paraquat were observed weekly for signs of filamentous fungi and their fruiting structures. In addition, non-sporulating hyphae from fruit were transferred under aseptic conditions to PDA. Over the course of these experimental runs, approximately 13% of paraquat-treated apples developed acervuli of C. acutatum, 36% of fruit showed conidia of A. alternata, and 18% exhibited pycnidia of B. dothidea. Surface-sterilized control fruit exhibited fungal activity, with 14% of fruit showing acervuli of C. acutatum and 20% of fruit showing conidia of A. alternata. B. dothidea was not observed in the control samples. The incidence of A. alternata and B. dothidea, but not C. acutatum, was significantly greater in the paraquat-treated fruit when compared to the control fruit ($P \leq 0.05$). The rate with which whole fruit senesced after exposure to paraquat declined with prolonged refrigerated storage. Several other genera of fungi were detected on the fruit used in the 1992 runs, including Penicillium, Cladosporium, Pullularia, Pestalotia, Arthrobotryis, Phoma, and Fusarium.

Studies with asymptomatic fruit sections and assessment of the predictive capability of the paraquat test results. In 1993, fewer genera of fungi were observed in our samples than in 1992 due to the modifications in fruit handling described above, mainly the use of a sterile metal coring and slicing template that resulted in the elimination of stem and calyx tissues that may be more difficult to surface disinfest. Predominant fungi observed on both cultivars were C. acutatum, B. dothidea, Phoma spp., P. solitaria, P. expansum, and Alternaria spp. Botryosphaeria obtusa, the cause of black rot, was not observed during the course of these experiments.

For Golden Delicious fruit, the brown, water-soaked appearance of fruit sections after 3 weeks was consistently associated with the paraquat-treated fruit sections, which showed significantly greater necrosis and water-soaking (97.3%) than the paraquat control (9.3%) or the whole fruit after 8 weeks (7.0%) (Table 1). The effect of the date on which the fruit were collected for the experimental runs was significant for water-soaking ($P \leq 0.05$) but was not significant for detection of any of the fungal pathogens (data not shown). Fruit harvested later in the season (Julian date 284) showed a greater percentage of water-soaked fruit sections than fruit harvested earlier in the season (Julian dates 215 and 243).

Treatment of noninoculated, asymptomatic fruit sections with paraquat facilitated the detection of B. dothidea and P. solitaria on Golden Delicious fruit (Table 1). A mean of 27.3% of treated fruit sections exhibited pycnidia of B. dothidea, and this was significantly greater than for control fruit sections (0.7%) or whole fruit (0%) (Table 1). For P. solitaria, a mean of 23.8% of fruit sections exhibited pycnidia, and this was significantly greater than for control fruit sections or whole fruit, both of which never exhibited signs of the fungus (Table 1). There were no significant differences among treatments for any of the other fungi.

For Nittany fruit, the paraquat-treated fruit sections showed significantly greater necrosis and water-soaking (76.2%) than the paraquat control (6.7%) or the whole fruit (13.7%) (Table 2). The effect of the date on which the fruit were collected for the experimental runs was not significant for water-soaking, but was significant ($P \leq 0.05$) for detection of C. acutatum and

P. expansum. No C. acutatum was detected on the earliest Julian date (228), and the amounts detected on the other three dates were significantly higher but were similar to each other (data not shown). The greatest amount of P. expansum (31.1%) was detected on the latest Julian date (299), and this was significantly greater than similar levels of symptoms observed on the other three dates (data not shown).

Data from symptomatic and asymptomatic fruit were combined and analyzed to determine the utility of paraquat exposure for detecting latent infections (Table 3). Exposure of Nittany fruit sections to paraquat facilitated the detection of several fruit pathogens. There were significant differences for detection of B. dothidea, P. expansum, Phoma spp, and P. solitaria (Table 3). No significant differences were observed for C. acutatum or Alternaria spp., pathogens to which the cultivar Nittany is highly susceptible. For P. expansum, paraquat-treated fruit exhibited an overall mean of 17.6% fruit infection, compared to 0.4% for the controls. For Golden Delicious, exposure of fruit sections to paraquat facilitated the detection of B. dothidea, Phoma spp., and P. solitaria.

The incidences of the various fungi detected with the paraquat test were examined for the presence of correlation with the incidences observed after 5 to 6 months in refrigerated storage and again after an additional 4 weeks at 22 C. The incidence of C. acutatum from paraquat-treated fruit was positively correlated with the incidence after storage (r = 0.98, P ≤ 0.0001) and after storage plus incubation at 22 C (r = 0.79, P ≤ 0.06) (Table 4). For B. dothidea, incidence from paraquat-treated fruit was not correlated with incidence after storage, except after fruit removed from storage had incubated for 4 weeks (r = 0.95, P ≤ 0.003). Incidences of P. expansum and A. alternata after paraquat treatment were correlated with their incidences after storage (r = 0.81, P ≤ 0.05, and r = 0.85, P ≤ 0.03, respectively), but they were not correlated after fruit had incubated for 4 weeks at 22 C. Incidences of Phoma spp. and P. solitaria from paraquat-treated fruit was not correlated with their respective incidences after storage nor after storage plus 4 weeks incubation at 22 ± 2 C.

Studies with naturally infected, symptomatic fruit and asymptomatic, inoculated fruit. For Golden Delicious fruit inoculated with B. dothidea or C. acutatum and then collected at 3 weeks prior to optimum harvest maturity, those treated with paraquat yielded 80% and 20% infection, respectively, from symptomless fruit, compared to 6.7% and 0%, respectively, for the controls (Table 5). Of the fruit inoculated with C. acutatum and then collected at optimum harvest maturity, 93% yielded the fungus after paraquat treatment, compared to 40% for the control (Table 5). Fruit subjected to the inoculation procedure, but without fungal conidia included, yielded more Alternaria at this time than the other treatments (60%) (Table 5). For inoculated fruit collected at 3 weeks after optimum harvest maturity, 100% of the inoculations with Botryosphaeria or Colletotrichum yielded the appropriate fungus when treated with paraquat, compared to 70% and 50%, respectively, for the control sections (Table 5). For fruit subjected to the inoculation procedure but with no conidia, 50% of these showed latent colonization by the B. dothidea (Table 5).

For inoculated Nittany fruit collected at 2 weeks after optimum harvest maturity, no

Botryosphaeria isolates were recovered from fruit inoculated with B. dothidea (Table 3). For fruit inoculated with C. acutatum, the fungus was recovered from 80% of paraquat-treated fruit as well as from 80% of fruit that were surface disinfested but not treated with paraquat (Table 3). In addition, 60% of the fruit not exposed to conidia yielded C. acutatum, a similar incidence to that observed in asymptomatic, noninoculated fruit (53%) (Table 2).

Fruit deemed symptomatic exhibited faint to pronounced reddish lesions with dark centers, usually associated with a lenticel. Following exposure to paraquat, symptomatic Golden Delicious fruit sections exhibited signs of B. dothidea (70%), P. expansum (20%), A. alternata (40%), Phoma spp. (20%), and P. solitaria (20%). No significant differences were observed among treatments for incidence of the various fungi (Table 2).

Discussion

Treatment of apple fruit with paraquat hastened the breakdown of fruit and facilitated the detection of latent infections of B. dothidea, Phoma spp., and P. solitaria on Golden Delicious; and A. alternata, P. expansum, Phoma spp., and P. solitaria on Nittany. Fruit from the nonsprayed orchards used in the 1993 runs had moderate to high levels of latent infections by fungi known to cause rots. For some fungi, such as A. alternata, fruit past maturity also may be less useful for applying the paraquat procedure, given that paraquat-treated and control fruit yielded similar numbers of isolates.

Growth of fungi from the stem and calyx end of the apples in the study conducted in 1992 limited the conclusions that could be made regarding the presence of latent infections. The observations of C. acutatum after 1 week from the middle portions of fruits is good evidence of latent infection. Only two of the Alternaria isolates emerged from middle portions of fruits, and because these did not sporulate until week 3, rapid colonization of fruits by other fungi emerging from the stem and calyx ends limited our ability to identify organisms associated with middle portions. The simple modifications in handling the fruit that were implemented in the 1993 experiments solved this problem. Latent infections by several genera of fungi on both cultivars were observed regularly in 1993.

The fungi C. acutatum, B. dothidea, and Phoma spp. are regarded as postharvest pathogens that initiate incipient or quiescent infections during the growing season (10). Symptom expression in refrigerated storage is considered minimal due to the effects of low temperatures on fungal growth. The effects of low temperatures may account for the lack of correlation after storage for B. dothidea, and the subsequent significant correlation after 4 weeks at 22 C. It is noteworthy then that the incidence of C. acutatum prior to storage, as determined with the paraquat test, was correlated with its incidence immediately following storage. This result suggests some ability of this fungus to develop within the fruit during storage. For P. expansum and A. alternata, both of which are regarded as primarily postharvest decay fungi (10), their significant correlation of incidence after the paraquat test with incidence after storage demonstrates that they can become established as latent infections in fruit prior to placement into storage.

These results demonstrate the utility of the paraquat technique for apples for detecting latent infections of pre- and postharvest pathogens. In addition, the technique appears to have practical utility to aid in the early identification of rot organisms, the initial symptoms of which are often very similar.

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Table 1. Percentage of fruit exhibiting surface breakdown and fungi observed 3 weeks following treatment of Golden Delicious apple fruit with paraquat

Treatment	≥90% fruit surface water-soaked	Colletotrichum acutatum	Botryosphaeria dothidea	Penicillium expansum	Alternaria spp.	Phoma spp.	Phyllosticta solitaria
Paraquat-treated	97.3 a[y,z]	0.7 a	27.3 a	2.7 a	11.1 a	4.7 a	23.8 a
Control	9.3 b	0.0 a	0.7 b	4.0 a	5.3 a	1.3 a	0.0 b
Whole fruit (8 wk)	7.0 b	0.0 a	0.0 b	2.7 a	0.0 a	0.0 a	0.0 b

[y] Each value is the mean of 150 observations from 30 fruit collected on each of five sample dates (Julian dates 215, 228, 243, 264, and 284).

[z] Different letters in columns denote significant differences according to the Waller-Duncan k-ratio t-test ($P \leq 0.05$). Means separations conducted on transformed data (arcsine square root of the percentage).

Table 2. Percentage of fruit exhibiting surface breakdown and fungi observed 3 weeks following treatment of symptomatic and inoculated Golden Delicious apple fruit with paraquat

Treatment	≥90% fruit surface water-soaked	*Colletotrichum acutatum*	*Botryosphaeria dothidea*	*Penicillium expansum*	*Alternaria* spp.	*Phoma* spp.	*Phyllosticta solitaria*
Symptomatic fruit							
Paraquat-treated	100.0 a[x,y]	0.0 c	70.0 ab	20.0 a	40.0 a	20.0 a	20.0 a
Control	10.0 b	0.0 c	10.0 bc	0.0 a	20.0 a	0.0 a	0.0 a
Whole fruit (8 wk)	39.3 ab	0.0 c	14.3 bc	16.1 a	1.8 a	0.0 a	0.0 a
Asymptomatic, *Botryosphaeria*-inoculated fruit							
Paraquat-treated	100.0 a	0.0 c	90.0 a	0.0 a	0.0 a	13.3 a	20.0 a
Control	45.0 ab	0.0 c	38.3 abc	0.0 a	20.0 a	0.0 a	0.0 a
Whole fruit (8 wk)	14.3 b	0.0 c	0.0 c	14.3 a	0.0 a	0.0 a	0.0 a
Asymptomatic, *Colletotrichum*-inoculated fruit							
Paraquat-treated	100.0 a	71.1 a	30.0 abc	3.3 a	10.0 a	0.0 a	11.1 a
Control	26.7 b	30.0 b	11.7 bc	4.4 a	13.3 a	0.0 a	0.0 a
Whole fruit (8 wk)	--[z]	--	--	--	--	--	--
Asymptomatic, inoculation control fruit							
Paraquat-treated	100.0 a	0.0 c	35.0 abc	8.3 a	30.0 a	25.0 a	6.7 a
Control	46.7 ab	0.0 c	17.7 bc	16.7 a	20.0 a	0.0 a	0.0 a
Whole fruit (8 wk)	35.3 ab	0.0 c	2.9 bc	14.7 a	0.0 a	0.0 a	0.0 a

[x] Each value is the mean of 45 observations from 15 fruit collected on each of three sample dates (Julian dates 243, 264, and 284). Symptomatic fruit exhibited faint to pronounced red halo symptoms (faint = dark center with faint red halo about 3-mm diam; pronounced = red halo very red and dark center appeared dark brown and/or purplish, whole symptom > 3-mm diam and ranged up to 10-mm diam).

[y] Different letters in columns denote significant differences according to the Waller-Duncan k-ratio t-test ($P \leq 0.05$). Means separations conducted on transformed data (arcsine square root of the percentage).

[z] Data not available.

Table 3. Contrast comparisons for percentage of fruit exhibiting surface breakdown and fungi observed 3 weeks following treatment of Golden Delicious and Nittany apple fruit with paraquat, surface disinfestation with no paraquat (control), or incubation of whole fruit at 22 C for 8 weeks

Treatment	≥90% fruit surface water-soaked	Colletotrichum acutatum	Botryosphaeria dothidea	Penicillium expansum	Alternaria spp.	Phoma spp.	Phyllosticta solitaria
Golden Delicious							
Paraquat-treated	100.0 a[y,z]	19.7 a	49.7 a	9.7 a	14.5 a	10.9 a	14.8 a
Control	29.1 b	8.2 a	13.3 b	6.1 a	13.3 ab	0.6 b	0.0 b
Whole fruit (8 wk)	19.8 b	0.0 a	2.9 b	5.2 a	0.3 b	0.0 b	0.0 b
Nittany							
Paraquat-treated	83.6 a	35.2 a	9.5 a	18.8 a	36.0 a	5.5 a	20.0 a
Control	11.9 b	19.5 a	0.9 b	0.9 b	30.5 a	0.0 b	2.9 b
Whole fruit (8 wk)	11.0 b	39.7 a	0.5 b	18.6 a	11.7 a	0.0 b	5.7 b

[y] Each value is the mean of 285 (Golden Delicious) or 150 (Nittany) observations from fruit collected on each of five (Julian dates 215, 228, 243, 264, and 284, for Golden Delicious), or four (228, 264, 284, and 299, for Nittany) sample dates.

[z] Different letters in columns denote significant differences according to matrix analyses of univariate hypotheses ($P \leq 0.05$). Means separations conducted on transformed data (arcsine square root of the percentage).

Table 4. Incidence of various apple rot pathogens following treatment with paraquat, after 5 months of refrigerated storage, after 5 months refrigerated storage plus 4 wk at 22 C, and the correlation of incidence after paraquat treatment with incidence after storage

Pathogen	Incidence after paraquat treatment	Incidence after storage and correlation		Incidence after storage plus 4 wk at 22 C and correlation	
Botryosphaeria dothidea	25.6[z]	0.5	r = ns	34.2	r = 0.95
Colletotrichum acutatum	13.3	1.8	r = 0.98	16.0	r = 0.79
Penicillium expansum	14.4	0.5	r = 0.81	20.7	r = ns
Alternaria alternata	30.6	3.0	r = 0.85	2.3	r = ns
Phoma spp.	7.8	3.7	r = ns	3.0	r = ns
Phyllosticta solitaria	25.6	1.7	r = ns	6.2	r = ns

[z] All data from Golden Delicious and Nittany combined. Data from paraquat test are from Julian dates 243, 263, and 284 (Golden Delicious), and Julian dates 263, 284, and 299 (Nittany) (180 combined observations). Storage data represent 600 combined observations.

Table 5. Percentage of fruit exhibiting surface breakdown and fungi observed 3 weeks following paraquat treatment of asymptomatic Nittany apple fruit that had been inoculated with B. dothidea or C. acutatum

Treatment	≥90% fruit surface water-soaked	Colletotrichum acutatum	Botryosphaeria dothidea	Penicillium expansum	Alternaria spp.	Phoma spp.	Phyllosticta solitaria
Asymptomatic fruit							
Paraquat-treated	76.2 abc[y,z]	19.2 cd	4.2 bc	20.4 abcd	52.9 abc	7.1 a	25.0 a
Control	6.7 d	9.2 cd	0.8 c	1.7 cd	20.8 abcd	0.0 a	2.5 a
Whole fruit (8 wk)	13.7 d	31.7 bc	1.7 bc	12.9 bcd	3.8 cd	0.0 a	1.7 a
Asymptomatic, Botryosphaeria-inoculated fruit							
Paraquat-treated	100.0 a	30.0 bc	30.0 a	30.0 ab	10.0 bcd	0.0 a	0.0 a
Control	20.0 cd	0.0 d	0.0 c	0.0 d	80.0 a	0.0 a	0.0 a
Whole fruit (8 wk)	0.0 d	25.0 bc	0.0 c	25.0 abc	0.0 d	0.0 a	0.0 a
Asymptomatic, Colletotrichum inoculated fruit							
Paraquat-treated	90.0 ab	80.0 a	20.0 ab	10.0 bcd	10.0 bcd	10.0 a	20.0 a
Control	20.0 cd	80.0 a	0.0 c	0.0 d	30.0 abcd	0.0 a	0.0 a
Whole fruit (8 wk)	28.6 bcd	92.9 a	0.0 c	53.6 a	0.0 d	0.0 a	0.0 a
Asymptomatic, inoculation control fruit							
Paraquat-treated	90.0 ab	60.0 ab	0.0 c	10.0 bcd	20.0 abcd	0.0 a	20.0 a
Control	10.0 d	20.0 bc	0.0 c	0.0 d	20.0 abcd	0.0 a	10.0 a
Whole fruit (8 wk)	0.0 d	32.2 bc	0.0 c	0.0 d	66.7 ab	0.0 a	33.0 a

[y] Each value for asymptomatic fruit is the mean of 120 observations from 30 fruit collected on each of four sample dates (Julian dates 228, 264, 284, and 299). Each value for inoculated (and inoculation control) paraquat-treated and control fruit is the mean of 10 observations. Each value for whole fruit (8 wk) is the mean of 28 observations. All inoculated fruit collected and treated on Julian date 299.

[z] Different letters in columns denote significant differences according to the Waller-Duncan k-ratio t-test ($P \leq 0.05$). Means separations conducted on transformed data (arcsine square root of the percentage).

Time, Temperature, and Sporulation of Monilinia fructicola in Overwintering Peach Cankers

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Introduction

Fruit growers, and particularly peach growers, are under increasing pressure to reduce the amounts of pesticides applied to their crops. Integrated pest management strategies to reduce pesticide applications have reduced fungicide use during bloom. Sometimes bloom sprays have been eliminated altogether, but other growers have been reluctant to reduce bloom sprays at all.

Materials and Methods

In 1991 and 1992, overwintering cankers were studied with the objective of identifying the relationships of time and temperature to sporulation of Monilinia fructicola. Twigs having cankers were placed in 1.3 X 12 mm test tubes containing a moistened ball of cotton to provide moisture and elevate the humidity in the tubes. Each tube was sealed with a screw cap. Forty tubes were placed in each of four incubators set at 4 C, 11 C, 15 C, and 22 C. The tubes were removed at 12-hour intervals for 72 hours and observed under a dissecting scope for sporulation. In 1992, twigs were observed at 3-hour intervals for 12 hours to ascertain the minimum wetting period necessary for sporulation at favorable temperatures. Twigs sampled in 1992 had been sprayed with fungicides the previous season but those in 1991 had not.

Results and Discussion

The optimum temperature for sporulation on overwintering cankers was found to be between 15 C and 22 C. Twelve hours of wetting was sufficient for sporulation at optimum temperature. Sporulation was observed on blighted blossoms, peduncles, abscission scars and cankers resulting from contact with infected fruits (Fig. 1). Sporulation on blossoms included those on the trees from the previous season and those which occurred on any part of them, including portions of the infected twig. Sporulation on peduncles followed infection of abscised fruit or partially detached blighted blossoms. Cankers also resulted from detachment of a blighted blossom or infected fruit, leaving only an abscission scar and associated twig infection.

The results show that at least 12 hours of wetting are needed for conidia to be produced on twig cankers regardless of temperature (Table I).

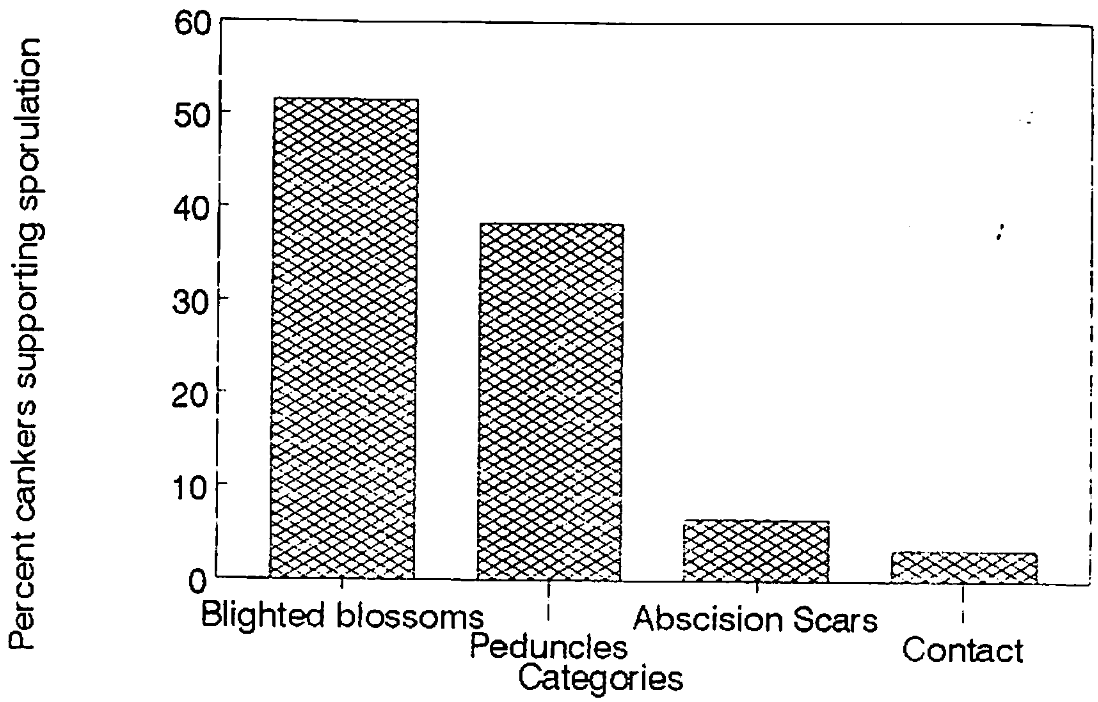
Table I. Peach twig cankers supporting sporulation of _M._ _fructicola_ by hours from 4 - 22 C.

Time (hours)	Number of twigs with sporulating cankers.
12	2.1 a
24	4.1 ab
36	5.6 bc
48	6.4 bc
60	7.0 c
72	7.3 c

NOTE: Twigs were counted in subsequent treatments following a sporulating canker. Treatments with the same letter are not significant when LSD alpha = .05.

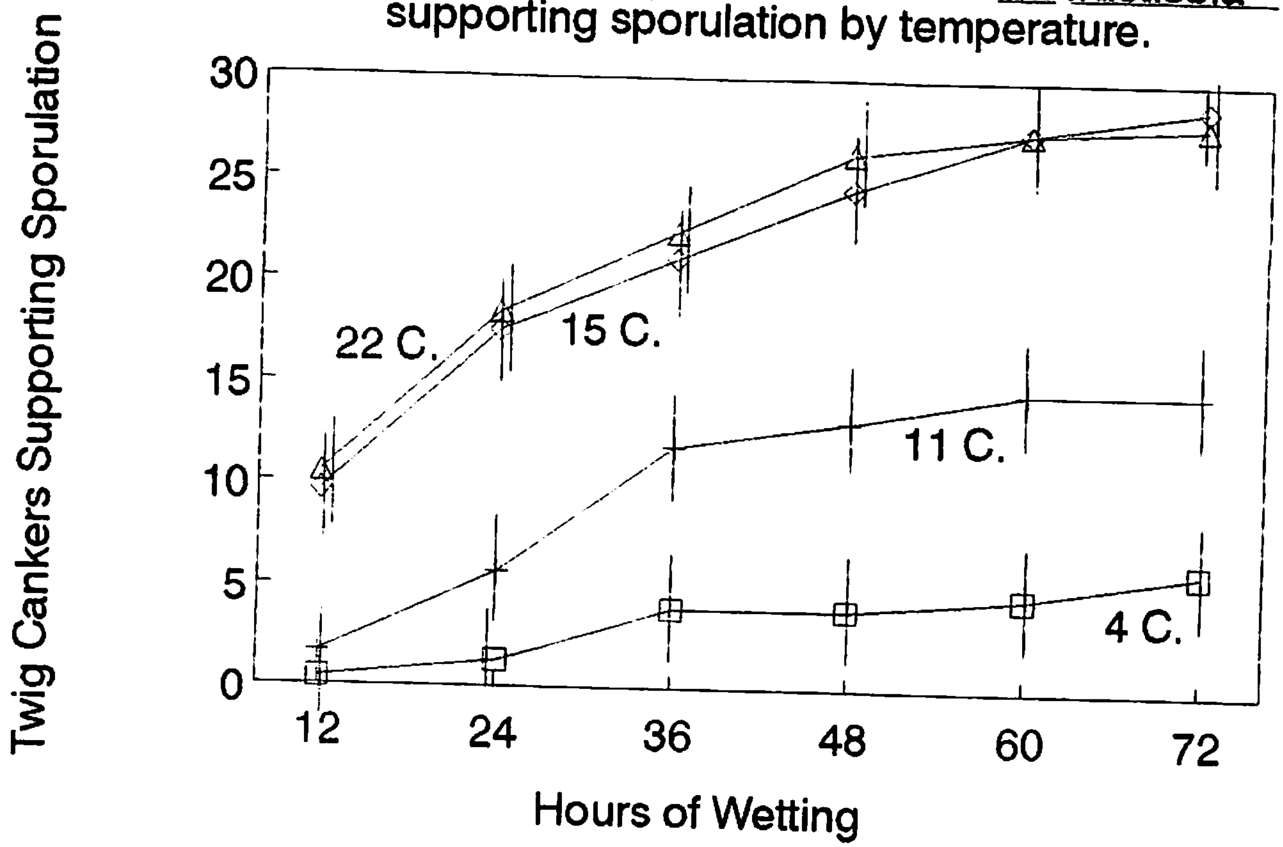
More than 12 hours may be needed if the mean temperature is 10 C or less (Fig. 2). Previous research shows that 5 to 18 hours of wetting are needed for germination and infection at 10 to 25 C depending on temperature. The combined data indicate that 17 to 30 hours of continuous wetting during bloom may be needed for blossom blight to become a problem. Since some fungicides available for blossom blight control are effective even after infection has already begun, there may significant opportunities to reduce the number of sprays applied during bloom, or even omit them entirely if weather conditions do not favor infection.

Fig 1. Percentages of cankers induced by M. fructicola originating from various entry points on peach twigs in 1991.



Percentages were calculated by dividing the total cankers sporulating into the total sporulating for each category.

Fig 2. Percent twigs with cankers of M. fructicola supporting sporulation by temperature.



All totals are cumulative, meaning once a twig was found with a sporulating canker it was removed from the experiment.

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Scab-Resistant Apple Cultivars: Susceptibility to Summer Diseases

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Introduction

Scab-resistant apple cultivars (SRCs), although immune to apple scab, are affected by other fungal diseases (1,3,5,6). In SRC orchards, fungicide treatments can be substantially reduced. As a result of reduced fungicide residue levels, the potential for fruit rot infection caused by summer diseases is higher than in routinely sprayed non-scab-resistant apple orchards. The summer fruit diseases, once considered "minor" diseases that were suppressed by fungicides for scab may become a major problem. The objective of this research project was to determine the susceptibility of SRCs to summer fruit rots. Our long term objective is to assess the natural occurrence of these minor diseases and evaluate those that could become problems in SRC orchards.

Materials and Methods

Laboratory Inoculations

In 1992 and 1993, fruit from 7 SRCs planted in 1989 on M26, were collected from the horticultural plots at the Russell E. Larson Research Center, PSU. Golden Delicious and Delicious controls were also included in this study. Apples of each cultivar were harvested when mature which was determined by 5 maturity parameters. At this time, an additional subsample of fruit was placed in cold storage (2C) for 30 days. Fruit of each cultivar were inoculated with each of the three pathogens at harvest and after being removed from a 30 day period in cold storage. The wounding device consisted of a 6-penny finishing nail that was embedded through the center of a cork which created a wound 1mm wide x 3mm deep. This wound would be similar in size to that of a stem puncture occurring under field conditions. Apples of each cultivar were inoculated with each of the three pathogens. Each apple was wounded on opposite sides (2 inoculations per fruit) and one of the pathogens was placed within each wound area. The wounding device was dipped for 30 seconds in a spore suspension of either *B. obtusa*, *B. dothidea*, or *G. cingulata* (10^5 conidia/ml) after which the apple was immediately inoculated. Inoculated apples were placed on a laboratory bench (21C) and measured for fruit rot development 1 week after inoculations. The area of rotted tissue (cm^2) per cultivar per pathogen was determined.

Field Inoculations

In 1992, a one acre plot consisting of four SRCs and a Golden Delicious control was established at the plant pathology farm at Rock Springs. Cultivars chosen were those having potential for the fresh and/or processing market. Orchard design was a randomized complete block with 10 replicate trees per cultivar. Row spacing was 20 ft and within-row spacing was 8 ft. All cultivars were planted on Mark rootstock. Maintenance sprays for weed and insect control were applied when needed. Fungicides were not applied in 1992-1994. Only on 1 and 10 July of 1992 was Nova and Captan applied for scab control on all Golden Delicious trees.

In 1994, fruit of Redfree, Jonafree, Freedom, Liberty, and Golden Delicious were inoculated with spores of *B. dothidea*. Because of the newly established planting and a limited number of fruit, it was decided to use only one fruit rot pathogen at this time. Fruit were inoculated when mature which was based on two previous harvest dates and a starch-iodine test was also used as an indicator of maturity. The inoculation consisted of four treatments. These included:

- ww - white rot-wounded: fruit were wounded then sprayed with a spore suspension of *B. dothidea*.

wnw - white rot non-wounded: fruit were sprayed with spore suspensions of *B. dothidea.*
cw - control wounded: fruit were wounded and then sprayed with sterile distilled water.
cnw- control non-wounded, fruit were sprayed with sterile distilled water.

The wounding device and spore concentration were the same as in the laboratory inoculations. Sixteen trees per cultivar were randomly selected. Four apples on each individual tree were randomly assigned treatments. Treatments were applied and all inoculated fruit were placed in plastic bags with a moistened paper towel to maintain high RH. Four days after inoculations, bags were removed, and apples were transferred to the laboratory to be rated for disease development. The rating system consisted of documenting the number of days for the first visible symptom of fruit rot to appear, the number of days for the rotted area to reach 8 mm, and when the area of fruit rot was 15 mm.

Field Observations - Sooty Blotch and Flyspeck

When inoculated apples were removed from the field and transferred to the laboratory, they were immediately rated for the presence of sooty blotch and flyspeck. Individual colonies of sooty blotch could not be determined on some cultivars and therefore a rating scheme was implemented. Individual colonies of flyspeck were counted per fruit.

Results

Laboratory Inoculations

Complete results from the 1992 laboratory inoculations have already been reported (4). Results from harvest inoculations are presented in Table 1. Significant differences among cultivars and the amount of fruit rot development caused by three summer diseases were observed when fruit was inoculated at harvest. Redfree, Nova Easygro and William's Pride were most susceptible to fruit rot infection caused by all pathogens in 1992 and 1993. These same cultivars when inoculated after 30 days in cold storage were still the most susceptible SRCs to the three summer fruit rots (data not shown). The amount of fruit rot caused by each pathogen varied with respect to the individual cultivar. In general, Jonafree was the least susceptible SRC to fruit rot caused by both black rot and white rot. The Delicious and Golden Delicious controls varied in their susceptibility to all pathogens. With respect to fruit rot incited by *G. cingulata*, the most susceptible cultivar was Nova Easygro in both years.

Field Inoculations

Treatment = ww

All apples of each cultivar that were wounded then inoculated with *B. dothidea* became infected. Isolations were made from all fruit and *B. dothidea* was consistently recovered. The total number of days for symptom development on SRCs and Golden controls that were wound-inoculated are presented in Table 2. Significant differences were observed among SRCs with respect to fruit rot development. The first visible symptom of white rot infection occurred within 4-5 days on Golden, Redfree, and Freedom, within 1 week on Liberty, and within 10.7 days on Jonafree. For the cultivars Redfree and Freedom it took an average of 6.6 days for the area of rotted tissue to reach 8 mm. Although not significant from these two cultivars, fruit of Golden Delicious took 7.9 days to reach this amount of rot development. Liberty and Jonafree differed significantly from these cultivars in that it took fruit of Liberty 8.9 days and that of Jonafree 13.5 days for fruit rot to reach 15 mm. Fruit rot development (15 mm) on Redfree and Freedom progressed at a faster rate than rot development on the other cultivars. Fruit of Jonafree took the longest for rot to develop.

Treatment = wnw

On certain cultivars, non-wounded apples spray inoculated with spores of *B. dothidea* became infected. Symptoms differed depending on the cultivar. On Redfree, symptoms appeared to be "lenticel infections" in that the entire apple was rotted but the area around each lenticel was darker in color than the rest of the fruit. All wnw-inoculated Redfree became infected within 3 weeks. Isolations from each fruit confirmed the causal organism to be *B. dothidea*. In many cases isolations were not necessary in that fruiting bodies of the fungus developed on the fruit surface and spores from these bodies were easily identified. Five weeks after inoculation, 69% of wnw-inoculated Freedom were infected. These infected fruit did not appear to have "lenticel infection," however, fruiting bodies of the fungus were visible on the fruit surface. To date, 8 weeks after inoculation, wnw-inoculated fruit of Golden, Liberty and Jonafree have not become infected.

Treatment = cw

The majority of wound-inoculated controls did not become infected. A few did develop fruit rots and isolations were made from these infected fruit. *Alternaria* spp. were primarily recovered, and in a few cases, bacteria.

Treatment = cnw

Most non-wound controls did not become infected. The few that developed infection, upon isolations showed the organisms involved to be *Alternaria*, *Fusarium*, and a yellow bacteria.

Field Observations - Sooty Blotch and Flyspeck

Golden Delicious was most susceptible to sooty blotch and flyspeck (Table 3). Fruit of Jonafree appeared to be the most susceptible SRC to sooty blotch with an average of 48.5% clean fruit, 38.2% fruit having less than 10 colonies/fruit, and 13.2% fruit having greater than 10 colonies/fruit. Liberty and Freedom were equally susceptible to sooty blotch. Sooty blotch and flyspeck infection was not apparent on Redfree. Significant differences were not observed for the cultivars Jonafree, Liberty, and Freedom with respect to the number of flyspeck colonies on fruit.

Discussion

Significant differences among SRCs and the amount of fruit rot development caused by three summer diseases were observed. When comparing the same cultivars that were inoculated under laboratory and field conditions, with respect to infection cause by *B. dothidea*, the susceptibility to this pathogen appeared to be constant. Redfree was the most susceptible SRC to white rot and Jonafree was least susceptible. This pattern was also observed when apples were inoculated in the field. Fruit of Redfree rotted significantly faster than fruit of Jonafree.

The early harvested apple cultivars Redfree, Nova Easygro, and Williams Pride are more susceptible to summer diseases. Non-wounded fruit of Redfree and Freedom became colonized by *B. dothidea* within 3 to 5 weeks. It is interesting to note that wounds were not necessary for infection to occur on these cultivars by this pathogen. More time may be necessary to determine if non-wounded Jonafree, Liberty, and Golden Delicious will become infected. These apples are still being observed.

When considering the susceptibility of SRCs to sooty blotch, flyspeck and other minor diseases, more time may be needed for inoculum to build up in our young orchard to be able to accurately assess these diseases on fruit. This first years observations showed that Jonafree was more susceptible to sooty blotch when compared to Liberty and Freedom and that all three cultivars had approximately the same amount of flyspeck. Sooty blotch and flyspeck were not observed on fruit of Redfree.

Conclusion

Our primary objective is to determine the commercial potential and optimum disease management program for SRCs. Interest in planting these cultivars is growing. Taste tests and evaluations of these cultivars were conducted by the Sustainable Agriculture Research and Education (SARE) program throughout the Northeast. These tests showed, " excellent consumer acceptance of several SRC " (2). Also, today there is increasing concern over environmental and health issues. However, the bottom line is profit. The grower's acceptance of the SRCs will depend on whether these cultivars are profitable.

We plan to continue researching the susceptibility of SRCs to summer diseases and to determine the best disease management strategies for SRC orchards. Next season we will begin testing reduced fungicide management strategies with the goal of controlling summer diseases in Pennsylvania with minimal fungicide spray and precise timing of applications.

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Table 1. Susceptibility of 7 scab-resistant apple cultivars to fruit rot infection incitied by 3 summer diseases at harvest[1], 1992-1993.

	Area of fruit rot (cm^2)[2]					
	B.obtusa		*B. dothidea*		*G. cingulata*	
Cultivar	**1992**	**1993**	**1992**	**1993**	**1992**	**1993**
Redfree	20.3 e[3]	11.6 e	32.0 e	8.4 d	4.0 d	3.4 e
Jonafree	1.4 a	3.9 c	1.1 a	2.1 b	0.1 a	1.0 b
Freedom	4.4 c	3.6 c	6.4 c	4.7 c	1.5 c	1.4 c
Nova Easygro	17.3 e	14.5 f	13.2 d	9.2 e	6.4 f	4.1 f
Williams Pride	10.7 d	11.8 f	9.9 d	8.3 e	5.1 e	4.5 f
Liberty	4.7 c	5.6 d	2.5 b	2.5 b	0.4 b	2.3 d
MacFree	4.2 c	8.4 e	2.2 b	2.3 b	0.2 a	0.7 b
Delicious	1.5 a	0.9 a	2.1 b	0.8 a	0.2 ab	0.4 a
Golden	3.1 b	1.7 b	2.0 b	0.9 a	1.5 c	1.0 b

[1] Apples were harvested when mature as determined by 5 maturity parameters.

[2] In 1992, numbers represent the mean of 20 inoculations and in 1993, numbers represent the mean of 36 inoculations/cultivars pathogen. Fruit were wound-inoculated and the area of rotted tissue was measured 1 wk after inoculations.

[3] Data was transformed by In (x + 1) prior to analysis. Actual values are presented. Means in the same column followed by the same letter do not differ significantly according to Duncans Multiple Range Test. ($P < 0.05$).

Table 2. Total number of days for symptom development on SRCs inoculated[1] with B. *dothidea.*

Cultivar	Number of Days: First visible rot	Number of Days: Fruit rot 8 mm	Number of Days: Fruit rot 15 mm
Golden	4.59 a[2]	7.88 ab	16.82 c
Redfree	4.94 a	6.71 a	8.91 a
Freedom	5.13 a	6.53 a	9.80 a
Liberty	7.18 b	8.89 b	13.94 b
Jonafree	10.69 c	13.53 c	18.47 c

Numbers represent the mean of 16 apples

[1] Apples were wounded then inoculated with 10^5 spores/ml of *B. dothidea* in the orchard.

[2] Means in the same column followed by the same letter do not differ significantly according to Duncans Multiple Range Test (p = 0.05).

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Table 3. Incidence and severity of sooty blotch and flyspeck on SRCs.

Cultivar	% fruit with sooty blotch: Clean	% fruit with sooty blotch: < 10 colonies	% fruit with sooty blotch: > 10 colonies	Flyspeck av.# colonies/fruit
Golden	7.4[1]	69.1	23.5	3.22 b[2]
Jonafree	48.5	38.2	13.2	1.46 a
Liberty	83.8	16.2	0.0	1.25 a
Freedom	87.5	10.9	1.6	1.06 a
Redfree	0.0	0.0	0.0	0.0

[1] Numbers represent the mean of 64-68 fruit.

[2] Means in the same column followed by the same letter do not differ significantly according to Duncans Multiple Range Test (p = 0.05).

APPLE: *Malus domestica* ('Rome Beauty')
Apple scab; *Venturia inaequalis*
Powdery mildew; *Podosphaera leucotricha*
Sooty blotch; *Gloeodes pomigena*
Fly speck; *Zygophiala jamaicensis*

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DISEASE INCIDENCE ON 'ROME BEAUTY' APPLE TREATED SEASONALLY WITH FUNGICIDES AT TRV RATES AND APPLIED CONCENTRATE IN 1994: Fungicide combinations applied concentrate with a conventional orchard airblast sprayer at tree-row-volume (TRV) rates were evaluated in a mature block of 'Rome Beauty'/seedlings. Trees were planted at 25 ft in rows 30 ft wide and pruned to a height of 12 ft. The calculated TRV for the orchard was 313,632 ft^3 or 55% of a standard orchard (TRV of 574,992 ft^3). Experimental plots consisted of double trees arranged in a randomized complete block design with four replicates. Sprayed plots were bordered by nontreated plots between and adjacent to the treated. Applications were made with a Metters Model 36 airblast sprayer operated at 2.5 mph with a manifold pressure of 200 psi under still air and low evaporation conditions to minimize spray drift and improve coverage. The fungicides were applied as complete sprays of 7-8 day intervals between 1/2"-green and 1st cover phenophases and at 12-16 day intervals during the cover sprays, except in treatments where the 5th cover spray was omitted. The six fungicide programs (combinations) were applied in 12 applications from 1/2" green through the 8th cover spray between 19 Apr and 23 Aug as follows: 19 Apr (1//2"-green), 26 Apr (open-cluster), 3 May (early bloom), 11 May (petal-fall), 1st through 8th cover sprays on 18, 31 May, 14, 30 Jun, 12, 26 Jul, 9 and 23 Aug Fungicide rates for each combination were calculated at 55% of the recommended rate for Pennsylvania apple orchard and applied at 50 gal/A, a standard gallonage for commercial orchards, or at 27.5 gal/A which provided the same amount of fungicide/A. Although the two gallonage rates/A contain the same amount of each fungicide, the concentration in the suspension for the 50 gal/A rate was 3.3 times the recommended amount/100 gal dilute but 6 times the dilute rate for the 27.5 gal/A gallonage. Apple scab inoculum in the test orchard was high and disease development favored by frequent rain periods. There were 12 primary and 3 secondary scab infection periods between 12 Apr and 29 Jun as determined by a Neogen apple scab predictor using the Modified Mills Predictor model. Powdery mildew inoculum was very low because of low winter temperatures and frequent rains were unfavorable for rapid spread. Scab and mildew incidence on terminal leaves was determined by observing all leaves on 10 vegetative terminals/tree on 8-22 Jul. Vegetative terminals observed were flagged and the youngest unfolded leaf marked on 19 May to distinguish the periods up to and after 1st cover. Frequent rains during the summer months favored the development of sooty blotch and fly speck. Disease incidence on fruit was determined by observing 100 fruits/replicate at harvest 12-14 Oct. All data obtained were analyzed by analysis of variance using appropriate transformations and the Tukey-Kramer HSD test for significance ($P \leq = 0.05$).

Frequent rain periods favored scab development and resulted in infection of 80.5% on nontreated terminal leaves. Scab incidence from green-tip through 1st cover periods was 89.7% and about 2/3 of the nonprotected leaves became infected between the 1st and 3rd cover periods. Most of the treatments provided fair to good control of scab considering the ideal conditions for infection, but the protectant fungicides (ziram - 1/2"-G; mancozeb - OC, B, PF; captan - 1C thru 8C) used alone were significantly less effective for scab infections on leaves. Several treatments applied at 27.5 gal/A allowed higher scab levels on leaves than those treated with 50 gal/A, but only three were significantly different. The Nova plus Ziram, Nova plus Polyram, and the Dithane M-45 (mancozeb) alone were significantly less effective when mixed at 6X concentrate and applied at 27.5 gal/A. Differences in scab incidence on fruit among treatments were not significant. Fair to good sooty blotch and fly speck control was provided by all treatments. Fly speck levels were slightly higher than sooty blotch in this test. The results in general showed that 6X concentrate fungicide mixtures were no more effective than 3X mixtures when applied with a conventional-type airblast sprayer. It is probable that spray coverage was somewhat poorer with the lower (27.5 gpa) gallonage which may have contributed to lower levels of control on leaves. Powdery mildew incidence on nontreated trees was low and control was 97-99% on leaves treated with the DMI plus protectant fungicides.

Disease Incidence in 1994 on 'Rome Beauty' Apple Sprayed with Seasonal Fungicide Programs Applied at Tree Row Volume Rates of 55 Percent at 27.5 GPA. Penn State Fruit Research and Extension Center, Biglerville, PA

Fungicide Programs	Amount/A Labeled rate	Amount/A TRV at 55%	Application Timing	Percent Disease Incidence: Apple Scab, Terminal Leaves GT-1C	Apple Scab, Terminal Leaves GT-3C	Apple Scab, Fruit at Harvest	P. mildew Term. Lvs GT-3C	Fruit Sooty blotch	Fruit Fly speck
Program 1 - 27.5 GPA*									
1. Spray Oil 6E	6.0 gal	3.3 gal	1/2"-G						
Nova 40W	5.0 oz	2.8 oz	OC,B,PF,1C,2C						
Polyram 80W	3.0 lb	26.0 oz	1/2"-G,OC,B,PF,1C,2C						
Captan 50W	6.0 lb	53.0 oz	3C,4C,6C,7C,8C	12.1bcd**	10.1cd	5.0a	2.5a	0.8a	13.8a
2. Spray Oil 6E	6.0 gal	3.3 gal	1/2"-G						
Nova 40W	5.0 oz	2.8 oz	OC,B,PF,1C,2C						
Dithane 75DF	3.0 lb	26.0 oz	1/2"-G,OC,B,PF,1C,2C						
Captan 50W	6.0 lb	53.0 oz	3C,4C,5C,6C,7C,8C	9.4abc	7.3abc	5.0a	0.6a	1.0a	5.5a
3. Spray Oil 6E	6.0 gal	3.3 gal	1/2"-G						
Nova 40W	5.0 oz	2.8 oz	OC,B,PF,1C,2C						
Penncozeb 75DF	3.0 lb	26.0 oz	1/2"-G,OC,B,PF,1C,2C						
Ziram 76W	6.0 lb	53.0 oz	3C,4C,6C,7C,8C	8.2abc	7.7abc	5.8a	1.5a	3.0a	7.5a
4. Spray Oil 6E	6.0 gal	3.3 gal	1/2"-G						
Nova 40W	5.0 oz	2.8 oz	OC,B,PF,1C,2C						
Ziram 76W	3.0 lb	26.0 oz	1/2"-G,OC,B,PF,1C,2C,						
Ziram 76W	6.0 lb	53.0 oz	3C,4C,5C,6C,7C,8C	15.5d	14.3de	5.3a	1.4a	1.0a	3.5a
5. Spray Oil 6E	6.0 gal	3.3 gal	1/2"-G,						
Rubigan 1E	9.0 fl oz	5.0 fl oz	OC,B,PF,1C,2C						
Dithane 75DF	3.0 lb	26.0 oz	1/2"-G,B,PF,1C,2C						
Ziram 76W	6.0 lb	53.0 oz	3C,4C,6C,7C,8C	8.7abc	8.7bc	2.8a	2.1a	1.0a	7.3a
6. Spray Oil 6E	6.0 gal	3.3 gal	1/2"-G						
Ziram 76W	8.0 lb	70.4 oz	1/2"-G						
Dithane 75DF	6.0 lb	53.0 oz	OC,B,PF						
Captan 50W	6.0 lb	53.0 oz	1C,2C,3C,4C,5C,6C,7C,8C..	23.2e	17.7e	7.8a	6.5b	1.8a	10.8a
7. Nontreated			....	89.7f	80.5f	86.0b	9.8c	56.3b	65.3b

* Rates were adjusted to 55% of recommended amounts based on tree row volume of 313,632 ft^3 by mixing labeled rates in 50 gallons and applying them at 27.5 GPA in complete airblast sprays at 7-8 day intervals through petal-fall and 13-16 day intervals during cover sprays.

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

Disease Incidence in 1994 on 'Rome Beauty' Apple Sprayed with Seasonal Fungicide Programs Applied at Tree Row Volume Rates of 55 Percent at 50 GPA. Penn State Fruit Research and Extension Center, Biglerville, PA

Fungicide Programs	Amount/A		Application Timing	Percent Disease Incidence					
				Apple Scab			P. mildew	Fruit	
				Terminal Leaves		Fruit at Harvest	Term. Lvs	Sooty blotch	Fly speck
	Labeled rate	TRV at 55%		GT-1C	GT-3C		GT-3C		
Program 2 - 50 GPA*									
1. Spray Oil 6E	6.0 gal	3.3 gal	1/2"-G						
Nova 40W	5.0 oz	2.8 oz	OC,B,PF,1C,2C						
Polyram 80W	3.0 lb	26.0 oz	1/2"-G,OC,B,PF,1C,2C						
Captan 50W	6.0 lb	53.0 oz	3C,4C,6C,7C,8C	6.8ab**	5.6ab	6.0a	1.0a	0.3a	9.8a
2. Spray Oil 6E	6.0 gal	3.3 gal	1/2"-G						
Nova 40W	5.0 oz	2.8 oz	OC,B,PF,1C,2C						
Dithane 75DF	3.0 lb	26.0 oz	1/2"-G,OC,B,PF,1C,2C						
Captan 50W	6.0 lb	53.0 oz	3C,4C,5C,6C,7C,8C	5.9a	4.8a	2.3a	0.8a	0.8a	6.8a
3. Spray Oil 6E	6.0 gal	3.3 gal	1/2"-G						
Nova 40W	5.0 oz	2.8 oz	OC,B,PF,1C,2C						
Penncozeb 75DF	3.0 lb	26.0 oz	1/2"-G,OC,B,PF,1C,2C						
Ziram 76W	6.0 lb	53.0 oz	3C,4C,6C,7C,8C	9.7a-d	9.5a-d	6.3a	2.2a	2.0a	7.5a
4. Spray Oil 6E	6.0 gal	3.3 gal	1/2"-G						
Nova 40W	5.0 oz	2.8 oz	OC,B,PF,1C,2C						
Ziram 76W	3.0 lb	26.0 oz	1/2"-G,OC,B,PF,1C,2C,						
Ziram 76W	6.0 lb	53.0 oz	3C,4C,5C,6C,7C,8C	6.8a	7.6abc	3.0a	1.1a	2.5a	7.5a
5. Spray Oil 6E	6.0 gal	3.3 gal	1/2"-G,						
Rubigan 1E	9.0 fl oz	5.0 fl oz	OC,B,PF,1C,2C						
Dithane 75DF	3.0 lb	26.0 oz	1/2"-G,B,PF,1C,2C						
Ziram 76W	6.0 lb	53.0 oz	3C,4C,6C,7C,8C	6.4a	6.2abc	2.5a	2.1a	1.0a	8.5a
6. Spray Oil 6E	6.0 gal	3.3 gal	1/2"-G						
Ziram 76W	8.0 lb	70.4 oz	1/2"-G						
Dithane 75DF	6.0 lb	53.0 oz	OC,B,PF						
Captan 50W	6.0 lb	53.0 oz	1C,2C,3C,4C,5C,6C,7C,8C..	13.3cd	10.8cd	3.8a	9.3c	3.3a	13.7a
7. Nontreated			....	89.7e	80.5e	86.0b	9.8c	56.3b	65.3b

* Rates were adjusted to 55% of recommended amounts based on tree row volume of 313,632 ft^3 and applied at 50 GPA in complete airblast sprays at 7-8 day intervals through petal-fall and 13-16 day intervals during cover sprays.

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

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APPLE: *Malus domestica* ('Golden Delicious', 'Red Delicious', 'Commander York')
Apple scab; *Venturia inaequalis*
Sooty blotch; *Gloeodes pomigena*
Fly speck; *Zygophiala jamaicensis*

DISEASE INCIDENCE ON APPLE TREATED WITH FUNGICIDES AT TRV 40% RATES APPLIED CONCENTRATE AS ALTERNATE-MIDDLE SPRAYS IN 1994: A seasonal fungicide spray program with rates adjusted to match tree size and applied at two different gallonages was evaluated for disease control in a high density experimental orchard. The test orchard was 17 years old and consisted of 10 half-acre plots of five tree-planting/training systems (2 replicated blocks for each system). Each plot was planted to 'Commander York', 'Red Chief Delicious' and 'Golden Delicious' which were moderately pruned and the orchard floor well managed. The randomized half-acre plots of each planting system served as five replicates for each of two fungicide programs. Two of the blocks located in different parts of the orchard and approximating the different systems were nontreated with fungicides and served as check plots. Fungicide rates were adjusted to match tree size and were applied as concentrate sprays from alternate-row middles with a conventional orchard sprayer (Metters Model 36) adjusted at a manifold pressure of 200 psi. Sixteen alternate-side applications (one side only) were made between 15 Apr (1/4"-green) and 29 Aug (7th cover, 2nd half) at 5-7 day intervals (mean 6.2) from 1/4"-green through petal-fall and at 6-17 day intervals (mean 10.5) during the cover sprays. The sprayer was calibrated to deliver 20 and 50 gallons/A (both sides) when operated at a ground speed of 2.5 miles per hour. Adjustments in manifold pressure or nozzle size was made when necessary to change delivery rate to match variable tree row spacing among the half-acre plots in order to apply the proper amount to each plot. Tree row volume of the five systems varied somewhat, but all were approximately 227,952 ft^3 requiring 40% of recommended amounts for a full-size mature orchard. Apple scab inoculum intensity was moderately high in the test block and frequent rain periods were favorable for summer disease development. Twelve primary and three secondary apple scab infection periods occurred between 12 Apr and 21 Jun. Scab incidence on cluster leaves of 'Delicious' was determined on 6-8 Jun by observing all leaves on 10 nonfruiting spurs (clusters) on each of 10 single-trees/plot. Terminal leaf infection was recorded on 25-28 Jun for 'York' and 28-30 Jun for 'Delicious' by observing all leaves on 10 vegetative terminals on each of 10 trees/plot. Scab, sooty blotch, and flyspeck incidence was determined on fruit at harvest (30 Sep, 'Del'; 10 Oct, 'G. Del'; 13 Oct, 'York') by observing 500 fruits/plot (50 fruit/tree on 10 trees). Scab severity per fruit was determined by counting all lesions on 50 of the most severely infected fruits/replicate. The data were analyzed for significance between treatments by utilizing the T-test comparison (P = 0.05).

Scab control provided by the fungicide treatments was only fair under the moderate disease pressure in this test. Nontreated plots of 'Delicious' showed 57.5% cluster leaf infection and 46.3% terminal leaf infection. Scab incidence was significantly higher on 'Delicious' trees sprayed with Program 1 where the fungicides were mixed at label rates for 50 gallons of mixture/A, but applied at 20 gallons/A equivalent to the TRV 40%. Differences between the two programs were not significantly different on the 'York' trees. Sooty blotch and fly speck incidence was 84.0 and 80.3 percent on nontreated plots, respectively. Differences between the fungicide treatments were nonsignificant and the level of control acceptable for commercially grown fruit.

Apple Scab Incidence on Apple Treated with Fungicides at TRV 40% Rates Applied at 20 and 50 Gallons Per Acre as Alternate-Middle Sprays in 1994. Penn State Fruit Research and Extension Center, USDA Block, Arendtsville, PA

	Application		Percent Scab					% Disease 'G. Delicious'	
			Cluster Leaves	Terminal Leaves		Fruit			
Fungicides and Rates/A*	Timing[2]	Gal/A	'Delicious'	'Del'	'York'	'Del'	'York'	S. blotch	Flyspeck
Program 1									
Nova 40W 2.4 oz + Dithane 75DF 19.2 oz[1]	TC[3],P[3],B[3],PF,1C,3C								
Captan 50W 25.6 oz	4C								
Captan 50W 25.6 oz + Topsin-M 85WDG 4.8 oz	6C,7C	20	15.7b[4]	15.4b	8.2a	20.3b	10.3b	7.1a	6.9a
Program 2									
Nova 40W 2.4 oz + Dithane 75DF 19.2 oz[1]	TC[3],P[3],B[3],PF,1C,3C								
Captan 50W 25.6 oz	4C								
Captan 50W 25.6 oz + Topsin-M 85WDG 4.8 oz	6C,7C	50	7.4a	10.1a	6.6a	11.3a	6.1a	3.6a	4.1a
Nontreated		....	57.5c	46.3c	45.4b	85.9c	66.8c	84.0b	80.3b

* Program 1 - Fungicide labeled rates/A (Nova 40W 6.0 oz, Captan 50W 4.0 lb, Dithane 75DF 3.0 lb, and Topsin-M 85WDG 12.0 oz) were mixed in 50 gallons and applied at 20 gallons of mixture per acre (equivalent amount of TRV 40%). Program 2 - Fungicide labeled rates/A (Same as Program 1) reduced to TRV 40% rates and applied in 50 gpa).

1 Applied with Spray Oil 6E 2.4 gal/A at 1/4"-green and 1/2"-green (half applications).
2 Applications made as two alternate-middle sprays (one side only) at phenological stages shown at 6-11 day intervals.
3 Applied in only one alternate-middle spray (on side only).
4 Means followed by the same letter(s) are not significantly different, Tukey-Kramer HSD ($P = \leq 0.05$).

APPLE: *Malus domestica* ('Rome Beauty', 'Golden Delicious', 'Delicious', 'Stayman', 'Cortland')
Apple scab; *Venturia inaequalis*
Sooty blotch; *Gloeodes pomigena*
Fly speck; *Zygophiala jamaicensis*

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APPLE DISEASE CONTROL WITH REDUCED TRV FUNGICIDE RATES APPLIED AS CONCENTRATE SPRAYS, 1994: A commercially acceptable fungicide program for apple disease control was evaluated when applied seasonally at reduced rates and variable gallonage in a nine-year old semi-dwarf orchard. The orchard was five acres in size and was divided into four 5-row sections which were sprayed with the various treatments. Each section contained 20 plots, each consisting of one tree of each of five cultivars planted 10 ft apart along the rows and separated by a 50 ft space between plots. The objective was to determine the effect of fungicide concentration of the tank mixture when used at tree-row-volume (TRV) rates or at other reduced amounts. The fungicide rates were based on labeled rates recommended in Pennsylvania orchards. The TRV rate was calculated for the tree size in the test block which was determined to be 186,686 ft^3 or 32% of the size of a standard orchard (TRV of 574,992 ft^3). A mixture of Nova 40W plus Dithane 80DF was applied in seven spray applications from 1/2"-green through 2nd cover sprays for scab and mildew control. Captan 50W applied in the 3rd through 8th cover (except the 5th C) or a combination with Topsin-M 85WP in the 6th, 7th, and 8th covers were used for summer disease control. A TRV rate of 32% of the standard recommended rate for Pennsylvania orchards and a 50% rate was suspended and applied in 50 gallons of water/A. The equivalent TRV 32% rate was also applied in a separate treatment by suspending standard label rates in 50 gallons of water but applying them at 17 gallons/A. Another treatment consisted of a 50% of standard rate applied in 25 gallons/A. The spray mixture concentrations for the various treatments compared to the standard dilute rate/100 gallons (i.e. Nova 40W 2.0 oz) were: 1.9X conc. for the TRV at 32% applied in 50 gallons/A, 6X for the TRV at 32% in 17 gallons/A, 3X for the 50% of standard in 50 gallons/A, and 6X for the 50% of standard in 25 gallons/A. All fungicide treatments were applied as complete sprays with a Metters Model 36 airblast sprayer operated at 2.5 mph and a manifold pressure of 200 psi. Application dates and phenological stages were: 14 Apr (1/4"-green), 21 Apr (open-cluster), 28 Apr (bloom), 7 May (late-bloom), 13 May (petal-fall), 1st through the 8th cover sprays on 20 May, 2,15 Jun, 1, 29 Jul, 12 and 25 Aug (5th C omitted). Environmental monitoring and apple scab infection periods were recorded with a Neogen Envirocaster which utilized the Mills Modified apple scab model for determining scab infection periods. Favorable conditions for apple scab infections occurred with 12 primary and 3 secondary apple scab infection periods between 12 Apr and 29 Jun. Inoculum for scab in the experimental orchard was moderate to low and mildew was very low because of low winter temperatures. Frequent rain periods were favorable for development of sooty blotch and fly speck. Disease incidence was determined on both leaves and fruit on the five cultivars. Scab incidence during the pre-bloom period was determined on cluster leaves of 'Stayman' by observing all leaves on 20 nonfruiting spurs (clusters)/tree (5 reps/treatment) on 6-7 Jun. Scab incidence on terminal leaves was recorded by observing all leaves on 10 vegetative terminals/single tree on each of the cultivars between 21 Jun and 9 Jul. On 'Rome Beauty' terminals were flagged and the youngest unfolded leaf marked on 18 May to distinguish the periods up to and after 1st cover. Both scab and powdery mildew were recorded on this cultivar on 7-8 Jul. Observations for scab on fruit of each cultivar were made between 8-19 Aug by observing 100 attached fruit per single-tree replicate. Sooty blotch and fly speck incidence on 'Golden Delicious' were recorded similarly at harvest on 23 Sep. Data obtained on both leaves and fruit were analyzed by analysis of variance using appropriate transformations and significance between means was determined by t-test comparisons ($P = 0.05$).

Scab infections in this orchard were lower than other nearby test orchards possibly because of lower inoculum levels. A relatively cool dry period between open-cluster and early bloom when no infection periods occurred prevented rapid development necessary for high disease levels. Scab incidence on terminal leaves of nontreated 'Rome Beauty' was 36% which occurred from green-tip through the 3rd cover period (Table 1). Leaf infection was higher during the period up to 1st cover with 48% incidence. Infection on nontreated leaves of 'Cortland', 'Golden Delicious', 'Delicious', and 'Stayman' ranged from 14.7 to 29.1%. Treatment means were not significantly different on cluster or terminal leaves on any of the cultivars and the highest incidence level was 5.2% on 'Rome Beauty'. Fruit infection level on nontreated attached fruit observed in Aug ranged between 5.2 and 14.2% among the cultivars and differences among treatments were also nonsignificant (Table 2). Incident levels among the treatments were too low to distinguish any pattern of difference. Powdery mildew incidence on nontreated 'Rome Beauty' was 3.2%. Treatment means ranged between 0.0 and 0.6% and were nonsignificant. The TRV 32% rate of Captan 50W or combination with Topsin-M applied at 6X concentrate in 17 gpa was significantly less effective for control of sooty blotch than when applied at 1.9 X conc. in 50 gpa. The incidence for both sooty blotch and fly speck on plots sprayed with the 17 gpa treatment was not significant different than the nontreated. Results in this orchard with similar fungicides used at TRV 32% rates and aplied in 50 gpa in 1992 and 1993 under high disease levels indicated that these low rates were either ineffective or very poor in providing scab control. Fungicide rates adjusted to 50% and applied at 50 gallons/A were significantly better and commercially acceptable.

Table 1. Incidence of Scab on Leaves of Five Apple Cultivars Treated with Seasonal Fungicide Programs Applied at Reduced Rates in Variable Gallonage Per Acre in 1994. Penn State Fruit Research and Extension Center, Dwarf Multi-Cultivar Block, Biglerville, PA.

				Percent Apple Scab on Leaves						
					Terminal Leaves					
									'Rome Beauty'	
Fungicide Program*	Rate/Acre	Application Timing	Applied GPA*	Cluster Lvs 'Stayman'	'G. Del'	'Cortland'	'Delicious'	'Stayman'	GT-1C	GT-3C
1. Spray Oil	1.92 gal	1/4"-Green								
Dithane 80DF	15.4 oz	1/4"-G,OC,B,LB,PF,1C,2C								
Nova 40W	1.9 oz	OC,B,LB,PF,1C,2C								
Captan 50W	20.5 oz	3C,4C,6C,7C,8C								
Topsin-M 85WDG	3.8 oz	6C,7C,8C	50	1.3a**	0.9a	2.2a	2.3a	1.2a	3.7a	3.8a
2. Spray Oil	1.92 gal	1/4"-Green								
Dithane 80DF	15.4 oz	1/4"-G,OC,B,LB,PF,1C,2C								
Nova 40W	1.9 oz	OC,B,LB,PF,1C,2C								
Captan 50W	20.5 oz	3C,4C,6C,7C,8C								
Topsin-M 85WDG	3.8 oz	6C,7C,8C	17	1.3a	1.8a	0.8a	1.7a	2.3a	1.8a	1.4a
3. Spray Oil	3.0 gal	1/4"-Green								
Dithane 80DF	24.0 oz	1/4"-G,OC,B,LB,PF,1C,2C								
Nova 40W	3.0 oz	OC,B,LB,PF,1C,2C								
Captan 50W	32.0 oz	3C,4C,6C,7C,8C								
Topsin-M 85WDG	6.0 oz	6C,7C,8C	50	2.6a	2.9a	1.6a	2.2a	4.7a	3.9a	2.5a
4. Spray Oil	3.0 gal	1/4"-Green								
Dithane 80DF	24.0 oz	1/4"-G,OC,B,LB,PF,1C,2C								
Nova 40W	3.0 oz	OC,B,LB,PF,1C,2C								
Captan 50W	32.0 oz	3C,4C,6C,7C,8C								
Topsin-M 85WDG	6.0 oz	6C,7C,8C	25	1.9a	2.7a	0.8a	2.5a	4.0a	5.2a	4.8a
5. Nontreated		--	....	9.6b	14.7a	14.7b	19.0b	29.1b	48.3b	35.7b

* TRV 32% (Treatment 1) or labeled rates at 50% (Treatment 3) were mixed and applied at 50 gallons per acre. Labeled rates were mixed in 50 gallons and applied at 17 gallons per acre (equivalent amounts of TRV 32% (Treatment 2) or 50% of labeled amounts mixed at 6X concentrate and applied in 25 gpa (Treatment 4).

** Means followed by the same letter(s) are not significantly different according to Tukey-Kramer HSD ($P<0.05$).

Table 2. Incidence of Scab, Sooty blotch, and Fly speck on Fruit of Five Apple Cultivars Treated with Seasonal Fungicide Programs Applied at Reduced Rates in Variable Gallonage Per Acre in 1994. Penn State Fruit Research and Extension Center, Dwarf Multi-Cultivar Block, Biglerville, PA.

	Fungicide Program*	Rate/Acre	Application Timing	Applied GPA*	Percent Apple Scab on Fruit				Percent Disease 'G. Delicious'	
					'Cortland'	'Delicious'	'Stayman'	'Rome Beauty'	S. blotch	Flyspeck
1.	Spray Oil	1.92 gal	1/4"-Green							
	Dithane 80DF	15.4 oz	1/4"-G,OC,B,LB,PF,1C,2C							
	Nova 40W	1.9 oz	OC,B,LB,PF,1C,2C							
	Captan 50W	20.5 oz	3C,4C,6C,7C,8C							
	Topsin-M 85WDG	3.8 oz	6C,7C,8C	50	1.8ab	2.2a	3.0a	0.4a	7.0a	15.4a
2.	Spray Oil	1.92 gal	1/4"-Green							
	Dithane 80DF	15.4 oz	1/4"-G,OC,B,LB,PF,1C,2C							
	Nova 40W	1.9 oz	OC,B,LB,PF,1C,2C							
	Captan 50W	20.5 oz	3C,4C,6C,7C,8C							
	Topsin-M 85WDG	3.8 oz	6C,7C,8C	17	0.8a	1.0a	1.0a	0.8a	44.2bc	50.2ab
3.	Spray Oil	3.0 gal	1/4"-Green							
	Dithane 80DF	24.0 oz	1/4"-G,OC,B,LB,PF,1C,2C							
	Nova 40W	3.0 oz	OC,B,LB,PF,1C,2C							
	Captan 50W	32.0 oz	3C,4C,6C,7C,8C							
	Topsin-M 85WDG	6.0 oz	6C,7C,8C	50	1.2a	3.2a	0.8a	0.4a	16.2ab	22.0a
4.	Spray Oil	3.0 gal	1/4"-Green							
	Dithane 80DF	24.0 oz	1/4"-G,OC,B,LB,PF,1C,2C							
	Nova 40W	3.0 oz	OC,B,LB,PF,1C,2C							
	Captan 50W	32.0 oz	3C,4C,6C,7C,8C							
	Topsin-M 85WDG	6.0 oz	6C,7C,8C	25	0.8a	1.4a	1.0a	0.0a	21.8ab	30.4a
5.	Nontreated		-		6.0b	14.2b	5.2a	12.2b	65.8c	75.2b

* TRV 32% (Treatment 1) or labeled rates at 50% (Treatment 3) were mixed and applied at 50 gallons per acre. Labeled rates were mixed in 50 gallons and applied at 17 gallons per acre (equivalent amounts of TRV 32% (Treatment 2) or 50% of labeled amounts mixed at 6X concentrate and applied in 25 gpa (Treatment 4).

** Means followed by the same letter(s) are not significantly different according to Tukey-Kramer HSD (P<0.05).

APPLE: *Malus domestica* ('Golden Delicious', 'Red Delicious', 'Rome Beauty')
Apple scab; *Venturia inaequalis*
Powdery mildew; *Podosphaera leucotricha*
Sooty blotch; *Gloeodes pomigena*
Fly speck; *Zygophiala jamaicensis*

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EFFICACY OF EXPERIMENTAL FUNGICIDES APPLIED SEASONALLY AS DILUTE SPRAYS FOR APPLE DISEASE CONTROL, 1994: Efficacy of several experimental fungicides was determined in a mature semi-dwarf orchard planted 30 X 35 ft and pruned to 12 ft high. Treatments were arranged in a randomized complete block design with four replicates. Plots consisted of three trees, one of each cultivar planted in a group at each tree site. Apple scab inoculum was high and environmental conditions were highly favorable for scab development. Twelve primary and three secondary apple scab infection periods were recorded between 12 Apr and 29 Jun by a Neogen apple scab predictor (Mills Modified Model). Inoculum for powdery mildew was low because of low winter temperatures. Frequent rains during the summer months were highly favorable for sooty blotch and fly speck development. Treatments were applied seasonally as dilute sprays timed at 7-8 day intervals from 1/4"-green through petal-fall and 14 day intervals through the 8th cover spray. Applications were made with a high pressure orchard sprayer operated at 400 psi and equipped with a 9-nozzle boom which delivered 2.8 gal/tree (280 gal/A). Application dates and phenological stages were: 12 Apr (1/4" green), 19 Apr (tight-cluster), 26 Apr (pink), 3 May (bloom), 11 May (petal-fall), 1st through the 8th cover sprays on 18, 31 May, 14, 28 Jun, 12, 26 Jul, 9 and 23 Aug, respectively. Scab development on cluster leaves of 'Starking Delicious' was determined on 1-2 Jun by observing all leaves on 25 nonblossoming clusters/tree. Terminal leaf infections of scab and powdery mildew were determined by observing all leaves on 15 vegetative terminals/tree on 27-29 Jun ('Delicious'), 12-15 Jul ('Rome Beauty'), and 1-5 Aug ('Golden Delicious'). The incidence of scab on 'Rome Beauty' during the periods before and after 1st cover was determined by flagging terminals and marking the youngest unfolded leaf on each on 23 May. Disease incidence on fruit was recorded at harvest (24-26 Sep, 'Del.'; 26 Sep, 'G. Del.'; 7 Oct, 'Rome') on 100 fruits/replicate. Scab severity was measured by counting total lesions on up to 10 of the most severely infected fruit/replicate. Fruit russeting on 'Golden Delicious' was determined by the Horsfall-Barratt rating scale using 20 fruits/replicate. All data obtained were analyzed by the analysis of variance using appropriate transformations and significance between means was determined by the Tukey-Kramer HSD test ($P \leq = 0.05$).

Frequent scab infection periods throughout the season favored scab development. Cluster leaf infection, which is a measure of infections occurring before petal-fall, was relatively low with only 18.6% of leaves infected on the nontreated 'Delicious' trees. Treatment means ranged between 0.0 and 1.4% incidence and were nonsignificant. Scab incidence on nontreated terminal leaves of 'Rome Beauty', 'Delicious', and 'Golden Delicious' was 62, 41, and 21 percent, respectively. Nontreated fruit of these cultivars were 64, 42, and 18 percent infected and showed 26, 12, and 5 lesions per fruit on the 10 most-severely infected fruit. All treatments provided good to excellent control of scab except Kaligreen 80SP which is known to be a mildewcide. Differences among the other treatment means on 'Delicious' and 'Golden Delicious' were not significant. TD-2323-2 75W allowed 7.5% scab incidence on 'Rome Beauty' terminal leaves which was a significantly lower level of control than other treatments. Fluazinam 500F 12.8 fl oz used alone through 2nd cover was as effective as its' combination with Nova 40W 1.7 oz. Experimental compounds CGA 219417 75W and RH-0611 62.2W 18.7 oz provided very good control of scab. RH-0611 was significantly better than CGA 219417 or Fluazinam for powdery mildew control. Frequent rain periods during Jun, Jul, and Aug were highly favorable for development of sooty blotch and fly speck with nontreated fruit showing 5-8 lesions per fruit. Spray intervals were 14 days between the cover sprays and 33 days between the last application and harvest. All treatments provided excellent sooty blotch control except Kaligreen 80SP. Fluazinam 500F 9.6 fl oz and TD 2323-275W 2.0 lb provided significantly better control of fly speck than other treatments. The combination of Benlate/Captan was significantly better than Topsin-M/Captan used during the 6C, 7C, and 8C sprays. Fruit russetting on 'G. Del.' ranged between 2.3 and 4.2 percent of fruit surface affected. Fluazinam treated fruit showed 4.2 percent of surface russetted and were significantly different from other treatments.

Scab, P. mildew, and Summer Disease Incidence on Apple Treated with Experimental and Registered Fungicides Applied as Protective Dilute Sprays in 1994. Penn State Fruit Research and Extension Center. Old 3-C Block.

			Percent Disease Incidence							
			Apple Scab					Summer Diseases		P. mildew
			'Starking Delicious'		'Rome Beauty'			'G. Delicious'		'Rome'
	Fungicide and Rate/100 gal	Applic. Timing*	Terminal Lvs Inf	Fruit	Terminal Lvs GT-1C	Terminal Lvs GT-3C	Fruit	Sooty blotch	Fly speck	Terminal lvs
1.	Fluazinam 500 F 12.8 fl oz	1/4"-G thru 2C								
	Fluazinam 500 F 9.6 fl oz	3C thru 7C								
	Captan 50W 1.0 lb	3C,4C,5C								
	Benlate 50W 3.0 oz	6C,7C,8C	1.1a**	0.3a	3.9b	3.3b	0.0a	0.0a	2.0abc	4.2d
2.	Fluazinam 500F 9.6 fl oz	1/4"-G thru 8C								
	Nova 40W 1.7 oz	1/4"-G thru PF...........	0.7a	0.0a	2.3ab	1.4ab	0.3a	0.0a	0.0a	1.5abc
3.	CGA 219417 75W 1.8 oz	1/4"-G thru PF								
	Captan 50W 2.0 lb	1C,2C,3C								
	Captan 50W 1.0 lb	4C,5C,6C,7C,8C								
	Topsin M 85WDG 3.0 oz	6C,7C,8C	0.5a	0.0a	3.2ab	2.5ab	0.0a	1.3a	9.0cde	4.7d
4.	CGA 219417 75W 1.8 oz +									
	Orbit 45W 0.3 oz	1/4"-G thru PF								
	Captan 50W 2.0 lb	1C,2C,3C								
	Captan 50W 1.0 lb	4C,5C,6C,7C,8C								
	Topsin M 85 WDG 3.0 oz	6C,7C,8C	0.3a	1.3ab	2.0ab	2.0ab	0.5a	6.5a	20.3e	3.3cd
5.	TD-2323-2 75W 2.0 lb	1/4"-G thru 8C..............	4.7b	0.3a	10.3c	7.5c	0.0a	0.0a	1.0ab	2.4bcd
6.	Rubigan 1E 9.0 fl oz +									
	Penncozeb 75DF 1.0 lb	1/4"-G thru 2C								
	TD 2323-2 75W 2.0 lb	3C thru 8C	0.1a	0.3a	1.2ab	1.2ab	0.0a	0.8a	4.0a-d	0.5a
7.	Rubigan 1E 9.0 fl oz +									
	Dithane 75DF 1.0 lb	1/4"-G thru 2C								
	Captan 50W 1.0 lb	3C thru8C								
	Topsin-M 85WDG 3.0 oz	6C,7C,8C	0.1a	0.0a	0.7a	0.7a	0.0a	5.5a	17.0de	1.3ab

Continued -

Scab and P. mildew Incidence on Apple Treated with Experimental and Registered Fungicides Applied as Protective Dilute Sprays in 1994. Penn State Fruit Research and Extension Center. Old 3-C Block.

			Percent Disease Incidence							
			Apple Scab					Summer Diseases		P. mildew
			'Starking Delicious'		'Rome Beauty'			'G. Delicious'		'Rome'
	Fungicide and Rate/100 gal	Applic. Timing*	Terminal Lvs Inf	Fruit	Terminal Lvs GT-1C	Terminal Lvs GT-3C	Fruit	Sooty blotch	Fly speck	Terminal lvs
8.	RH 0611 62.2W 18.7 oz Captan 50W 1.0 lb Topsin-M 85WDG 3.0 oz	1/4"-G thru 2C 3C thru 8C 6C, 7C,8C	0.1a	0.0a	2.8ab	2.2ab	0.0a	1.8a	6.8b-e	0.5a
9.	Captan 50W 2.0 lb Kaligreen 80SP 6.7 oz	1/4"-G thru TC P thru 8C	11.7c	3.0b	33.2d	27.6d	7.0b	86.0b	89.3f	1.4ab
10.	Nova 40W 1.67 oz Dithane 75DF 1.0 lb Captan 50W 1.0 lb Topsin-M 85WDG 3.0 oz	1/4"-G- thru 2C TC thru 2C 3C thru 8C 6C,7C,8C	0.2a	0.3a	0.8a	1.2ab	0.0a	4.8a	12.0de	0.3a
11.	Nontreated	-	40.8d	42.3c	79.8e	62.1e	64.3c	99.3c	99.5f	15.5e

* 1/4 inch-Green, Tight-cluster, Pink, Bloom, Petal-fall, First through Seventh Cover Sprays.

** Means followed by the same letter(s) are not significantly different according to the Tukey-Kramer HSD Test (P<0.05).

APPLE: (*Malus domestica* 'Rome Beauty')
Fire Blight; *Erwinia amylovora*

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COMPARATIVE EFFICACY OF THREE BACTERIAL ANTAGONISTIC TO *Erwinia amylovora* AND STANDARD BACTERICIDES FOR FIRE BLIGHT BLOSSOM BLIGHT ON APPLE, 1994: Three bacterial antagonists previously shown to provide partial protection against fire blight blossom blight were evaluated in a mature 'Rome Beauty' orchard located near Fairfield, PA. Standard bacteriacides were applied as comparative treatments. Trees were spaced at 8.5 m in rows 9.8 m apart, 4.6 m high and were heavily pruned during dormancy to remove previous infected branches. Fire blight occurred annually in the block previously for 10 or more years. Blossom treatments were arranged in a randomized complete block design with double-trees in each of four replicates. The bacterial antagonists were grown on nutrient yeast glucose agar (NYGA) in petri-dishes for 24 hours. Bacterial suspensions of 1 X 10^8 cfm/ml in phosphate buffer were atomized onto all five blossoms in each inoculated terminally born blossom clusters. Twenty-five clusters located on double-tree plots replicated four times for each treatment were inoculated and later observed for fire blight development. The approximately 2.0 ml of inoculum applied to each blossom cluster thoroughly covered all floral part with small droplets. All trees were sprayed with tap water applied with a dilute orchard sprayer to wet blossoms before inoculations. Two applications of the antagonist were made: 27 Apr, 1750-1800 hr, only king blossoms open, temp. 18.6° C, and R.H. 94% with showers producing wetness for three hours and overnight low of 14.4° C; 28 Apr, 1700-1750 hr, 97% blossoms open, temp. 18.1° C, 88% R. H. with overnight low of 13.4° C. Because of the rapid bloom opening challenged inoculations of *E. amylovora* were made on 29 Apr between 1030 and 1430 hr under wet overcast conditions, temp. 15.8° C with a foggy overnight low of 13.6° C. *E. amylovora* suspensions in phosphate buffer at 1 X 10^5 cfu/ml was applied to open floral parts with cotton swabs to avoid spread of the pathogen to other flowers. Inoculated blossom clusters were covered with a 9 cm diameter by 23 cm long mesh screen sleeve (made of HDFE screening, Chicopee Mft., Gainesville, GA) to prevent bees from visiting the inoculated blossoms. Environmental conditions were favorable for fire blight development in this orchard with 401 DD = > 55° F (13.1° C) since the green-tip phenological stage and with 804 DDH = > 65° F (18.3° C) since first open blossoms on 25 Apr. The bactericides evaluated were suspended in water and applied to the point of "complete wetness" at 3.0 gal/tree (300 gal/A) with a single-nozzle spray gun at 400 psi. Two applications were made on 25 Apr (pink) and 29 Apr (full-bloom), four days and eight hours before inoculation with the pathogen, respectively. The percentage of inoculated blossoms which developed typical blight symptoms was determined four weeks after inoculation. The number of naturally occurring infections per tree was determined on 2-3 Jun. All data were subjected to the analysis of variance using appropriate transformations and differences between means were tested using Tukey-Kramer HSD tests, $P \leq 0.05$.

Environmental conditions were highly favorable for fire blight development in this orchard during the blossoming period (25 Apr - 30 Apr). A mean temperature of 20.5° C for this six day period with a high range of 24.4 to 25.6° C and a low range of 13.9 to 16.7° C with an accumulative degree hours from full pink of 804 hr above 18.3° C (≥ 65° F = 804) was favorable for epiphytic bacterial development on floral parts. Inoculations of nontreated blossoms with *E. amylovora* resulted in blight development in 66% of the clusters. Infection from natural inoculum was only 7.0% on blossom clusters marked for observation and atomized with water only. Natural infection on the remainder of the nontreated trees was 17.6 blighted shoots/tree. Efficacy of the antagonist in protecting blossoms against infection ranged between 35.0 - 74.0% compared to the nontreated checks. Differences among the bacterial strains were not significant but variation among replicates was high (standard error range of 8.2 to 9.2.). *E. herbicola* was 49% more effective than *P. fluorescens* (A - 506) in this test. The level of control with the antagonist was similar to that obtained with streptomycin 80 ppm. Copper Count-N was the best treatment and allowed only 4.0% infection but was not significantly different from streptomycin because of the variability among replicates (standard errors of 1.6 for copper and 6.8 for streptomycin).

Fireblight Incidence on 'Rome Beauty' Apple Treated with Antagonistic Bacteria or Bactericides During Bloom and Inoculated at Full Bloom with *Erwinia amylovora* in 1994. Penn State Fruit Research and Extension Center, Roth Farm, Fairfield, PA. K. D. Hickey.

Blossom Treatments	Rate	Percent Blossom Clusters Infected	
		Inoculated[2]	Natural Infections[3]
1. *Pseudomonas fluorescens* (A-506)	1 X 10^8 cfu/ml[1]	47.0bc[4]	--
2. *Pseudomonas fluorescens* (LE-15)	1 X 10^8 cfu/ml[1]	49.0bc	--
3. *Erwinia herbicola* (H-318)	1 X 10^8 cfu/ml[1]	23.0ab	--
4. Agri-mycin-17	80 ppm	33.0abc	8.8a
5. Copper Count-N	400 ppm	4.0a	3.5a
6. Nontreated (Inoculated)	--	66.0c	7.8a
7. Nontreated (Noninoculated)	--	7.0a	17.6a

1 Bacteria applied to blossom clusters by atomizing previously wet blossom clusters on: 27 Apr (20% bloom, 78 F., 94% RH at time of inoculation; high and low temp. for 24 hr following inoculations was 79 F. and 58 F., respectively, and 28 Apr (97% bloom, 76 F., 88% RH at inoculation; high and low temp. for 24 hr following inoculation was 79 F. and 56 F., respectively.

2 Based on observations of 100 inoculated blossoming clusters (25/clusters on each of 4 replicates double-tree plots). Inoculation made by swabbing a suspension of 1 X 10^5 cfu/ml) of *E. amylovora* on each blossom in the clusters on 29 Apr (100% bloom, rain during inoculation with 100% RH at 66 F. high and 57 F. low and 804 DH > 65° F between 25-30 Apr.

3 Determined by counting all naturally infected blossom cluster per tree (mature trees 15' high) on 2-3 Jun .

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

CHERRY: (RED TART *Prunus ceraus* 'Montmorency')
Brown rot; *Monilinia fructicola*
Cherry leaf spot; *Coccomyces hiemalis*
Powdery mildew; *Podosphaera clandestina*

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DISEASE INCIDENCE ON MONTMORENCY CHERRY SPRAYED SEASONALLY WITH FUNGICIDES IN 1994: The efficacy of seasonal fungicide sprays was determined in a 15 year-old orchard planted 30 X 30 ft and well-pruned to a height of 12 ft. Environmental conditions for brown rot blossom blight infection was unfavorable and only light to moderately favorable for fruit decay development at harvest. Inoculum level for leaf spot in the orchard was high and contributed to rapid disease development after harvest. Fungicide treatments were arranged in a randomized complete block design and applied seasonally as protective dilute sprays. Trees were sprayed to "complete wetness" with a high pressure (400 psi) sprayer equipped with a 9-nozzle boom which delivered 3.0 gal/tree (300 gal/A). Sprays were applied on: 27 Apr (bloom); 7 May (shuck-fall); 1st through 5th covers on 16, 25 May, 9, 22 Jun, and 6 Jul (harvest), respectively; and 20 Jul (post-harvest). Incidence of brown rot on fruit at harvest from natural inoculum was recorded by observing all fruit on 10 fruiting branches (100-200 fruits/branch) per replicate on 8-9 Jul. A random sample of 100 fruits from each single-tree replicate was harvested one hour after the harvest application was applied on 6 Jul. Fruits were placed stem-end down on styrofoam plates and inoculated by atomizing with *Monilinia fructicola* conidia at 1×10^5 conidia/ml. Incubation for 9 da was at 72-76° F (mean 74° F) and 100% relative humidity under polyethylene tarp. Soluble solids in fruit juice was determined at harvest with a Atago PR-1 refractometer from a 50-fruit composite sample. Incidence of cherry leaf spot and powdery mildew on leaves was determined in Jul and Aug by observing all leaves on 10 vegetative terminals/replicate. The percent defoliation from leaf spot was made in Sep and Oct by observing the same vegetative terminals used in incident readings. A second test in two adjacent rows of trees was conducted to determine the efficacy of one or two applications of Elite 45DF or RH 7592 2F. Dilute applications were made on 20 Jul (14 da post-harvest) and on 12 Aug. Leaf spot incidence and percent defoliation was determined on 23 Aug. All data obtained were subjected to an analysis of variance using appropriate transformations and significance between means was determined by the Tukey-Kramer HSD test ($P \leq 0.05$).

Cool weather with daily mean temperatures generally below 55° F during the bloom period was unfavorable for brown rot blossom blight. Fruit infection at harvest was low with 12.8% infection on nontreated (Table 1). Infection was light on treated trees but differences among treatments were not significant. Differences in brown rot development on inoculated fruit treated five hours before inoculation were insignificant among treatments after five-day incubation, but were more apparent after nine days. The RH-7592 treatment provided the best control, but differences were not significant among most treatments. Rovral 4F 8.0 fl oz plus CS-7 Spreader was not significantly better than Rovral alone. Leaf spot incidence was low at harvest, but developed rapidly on the nontreated to 99.8% leaf infection by 15 Aug (26 da after the last application). The TD-2350-1 50DF and Rovral 4F treatments allowed rapid leaf spot development after the post-harvest application (20 Jul). Most treatments were ineffective in controlling powdery mildew. RH-7592 was significantly better than other treatments. In the separate experiment, Elite 45DF and RH-7592 4F were applied after considerable leaf spot infection occurred. A second application of RH-7592 provided significantly better control than a single application (Table 2). Both fungicides reduced defoliation significantly and two applications was more effective than one.

Table 1. Brown Rot, Leaf Spot, and Powdery mildew Incidence on Montmorency Cherry Sprayed with Dilute Fungicide Treatments in 1994. Penn State Fruit Research Laboratory, Tart Cherry Block.

			Percent Brown rot on Fruit			Percent Leaf Spot				Percent
		No. fruit/ Kg	Non-inoc. @ harv.	Inoc. at harvest Incubation Days		Incidence			Defoliation	P. mildew
Fungicide and Rate/100 Gal	Applic. Timing			5	9	12 Jul	29 Jul	15 Aug	19 Oct	12 Jul
1. Elite 45DF 2.0 oz	B,SF,21,14,7 da PHI Harvest, Post-harv.	177ab**	6.0ab	0.3a*	11.8ab*	1.3a	6.1ab	18.2a	43.0ab	38.3bcd
2. TD-2350-1 50DF 10.7 oz	B - Post-harvest	211bc	5.7ab	0.3a	15.3ab	4.3a	24.7c	95.8d	3.3a	34.7bc
3. Nova 40W 2.0 oz Captan 50W 1.0 lb + Microfine Sulfur 90W 3.0 lb RH-7592 75W 0.8 oz + Latron B-1956 4.0 fl oz	B,2C,3C,Post-harvest SF,1C 4C,5C (Harvest),PH	185abc	2.9a	0.3a	4.8a	0.7a	3.2a	14.7a	82.5bc	25.2a
4. Bravo 720F 16.0 fl oz Captan 50W 1.0 lb + Microfine Sulfur 90W 3.0 lb Rovral 4F 8.0 fl oz + CS-7 Spreader 4.0 fl oz Bravo 720F 24.0 fl oz	B SF,1C,2C,3C 4C,5C, (Harvest) Post-harvest	188abc	1.4a	0.0a	12.3ab	0.8a	15.6bc	54.2b	100.0c	40.6cd
5. Rubigan 1E 3.0 fl oz Captan 50W 1.0 lb + Microfine Sulfur 90W 3.0 lb Rovral 4F 8.0 fl oz	B,2C,3C,PH SF,1C 4C,5C (Harv.),PH	215c	2.7a	2.3ab	32.3bc	0.8a	16.7bc	79.8c	98.0c	31.6ab
6. Nontreated	--	167a	12.8b	9.8c	85.3d	17.9b	64.7d	99.8d	100.0c	43.6d

* Brown rot incidence on replicated samples collected before the harvest application (7 days since last application) showed 4.8 and 42.0 percent brown rot after 5 and 9 days incubation, respectively.

** Means followed by the same letter(s) are not significantly different according to the Tukey-Kramer HSD (P<0.05).

Table 2. Leaf Spot Incidence on Montmorency Cherry Sprayed with Fungicides Applied in One or Two Applications. Penn State University. Fruit Research Laboratory, Biglerville, PA

Fungicide and Rate/100 Gal	No. Sprays	Leaf Spot % Infection	Leaf Spot % Defoliation
1. Elite 45DF 2.0 oz	1	92.7bc*	25.0ab
2. Elite 45DF 2.0 oz	2	83.3ab	18.3a
3. RH-7592 2F 2.5 fl oz + Latron B-1956 2.5 fl oz	1	95.0c	33.1b
4. RH-7592 2F 2.5 fl oz + Latron B-1956 2.5 fl oz	2	77.0a	14.6a
5. Nontreated	-	100.0c	99.8c

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

PEACH BACTERIAL SPOT CONTROL WITH FOLIAR SPRAYS OF BACTERICIDES, 1994

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Foliar sprays to control bacterial spot caused by *Xanthomonas campestris* pv. *pruni* were applied on 6-yr-old Summer Pearl peach trees at the S. C. Agricultural Experiment Station, Pendleton, SC. Copper hydroxide (Kocide DF and LF) was applied at late dormancy (4 March) and pink bud (11 March) without further sprays or in one Kocide DF treatment followed by Mycoshield beginning at petal fall. One treatment of Kocide LF at a reduced rate was applied postbloom without prebloom sprays. Sprays for all other treatments began at petal fall (24 March), and were continued on 31 March; 7 and 21 April; 5, 17, and 31 May; and 13 and 22 June. Sprays were applied by handgun (250 psi) to runoff. Insecticides, applied separately by airblast sprayer, were Penncap M, 2 qt/A on 5 April, 27 May, 22 June, and 6 July; Guthion 2L, 3 pt/A on 19 April, and Imidan 80W, 1 lb/A on 3 and 13 May. Wettable sulfur, 10 lb/acre was added to insecticide sprays on 5 and 19 April, and 3 and 13 May to control scab. Near maturity of fruit (21 and 22 July), 50 fruit per replicate were harvested and examined for bacterial spot. Ten shoots per tree were cut at random,the number of leaves and leaf scars were counted, and the number of bacterial spot lesions per sample were counted (1500 or more lesions per sample were counted as 1500).

Rainfall during the test period was relatively light during the first half of the growing season (2.42 inches in April and 1.80 inches in May) but was heavy thereafter (7.60 inches in June and 6.70 inches in July). Very few symptoms of bacterial spot were observed prior to early June, but leaf lesions became numerous after that time. Fruit infection was light in all treatments. Leaf infections and defoliation were least on treatments receiving Mycoshield or Syllit and on the control trees. Treatments of Kocide, captan, or ziram actually seemed to increase the amount of leaf infection and defoliation relative to the control. Kocide LF was injurious to foliage (although not to fruit) when applied after petal fall, and treatment was discontinued after four applications.

Treatment and rate per 100 gallons	Bacterial spot		
	% defoliation	No. spots/leaf	% fruit infected
Kocide 61.4 DF 4.0 lb*	22.8	2.8	4.0
Kocide 1.5 LF 5.33 pt*	26.5	3.4	2.5
Kocide 1.5 LF 1.0 pt**	23.2	3.1	4.0
Kocide 61.4 DF prebloom; Mycoshield 17W 12 oz postbloom	18.7	0.1	1.3
Mycoshield 17W 12 oz	16.2	0.2	0.0
Mycoshield 17W 12 oz (1st 4 postbloom sprays only)	14.8	1.5	1.0
Ziram 76W 2.5 lb	24.5	3.0	4.5
Ziram 76W 2.5 lb + Captan 50W 2.0 lb	19.8	4.8	7.5
Syllit 65W 1.0 lb	17.0	0.2	2.0
Syllit 65W 1.0 lb + Captan 50W 2.0 lb	17.2	0.6	2.5
Captan 50W 2.0 lb	29.5	3.4	6.0
Check (wettable sulfur only)	15.0	0.3	1.5
L.S.D. 0.05	10.6	3.2	7.4

*Applied late dormant and pink bud only.
**Applied beginning at petal fall but discontinued after 4 sprays because of foliage injury.

ANALYSIS OF THE ACCURACY OF PREDICTED WEATHER DATA ON THE IMPACT OF APPLE DISEASE MANAGEMENT

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Introduction

Apple scab, caused by the fungus *Venturia inaequalis* (Cooke) Wint., is the driving force in an apple disease control program in the northeastern United States (Biggs, 1990). Because the epidemiology of apple scab is well characterized, models to predict apple scab occurrence have been developed (Jones, 1980). These models all rely on environmental data to predict scab occurrence.

The impact of environmental monitoring has not been addressed thoroughly in the context of plant pathology. Many review articles address technology issues revolving around research use of environmental monitoring equipment (Sutton et. al., 1984). Currently, environmental monitoring performed by growers is primarily through the use of hygrothermographs, thermometers, rain gauges, and data loggers (Bingham et. al., 1990). Widespread use of forecast weather data is not occurring (Seem and Russo, 1983).

Currently "prediction" of disease occurrence is based on models extrapolating disease from the recent environmental data, not on forecast environmental data (Jones, 1983). The models are reactive to the environmental conditions, not proactive in a protective sense. Therefore, forecasted weather data is necessary to have true predictions of disease occurrence. Recently, weather forecasts for a near local scale (1 km^2) have become available. For the forecast weather data to be useful for actual predictive models or decision making, the accuracy of the forecast data must be tested. The purpose of this study is to test the accuracy of forecast weather data, and measure the impact of the accuracy on decision making.

Materials and Methods

A site in Rock Springs, PA was setup as a reference agrometeorological site as described by Russo (Russo, 1983). The site consists of mowed grass, instrumentation, and shelters to house the instruments.

Manual data. Data is collected manually from the Rock Springs site daily at 8 AM from a set of calibrated minimum and maximum temperature thermometers, a rain gauge, and a hygrothermograph.

Automated Data. Four separate data loggers have been donated for participation in this experiment:

- KMS-P by Anton Paar (1030A Wilmer Ave, Richmond, VA 23227)
- Field Monitor produced by the Sensor Instrument Co. (41 Terrill Park Drive, Concord, NH 03301).
- Metos Model D, distributed by Pest Management Supply Inc. (311 River Dr., Hadley, MA 01035).
- Lufft HP-100, distributed by Abbeon Cal, Inc. (123 Gray Ave., Santa Barbara, CA 93101-1895).

The features of the data loggers are summarized in Table 1.

Forecast Data. The forecast data used in the experiment is supplied by SkyBit, Inc. (P.O. Box 10 Boalsburg, PA 16827). SkyBit supplies a 24 hour hourly forecast of temperature, relative humidity, leaf wetness, rainfall, and wind speed for the research site in Rock Springs. Skybit combines forecast models, multi-level error-checking, sophisticated interpolation techniques, and special-variable algorithms to transform station observations and field forecasts into high resolution weather values for local IPM decision making. The SkyBit data is received by Internet e-mail at approximately 6 AM on the day the forecast is calculated.

Statistical comparisons. Analysis of variance using SuperANOVA statistical software (Abacus Concepts, Inc., Berkeley, CA) was used for evaluating differences of hourly temperature, hourly relative humidity, daily minimum temperature, daily maximum temperature, daily rainfall accumulation, and hours of leaf wetness between May 15, 1994, and June 15, 1994. Since leaf wetness measurements are different in each of the data loggers, leaf wetness was converted to a binary measurement for any hour. If more than 29 minutes of wetness was observed by a datalogger, the hour was considered wet. Manually collected data was not included in hourly comparisons. Mean separation used the Tukey Honestly Significant Difference test.

Comparisons with decision making. The crucial element in usable weather data is the effect the data would have on disease management. To test the impact of the different data sets on decision-making, an expert system was used. An expert system is a computer program which emulates the logic and problem-solving proficiency of a human expert (Travis and Latin, 1991). The expert system used for the tests was the Penn State Apple Orchard Consultant (PSAOC), described previously (Travis et. al., 1991). PSAOC asks the user questions about the site, and then using the answers supplied by the user and weather data PSAOC compiles a chemical recommendation. PSAOC was only used with regard to its apple scab management recommendations. Different weather variables affect the apple scab decision making process at different points, illustrating the complexity of the decision-making process in PSAOC (Figure 1). These interactions of information may provide a better test of the forecast data than statistical comparison alone.

In order to use the weather data in PSAOC to simulate decision making, all data sets (manual, Lufft, Metos, Field Monitor, and SkyBit) were converted to PSAOC files containing daily minimum and maximum temperatures, rainfall, predicted maximum temperatures, and leaf wetness periods. An orchard profile was created (Figure 2), and the system ran until May 15 using the manual data set. From May 15 through June 15 the system ran weekly using each data set, and the recommendations were recorded for each data set. This period of time reflected bloom through second cover in Pennsylvania, a time when apple scab management is important.

Results

Statistical Comparisons. The daily maximum temperature and daily precipitation contained no statistical differences. The SkyBit forecasts of minimum temperature were statistically different from all others at a level of $p = 0.01$ (Figure 2). Hourly relative humidity, hourly temperature, and hourly leaf wetness contained many statistical differences at a level of $p = 0.0001$ (Figures 3-4, Table 2).

Use in Decision Making. Despite differences observed during statistical comparisons, the expert system recommendations contained few differences. On each weekly date the expert system recommended the same chemical rates for each data set, and the only differences observed were the recommended application dates. The data logger and forecast data recommendations required immediate application on the May 29 recommendation, while the manual data did not (Table 3). This effect was amplified in the June 5 recommendations, but the June 12 recommendations were identical for all data sets. Since the apple scab control module in PSAOC does not use relative humidity, it was not tested for any effect on decision making.

The data logger systems performed as well as the manual system for decision making, though some statistical differences were observed. The Field Monitor and KMS-P temperature and humidity sensors are housed in a larger shelter than the Metos and Lufft. This may have contributed to the lower temperatures observed, as well as the differences in relative humidity since the Field Monitor and KMS-P grouped together statistically.

The tests using PSAOC showed the forecast data are accurate enough to ensure proper decision making, despite some observed statistical differences. The other factors involved in an apple scab decision management scheme are over-riding the statistical differences observed in the weather data. According to Mill's Table (Biggs, 1990), each data set recorded the proper environmental conditions for an infection period on May 25. Despite the proper conditions for an infection period, the expert system did not record an infection for any data set because of the chemical residues. There was not enough rainfall or time since the fungicide application for susceptible tissue to be at risk of infection. The interaction of other decision-making factors may preclude a slight error in the weather data.

Significant differences were observed in the number of hours of leaf wetness, but this does not reflect actual wetting periods. When any wetting period was long enough for infection, generally each data set contained the period. Most often differences occurred as short periods, or an hour at the beginning or end of a period. These differences may be due to differing sensitivity of the leaf wetness sensors used by the data loggers. In PSAOC, the amount of rainfall has more impact on infection than the leaf wetness period because of its interaction with chemical residues. Since the rainfall measurements and forecasts were not statistically different, the impact of the similarity of the rainfall amounts had more effect on decision making than the differences observed in the leaf wetness periods.

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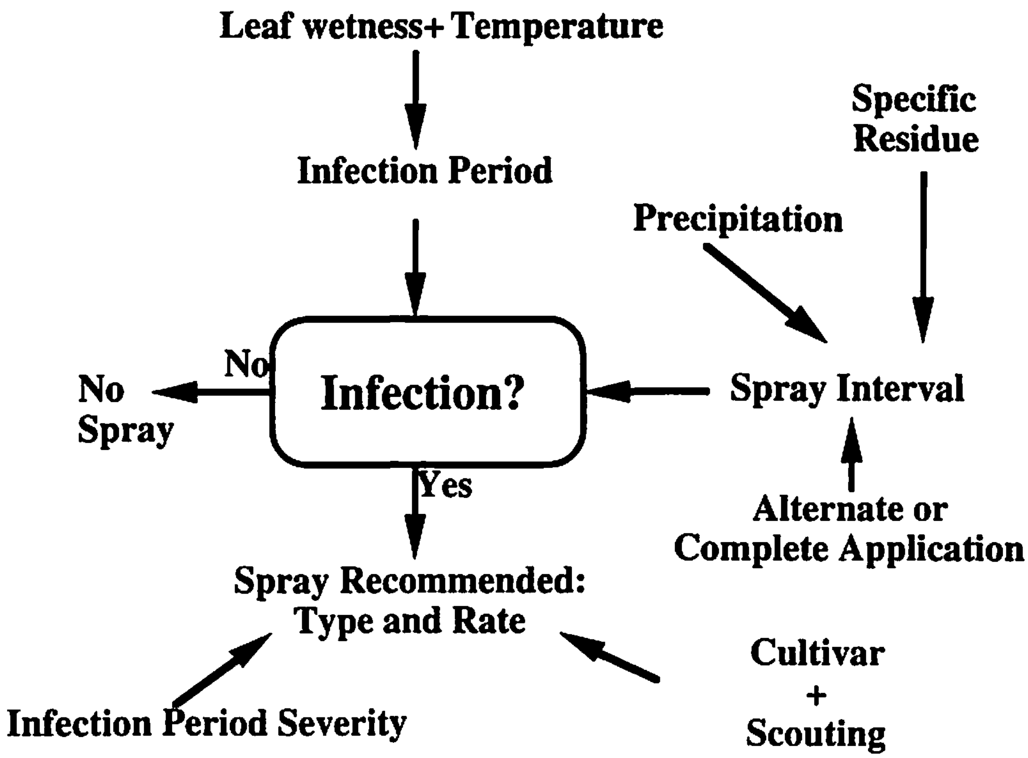

Figure 1. The factors involved in apple scab decisions in PSAOC

Table 1. The data logger models used in the experiment and selected features of each.

	KMS-P	Field Monitor	Metos Model D	Lufft HP-100
Temperature	C	F	C	C
Rel. Humidity	%	%	%	%
Leaf Wetness	Yes/No	Minutes	Yes/No	0-255
Precipitation	mm	in	mm	mm
Frequency of data	Hourly ave.	Hourly	12 min.	12 min.
Data Transfer	Paper	Computer	Computer	Computer
Apple Simulation Models	Scab	None	Scab, P. Mildew	Scab, P. Mildew

Table 2. Hours of leaf wetness from May 15, 1994 to June 15, 1994.

Data Source	Total Hours of Wetness	Mean Hourly Leaf Wetness
SkyBit	138	0.192 a
KMS-P	148	0.213 ab
Sensor	201	0.266 bc
Metos	210	0.278 c
Lufft	295	0.391 d

Means in columns followed by the same letter do not differ significantly at P=0.05, according
to Tukey's Honestly significant difference test

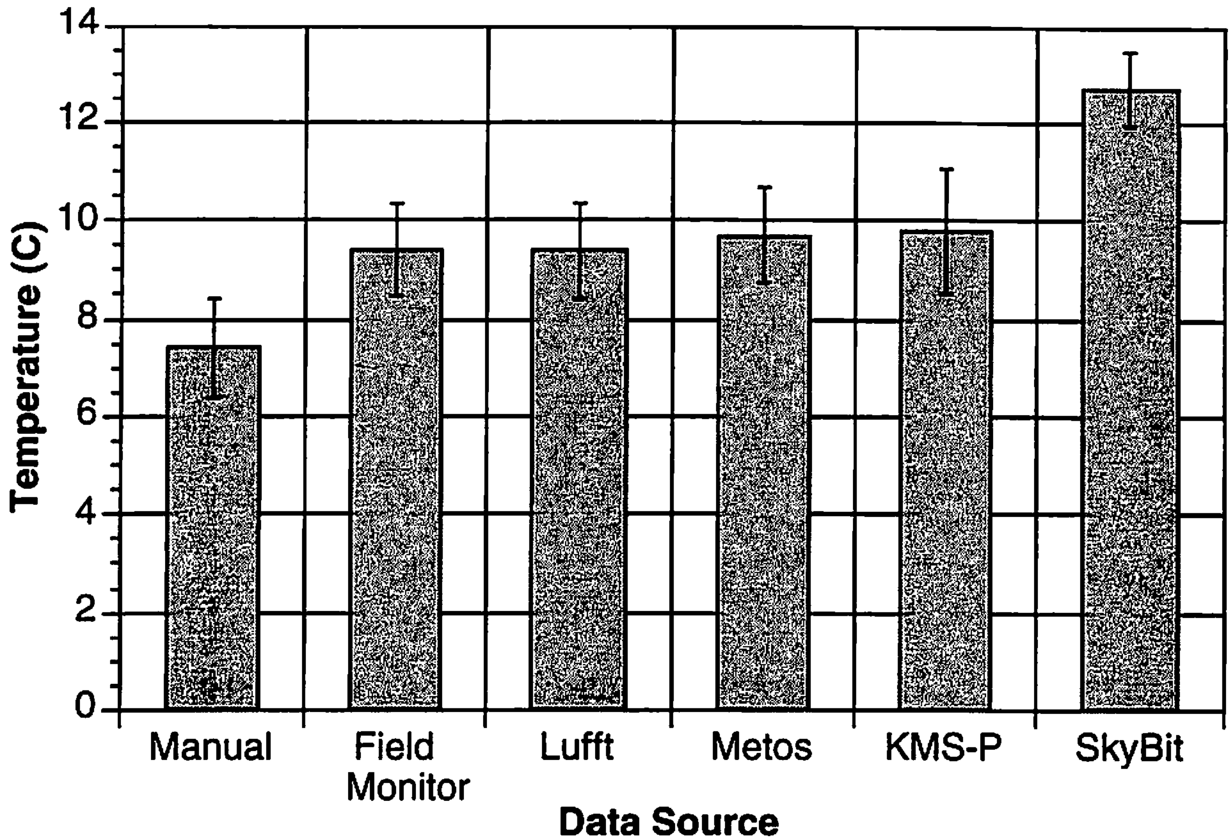

Figure 2. Mean minimum temperatures for each data source.

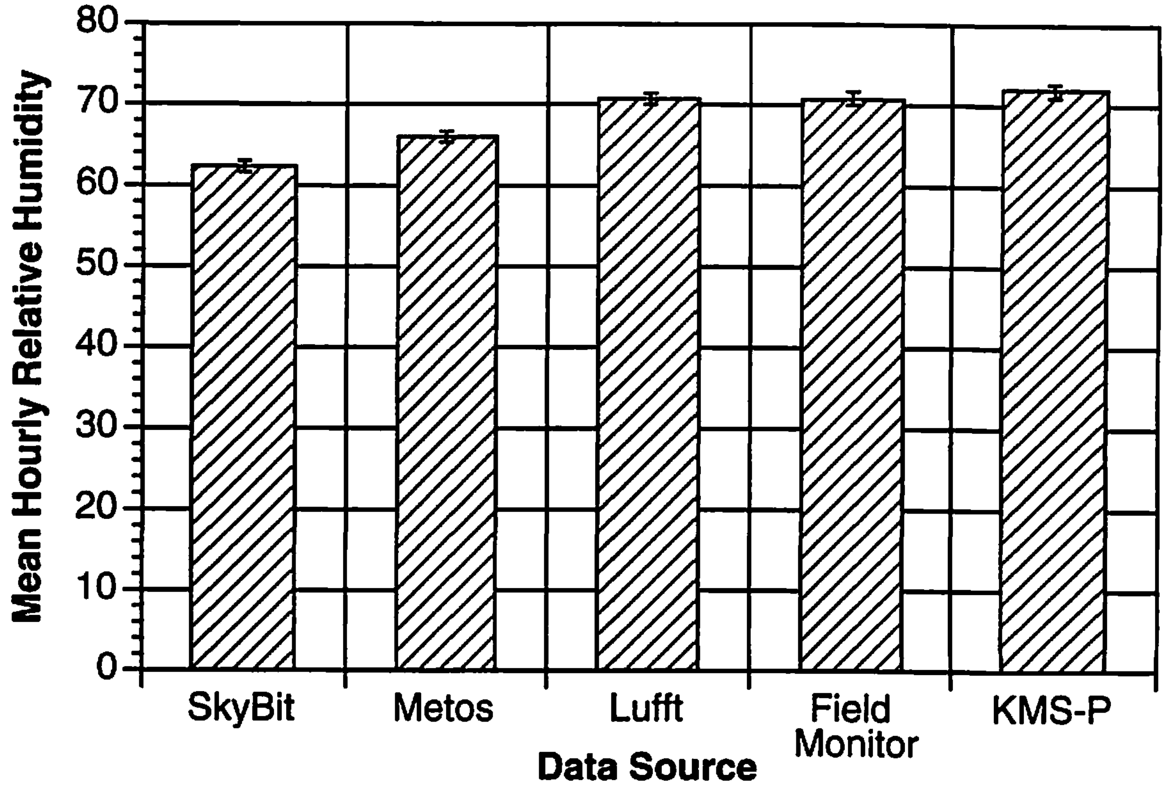

Figure 3. Mean hourly relative humidity for each data source

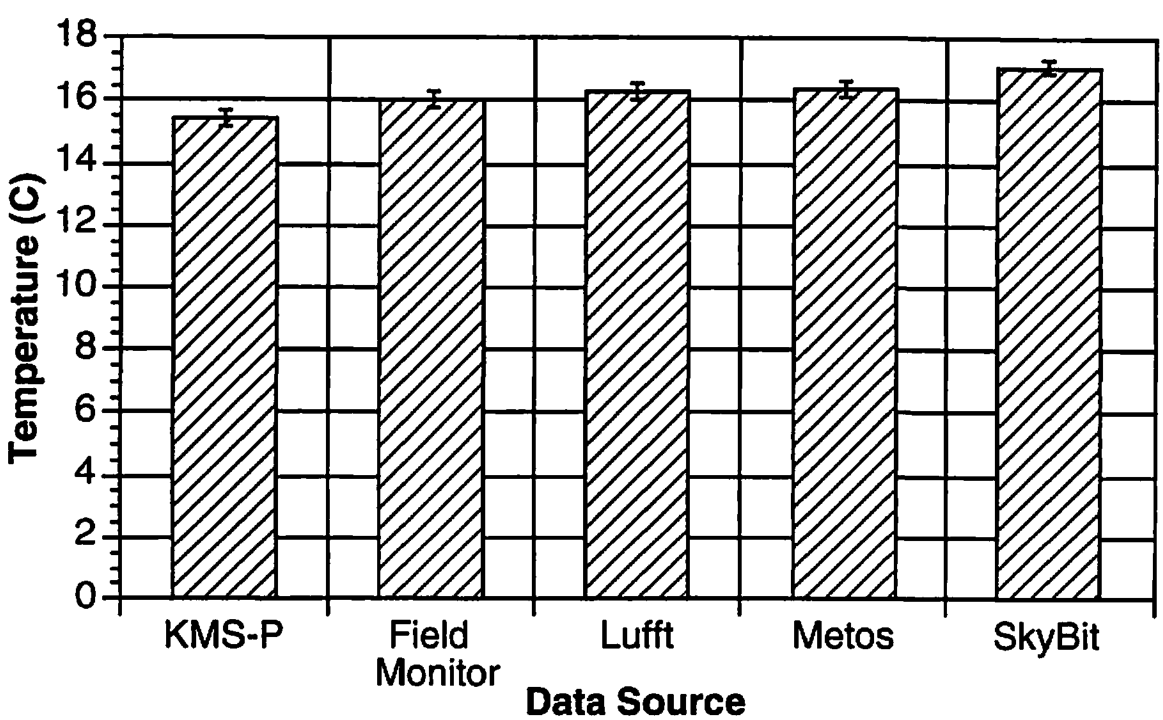

Figure 4. Mean hourly temperature for each data source.

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Table 3. Differences in recommended application dates by PSAOC

Date	Data Source	Recommended application date
5/29/94	SkyBit	ASAP
	KMS-P	ASAP
	Sensor	ASAP
	Metos	ASAP
	Lufft	ASAP
	Manual	By 6/3/94
6/5/94	SkyBit	By 6/10/94
	KMS-P	By 6/10/94
	Sensor	By 6/10/94
	Metos	By 6/10/94
	Lufft	By 6/10/94
	Manual	By 6/21/94

A *Phytophthora* Detection System for Cranberry (*Vaccinium macrocarpon*) Root Rot

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Phytophthora cinnamomi causes a root rot of more than 1000 species of plants (Zentmyer, 1980). Many of the susceptible species belong to the Ericaceae and are native to New Jersey. They include species of *Rhododendron*, *Erica*, *Arctostaphylos*, *Gaultheria*, and *Vaccinium* (Hoitink, *et al.*, 1986). The first report of phytophthora root rot (PRR) of *Rhododendron* was in 1927 from New Jersey (White, 1927). Since that time it has become recognized throughout the United States and Europe as a major disease of that crop. PRR is also considered to be a serious disease of both cranberry (Caruso and Wilcox, 1990) and highbush blueberry (Royle and Hickman, 1963).

Unnecessary fungicide applications can be avoided by improved diagnostic methods to ensure that the correct dosage/fungicide is applied for a particular disease situation. Development of a reliable monitoring method is essential when developing disease control strategies. For example, fungicide applications should correspond with the phenology of the pathogen. In the case of *Phytophthora* spp., pathogenic activity may vary greatly during the season with each species having a distinct pattern of seasonal fluctuation (Jeffers and Aldwinkle, 1986). In many instances more than one species of *Phytophthora* will occur on a single host. Examples of this include cranberry (Caruso, pers comm), apple (Jeffers and Aldwinkle, 1986), walnut (Matheron and Mircetich, 1985), cherry (Wilcox and Mircetich, 1985), and raspberry (Duncan *et al.*, 1991). Different species also exhibit diverse responses to fungicides such as metalaxyl (Coffey and Bower, 1984) making it critical to monitor the composition of species complexes for disease control.

The purpose of this study was to develop methods for rapid, simple detection of *Phytophthora* spp. and to monitor spore populations during the growing season. The resulting information should help avoid needless applications of the fungicide metalaxyl, and, when the pathogen is present, improve timing of fungicide applications. The monitoring will also include methods to detect development of metalaxyl resistance should it begin to occur.

Materials and Methods

Trap plant bioassay: Seeds of Russells lupin were planted in sterile potting mix in the greenhouse. Five to seven-day-old seedlings were positioned in styrofoam boats with the roots extending 1"-2" below the base. The boats were then floated in drainage ditches which surround commercial cranberry bogs. The boats and seedlings were withdrawn from the drainage ditches after 48 hours. The roots were excised, washed with sterile distilled H_20 and plated on a *Phytophthora* selective medium (Tsao and Ocana, 1969). The plates were incubated for two to four days at 20 C or until visible mycelial growth was observed. If no growth occurred after ten days, the test was considered negative. Three commercial cranberry bogs were monitored weekly for the majority of the growing season. Four other bogs including one native bog were sampled periodically throughout the summer.

Fungal identification: Fungi growing from the roots were isolated into pure culture on V8-medium. Identifications were made using morphological characteristics and later confirmed by use of a diagnostic isozyme marker, malate dehydrogenase (MDH) (Oudemans and Coffey, 1990). Results were recorded by determining the proportion of lupins infected by *P. cinnamomi* at the three locations during each time period.

Metalaxyl sensitivity: The fungicide metalaxyl (N-[2,6-dimethylphenyl]-N-[methoxyacetyl]-alanine methyl ester, technical grade) was diluted in 95% ethanol and added to autoclaved corn meal agar which had been allowed to cool to 45 C. Metalaxyl concentrations were 0.5, 0.1, 0.05, 0.01 and 0.005 ug/ml of culture medium. All treatments including a control received a total of 1ml of 95% ethanol.

Linear growth responses and EC50 values were determined by methods described by Coffey and Bower (1986).

Results

Selective medium: All fungal growth could be readily detected visually on the selective medium and was identified as either *Phytophthora* or *Pythium*. However, one non-pythiaceous fungus consistently grew on the selective medium, covering the plate within 48 hours. It was found that addition of 20 mg/l of benomyl (technical grade) inhibited the growth of this contaminant.

Species isolated: Three *Phytophthora* species were isolated from lupin roots. The most common was identified as *P. cinnamomi* based on the corraloid mycelium, chlamydospore production and formation of non-papillate sporangia (Zentmyer, 1980). The second species produced non-papillate sporangia, did not produce chlamydospores or oospores, nor did it have the typical corraloid mycelium of *P. cinnamomi*. This species was never isolated from diseased cranberry roots. A third species identified as *P. megasperma* was isolated from both diseased cranberry roots and lupin baits in one location. These three species were readily differentiated by the isozyme marker MDH.

Phytophthora cinnamomi isolations: *P. cinnamomi* was recovered from drainage ditches from May 17, 1994 until October 31, 1994. However, the frequency of isolation varied from 0% - 100% during the season. The frequencies for each location are presented in Figure 1.

Metalaxyl sensitivity: Isolates were collected through the growing season and their sensitivity to metalaxyl was determined. A total of 104 isolates of *P. cinnamomi* were tested and showed a mean EC50 of 0.14 ± 0.08µg /µl. Two isolates of *P. megasperma* were recovered from one location and showed a mean EC50 of 1.66 ± 0.50µg /µl. The distribution of EC50 values for the *Phytophthora* spp. sample is shown in Figure 2.

Discussion

Two species, *P. cinnamomi* and *P. megasperma* were isolated from roots of diseased cranberry vines in New Jersey. A third unidentified species was isolated from drainage ditches but not root tissue. It is unlikely therefore that the unidentified species is an important component of cranberry root rot. Both of the other species are considered important components of cranberry root rot although *P. cinnamomi* is much more widespread (Oudemans, data not presented).

Use of lupin baits appears to be a convenient method for detection and possibly quantification of *P. cinnamomi* in cranberry drainage ditches. This method presumably detects dispersal of zoospores released from sporangia formed on infected plant tissue. It does not reflect colonization activity of the pathogen after infection has occurred. *P. cinnamomi* was not detected until June 13, 1994. However, only one sample was taken earlier, on May 17. To accurately determine when the dispersal phase of the disease begins, sampling should begin before the pathogen is detectable and continue until it is no longer detectable.

Two major fluctuations were seen in the proportion of lupins infected during the growing season (Fig. 1). The first fluctuation occurred near July 5 and corresponded with the second commercial metalaxyl application by the growers. It is reasonable to assume that metalaxyl could reduce the activity of *P. cinnamomi* and therefore cause a drop in lupin infection. A second fluctuation occurred near August 15 despite high rainfall and otherwise conducive conditions for disease development.

Isolates were collected through the growing season and their sensitivity to metalaxyl was determined. Sensitivity is measured by finding the concentration of fungicide which inhibits the fungus by 50%. This measurement is called the EC50 value. The sensitivity of *P. cinnamomi* to metalaxyl remained relatively constant throughout the season. The baseline EC50 value for *P. cinnamomi* is 0.2 ug/ml (Ciba Geigy, Technical Bulletin). Resistance to metalaxyl is expressed as a 100-fold or greater increase in EC50 over the sensitive value (Davidse, 1982). Thus for *P. cinnamomi*, EC50 values of 20 ug/ml or higher would be considered resistant. The values found in this study (Figure 2) do not reflect development of resistance and are well within the sensitive range for this species. The published EC50 values for *P. megasperma* are less than *P. cinnamomi* (Ciba Geigy, Technical Bulletin). However, the EC50 values seen for *P. megasperma* in this study are considerably higher than those found for *P. cinnamomi*. Intraspecific variability for *P. megasperma* is known to be very high and it is likely a species complex (Hansen *et al.*, 1986).

The utility of the trapping method described here will be to estimate the optimum timing of fungicide applications to control *Phytophthora*. Recommendations suggest three applications beginning in early spring followed by a mid-summer application and ending with one post-harvest. If the application is made too early there may be a loss of activity due to dissipation before the pathogen becomes active. Thus early detection of *P. cinnamomi* may provide information for determining the most effective timing for the spring application. Also, very little activity was seen after October 3, 1994 therefore applications made after that date would have very little effect on preventing spread. More information is needed on the colonization stage to determine what effect this final application is having.

Many symptoms resemble Phytophthora root rot. For example grub damage, early stages of fairy ring or even herbicide damage. Lupin baiting can provide an excellent approach for measuring the activity and also rapidly determining the presence of *Phytophthora* in specific situations.

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Figure 1: Proportion of infected lupin seedlings recovered from drainage ditches

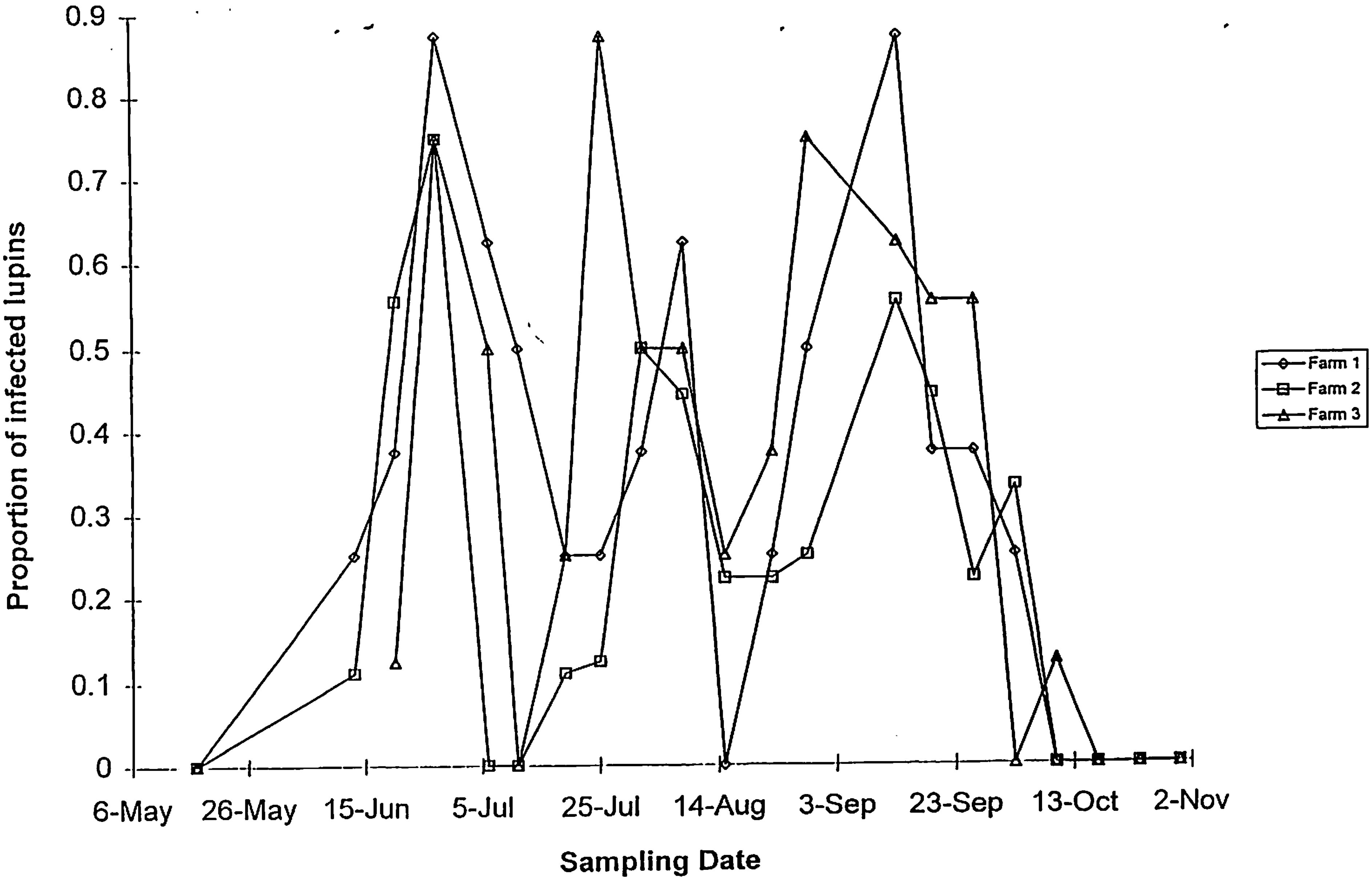
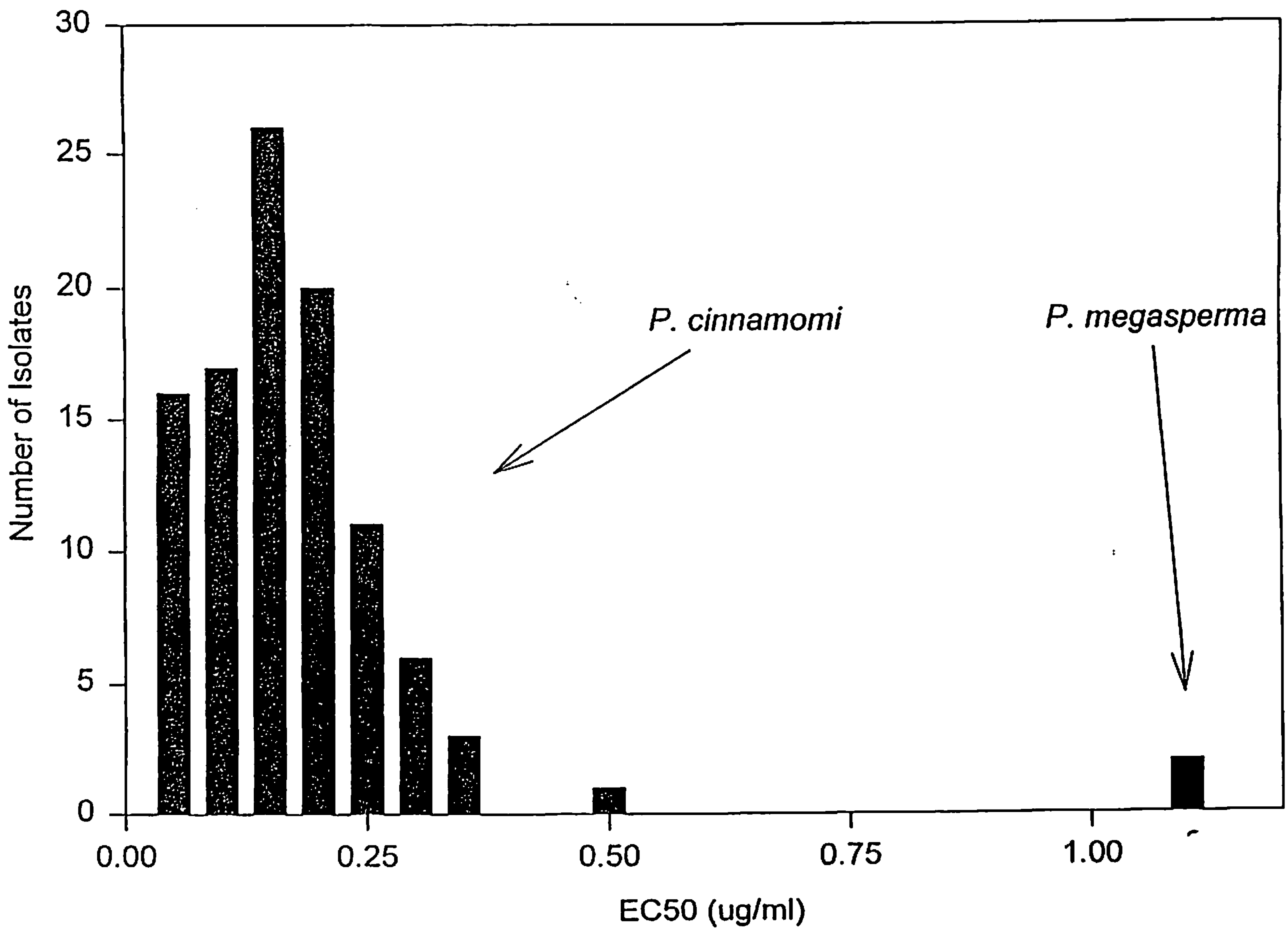


Figure 2: Distribution of sensitivities to metalaxyl



APPLE (*Malus domestica* 'Stayman Winesap', 'Idared', 'Granny Smith')
Scab; *Venturia inaequalis*
Powdery mildew; *Podosphaera leucotricha*
Fireblight; *Erwinia amylovora*
Sooty blotch; *Gloeodes pomigena*
Fly speck; *Zygophiala jamaicensis*
Brooks spot; *Mycosphaerella pomi*
Fruit finish

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DISEASE CONTROL BY EXPERIMENTAL FUNGICIDES ON STAYMAN, IDARED AND GRANNY SMITH APPLES, 1994: Ten treatments involving experimental and registered fungicides were compared on eight-yr-old trees in a test conducted in a randomized block design with four three-cultivar replicate tree sets separated by untreated border rows. Treatment rows had not been treated with fungicides in 1993 to encourage heavy mildew inoculum pressure. Tree-row-volume was determined to require a 400 gal/A dilute base for adequate coverage. Treatments were applied at 100 gallons per acre from both sides of the tree on each application date with a Swanson Model DA-400 sprayer as follows: 8 Apr (GT, half-inch green tip - Stayman; Idared tight cluster); 15 Apr (TC, tight cluster Stayman, Idared open cluster); 26 Apr (petal fall); first through sixth covers, respectively 10 May, 24 May, 9 Jun, 30 Jun, 14 Jul, and 27 Jul. Insecticides applied separately to the entire test block included: Supracide 2E, Dipel 2X, Guthion 3F, Lannate, Penncap-M, and Sevin XLR. Calcium chloride 6 lb/A was included with insecticides 30 Jun and 13 Jul. Provide 8 oz/100 gal was applied only to Stayman trees 26 Jul, 10 Aug and 24 Aug. Foliar data represent averages of counts of all leaves on 10 terminal shoots from each of four replicates 28-30 Jun (Idared) and 7-12 Jul (Stayman). A 25-fruit sample was taken from each replicate tree 27-28 Sep and rated after 4 wks storage at 2C.

All diseases developed from inoculum naturally present in the test area. Although one set of treatments was first applied at green tip stage 8 Apr, the first scab infection period did not occur until 15 Apr, the day all treatments were applied. The first secondary scab infection period occurred 29 Apr and the heaviest scab test pressure occurred 3-8 May with two wetting periods totaling 59 hr and 1.87 inches of rain. Under relatively low disease pressure the treatments involving Rubigan, Nova, Orbit and CGA-219417 gave significantly better control of scab on foliage than the protectant treatments Dithane + captan, TD 2350-1, TD 2323-2 and Fluazinam. The early season copper treatment schedule involving Kocide and Basicop gave significantly better control of foliar scab than Dithane + captan applied on the same schedule. Fruit scab incidence was light and all treatments except TD 2350-1 gave acceptable control. Powdery mildew conidia were available for infection 5 Apr and there were numerous periods favorable for infection throughout April, May and June. Treatments involving Nova, Rubigan and Orbit gave the best mildew control. Considering the heavy mildew pressure, TD 2323-2 also gave strong mildew suppression. CGA-219417 gave strong mildew suppression on Stayman, but was less effective on the more susceptible cultivar Idared. Other treatments gave significant mildew suppression compared to "no fungicide" but did not provide acceptable commercial control. Fireblight infection of blossoms occurred primarily 26-29 Apr. The only significant suppression of fireblight strikes compared to no treatment was by Dithane + captan. Summer disease development was delayed by dry weather through mid-June. Under moderate sooty blotch, fly speck and Brooks spot pressure, Fluazinam and TD 2323-2 gave control comparable to or better than treatments which included captan + ziram as the summer fungicides. TD 2350-1 suppressed sooty blotch and fly speck, particularly on Granny Smith, but was significantly weaker than most treatments involving captan + ziram on Stayman and Idared. The copper treatment (Kocide-Basicop) through second cover showed a significant increase in russet on Stayman and Granny Smith and opalescence on Idared.

Table 1. Early season disease control by experimental fungicides on Stayman, Idared and Granny Smith apples

	Stayman Winesap				Idared					Granny Smith	Fireblight strikes/
	Scab incidence (%)		Mildew infection (%)		Mildew infection (%)			Scab %		fruit,	3-cultivar
Treatment and rate/A	leaves	fruit	leaves	area	leaves	area	fruit	leaves	fruit	% scab	tree set *
No fungicide	9.1 f	9 b	61 g	58 c	62 f	75 d	13 b	1.2 c	5 b	22 c	23.3 b
Fluazinam 500F 38.4 fl oz (GT-6C)	3.9 cd	2 ab	30 e	8 ab	48 def	37 bc	0 a	0.1 ab	0 a	2 ab	10.3 ab
Fluazinam 500F 12.8 fl oz (GT-6C)	2.6 bc	0 a	40 f	23 b	52 ef	48 c	1 a	0.5 abc	1 a	2 ab	16.8 ab
TD 2350-1 50DF 4 lb (TC-6C)	6.2 e	7 ab	29 de	11 ab	46 de	38 bc	2 a	0.3 ab	2 a	8 b	21.5 ab
TD 2323-2 76DF 5.9 lb (TC-6C)	4.1 cde	0 a	18 bc	4 a	22 bc	7 a	4 a	0.9 bc	1 a	1 ab	6.8 ab
CGA-219417 75W 5.3 oz (TC-2C) Captan 50W 3 lb + Ziram 76DF 3 lb (3C-6C)	0.5 ab	0 a	21 cd	5 a	39 de	24 abc	5 a	0.1 ab	2 a	1 ab	13.0 ab
CGA-219417 75W 5.3 oz + Orbit 45W 26.7 g (TC-2C) Captan 50W 3 lb + Ziram 76DF 3 lb (3C-6C)	0.3 a	0 a	10 ab	2 a	17 ab	5 a	4 a	0.3 ab	0 a	1 ab	15.3 ab
Nova 40W 4.5 oz + Dithane 75DF 3 lb (TC-2C) Captan 50W 3 lb + Ziram 76DF 3 lb (3C-6C)	0.3 a	0 a	4 a	1 a	4 a	1 a	2 a	0.0 a	0 a	0 a	9.5 ab
Rubigan 1E 9 fl oz + Dithane 75DF 3 lb (TC-2C) Captan 50W 3 lb + Ziram 76DF 3 lb (3C-6C)	0.2 a	0 a	9 ab	2 a	8 ab	2 a	4 a	0.1 ab	0 a	0 a	7.8 ab
Dithane 75DF 3 lb + Captan 50W 3 lb (GT-2C) Captan 50W 3 lb + Ziram 76DF 3 lb (3C-6C)	5.8 de	0 a	31 e	10 ab	35 cd	19 ab	1 a	0.3 ab	2 a	0 a	3.8 a
Kocide 40DF 8 lb (GT) Basicop 53W 8 oz (TC-2C) Captan 50W 3 lb + Ziram 76DF 3 lb (3C-6C)	2.4 abc	0 a	31 e	14 ab	39 de	37 bc	5 a	0.1 ab	0 1	0 a	10.3 ab

Averages of all leaves from 10 terminal shoots from each of four single-tree replicates 7 Jul. Mean separation by Waller-Duncan K-ratio T test ($p = 0.05$).
*Fireblight strike counts 8 Jun transformed by square root ($X + 0.5$) for statistical analysis.

Table 2. Summer disease control and fruit finish on Stayman, Idared and Granny Smith apples

Treatment and rate/A	% fruit with sooty blotch			% fruit with fly speck			% fruit Brooks spot, Idared	Russet rating*		% fruit without russet, Granny Smith
	Stayman	Idared	Granny Smith	Stayman	Idared	Granny Smith		Stayman	Granny Smith	
No fungicide	63 c	74 c	50 b	60 c	71 d	55 b	8 b	1.4 a	1.4 a	82 cd
Fluazinam 500F 38.4 fl oz (GT-6C)	0 a	0 a	0 a	0 a	0 a	0 a	0 a	1.2 a	0.8 a	86 bc
Fluazinam 500F 12.8 fl oz (GT-6C)	0 a	1 a	0 a	0 a	1 a	2 a	2 ab	2.1 ab	1.2 a	81 cd
TD 2350-1 50DF 4 lb (TC-6C)	13 b	18 b	1 a	18 b	26 c	13 a	6 ab	1.6 ab	1.3 a	83 cd
TD 2323-2 76DF 5.9 lb (TC-6C)	0	1 a	1 a	3 a	5 a	2 a	1 a	2.2 ab	0.7 a	86 bc
CGA-219417 75W 5.3 oz (TC-2C) Captan 50W 3 lb + Ziram 76DF 3 lb (3C-6C)	4 ab	0 a	0 a	11 ab	18 bc	5 a	1 a	1.7 ab	0.8 a	89 abc
CGA-219417 75W 5.3 oz + Orbit 45W 26.7 g (TC-2C) Captan 50W 3 lb + Ziram 76DF 3 lb (3C-6C)	4 ab	4 a	2 a	22 b	10 ab	5 a	0 a	1.4 ab	0.5 a	92 ab
Nova 40W 4.5 oz + Dithane 75DF 3 lb (TC-2C) Captan 50W 3 lb + Ziram 76DF 3 lb (3C-6C)	0 a	1 a	0 a	8 ab	3 a	0 a	0 a	1.3 a	0.3 a	96 a
Rubigan 1E 9 fl oz + Dithane 75DF 3 lb (TC-2C) Captan 50W 3 lb + Ziram 76DF 3 lb (3C-6C)	1 a	1 a	0 a	8 ab	3 a	0 a	0 a	1.2 a	0.7 a	88 abc
Dithane 75DF 3 lb + Captan 50W 3 lb (GT-2C) Captan 50W 3 lb + Ziram 76DF 3 lb (3C-6C)	0 a	1 a	0 a	3 a	7 ab	2 a	0 a	1.6 ab	0.7 a	89 abc
Kocide 40DF 8 lb (GT) Basicop 53W 8 oz (TC-2C) Captan 50W 3 lb + Ziram 76DF 3 lb (3C-6C)	1 a	1 a	0 a	3 a	2 a	0 a	0 a	2.5 b	2.7 b	70 d

Averages of 25 fruit from each of four single-tree replicate trees 26-28 Oct after one month's storage at 2C. Mean separation by Waller-Duncan K-ratio T test (p = 0.05).
*Rated on a scale of 0-5 (0 = perfect finish; 5 = severe russet). Rating may include mildew russet as well as chemical russet.

APPLE (*Malus domestica* 'Golden Delicious')
Scab; *Venturia inaequalis*
Powdery mildew; *Podosphaera leucotricha*
Brooks spot; *Mycosphaerella pomi*
Sooty blotch; *Gloeodes pomigena*
Fly speck; *Zygophiala jamaicensis*
Rots
Fruit finish

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DISEASE CONTROL BY CONCENTRATE FUNGICIDE APPLICATIONS ON GOLDEN DELICIOUS APPLE, 1994: Experimental and registered compounds and mixtures were compared for disease control and fruit finish effects on 22-yr-old trees at the Virginia Tech Agricultural Research & Extension Center 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. Tree-row-volume was determined to require a 400 gal/A dilute base for adequate spray coverage. Treatments were applied to both sides of the tree on each application date with a Swanson Model DA-400 airblast sprayer at 100 gal/A as follows: 20 Apr (P, pink); 28 Apr (Bl, bloom to petal fall); first through sixth covers, respectively (1C-6C) 10 May, 24 May, 9 Jun, 28 Jun, 12 Jul, 26 Jul. Other applications applied to the entire test block with the same equipment included Ambush 2E, Dipel 2X, Sevin XLR, NAA 800, Guthion 3F, Lannate, and Penncap-M. Calcium chloride 6 lb/A was included with the last five insecticide applications 9 Jun, 28 Jun, 12 Jul, 27 Jul and 9 Aug. Cedar-apple rust galls and bramble canes infected with sooty blotch and fly speck fungi were placed in baskets over each test tree. Foliar data represent averages of counts of all leaves on 10 terminal shoots from each of four replicate trees 22-24 Jun. A 25-fruit sample from each replicate tree was harvested 29 Sep and rated after 25 days' storage at 2C.

The first fungicide application was applied five days after the first primary scab infection period. The first secondary scab infection period occurred 29 Apr, the day after the second application. The heaviest scab test pressure occurred 3-8 May with two wetting periods totaling 59 hr and 1.87 inches of rain. Treatment schedules which retained a sterol-inhibiting (SI) fungicide through second cover (RH-0611 and Nova + Dithane) gave excellent control of scab and powdery mildew. Treatments involving only coppers, captan, or captan + ziram during this period were significantly less effective for foliar scab control and did not provide adequate mildew control. Copper treatments were generally less effective than captan or captan + ziram for scab control on foliage and fruit. The combination of captan + ziram gave generally good control of summer diseases where cover sprays were applied. Omission of the second through sixth cover sprays in one treatment schedule gave a significant increase in sooty blotch, fly speck and rots compared to a schedule which included captan + ziram in these applications. In one treatment the second, third and fourth cover sprays were omitted based on a tentative 250 cumulative wetting hours threshold starting ten days after petal fall. Omission of these sprays followed by captan + ziram + Topsin-M in the fifth and sixth cover sprays did not significantly increase Brooks spot, fly speck or sooty blotch incidence, but did result in increased rots, compared to a schedule which included captan + ziram + Topsin-M in the 2nd-4th cover sprays. All copper treatments applied through first cover significantly increased the amount of fruit russet.

Table 3 . Disease control by concentrate fungicide applications on Golden Delicious apple

Treatment, rate/A and timing	Scab incidence		Mildew infection		Fruit disease incidence (%)				Russet	
	leaves	fruit	% leaves	% area	Brooks spot	Sooty blotch	Fly speck	Rots	Rating (0-5)*	% Extra Fancy & Fancy**
No fungicide	26 g	34 c	33 d	10 d	6 c	89 c	85 c	42 d	1.8 a	90 a
RH-0611 62.25W 4.0 lb (P-2C) Captan 50W 3 lb + Ziram 76DF 3 lb (3C-6C)	1 a	0 a	2 a	1 a	0 a	2 a	0 a	0 a	1.8 a	87 ab
Nova 40W 5 oz + Dithane 75DF 3 lb (P-2C) Captan 50W 3 lb + Ziram 76DF 3 lb (3C-6C)	2 a	0 a	2 a	1 a	0 a	3 a	3 a	1 a	2.2 ab	76 abc
Rubigan 1E 9 fl oz + Polyram 80W 3 lb (P-BI) Polyram 80W 3 lb + Captan 50W 3 lb (1C-2C) Captan 50W 3 lb + Ziram 76DF 3 lb (3C-6C)	4 ab	0 a	3 a	1 a	0 a	9 a	12 a	0 a	2.2 ab	81 a-d
Rubigan 1E 9 fl oz + Dithane 75DF 3 lb (P-BI) Dithane 75DF 3 lb + Captan 50W 3 lb (1C-2C) Captan 50W 3 lb + Ziram 76DF 3 lb (3C-6C)	9 bc	0 a	8 ab	2 ab	0 a	11 a	9 a	2 ab	1.9 a	91 a
Kocide 40DF 1 lb (P-1C) Captan 50W 3 lb + Ziram 76DF 3 lb (2C-6C)	15 def	10 b	16 bc	3 ab	0 a	0 a	0 a	0 a	2.6 bc	59 cd
Kocide LF 2.4F 1.33 pt (P-1C) Captan 50W 3 lb + Ziram 76DF 3 lb (2C-6C)	16 ef	5 ab	14 bc	3 ab	0 a	3 a	1 a	3 ab	3.0 c	54 d
COCS 50WDG 12.8 oz (P-1C) Captan 50W 3 lb + Ziram 76DF 3 lb (2C-6C)	19 ef	5 ab	21 c	4 bc	1 ab	0 a	0 a	2 ab	3.0 c	60 bcd
Captan 50W 6 lb (P-6C)	8 bc	0 a	18 bc	3 bc	0 a	11 a	11 a	1 a	1.7 a	86 ab
Captan 50W 3 lb + Ziram 76DF 3 lb (P-6C)	10 cd	0 a	21 c	4 bc	1 ab	15 a	16 a	7 ab	2.1 ab	79 a-d
Captan 50W 3 lb + Ziram 76DF 3 lb (P-1C only)	8 bc	7 ab	20 c	4 bc	4 bc	79 b	73 b	23 c	1.9 a	83 a-d
Captan 50W 3 lb + Ziram 76DF 3 lb (P-1C) Captan 50W 3 lb + Ziram 76DF 3 lb + Topsin-M 70W 10 oz (5C-6C)	13 cde	10 b	23 cd	6 c	0 a	8 a	12 a	9 b	2.0 a	90 a
Capan 50W 3 lb + Ziram 76DF 3 lb (P-1C) Captan 50W 3 lb + Ziram 76DF 3 lb + Topsin-M 70W 10 oz (2C-6C)	11 bc	1 ab	22 c	4 bc	0 a	8 a	9 a	1 a	2.2 ab	87 a

Counts of all leaves on 10 terminal shoots (22 Jun) or 25 fruit from each of four single-tree replicates. Mean separation by Waller-Duncan K-ratio T test (p = 0.05).
*Rated on a scale of 0-5 (0 = perfect finish; 5 = severe russet). ** USDA grades after down-grading by russet.

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

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EVALUATION OF PROTECTIVE TREATMENTS FOR FIREBLIGHT CONTROL ON ROME BEAUTY AND GOLDEN DELICIOUS APPLES, 1994: Fourteen treatments involving streptomycin and adjuvants, copper materials, Aliette, and combinations with streptomycin were tested as blossom protectants and for fruit finish effects. Treatments were applied to pairs of adjacent 22 yr-old trees of each cultivar in four randomized blocks. Treatments were applied dilute to the point of runoff with a single nozzle handgun at 200 psi 20 Apr (Rome, pink; Golden Delicious, bloom), 25 Apr (Rome, full bloom; Golden Delicious, late bloom); 11 May (post-bloom) and 24 May. Ten Rome blossom clusters per tree were tagged, open blossoms on each cluster were noted, and clusters were inoculated on 23 Apr by misting 2 ml of a suspension containing 1 X 10^6 *E. amylovora* cells/ml into each tagged blossom cluster. Blossoms were inoculated at 13C in the evening in anticipation of warmer temperatures which reached a high of 27C on 24 Apr. The Golden Delicious trees were past the peak of bloom and were not inoculated directly. Natural blight infection periods, as indicated by the MARYBLYT predictive system also occurred each day 26-29 Apr. Maintenance applications, applied throughout the season with a commercial airblast sprayer at 100 gal per acre, included Ambush 2E, Dipel 2X, Guthion 3F, Lannate, Penncap-M, Nova, Captan 50W, Ziram 76 and calcium chloride. Insecticides specific for leafhopper control were avoided in the post-bloom period to encourage white apple leafhopper population and possible secondary spread of fireblight throughout May.

With warm temperatures favoring rapid blight development the week after inoculation, blossom infection was evident 1 May. Although there was more than a two-fold difference in the mean percent of individual inoculated blossoms infected, treatment differences were not significant ($p = 0.05$). Treatment effects were more significant in counts of inoculated clusters and strikes throughout the tree on parts not directly inoculated. Agri-mycin 4 oz and Agri-mycin 4 oz + Kocide DF significantly reduced the percent of inoculated blossom clusters infected compared to no treatment and the water check. All treatments significantly reduced secondary infection as indicated by non-inoculated strikes per tree on Rome and Golden Delicious. On Rome treatments or combinations involving streptomycin had the fewest strikes. Agri-mycin 4 oz + Regulaid was significantly more effective than the Aliette treatments and Kocide DF, Kocide LF and Basicop. There were no significant differences among the copper treatments applied without streptomycin, between the two Aliette rates, or between any of the treatments involving streptomycin including combinations with Regulaid and LI-700. All treatments involving copper significantly increased the amount of russet on Golden Delicious, causing a significant downgrading of fruit compared to untreated or water-treated checks. Among treatments involving copper, significantly fewer fruit were downgraded to utility grade by Kocide LF and by Agri-mycin + COCS than by COCS alone or by Agri-mycin + Kocide DF. Copper treatments had little effect on fruit finish of Rome. Treatments of Agri-mycin 4 oz alone or in combination with LI-700 or Aliette significantly increased the russet rating compared to the water treatment.

Table 4. Evaluation of protective treatments for fire blight control on Rome Beauty and Golden Delicious

Treatment and rate/100 gal dilute	% of inoculated Rome blossoms or clusters infected: blossoms 3 May	clusters 23 May	Mean non-inoculated strikes/tree 23 May: Rome	Golden Del.	Fruit finish ratings (0-5)*: Opalescence Rome	russet: Rome	G.Del.	% G.Del. fruit in USDA grade**: Extra Fancy and Fancy	Utility
No treatment	28.7 a	97.5 c	36.3 g	4.3	1.5 ab	1.7 bc	2.2 ab	66 ab	2 a
Water only	26.4 a	97.5 c	21.5 fg	0.8	1.7 ab	1.5 abc	1.8 a	75 ab	0 a
Agri-mycin 17 8.0 oz	23.3 a	72.5 abc	3.5 a-e	0.0	1.2 ab	1.1 ab	2.1 ab	73 ab	0 a
Agri-mycin 17 4.0 oz	15.1 a	56.4 a	2.5 a-d	0.0	1.5 ab	1.2 ab	2.4 bc	67 abc	3 a
Agri-mycin 17 4.0 oz + Regulaid 1.0 pt	22.3 a	67.5 abc	2.3 a	0.0	1.3 ab	1.4 abc	2.0 ab	74 ab	1 a
Agri-mycin 17 4.0 oz + LI-700 1.0 pt	23.8 a	85.0 abc	4.0 a-e	0.0	1.0 a	0.9 a	2.5 bcd	60 bcd	4 a
Aliette 80WG 20.0 oz + Potassium Carbonate 12.0 oz	24.8 a	91.4 bc	11.8 c-f	1.0	1.6 ab	1.5 abc	2.3 ab	68 ab	4 a
Aliette 80WG 10.0 oz + Potassium Carbonate 6.0 oz	29.2 a	87.5 abc	10.0 b-f	0.0	1.1 a	1.3 abc	1.9 ab	76 a	0 a
Agri-mycin 17 4.0 oz + Aliette 80WG 10.0 oz	21.1 a	80.0 abc	3.0 abc	0.0	1.1 a	1.3 ab	2.3 bc	6 ab	3 a
Kocide DF 4.0 oz	16.5 a	90.4 bc	11.5 def	0.0	2.0 b	1.9 c	3.4 ef	18 e	22 bc
Kocide LF 5.3 fl oz	23.8 a	92.5 c	13.3 ef	0.5	1.6 ab	1.5 abc	2.9 de	39 de	10 ab
COCS 50WDG 3.2 oz	19.9 a	92.5 bc	8.8 a-f	0.8	1.5 ab	1.6 abc	3.5 f	18 e	29 c
Basicop 53W 3.0 oz	22.5 a	90.0 bc	14.0 def	0.0	1.4 ab	0.9 a	3.5 ef	22 e	20 bc
Agri-mycin 17 4.0 oz + Kocide DF 4.0 oz	19.6 a	59.2 ab	4.0 a-e	0.0	1.7 ab	1.3 abc	3.1 ef	32 e	31 c
Agri-mycin 17 4.0 oz + COCS 50WDG 3.2 oz	13.6 a	69.5 abc	2.5 ab	0.0	1.1 a	0.9 a	2.9 cde	41 cde	11 ab

Mean separation by Waller-Duncan K-ratio t-test ($p = 0.05$). Strike counts transformed by the formula, square root $(X + 0.5)$ for analysis.

* Rated on a scale of 0-5 excluding presumed mildew russet (0 = perfect finish; 5 = severe russet or opalescence).
**Percentage of fruit in indicated USDA grades after down-grading by russet.

APPLE (*Malus domestica* 'Red Delicious', 'Golden Delicious', 'Rome Beauty')
Scab; *Venturia inaequalis*
Sooty blotch; *Gloeodes pomigena*
Fly speck; *Zygophiala jamaicensis*
Rot complex

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SUMMER DISEASE CONTROL BY MIXTURES OF REGISTERED FUNGICIDES AND ADJUVANTS, 1994: Nine treatments involving mixtures of captan and ziram and selected adjuvants were compared as cover sprays on 5-yr-old three-cultivar tree sets in a four-replicate randomized block. Treatments were applied dilute to the runoff point with a single nozzle handgun at 200 psi 18 May, 25 May, 12 Jul, 26 Jul and 10 Aug. The test trees had not received a fungicide application prior to initiation of the treatment series, resulting in scab lesions in the trees and relatively heavy inoculum for additional fruit infection 25 May, 11 Jun and 16 Jun. Treatments were not applied during June because rainfall and total cumulative wetting hours were light. A 25-fruit sample was harvested 29 Sep (Red Delicious and Golden Delicious) or 11 Oct (Rome) and disease and fruit finish ratings were conducted after 3-4 wks storage at 2C.

Applications of captan + ziram + Nu-Film-17 on 18 and 25 May resulted in a significant reduction of scab on Red Delicious fruit compared to untreated trees. Sooty blotch and fly speck did not appear on untreated Golden Delicious trees until late August and, under relatively light disease pressure, all treatments gave significant control. Treatment differences appeared in incidence of rots on Rome. The best rot control was provided by the highest rates of captan, ziram, captan + ziram and by lower rates of captan + ziram in combination with Topsin-M. Although significant treatment differences did not appear with individual diseases and cultivars, fruit treated with captan 2 lb or captan + ziram + Topsin-M had the lowest incidence of fruit with summer diseases, considering sooty blotch, fly speck and the rot complex on all cultivars. No treatment significantly affected fruit finish of any cultivar compared to trees not receiving a fungicide.

Table 5. Summer disease control on Red Delicious, Golden Delicious and Rome Beauty apple fruit

	Disease incidence (%)								
	Scab	Sooty blotch			Fly speck			Rots	
Treatment	R.Del.	R.Del.	G.Del	Rome	R.Del.	G.Del	Rome	G.Del.	Rome
No fungicide	31 b	24 b	47 b	32 b	37 b	44 b	38 b	16 b	21 c
Captan 50W 8 oz + Ziram 76DF 8 oz	18 ab	0 a	3 a	3 a	3 a	10 a	8 a	9 ab	7 ab
Captan 50W 8 oz + Ziram 76DF 8 oz + Nu-Film-17 4 fl oz	7 a	0 a	6 a	5 a	8 a	9 a	14 a	1 a	8 ab
Captan 50W 8 oz + Ziram 76DF 8 oz + LI 203-765A 4 fl oz + LI 203-765B 4 fl oz	16 ab	0 a	2 a	3 a	8 a	4 a	8 a	3 a	3 ab
Captan 50W 8 oz + Ziram 76DF 8 oz + LI 203-765A 4 fl oz + LI 203-765B 2 fl oz	14 ab	0 a	3 a	3 a	5 a	5 a	11 a	1 a	15 bc
Captan 50W 8 oz + Ziram 76DF 8 oz + Topsin-M 70W 2 oz	15 ab	0 a	0 a	0 a	1 a	5 a	5 a	1 a	2 a
Captan 50W 1 lb + Ziram 76DF 1 lb	16 ab	0 a	10 a	1 a	4 a	11 a	3 a	3 a	2 a
Captan 50W 2 lb	14 ab	0 a	0 a	1 a	3 a	3 a	2 a	4 a	0 a
Ziram 76DF 2 lb	11 ab	0 a	2 a	0 a	1 a	4 a	9 a	2 a	3 ab
Ziram Granuflo 76DF 2 lb	12 ab	1 a	4 a	0 a	5 a	8 a	4 a	3 a	0 a

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

APPLE (*Malus domestica* 'Oregon Spur Red Delicious', 'Redchief Red Delicious')
Leaf blotch; *Alternaria mali*

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CONTROL OF ALTERNARIA LEAF BLOTCH IN A COMMERCIAL RED DELICIOUS APPLE ORCHARD, 1993-1994: Alternaria blotch control tests were conducted in a commercial orchard with a 4-yr history of the disease near Wytheville, VA. The treatments were applied at 150 gal/A as supplemental treatments to the grower's regular spray schedule. Each treatment was applied to both sides of one test row which included four trees of each Red Delicious strain and to one side of adjacent border rows. In 1993 approximately 50% of the leaves were infected 28 Jun and supplemental treatments were applied 16 Jul, 30 Jul and 13 Aug. The 1994 test plots were established on orchard rows which had not received supplemental treatments in 1993. On 28 Jun 94 pretreatment counts showed 76% of Redchief leaves infected with 5.1 lesions per leaf and Oregon Spur with 62% disease incidence and 2.2 lesions per leaf. The 1994 treatments were applied 1 Jul, 16 Jul and 1 Aug. The regular maintenance program, applied uniformly to the entire orchard block, included registered fungicides and insecticides, five miticide applications in 1993 and four miticide applications in 1994. Leaf counts represent averages of 10 terminal shoots from each of four trees 25-27 Aug 93 and 1-2 Sep 94. In 1994 infected leaf area was rated on the Barrat-Horsfall rating system and ratings were converted to percentages for statistical analysis. In 1994 soluble solids and firmness were recorded on 10-fruit samples harvested 1 Sep and stored 5 days at 4C.

With light disease pressure and a delay of the first treatment until 16 Jul in 1993, supplemental Rovral treatments significantly reduced lesions per leaf on both Red Delicious strains and reduced severity (% leaves with < 6 lesions) on Redchief. Lorsban had no positive control effect and significantly increased the number of lelsions on Redchief. Under heavier disease pressure, but earlier initiation of the treatment series in 1994, the three supplemental applications of Rovral + oil and EXP 10566A nearly eliminated defoliation and significantly reduced % remaining leaves infected with *Alternaria* compared to trees not receiving supplemental treatments. Rovral + oil had significantly fewer leaves infected than EXP 10566A, but there was no significant difference in the amount of defoliation on the treated trees. Rovral + oil significantly improved firmness of Redchief, but not Oregon Spur fruit. No significant difference could be shown in soluble solids content. The severity of the disease pressure in 1994 is shown by the fact that, of the more than 1200 leaves in the samples from the non-treated test row, none were without an *Alternaria* lesion.

Table 6. Control of Alternaria leaf blotch by supplemental treatments in a commercial apple orchard, Crockett, VA

Test 1, 1993

Supplemental treatment and rate per acre*	Alternaria leaf blotch** Oregon Spur Red Delicious lesions per leaf	% leaves uninfected	% lvs with < 6 lesions	Redchief Red Delicious lesions per leaf	% leaves uninfected	% lvs with < 6 lesions
None	16.7 b	4.8 a	29.9 a	6.4 b	16.2 ab	56.1 b
Rovral 4F 2 pt/A + Latron CS-7 1 pt/100 gal	11.4 a	4.6 a	30.9 a	3.8 a	24.8 a	75.9 a
Lorsban 50W 3 lb/A	17.1 b	2.7 a	22.7 a	10.9 c	7.1 b	35.1 c

Mean separation by Waller-Duncan K-ratio t-test. Averages of 10 shoots from four replicate trees of each Red Delicious strain 25-27 Aug.

Test 2, 1994

Supplemental treatment and rate per acre*	Redchief Red Delicious % defoliation	% remaining leaves infected	% remaining leaf area affected	Pressure test (Kg/cm^2)	Oregon Spur Red Delicious % defoliation	% remaining lvs inf with Alternaria	% area of remaining leaves affected
None	43.3 b	100.0 c	61.6 b	8.04 b	29.0 b	100.0 c	51.3 b
Rovral 4F 1 qt + 70 sec oil 0.125%	3.1 a	42.1 a	2.7 a	8.89 a	6.4 a	43.3 a	2.6 a
EXP 10566A 2.33SC	3.9 a	64.1 b	3.9 a	8.20 b	5.5 a	76.2 b	4.6 a

Mean separation by Waller-Duncan K-ratio t-test (p = 0.05). Averages of 10 shoots from four replicate trees of each Red Delicious strain 1 Sep 94.

APPLE (*Malus domestica*)
Cedar-apple rust;
Gymnosporangium juniperi-virginianae
Powdery mildew; *Podosphaera leucotricha*

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SUSCEPTIBILITY OF SCAB-RESISTANT APPLES TO CEDAR-APPLE RUST AND POWDERY MILDEW, 1992-94: Scab-resistant apple cultivars and selections considered to have potential for the mid-Atlantic processing market were planted at the Virginia Tech Ag. Research and Extension Center near Winchester, VA in 1990. The long-term objective is to study susceptibility of these cultivars to other diseases, particularly powdery mildew, the rusts and summer diseases. The planting was established on M27 rootstock in four randomized blocks in two rows spaced at 30 ft. In-row spacing of the resistant cultivars is 10 ft. Two of the blocks were interplanted with Jonagold/M26 or GingerGold/M26 in 1991 to help stabilize mildew inoculum pressure. The test planting receives dormant copper sprays and streptomycin bloom sprays for fireblight control and routine insecticides. No fungicides were applied 1990-93. Sulfur APK 1 lb/100 gal dilute was applied to the entire planting 3 Jun and 30 Jun 94 to reduce mildew pressure. Disease developed from inoculum naturally present for mildew in the test area in 1992-94 and for rust in 1992. Rust galls were placed around each test tree in 1993 and 1994.. Disease ratings were conducted 13-14 Jul 92, 9 Aug 93, and 19 Aug 94 by evaluating all the leaves on four terminal shoots from each replicate tree.

Under moderate rust inoculum pressure, the cultivars Redfree, Liberty, Dayton, Enterprise, and Williams' Pride and several unnamed selections were highly resistant to foliar infection. GoldRush, Jonafree, Co-op 25, Co-op 31 and Co-op 36 were moderately susceptible to foliar rust infection. Jonafree, Liberty, Williams' Pride, Dayton and Enterprise remained relatively resistant to mildew infection throughout the 3-yr rating period, but Co-op 29 and selections CLR13T45, HFR31T91 and PAR9T70 were quite susceptible to foliar mildew infection. Dayton, Enterprise, Liberty, Williams' Pride, and selections NY 73334-35, NY 75413-30, HFR19T127, HFR17T96, HCR23T113 and PAR23T209 had less than 5% of the leaves infected with cedar-apple rust and 5% or less of the leaf area affected by powdery mildew throughout the 3-yr period. Named cultivars or Co-op selections which had 25% or more of the leaves infected with powdery mildew in 1992, 1993, or 1994 were Redfree, Pristine, Co-op 25, Co-op 27, Co-op 29 and Co-op 31. The trees began to fruit in 1993 and, without artificial summer disease inoculum in the test area, no unusual susceptibilities to rots, sooty blotch or fly speck have been recognized. Fruit susceptibility to these diseases will continue to be evaluated as the trees produce more fruit.

	Leaves with infection (%)						Mildew, % leaf area affected		
	cedar-apple rust			mildew					
Cultivar/selection	1992	1993	1994	1992	1993	1994	1992	1993	1994
Cultivars									
Dayton	4 abc	0 a	0 a	5 ab	4 abc	13 a-d	1 a	1 a	2 ab
Enterprise	1 a	0 a	0 a	8 ab	9 a-d	17 a-e	2 a	2 a	3 ab
GoldRush	13 d-g	11 bcd	25 d	18 a-d	47 gh	0 a	9 ab	33 abc	0 a
Jonafree	11 c-g	7 b	19 cd	4 a	2 a	13 a-d	2 a	1 a	3 ab
Liberty	0 a	0 a	0 a	18 a-d	21 a-e	10 abc	4 a	2 a	2 ab
Redfree	0 a	0 a	0 a	7 ab	15 a-e	39 fg	2 a	2 a	36 c
Pristine	14 efg	0 a	0 a	12 a-d	34 e-h	43 gh	4 a	10 a	35 bc
Williams' Pride	1 a	0 a	0 a	8 ab	20 a-e	14 a-e	2 a	3 a	2 ab
Advanced selections									
Co-op 25	18 g	11 bcd	24 d	11 ab	28 c-g	7 abc	3 a	8 a	2 ab
Co-op 27	6 a-e	0 a	0 a	11 abc	28 d-g	26 b-g	4 a	7 a	10 bcd
Co-op 29	1 a	0 a	0 a	47 f	45 fgh	30 c-g	39 c	22 ab	11 bcd
Co-op 31	13 efg	9 bc	8 ab	9 ab	33 e-h	36 efg	3 a	24 ab	27 bcd
Co-op 36	7 a-e	14 cd	23 cd	38 ef	24 a-f	14 a-e	36 bc	3 a	2 ab
NY 73334-35	1 a	0 a	0 a	12 a-d	24 a-f	11 abc	2 a	5 a	2 ab
NY 75413-30	1 a	0 a	0 a	9 ab	21 a-e	20 a-f	2 a	4 a	5 ab
Selections from the Purdue Collection									
CLR13T45	0 a	0 a	0 a	31 def	55 h	35 d-g	11 ab	60 c	16 bcd
HCR23T113	0 a	0 a	0 a	6 ab	20 a-e	12 abc	2 a	2 a	2 ab
HFR17T96	0 a	0 a	0 a	12 a-d	11 a-e	18 a-e	2 a	2 a	2 ab
HFR19T127	0 a	0 a	0 a	10 ab	3 ab	0 a	3 a	1 a	0 a
HFR31T91	1 a	0 a	0 a	24 b-e	52 h	61 h	19 abc	46 bc	74 d
OR53T43	14 efg	16 d	2 a	12 a-d	26 b-g	14 abc	4 a	8 a	3 ab
PAR9T70	15 fg	14 cd	14 bc	30 c-f	48 gh	23 a-g	24 abc	33 abc	4 ab
PAR23T209	7 a-e	7 b	16 bcd	7 ab	0 a	0 a	2 a	0 a	0 a
PWR36T242	3 ab	0 a	0 a	8 ab	28 d-g	4 ab	3 a	11 a	1 a

Averages of all leaves on four shoots from two-four single tree replicates 13-14 Jul 92, 9 Aug 93, and 19 Aug 94.
Mean separation by the Waller-Duncan K-ratio t-test (p = 0.05).

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

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POSTHARVEST TREATMENTS FOR CONTROL OF APPLE ROTS UNDER ARTIFICIAL INOCULATION AND COMMERCIAL STORAGE INOCULUM CONDITIONS, 1993-94: In Test 1, fruit grown under a commercial spray schedule were selected for uniformity after 72 days in commercial cold storage, surface sterilized by dipping 1 minute in 200 ppm sodium hypochlorite, allowed to dry overnight, wounded in three places 5 mm deep with a 6 mm diameter dowel rod, and dip-treated 30 seconds. Treated fruit were placed on fiber trays to dry then mist inoculated with either benzimidazole-sensitive *Penicillium expansum* (2 X 10^4 conidia/ml) or *Alternaria alternata* (1 X 10^5 conidia/ml) and the tray containing the inoculated fruit was enclosed in a polyethylene bag for cold storage and incubation. Fruit were evaluated for rot incidence after 46 days' storage at 1C and again after an additional 13 days incubation at 21C. In Test 2, uniformly ripe Golden Delicious fruit grown under a commercial spray program were removed from cold storage, surface sterilized by dipping 1 min in 200 ppm sodium hypochlorite, allowed to dry overnight, wounded in three places with a 6 mm dowel rod, dipped 30 seconds in the treatment, and placed in open-sided plastic storage containers. The storage containers were randomly palletized so that one side of each open container was exposed to ambient commercial storage conditions. Test 2 fruit were evaluated for rot incidence after 83 days incubation at 1C and again after an additional 6 days' incubation at 13-18C.

In Test 1 treatments with Rovral, Rovral + Mertect, Mertect, or EXP 10412A gave excellent control of blue mold on fruit inoculated with benzimidazole-sensitive *Penicillium.* Nu-Coat and DPA did not effectively control blue mold under these test conditions. Alternaria rot incidence on inoculated fruit was lower than expected but increased somewhat after further incubation at warmer temperatures. Rovral and EXP 10412A gave complete control of *Alternaria* rot, and Mertect near complete control under light disease pressure. Nu-Coat and DPA were ineffective when applied separately but gave a significant reduction in Alternaria when applied in combination. In Test 2 only Mertect + captan and Nu-Coat + DPA gave significant suppression of the rot complex compared to the water check. Mertect + captan was the only treatment that significantly suppressed blue mold infection under natural inoculum conditions in which benzimidazole-resistant inoculum is common. No treatment significantly suppressed *Penicillium* growth progression into the fruit or percent fruit infected with rots other than blue mold and there were no significant differences in percent of unrotted fruit.

Table 7. Postharvest treatments for rot control on Golden Delicious apples, 1993-94

Test 1. Penicillium blue mold and Alternaria rot control on inoculated Golden Delicious apples

Treatment and rate per 100 gallons	Blue mold incidence after 46 days at 1C: % fruit infected	Blue mold incidence after 46 days at 1C: % wounds infected	Alternaria rot after 46 days at 1C: % fruit infected	Alternaria rot after 46 days at 1C: % wounds infected	Alternaria rot after 46 days at 1C + 13 days at 21C: % fruit infected	Alternaria rot after 46 days at 1C + 13 days at 21C: % wounds infected
Water	99 b	94 c	6 b	2 a	12 c	6 c
Rovral 50W 2.0 lb	0 a	0 a	0 a	0a	0 a	0 a
Rovral 50W 2 lb + Mertect 340-F 8 fl oz	0 a	0 a	0 a	0 a	0 a	0 a
Mertect 340-F 16.0 fl oz	3 a	1 a	0 a	0 a	1 a	0 a
EXP 10412A 4.73 SC 600 ml	0 a	0 a	0 a	0 a	0 a	0 a
Nu-Coat 1.6% 1.64 gal	99 b	76 b	4 ab	2 a	9 bc	3 abc
Nu-Coat 1.6% 1.64 gal + DPA 1000 ppm (2.5 pt)	99 b	91 c	2 ab	1 a	3 ab	1 ab
DPA 1000 ppm (2.5 pt)	99 b	92 c	5 ab	2 a	10 bc	4 bc

Average of four replications of 25 fruit. Mean separation by Duncan's Multiple Range Test (p = 0.05).

Test 2. Development of apple rots from commercial cold storage inoculum conditions

Treatment and rate per 100 gallons	Rots after 83 days at 1C: % rotted fruit	Rots after 83 days at 1C: % wounds infected	After 83 days at 1C and 6 days at 13-18C, blue mold: % fruit infected	After 83 days at 1C and 6 days at 13-18C, blue mold: mm rot progression	After 83 days at 1C and 6 days at 13-18C: % fruit infected with rots other than blue mold	After 83 days at 1C and 6 days at 13-18C: % unrotted fruit
Water only	74 c	41 ab	60 b	16.5 a	44 a	14 a
Nu-Coat 1.6% 1.64 gal	62 abc	39 ab	50 ab	16.1 a	48 a	25 a
DPA 1000 ppm 2.5 pt	68 bc	42 b	53 ab	16.1 a	38 a	24 a
Nu-Coat 1.6% 1.64 gal + DPA 1000 ppm 2.5 pt	50 ab	28 ab	55 ab	15.9 a	35 a	27 a
DPA 1000 ppm 2.5 pt (fruit allowed to dry) Nu-Coat 1.6% 1.64 gal	61 abc	31 ab	55 ab	16.8 a	51 a	16 a
Mertect 340F 1 pt + Captan 50W 1.0 lb	44 a	24 a	31 a	16.2 a	45 a	37 a

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

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

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EFFECTS OF PRE-HARVEST FUNGICIDE TREATMENTS ON PRE-HARVEST AND POSTHARVEST DISEASE DEVELOPMENT ON REDSKIN PEACH, 1994: Following a loss of most Winchester-area peach crops to winter bud kill, pre-harvest fungicide test plots were established in a mature commercial orchard with a light crop. Prior to establishment of the test plots the entire orchard had been sprayed with sulfur and an insecticide on a minimal commercial schedule. Overwintering brown rot mummies were numerous in the unpruned test trees. Dilute treatments were applied to the point of runoff (approximately 200 gal/A) with a single nozzle handgun at 200 psi in a randomized block design with four replicates composed of one to four trees each. Treatments were applied as 3-wk and 1-wk preharvest sprays 2 Aug and 16 Aug. Brown rot was rated on the tree 22 Aug by scanning 25 fruit per replicate. Fruit were harvested 23 Aug and 20 apparently rot-free fruit per replicate were selected for uniform ripeness, placed on fiber trays, and incubated in polyethylene bags at ambient temperature 16-26C. All fruit with rot symptoms were removed from the sample unit at each evaluation interval.

During the 3-wk preharvest period, 5.6 inches of rain and 116 hr of wetting and heavy brown rot inoculum contributed to strong test conditions.All registered pre-harvest treatments gave a significant reduction of brown rot incidence on the tree. Botran was significantly weaker than Orbit, Rovral, Topsin-M + Captan, and experimentals RH-7592, EXP 10566A, and EXP 10370B. Among the most effective materials for postharvest brown rot control were EXP 10566A (29 fl oz), Orbit and Elite. Treatments which were weak for postharvest brown rot suppression were Nova, Botran and Topsin-M + Captan. Testing of isolates from fruit treated with Topsin-M + Captan indicated that 10% were resistant to 5 ppm benomyl, possibly explaining the poor correlation between pre-harvest and postharvest control by this treatment. Rhizopus rot was significantly suppressed after six days postharvest by all treatments except Nova and RH-7592. After 8 days' incubation only several Rovral treatments significantly suppressed Rhizopus rot. Control of brown rot and Rhizopus rot was not significantly improved by adding Latron CS-7 or 70 sec oil to pre-harvest applications of Rovral 4SC.

Table 8. Effects of pre-harvest treatment on pre-harvest and postharvest disease development in Redskin peach

Treatment and rate per 100 gallons dilute*	Brown rot %, 1 day pre-harvest	Disease incidence (%), indicated days postharvest					
		Brown rot			Rhizopus rot		
		3 days	6 days	8 days	3 days	6 days	8 days
No pre-harvest fungicide	63 c	56 d	99 c	100 d	5 a	26 d	28 cd
Nova 40W 2.5 oz	4 ab	34 bcd	86 c	93 cd	3 a	18 cd	18 abc
RH-7592 75W 1.0 oz + Latron B-1956 4.0 fl oz	1 a	14 ab	41 ab	50 ab	1 a	15 bcd	28 cd
Elite 45DF 2.0 oz	7 ab	5 a	23 a	41 a	1 a	6 abc	19 abc
Orbit 3.6E 2.0 fl oz	2 a	9 a	21 a	35 a	3 a	14 abc	30 d
EXP 10566A 2.2SC 14.5 fl oz	0 a	17 abc	44 ab	63 ab	1 a	14 abc	26 cd
EXP 10566A 2.2SC 29.0 fl oz	1 a	5 a	11 a	26 a	0 a	6 abc	19 abc
EXP 10370B 50WG 1.0 pt + Latron CS-7 1.0 pt	1 a	5 a	29 ab	51 ab	0 a	6 abc	14 abc
Botran 75W 1.5 lb	13 b	40 cd	98 c	100 d	5 a	14 abc	14 abc
Rovral 4SC 1 pt + Latron CS-7 1 pt	6 ab	24 abc	50 ab	63 ab	0 a	8 abc	11 ab
Rovral 4SC 1 pt + 70 sec oil 1 pt	4 ab	13 ab	21 a	40 a	0 a	4 ab	18 abc
Rovral 4SC 1 pt + 70 sec oil 1 qt	5 ab	14 ab	38 ab	52 ab	0 a	8 abc	15 abc
Rovral 4SC 1 pt + 70 sec oil 1 gal	3 ab	16 abc	33 ab	44 ab	0 a	3 a	11 ab
Rovral 4SC 1 pt	2 a	19 abc	41 ab	56 ab	1 a	4 ab	8 a
Topsin-M 70W 4 oz + Captan 50W 1 lb	0 a	21 abc	59 b	76 bc	0 a	13 abc	15 abc

Averages of four replicates composed of one to four trees each.
Mean separation by Waller-Duncan K-ratio t-test (p = 0.05).

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

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EFFECTIVENESS OF POSTHARVEST DIP TREATMENTS FOR CONTROL OF BROWN ROT AND RHIZOPUS ROT, 1993: Uniformly ripe fruit were randomly selected from a pooled sample taken from trees which had not received any fungicide throughout the growing season. Fruit of each of the four 25-fruit replicates were wounded to a depth of 6 mm with a 6 mm dowel rod and then either dipped in de-ionized water (non-inoculated, Table 1) or inoculated by dipping in a spore suspension of 10,000 M. fructicola (Table 2) or Rhizopus spores/ml (Table 3). Following the submersion in water or an inoculum suspension, fruit were dipped 20 seconds in the treatment, allowed to dry on fiber packing trays placed in polyethylene bags, boxed and placed in a commercial cold storage at 2C for 33 days. After cold storage the bagged fruit were incubated at 13-20C for the indicated period before rot assessment.

On untreated, non-inoculated fruit there was considerable development of brown rot within two days after removal from cold storage and some Rhizopus rot within 6 days. All treatments gave excellent control of brown rot through 3 days and had broken down equally by 6 days. Under light Rhizopus pressure on non-inoculated fruit all treatments gave good to excellent control through 6 days out of cold storage. Heavier brown rot pressure on Monilinia-inoculated fruit (Table 2) brought earlier, higher rot incidence on water-dipped and Botran-treated fruit, but the other treatments remained equally effective and were not significantly better than Botran after 6 days. A low incidence of Rhizopus appeared in the set of fruit which was inoculated with Monilinia. None was present on the water-dipped fruit of this set after 6 days and the apparent significant effect by EXP 10412A + DECCO 251 compared to Rovral + DECCO 251 or Botran is questionable. Rhizopus inoculation also increased rot pressure (Table 3). All treatments gave excellent control through 3 days, but began to break down by 8 days. Botran was significantly more effective than Rovral + DECCO 251 after 8 days. The Rovral + DECCO 251 treatment was also weaker as evidenced by total rots (Rhizopus and mostly brown rot) after 8 days.

Table 1. Disease incidence on non-inoculated Loring peach fruit, indicated days after removal from cold storage

Treatment and formulated rate per 100 gallons	% Brown rot 2 days	% Brown rot 3 days	% Brown rot 6 days	% Rhizopus rot 2 days	% Rhizopus rot 3 days	% Rhizopus rot 6 days
Water	40 b	62 b	100 b	0 a	13 b	22 b
Rovral 50WG 2.0 lb	0 a	0 a	59 a	0 a	0 a	0 a
EXP 10412A 4.73SC 20.3 fl oz	0 a	0 a	63 a	0 a	0 a	2 a
EXP 10412A 4.73SC 20.3 fl oz + DECCO 251 5.0 gal	1 a	1 a	61 a	0 a	0 a	1 a
Rovral 50WG 2.0 lb + DECCO 251 5.0 gal	0 a	0 a	78 a	0 a	0 a	5 a
Botran 75W 1.0 lb	2 a	2 a	66 a	0 a	0 a	2 a

Averages of four replications, 25 fruit per replication.
Mean separation by Duncan's Multiple Range Test (p = 0.05).

Table 2. Disease incidence, indicated days after removal from cold storage, on Loring peach fruit inoculated with *Monilinia fructicola*.

Treatment and formulated rate per 100 gallons	% Brown rot 2 days	% Brown rot 3 days	% Brown rot 6 days	% Rhizopus rot 2 days	% Rhizopus rot 3 days	% Rhizopus rot 6 days
Water	100 c	100 c	100 b	0 a	0 a	0 a
Rovral 50WG 2.0 lb	0 a	0 a	77 a	0 a	0 a	3 ab
EXP 10412A 4.73SC 20.3 fl oz	0 a	0 a	62 a	0 a	0 a	1 ab
EXP 10412A 4.73SC 20.3 fl oz + DECCO 251 5.0 gal	0 a	0 a	89 ab	1 a	1 a	0 a
Rovral 50WG 2.0 lb + DECCO 251 5.0 gal	0 a	0 a	78 ab	0 a	0 a	5 b
Botran 75W 1.0 lb	20 b	67 b	83 ab	0 a	0 a	5 b

Averages of four replications, 25 fruit per replication.
Mean separation by Duncan's Multiple Range Test (p = 0.05).

Table 3. Disease incidence, indicated days after removal from cold storage, on Loring peach fruit inoculated with *Rhizopus*.

Treatment and formulated rate per 100 gallons	% Brown rot 2 days	% Brown rot 3 days	% Brown rot 8 days	% of fruit with any rot, 8 days*
Water	81 b	93 b	100 c	100 b
Rovral 50WG 2.0 lb	0 a	0 a	15 ab	68 a
EXP 10412A 4.73SC 20.3 fl oz	0 a	0 a	25 ab	59 a
EXP 10412A 4.73SC 20.3 fl oz + DECCO 251 5.0 gal	0 a	0 a	20 ab	77 a
Rovral 50WG 2.0 lb + DECCO 251 5.0 gal	0 a	0 a	28 b	94 b
Botran 75W 1.0 lb	2 a	2 a	13 a	77 a

Averages of four replications, 25 fruit per replication.
Mean separation by Duncan's Multiple Range Test (p = 0.05).
*Includes Rhizopus and brown rot and possibly other background rots. These were combined because Rhizopus quickly grows over other rots, making them indistinguishable.

Entomology

"Strawberry Thrips Plague of 1994"

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Abstract: A highly unusual late invasion of flower thrips, *Frankliniella tritici*, occurred in strawberries the northeast in the spring of 1994. Many growers from Maryland to Illinois who did not apply insecticide applications for plant bug or meadow spittlebug suffered 50-100% losses. Scouting and control recommendations are discussed.

Introduction: Formally known as the "strawberry thrips" (Slingerland & Crosby 1924), the flower thrips, *Frankliniella tritici*, is an eastern species, unofficially known as the 'eastern flower thrips', that has been reported to injure numerous horticultural crops (Stannard 1968). This species is not to be confused with the western flower thrips, *F. occidentalis*, which has recently become established in the east, and is widespread in Pennsylvania (Felland et al. 1994). As opposed to the western flower thrips, flower thrips does not generally overwinter in the northeast, but rather is thought to reinfest from the southeast on frontal systems in the spring (Stannard 1968).

Injury to strawberries by the flower thrips was documented by Forbes (1892) in Illinois, who described an experiment conducted April 23, 1889 in year of heavy thrips invasion. He observed two plants in his office, one infested (from cherry and pear blossoms) and the other a control. Injury occurred in "a short time...first as brownish, and later as blackish, specks upon the pistil and filaments of the anthers, then upon the bases of the petals, and finally even upon the calyx and flower stem. All these parts gradually blackened and withered, the flowers sometimes drying up completely...As the injury began before it was possible for the seed to have been fertilized, its effect to blast the flower was evident; and as the botonists tell us that the receptacle of the strawberry will not swell out to form the fruit unless the seed develops, the connection of the Thrips with the so-called 'buttoning' seems beyond dispute." Quaintance (1897) described similar injury in Florida. He stated "The bloom of the strawberry plant seems to be a favorite food for this insect, and unfortunately, its effects upon these particular flowers are much more severe than on many others which it infests. In the strawberry, however, the attack on the pistil, if severe, will result in the destruction of the bloom."

Allen & Gaede (1963) documented injury by western flower thrips on strawberries in California. They placed 10 adults per blossom through petal fall in a greenhouse test, but saw no fruit injury. However, they reported that 10 or more adults per blossom in the field could result in destruction of some of the smaller flowers. They also reported field observations of "moderate" populations causing scarring under the calyx and abnormal brown areas around the seeds, without causing serious losses, and of "very high" populations that resulted in a golden brown discoloration of the entire fruit surface and "definitely warrant(s) the application of insecticides for control of thrips." Western flower thrips can be a limiting factor in greenhouse strawberry production. M. Pritts (Cornell) and D. Handley (Univ. Maine) both report injury to strawberries including small, bronzed fruit as a results of severe thrips infestion in the greenhouse.

What constitutes a 'severe' infestation has not been clearly documented. Populations in the northeast in recent years have gone largely unnoticed in strawberry. However, in 1994 thrips were associated with substantial yield losses in strawberry in parts of Maryland, New Jersey, Pennsylvania, Ohio, Indiana, and at least as far west as Illinois. In this report we discuss the observations of injury, losses, and control options for the flower thrips in strawberries in Pennsylvania and surrounding region.

Materials and Methods: Extension calls concerning losses of strawberries attributed to thrips were recorded. A survey was sent to representative growers to further define the extent and timing of the injury and the effects of insecticide applications. Monitoring and control options for flower thrips on strawberry are discussed.

Results and Discussion: In Maryland, G. Dively and R. Heflebower confirmed thrips injury on strawberries early during the outbreak noting thrips associated with scarring under the sepals. Injury was more common in western and northern Maryland than in southern Maryland and the eastern shore. They noted cool weather during green berry development but that temperatures were not low enough to activate the sprinkler system.

Sixteen eastern Pennsylvania strawberry growers with a total of 48 acres responded to survey of insect damage in 1994. Thirteen of these growers attributed substantial losses to thrips. Of the sixteen growers, ten applied no insecticide during the growing season to some part of their bearing crop, three applied carbaryl, two applied azinphosmethyl, one applied chloppyrifos, and one applied diazinon to part of his acreage. Growers who applied chloppyrifos at 10 and 50% bloom and diazinon in mid-May did not report the thrips injury. Growers who applied carbaryl reported significant losses, although one grower reported 95% control of thrips infesting sweet cherries with this material. S. Guiser (Bucks Co.) reported some growers achieved some control with carbaryl on late varieties and that chloppyrifos and endosulfan applied pre-bloom resulted in minimal thrips injury. Azinphosmethyl applied early in bloom did not give control.

Thrips injury in Pennsylvania was first noted in most survey results one week after starting to pick. At a farm with 16 acres of bearing strawberries in Noblesville, Indiana the grower saw no problems with the crop on 25 May. Then he noted injury to calyx and bronzing of fruit that occurred virtually "overnight". Examination of the blossoms under a light on the night of 1 June revealed what looked like the whole flowers were crawling because of being covered with thrips. By 17 June thrips density in clover next to strawberries at this farm averaged 9800 per sq-m. One grower in Pennsylvania reported that he "wore a yellow shirt one day in the field and was swarmed." Other observations from throughout the region ranged from 10 to more than 40 thrips per blossom or berry. R. Williams (OARDC) video-taped densities of ca. 30 thrips per blossom on strawberry in Ohio.

Losses for those growers attributing injury to thrips ranged from 50 to 100%. Injury in the survey results was described as fewer, smaller, seedy, dull, off-color, or bronzed berries that would not ripen properly. In some cases the berries were also catagorized as rubbery and shriveled or deformed. Some fruit failed to form at all and one grower noted that the blossom clusters stood straight up instead of dropping. This grower initially blamed cold weather, but later was convinced that it was a result of thrips injury after observing that two growers in the same county "who did not practice IPM had a normal crop." These growers "sprayed insecticide weekly from blossom to harvest."

Varietal differences were observed in thrips losses. One grower reported "almost a total loss" for 'Earliglow' but 50% losses for 'Allstar'. D. Swartz (Perry Co.) reported a grower with "almost total loss" for 'Earliglow' but 'Annopolis' in the same field was not affected.

E. Oesterling (Westmoreland Co.) reported no thrips injury, as did T. Obourn (Erie Co.) who reported instead that the black vine weevil was a major pest. Overall, thrips injury in Pennsylvania was most common in the southeast (Fig. 1).

Weather conditions were reported by some growers as ideal for strawberries, although G. Perry (Schuykill Co.) reported a hard freeze on 27 May between 5 and 6 a.m. Some of the injury appeared similar to that of drought-stressed berries, but the no moisture stress was observed.

Thrips were numerous elsewhere during this period. Severe thrips injury was observed on untreated sweet cherries from Franklin County. Thrips were observed damaging roses in Lancaster County. G. Hostetter (Juniata Co.) received a sample of thrips from a home owner's swimming pool in town on 27 May which were identified as *F. tritici*.

In contrast to low *F. tritici* and moderate *F. occidentalis* density in clover in southcentral Pennsylvania during the summers of 1992 and 1993 (Felland et al. 1994), very high densities of *F. tritici* were observed during the summer of 1994 and *F. occidentalis* was not found until September. In 1992 and 1993 average density of *F. triciti* adults per sq-m of patches of white clover was 22 throughout Pennsylvania and this species was first observed in water traps in early April, with sustained flight beginning in mid-May. Density in clover was several thousand fold higher in 1994 than in the previous years. Unfortunately water trap monitoring was discontinued in 1994.

Thrips probably began arriving as early as March and continued arriving all spring on frontal systems. R. Brandenburg (NC State) reported dry conditions with winds from the south in spring 1994, with *F. tritici* density about 5-times above average. During the period from 28 to 31 May surface winds at Biglerville, Penn. were out of the south and southwest and averaged 3 m per sec (7 mph). Potato leafhopper, which also invades annually had an early and extended invasion in 1994. Most of the early arrivals would not have had enough degree days to complete a generation in the north before the end of May. Movement, therefore, may have been directly into strawberries or from other local hosts. J. Price (Univ. Florida) notes that *Frankliniella bispinosa* is generally found in low densities in strawberry (2-4/blossom) with a sudden rapid increase (10+/blossom) coinciding with bloom phenology of the alternate hosts citrus and oak.

Thrips injury was noted in the Lancaster Farmer (11 June), the Indianapolis Star (16 June) and reported to the Senate Agricultural Committee (8 July). Some growers obtained Federal Disaster Relief Funding to compensate losses in strawberries.

Thrips can be easily scouted by placing 10 blossoms in a small ziplock bag and counting the thrips. Less than 100 thrips (10 per blossom) are not thought to cause significant losses. With more than 100 thrips or similar weather conditions as in 1994 along with high thrips populations in the south an insecticide application may be recommended. Aside from the aforementioned materials (treatments for other pests including plant bug and/or the meadow spittlebug) malathion, methoxychlor, or sulfur materials may provide control. Under some conditions Pyrellin has controlled thrips. Sprays should be applied to minimize bee kill (i.e. at night) and to optimize coverage.

Conclusion: This thrips invasion in 1994 was unusual in its severity, and in that the most damage seemed to occur early in harvest, rather than during bloom. Damage was in a large part limited to "You Pick" and other low pesticide input growers. The potential for injury in 1995 is probably not related to overwintering but to similar weather patterns and regional abundances of thrips as in 1994.

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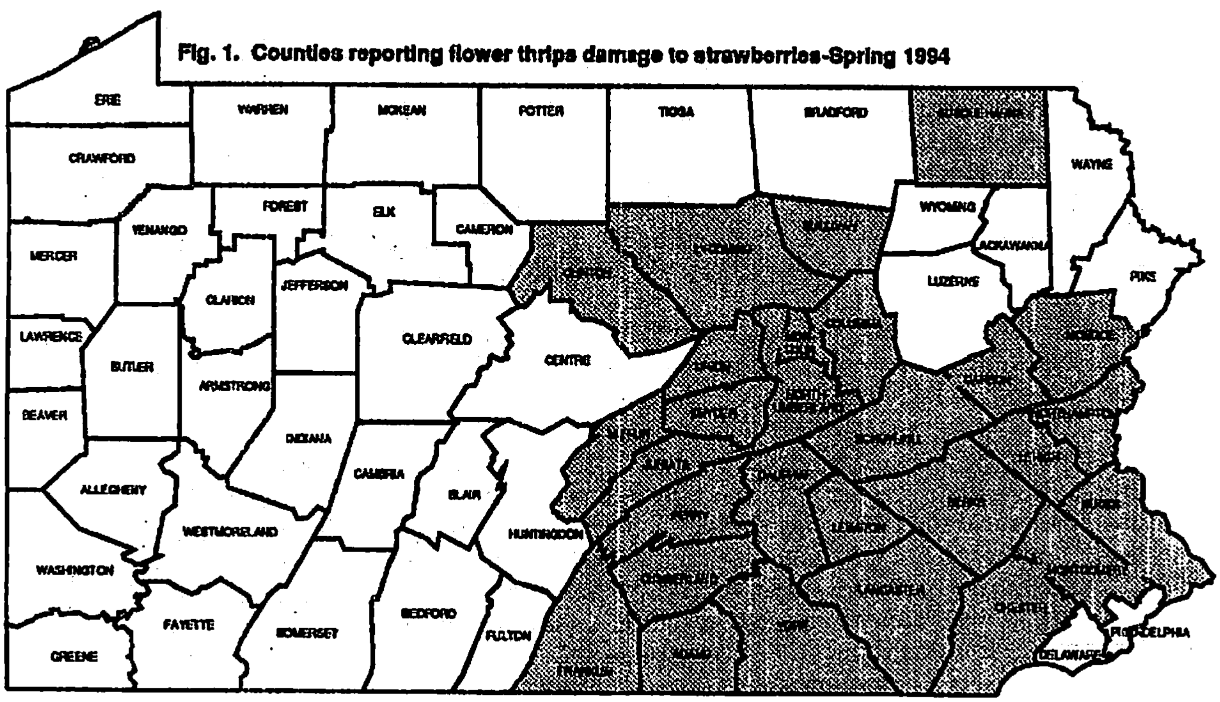
Fig. 1. Counties reporting flower thrips damage to strawberries-Spring 1994



Other states:
Maryland: Cecil and Hardford Counties
New Jersey: Warren County

Leafroller Mating Disruption in Pennsylvania

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Abstract: Mating disruption for tufted apple bud moth (TABM) and a multiple leafroller complex was evaluated in large and small plot trials in Pennsylvania. The TABM pheromone tended to perform better than generic treatments on TABM, although in sites of low leafroller pressure a generic treatment may be preferred. Dispenser placement in the canopy appears to impact the level of mating disruption of TABM.

Introduction: Mating disruption of tufted apple bud moth (TABM) conducted over three consecutive years in two orchards in Adams County has provided excellent control of TABM in the absence of broad-spectrum insecticides after petal fall. Internal fruit injury has not increased, although a slight increase in other leafroller injury has been a concern, as well as the limited nature of the observations. In 1994 we continued TABM mating disruption trials, adding a generic leafroller treatment designed to disrupt multiple leafroller species. Trials were continued for the fourth year in the aforementioned orchards and begun in four additional orchards. Small plot generic leafroller trials from 1993 and 1994 are reported, as well as small plot trials conducted in 1994 examining dispenser density and placement in the canopy.

Materials and Methods: *Fourth year large plot trials.* Full season mating disruption trials were conducted in 1994 in two orchards that had been treated with NoMate® TABM Spirals (Ecogen Inc.) at the label rate of 988/ha (49.5 g ai/ha) for the previous three years. Adjacent halves of 4 ha blocks at each orchard were treated with TABM Spirals and Generic II Spirals (Ecogen Inc.) (E11-14OH, E11-14Ac, and Z11-14Ac in a 3:3:4 ratio), both at the label rate. Dispensers were applied before sustained TABM flight to the middle third of the canopy (2.0-2.3 m; canopy height 4.5 m) at the Hall orchard and in the upper third (2.0-2.3 m; canopy height 2.9 m) at the Slaybaugh orchard. No broad-spectrum insecticides were applied to the mating disruption treatments after petal fall. The grower standard was contiguous with the treatments at the Slaybaugh orchard and was separated from both treatments by 0.2 km at the Hall orchard. Pheromone trap monitoring of TABM, variegated leafroller (VLR), redbanded leafroller (RBLR), obliquebanded leafroller (OBLR), and codling moth (CM) was conducted from late May though mid September in each orchard. Monitoring traps for TABM were placed on poles between trees in a row at 2.0 and 3.5 m in the center and along the edge of each treatment. For the other leafroller species single traps were monitored at 2.0 m in the tree canopy in the center and edge positions and for CM single traps were monitored in the center of each treatment block. Cumulative moth capture was calculated during each brood of TABM and for the season total for the other species. Densities of white apple leafhoppers (WALH), spirea aphids and aphid predators, and spotted tentiform leafminers (STLM) were determined in May, June, and July, respectively. Density of European red mites (ERM) and the mite predator *Zetzellia mali* was determined through June and July. A harvest fruit evaluation of a total of 100 apples from the upper and lower canopy and 25 dropped fruit was taken from each of 10-15 trees ('Yorking') throughout each treatment block. Only trees with a full fruit load were sampled.

First year large plot trials. First year full season mating disruption trials were conducted in four orchards in 1994. In three orchards three treatments were evaluated. Two of the treatments were TABM pheromone blends (E11-14OH and E11-14Ac in 1:1 ratio), one from Ecogen (NoMate® TABM Spirals, 988/ha, 49.5 g ai/ha) and the other from Consep

(TABM, 494/ha, 99 g ai/ha). The third treatment was a generic leafroller pheromone (E11-14OH, E11-14Ac, and Z11-14Ac in a 3:3:4 ratio) from Consep (Generic II, 494 per ha, 99 g ai /ha). Treatments were applied to contiguous 2 ha blocks in each orchard. At a fourth orchard (ACN) TABM spirals were applied to a 2 ha block and this treatment compared to the grower standard in a block 0.5 km removed. No insecticides for TABM were applied after petal fall. Dispensers were placed at 2.0 m in all orchards but Lerew in which dispensers were placed at 2.3 m. In the Knouse and Lerew orchards a 1 ha block without insecticide or mating disruption was also monitored. Canopy height averaged 3.8, 3.8, 2.8, and 4.0 m, respectively, at the Lerew, Knouse, Rice, ACN orchards. Monitoring was conducted similarly to the previous trial with the exception of having only two TABM traps per treatment, both placed at 2.0 m in the canopy. Secondary pests and beneficials were monitored as in the previous trial, except that no WALH were monitored and ERM was monitored through August at the Knouse orchard.

Generic leafroller small plot trials. Mating disruption with TABM pheromone blend (NoMate® TABM spirals) compared with generic leafroller pheromone blends also released from spirals (Ecogen Inc.) were evaluated in small (30 x 30 m) orchard plots during broods 1 and 2 of TABM in 1993 and 1994. A new set of four orchard sites was selected for each brood of TABM. All treatments were applied at 988 dispensers/ha (49.5 g ai/ha). Generic I (E11-14OH and Z11-14Ac in a 1:1 ratio) and Generic II (see above) were compared with TABM Spirals in 1993. The experiment was repeated in 1994, substituting Generic III (E11-14OH, E11-14Ac, and Z11-14Ac in a 4:4:2 ratio) for Generic I. The effect of treatment on cumulative trap capture of males per generation in lure-baited traps was recorded for TABM, VLR, RBLR and OBLR in 1993 and 1994. All small plot trials received a standard insecticide program.

Dispenser density small plot trial. NoMate® TABM Spirals were applied to the trees at a height of 2.0-2.3 m in small plots at densities of from 494 to 1482/ha (24.8-74.3 g ai/ha) at each of four orchards in 1994. The effect of dispenser density on cumulative male capture of TABM during the broods 1 and 2 was tested using pheromone monitoring traps placed in the centers of the plots at a height of 2 m.

Dispenser placement small plot trial. Pheromone trap evaluation. Two studies were conducted to measure the effect of dispenser placement within an apple tree on the efficacy of mating disruption with TABM NoMate® spirals (Ecogen Inc.). Spirals were placed at the following heights: 2.0, 3.5 m and a split application at 2.0 and 3.5 m. The density of dispensers of all height treatments was equivalent to 988 dispensers/ha. TABM was monitored in pheromone traps placed on a pole within the center of each plot (30 x 30 m) at heights of 1, 2, 3, and 4 m. The upper trap averaged 0.2 m below the top of the canopy.

Dispenser placement small plot trial. Passive trap evaluation. Three treatments were tested in a conventionally managed orchard including NoMate® TABM Spirals placed at the 988 dispensers per hectare at either 2.0 or 3.5 m (canopy height = 4.5 m) and a control with no pheromone. Plot size was nine trees (0.05 ha) and treatments were established midway through the period of the brood 1 flight in June. Each treatment was replicated three times and treatment plots were arranged in a RCBD. Six panes were hung in the center tree in each of the nine plots. The panes were hung at heights of 1.0, 2.0 and 3.5 m about midway from the trunk to the dripline both perpendicular and parallel to the tree row. Panes were 37 cm square and were coated with STP oil treatment. Moths were removed from the panes every 2 to 4 days and the panes re-coated every 4 to 11 days. The sex and side of trap were recorded for each moth. Females were dissected to determine mating status and the number of spermatophores.

Results: *Fourth year large plot trials.* Fewer TABM were captured in the TABM spiral than in the Generic II treatment in both orchards (Table 1). Most TABM were captured at 3.5 m at the Hall orchard and at 2.0 m at the Slaybaugh orchard. Efficacy at these heights was similar for the two treatments in brood 1, but dropped off more severely in the Generic II that the TABM treatment during brood 2. Other lepidoptera were uncommon except for RBLR, for which the Generic II treatment worked better than the TABM treatment. Injury tended to the slightly higher in the mating disruption treatments than the standard at the Hall orchard and not different in the Slaybaugh orchard. Density of WALH was lower in the pheromone than in the standard plots in May (Table 2). ERM failed to build in either trial.

First year large plot trials. With the exception of brood 1 in the Rice orchard, Consep TABM performed better than the other treatments in reducing capture of TABM. Efficacy on TABM for both the Generic II and TABM treatments dropped off severely in brood 2. Both VLR and RBLR were relatively common. Generic II performed best against RBLR. CM were above threshold on several occasions at the ACN orchard with a corresponding increase in internal injury in the mating disruption block (Table 3). Brood 2 TABM injury tended to be high in all treatments at the Lerew site; the mating disruption blocks were no better than the untreated block. At the Knouse orchard, the Consep TABM treatment performed better than the untreated plots and both Consep treatments tended to perform better than the TABM treatment. Other leafroller injuries were at a relatively low level and did not show consistent treatment trends. Percent clean fruit in the mating disruption treatments was generally similar to the full season insecticide standard. Few differences were observed in secondary pests and predators in the first year trials. ERM density was low except in the Knouse orchard where an acaricide was used in the standard treatment, but not in the pheromone treatments (Fig. 1).

Generic leafroller small plot trials. The TABM blend was most efficient against TABM in 1993, but not significantly better than the generics in 1994 (Table 4). All treatments reduced capture of VLR and RBLR to a similar extent. OBLR capture was low; the treatments reduced capture in 1994, but not in 1993.

Dispenser density small plot trial. Increased efficacy as determined by percent trap shutdown occurred over the range of densities tested in 1994 (Fig. 2). Shutdown was higher during brood 1 than during brood 2. Variation in response was substantial at most of the densities tested.

Dispenser placement small plot trial. Pheromone trap evaluation. Efficacy tended to be lower both above and below the placement of the pheromone dispensers in the tree canopy (Fig. 3A&B). During both broods the 4 m trap in the 2 m treatment had the lowest shutdown. Efficacy also dropped off at increasing distances below the dispensers placed at 3.5 m. A model is being developed for predicting percent shutdown of trap capture above and below the height of dispenser placement.

Dispenser placement small plot trial. Passive trap evaluation. Average daily capture per side of the trap for males and females was 0.032 and 0.007, respectively, in brood 1 and 0.238 and 0.459, respectively, in brood 2. Mating status and number of spermatophores per mated female showed no treatment effects during the brood 2, although for one two week period percent mated females was higher on the 1 m traps than on the 2 or 3.5 m traps. The mating disruption had significant effect on capture of both males and females on the panes during the brood 1 (Fig. 4A&B). Capture was lower in pheromone treated than in the untreated plots. Both males and females were most numerous on the southeast side of the traps (Fig. 5A&B). The height of pane traps influenced capture of both sexes (Fig. 6A&B). Males were captured more often on the 3.5 m traps than the females. A significant treatment by trap height interaction occurred on two dates. In June capture of males was suppressed in the 3.5 m traps in both pheromone treatments (Fig. 7A) and in early August capture of males was suppressed in the 3.5 m trap in the high pheromone placement (Fig. 7B). It was not determined if the differences were a function of moth density or of frequency of movement.

Discussion: In the fourth year studies both treatments performed well and neither had as high injury by other leafrollers as in 1993. In the first year trials the Consep treatments with a two-fold higher release rate than TABM spirals tended to perform better. The Consep TABM treatment maintained efficacy as measured by prevention of catch in pheromone traps longer than did Consep Generic II. Treatments lost efficiency as the distance above and below the dispensers increased, especially during brood 2, suggesting a possible reason for the poor performance observed at some sites. More work is planned on using passive traps to monitor mating status of female TABM in full season orchard trials.

Conclusion: Mating disruption appears to be a useful tactic for management of TABM. However, more research is required because results are not consistent. Generic blends also appear to have potential, especially in situations where leafroller populations are already relatively low.

Table 1. Effect of mating disruption on tufted apple bud moth (TABM), other lepidoptera, and fruit injury in fourth year trials, Adams Co., Pa. 1994

	Cum. TABM/trap (2 heights)										Injuries/100 apples				
	Br. 1		Br. 2		Total		Cum. males/trap[1]				TABM		Other	Internal	% clean
Treatment	2 m	3.5 m	2 m	3.5 m	2 m	3.5 m	VLR	RBLR	OBLR	CM	Br. 1	Br. 2	LR	feeders	fruit
Hall (Canopy height 4.6 m)															
NoMate TABM	1	20	2	19	2	39	0	20	0	6	0.58 a	1.47 b	0.42 ab	0.00 a	97.5 b
Generic 2	14	21	47	42	61	63	0	12	0	8	0.26 a	0.74 a	0.94 b	0.05 a	98.0 b
Standard	118	203	49	106	167	309	0	48	3	2	0.16 a	0.42 a	0.05 a	0.00 a	99.4 a
Slaybaugh (Canopy height 2.9 m)															
NoMate TABM	18	6	128	37	146	43	1	31	6	1	0.75 a	2.51 a	0.74 b	0.00 a	95.8 a
Generic 2	34	24	214	99	247	123	1	15	1	1	1.57 a	1.36 a	0.82 b	0.05 a	96.3 a
Standard	648	60	618	74	1266	133	11	79	4	5	1.00 a	2.34 a	0.10 a	0.00 a	96.6 a

Means within orchard followed by the same letter are not different, $p > 0.05$, Fisher's Protected LSD

[1] VLR = variegated leafroller; RBLR = redbanded leafroller; OBLR = obliquebanded leafroller; CM = codling moth

Table 2. Impact of mating disruption on selected secondary pests and natural enemies in two four year orchard trials, Adams Co., Pa., 1994

	White apple leafhopper		Spirea aphid (SA)			No. spotted tentiform
Treatment	No. /leaf	% Infested leaves	No. infested lvs/shoot	No./most infested leaf	No. SA natural enemies/10 shoots	leafminers /100 lvs.
NoMate TABM	0.2 a	8.3 a	3.7 a	1.5 a	0.6 a	0.7 a
Generic 2	0.2 a	10.0 a	4.0 a	1.6 a	1.2 a	2.1 a
Standard	0.5 b	24.6 b	4.2 a	1.8 a	1.5 a	0.1 a

Means followed by the same letter are not different, $p > 0.05$, Fisher's Protected LSD

Table 3. Effect of mating disruption on tufted apple bud moth (TABM), other lepidoptera, and fruit injury in first year trials in Adams Co., Pa, 1994

Treatment	Cum. TABM males/trap			Cum. males/trap 1				Injuries/100 apples				% clean fruit
								TABM		Other leafrollers	Internal feeders	
	Brood 1	Brood 2	Total	VLR	RBLR	OBLR	CM	Brood 1	Brood 2			
Lerew (Canopy height 3.8 m)												
Consep TABM	11	23	34	5	17	2	11	1.5 a	37.69 b	1.43 a	0.00 a	59.9 b
Consep Gen 2	34	92	126	5	10	1	13	2.3 ab	39.36 b	2.00 ab	0.00 a	56.9 b
NoMate TABM	24	75	99	6	47	9	8	3.3 bc	42.27 b	2.57 b	0.07 a	53.5 b
Standard	462	299	761	54	91	9	38	2.0 ab	20.22 a	1.30 a	0.08 a	76.6 a
Untreated	370	344	714	25	69	4	18	3.9 c	41.79 b	1.86 ab	0.08 a	54.2 b
Knouse (Canopy height 3.8 m)												
Consep TABM	7	11	18	6	2	1	5	0.6 a	2.13 a	0.11 a	0.00 a	97.2 a
Consep Gen 2	35	123	158	11	1	0	0	0.9 a	3.94 ab	0.05 a	0.00 a	95.2 ab
NoMate TABM	24	43	67	23	9	3	17	1.2 a	7.48 c	0.15 a	0.00 a	91.2 c
Standard	482	314	796	27	29	1	7	0.3 a	3.52 ab	0.05 a	0.00 a	96.2 ab
Untreated	336	423	759	84	44	3	9	1.0 a	4.98 bc	0.05 a	0.16 a	94.0 bc
Rice (Canopy height 2.8 m)												
Consep TABM	28	42	70	2	27	2	3	0.3 a	1.79 a	1.17 a	0.00 a	96.8 a
Consep Gen 2	11	76	87	1	9	2	3	0.4 a	1.44 a	0.91 a	0.00 a	97.3 a
NoMate TABM	15	69	84	0	16	0	0	0.6 a	2.99 a	1.35 a	0.00 a	95.1 a
Standard	139	218	357	8	48	2	0	0.5 a	1.84 a	0.38 a	0.00 a	97.3 a
ACN (Canopy height 4.0 m)												
NoMate TABM	22	145	167	n/a	n/a	n/a	40	1.59 b	5.83 a	0.80 b	0.24 a	92.3 b
Standard	505	452	957	n/a	n/a	n/a	109	0.92 a	3.83 a	0.13 a	0.00 a	95.1 a

Means within orchard followed by the same letter are not different, $p > 0.05$, Fisher's Protected LSD

1 VLR = variegated leafroller; RBLR = redbanded leafroller; OBLR = obliquebanded leafroller; CM = codling moth

Table 4. Effect of NoMate and three generic leafroller treatments on capture of leafrollers in pheromone traps, Adams Co., Pa.

Treatement [1]	Cum. males per brood per trap: Tufted apple bud moth 1993	Tufted apple bud moth 1994	Redbanded leafroller 1993	Redbanded leafroller 1994	Variegated leafroller 1993	Variegated leafroller 1994	Obliquebanded leafroller 1993	Obliquebanded leafroller 1994
Generic I	19.9 b	n/a	2.3 a	n/a	0.0 a	n/a	0.3 a	n/a
Generic II	10.9 b	16.9 a	1.5 a	1.1 a	0.5 a	0.6 a	0.0 a	0.0 a
Generic III	n/a [2]	10.5 a	n/a	2.0 a	n/a	0.4 a	n/a	0.0 a
NoMate TABM	2.3 a	4.6 a	6.0 a	1.0 a	0.4 a	0.4 a	0.6 a	0.3 a
Control	187.0 c	197.8 b	64.8 b	27.9 b	6.6 b	8.9 b	4.1 a	4.4 b

Means followed by the same letter are not different, $p > 0.05$, Fisher's Protected LSD.

[1] See text

[2] Not tested

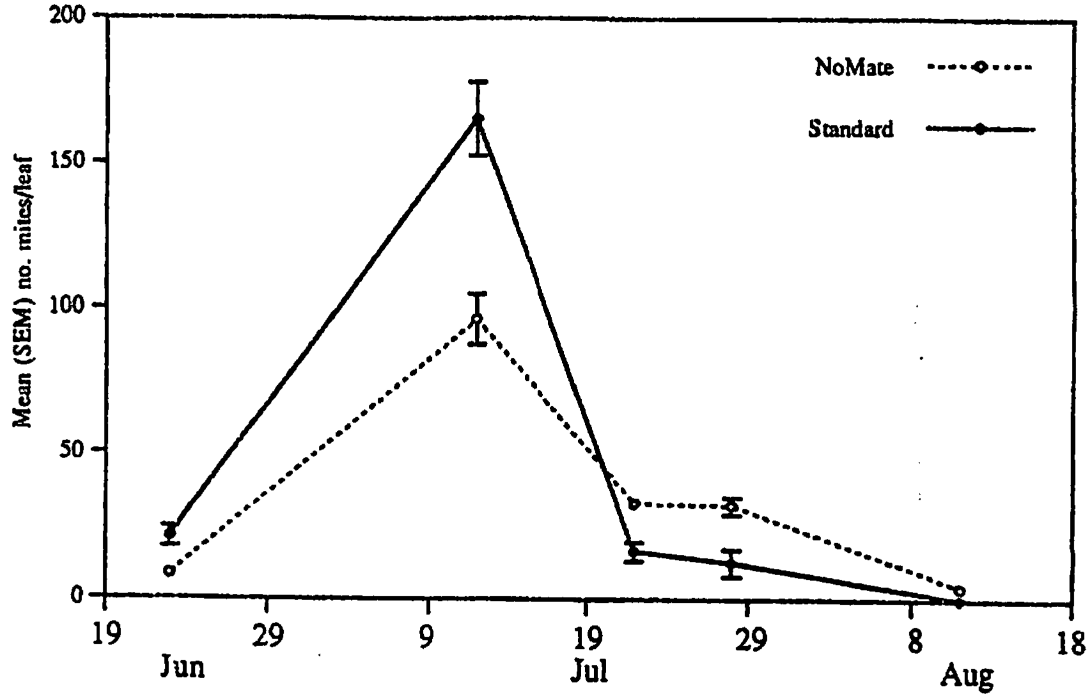

Fig 1. Effect of mating disruption for tufted apple bud moth (no broad-spectrum insecticide after petal fall) on density of European red mite in the Knouse orchard, 1994.

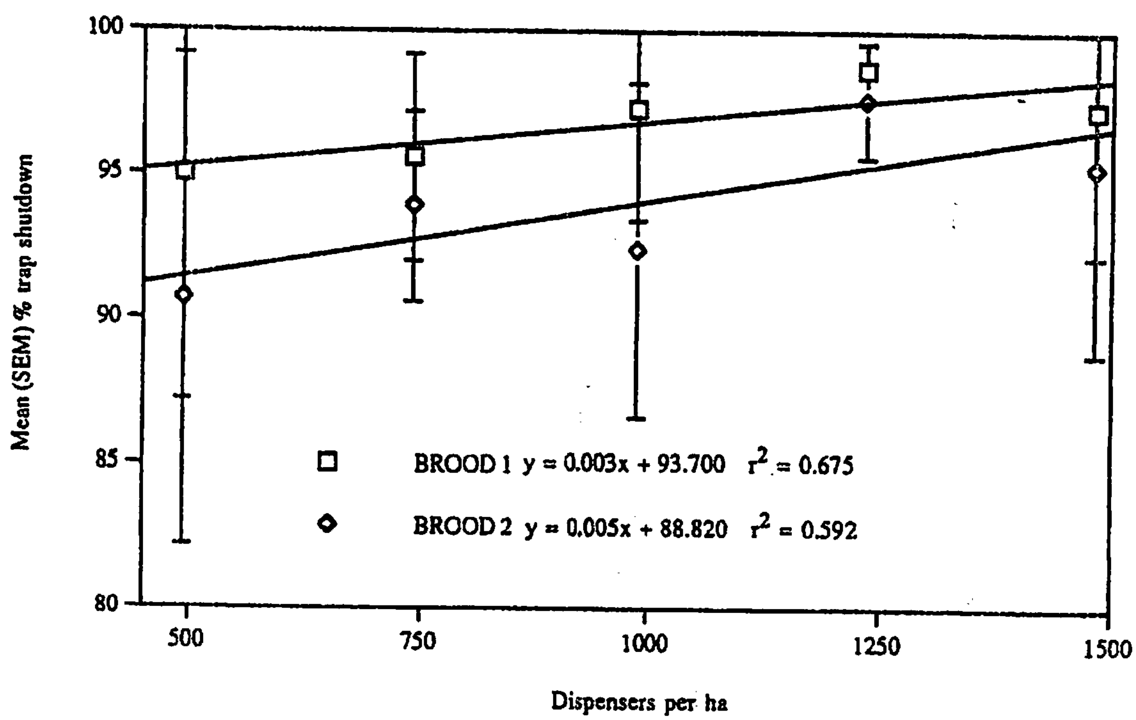

Fig 2. Effect of NoMate TABM spiral density on trap shutdown of tufted apple bud moth (TABM) in four orchards, 1994.

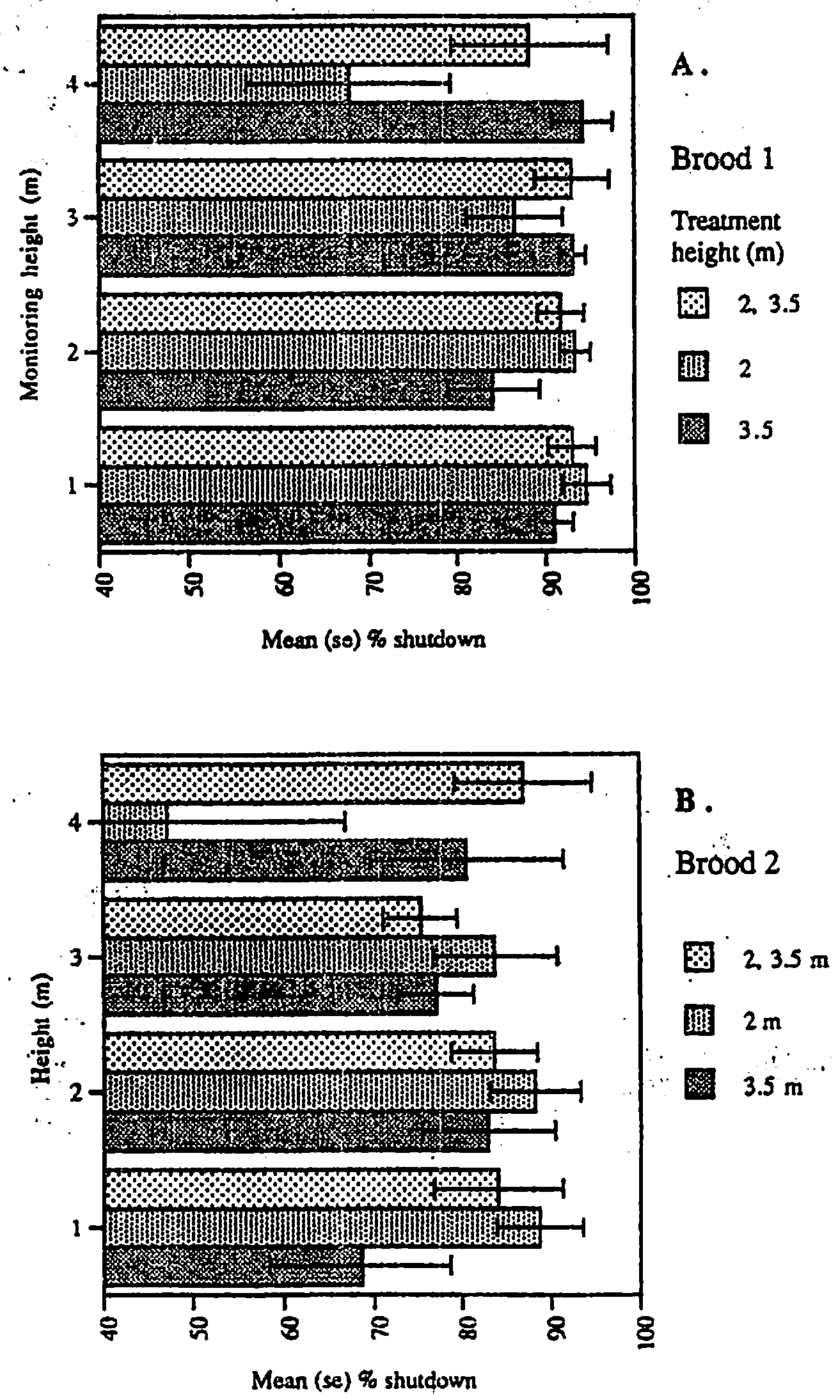

Fig. 3. Effect of dispenser placement on efficacy of mating disruption of TABM at four heights in the canopy, brood 1 (A) and 2 (B), 1994.

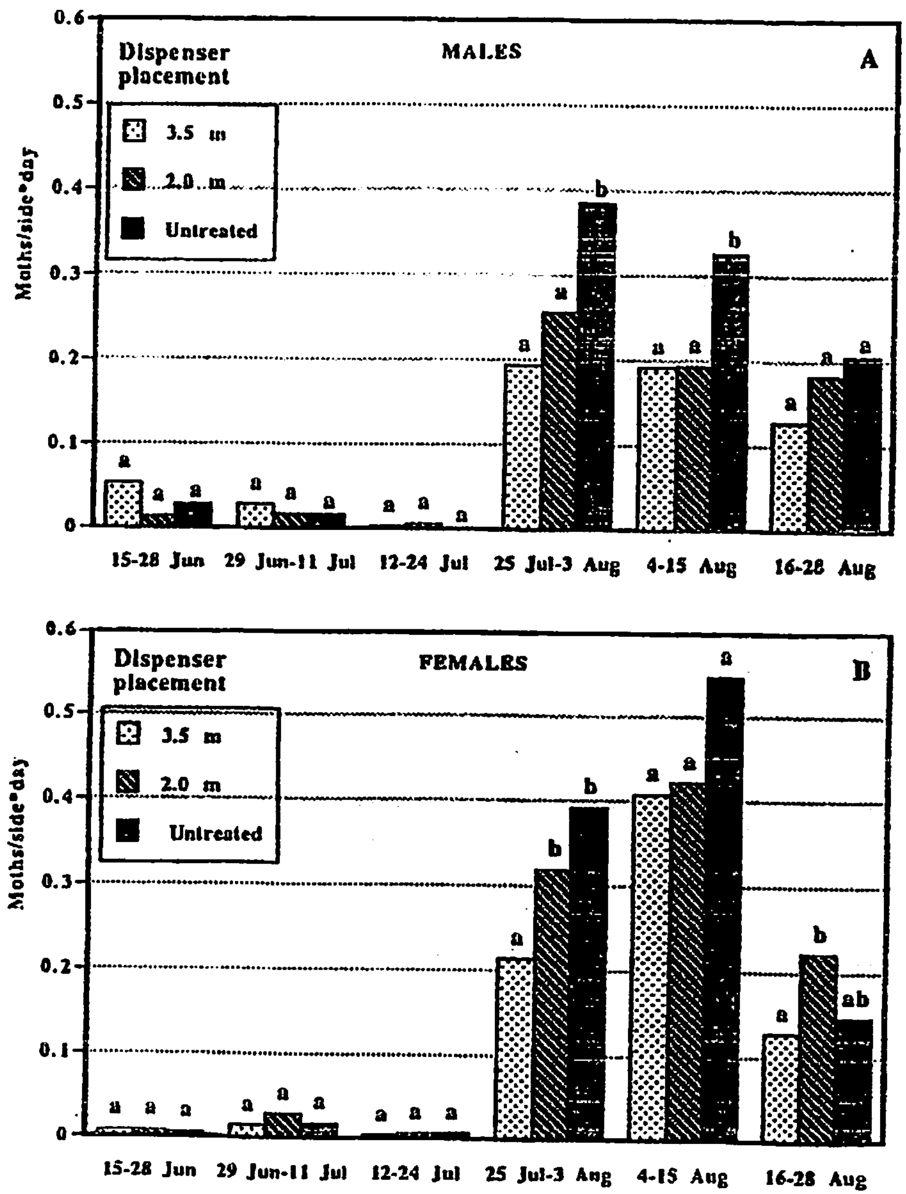

Fig 4. Effect of dispenser placement on capture of tufted apple bud moth males (A) and females (B) over all trap heights and orientations, 1994.

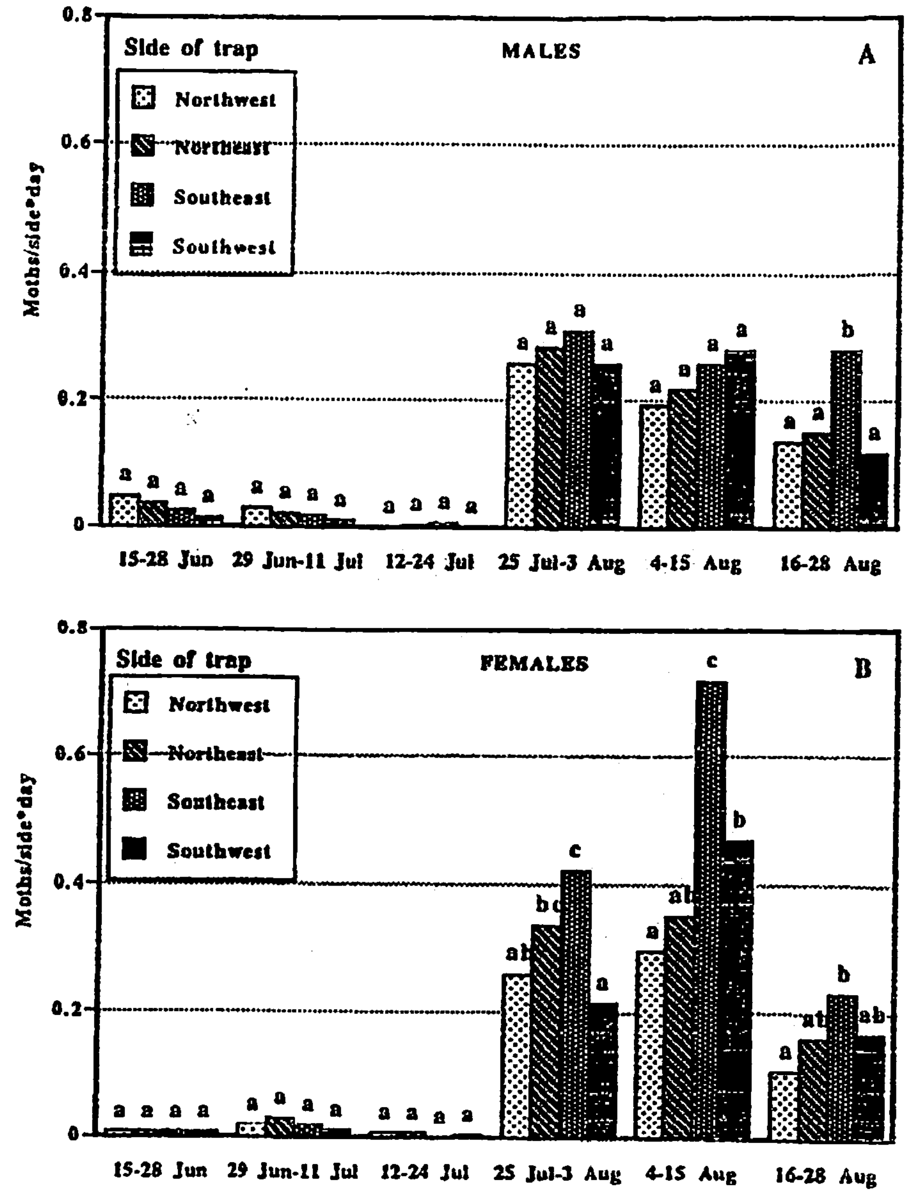

Fig 5. Effect of trap orientation on capture of tufted apple bud moth males (A) and females (B) over all treatments and trap heights, 1994.

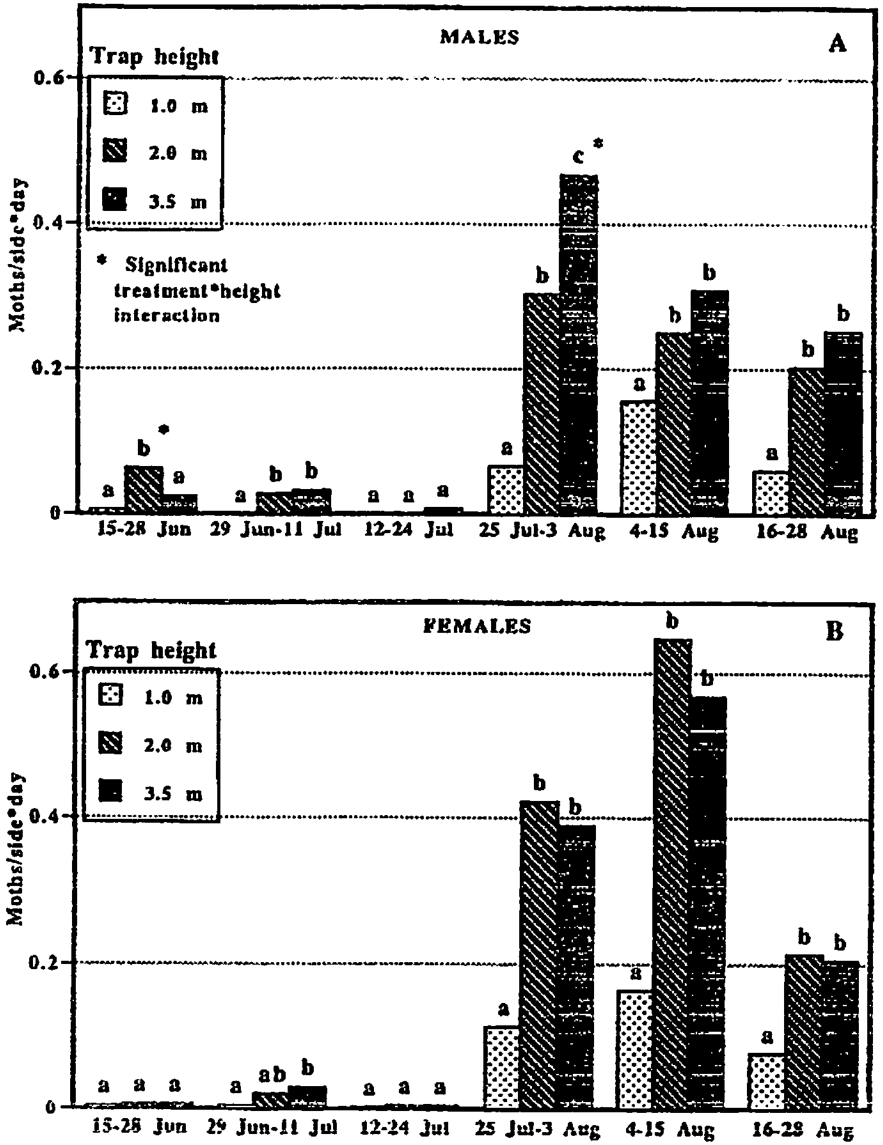

Fig 6. Effect of trap height on capture of tufted apple bud moth males (A) and females (B) over all dispenser placements and trap orientations, 1994

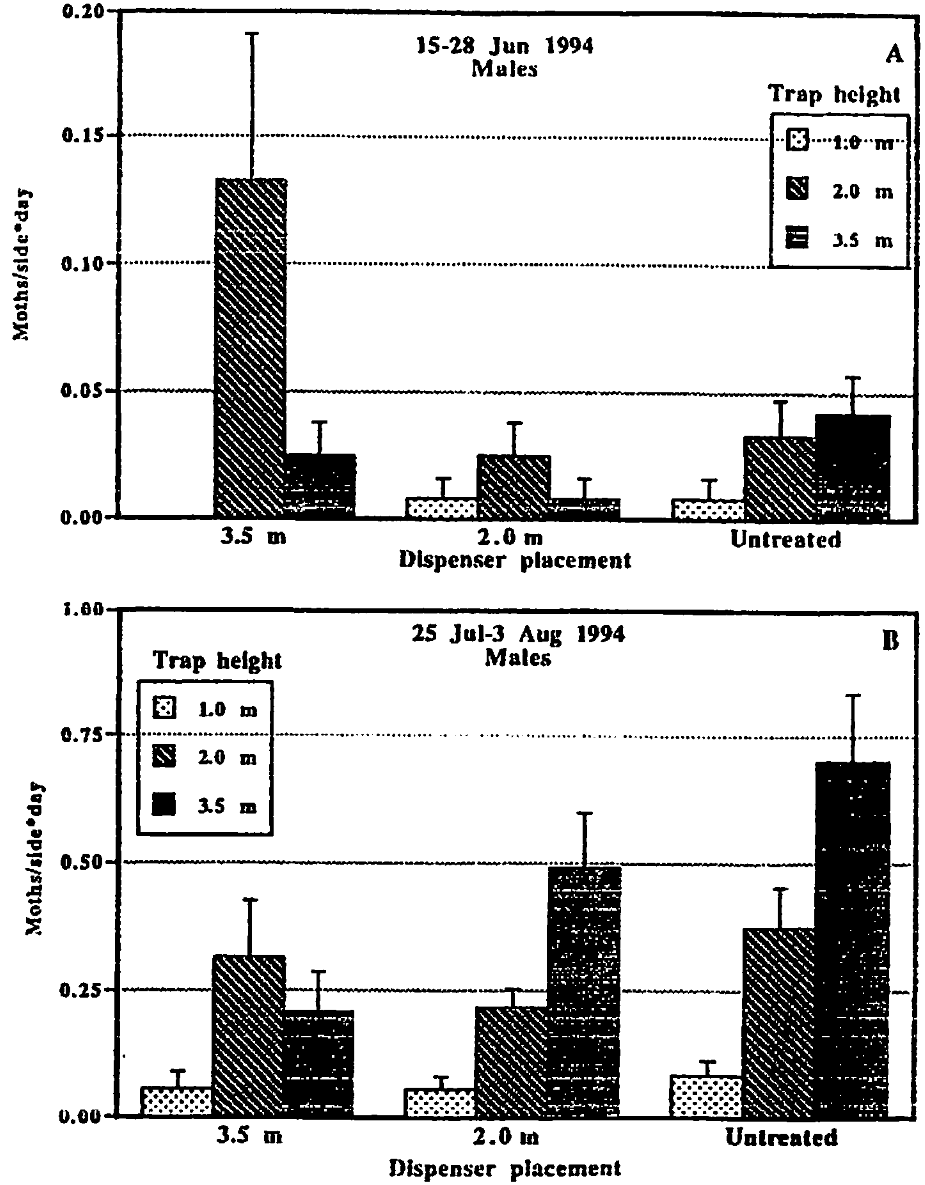

Fig 7. Effect of dispenser placement on capture of tufted apple bud moth males at three heights in the canopy on 15-28 Jun (A) and 25 Jul-3 Aug (B), 1994

Scab-Resistant Apple Cultivars: Susceptibility to Insect Pests

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Introduction

It is known that scab-resistant apple cultivars (SRCs), are not only immune to apple scab but are resistant to several other major diseases in the Northeast. However, here in Pennsylvania, there is little information on the susceptibility of SRCs to the major orchard pests. Complexes of pests and diseases found on these cultivars may differ from those found in an orchard that receives regular pesticide applications. The objectives of this project were to identify the major insect pests and determine those that may become a problem in SRC orchards.

Materials and Methods

Scouting 1993 and 1994

In 1992, four SRCs having potential for the fresh and/or processing market were planted at the Russell E. Larson Research Center at Rock Springs, PSU. A Golden Delicious control was also included in this planting. Orchard design was a randomized complete block with 10 replicate trees per cultivar. Row spacing was 20 ft and within-row spacing was 8 ft. All cultivars were planted on Mark rootstock. Maintenance sprays for weed control were applied when needed. Sprays for insect pests included two applications of Dipel applied on 7 and 14 May and two applications of Imidan applied on 15 July and 5 August. Scouting for the presence of insect pests began on 4 May, 1993. Once insect pests were observed in the field they were scouted for on a weekly basis. Seven major insect pests were present on SRCs during the 1993 growing season. These included the green apple aphid, gypsy moth, Japanese beetle, potato leafhopper, leafroller, and leafminer. Scouting methods and scouting times have already been described (2). Fruit damage due to insect feeding was not assessed the first year, however, damage was visible.

In 1994, scouting began on 9 June and scouting methods were modified. To determine the incidence of green apple aphid, 10 succulent terminals per cultivar (10 trees) were chosen and the total number of terminals having aphid colonies were counted. To determine the incidence of potato leafhopper, 20 leaves/tree per cultivar, leaf positions 3 and 4 were selected and the total number of leaves with potato leaf hoppers (nymphs and adults) were counted. Leafrollers were assessed by selecting 10 terminals/tree per cultivar and counting the number of terminals with leafrollers present. On 9 and 19 June, fruit of SRCs were assessed for damaged caused by leafroller and plum curculio. Twenty randomly chosen fruit per tree/cultivar were selected and the total number of fruit damaged by each insect pest recorded. Gypsy moth and Japanese beetle were not included in the scouting program in 1994. Insecticides applied for the 1994 season included an application of Dipel (6 May), Imidan (23 May) and two applications of liquid Sevin applied on 11 July and 12 August.

Results

Significant differences in insect infestations occurred between SRCs during the 1993 season (Table 1). Golden Delicious had higher levels of aphid infestation and leafroller damage whereas differences were not observed among the four SRCs with respect to these insect pests. Season-long differences were also not observed among cultivars when observing gypsy moth and Japanese beetle populations, however, at specific rating times, differences were detected. On 13 and 27 July, the cultivar Liberty had significantly more beetle damage than the other cultivars (data not shown). Freedom was most affected by leafminer feeding followed by Jonafree. Mites were not detected in the orchard and the presence and numbers of rosy apple aphids were extremely low and not counted.

In 1994, mites and leafminers were not observed in the orchard. Significant differences among all cultivars with respect to populations of green apple aphid and leafrollers were not observed. Significant differences were observed in the incidence of potato leafhopper populations on SRCs (Table 2). Golden Delicious had the least damage from leafhopper infestation (35.3%) when compared to Redfree (54.8%). There were no significant differences among cultivars in the amount of fruit damage caused by plum curculio and leafrollers.

Discussion

Fruit damage caused by plum curculio and leafroller was the most serious problem observed during the 1993 and 1994 seasons. Although significant differences were not observed among the SRCs, the fruit surface was damaged by these pests reducing fruit quality and marketability. Others have reported significant differences among SRCs with respect to various arthropod pests (1). In this study, plum curculio caused the greatest damage to fruit.

By using an IPM approach to the management of scab-resistant cultivars and applying insecticides only when needed, it is possible that quality, marketable fruit could be produced by the use of a relatively low number of insect sprays.

References

1. Goonewardene, H. F., Pliego, G., McCabe, G. P., Howard, P. H., and Oliver, P. J. 1989. Control of arthropods for scab (Ascomycetes: Mycosphaerellacea) and apple maggot (Diptera: Tephritidae) resistance in an orchard in Indiana. J. Econ. Entomol. 82:1426-1436.

2. Travis, J. W. and Rytter, J. L., Rajotte, E. G., and Waresak, S. L. 1994. Susceptibility of scab-resistant apple cultivars to leafspots and six insect pests in Pennsylvania. Biological and Cultural Tests for Control of Plant Diseases 9:14.

Table 1. Susceptibility of four scab-resistant cultivars to insect pests.

Incidence and Severity of Six Inset Pests Over the 1993 Growing Season

Cultivar	% Aphid Incidence[1]	Mean Number of Insects: Gypsy Moth[2]	Japanese Beetle[3]	Potato Leafhopper[4]	Leafrollers[5]	Leafminers[6]
Golden	0.37 b[7]	1.33 a	3.84 a	1.36 ab	0.48 b	2.3 ab
Freedom	0.14 a	1.43 a	6.26 a	0.85 a	0.16 a	4.8 c
Jonafree	0.24 a	1.53 a	1.58 a	1.34 a	0.20 ab	3.9 bc
Liberty	0.22 a	1.87 a	9.80 a	2.63 c	0.22 ab	2.2 a
Redfree	0.22 a	1.30 a	1.72 a	2.43 bc	0.19 ab	2.6 ab

[1]Numbers represent the average of 10 rating periods.
[2]Numbers represent the average of 3 rating periods.
[3]Numbers represent the average of 5 rating periods.
[4]Numbers represent the average of 8 rating periods.
[5]Numbers represent the average of 11 rating periods.
[6]Numbers represent the average of 3 rating periods.
[7]Means in a column followed by the same letter do not differ significantly, Tukey-Kramer HSD (P = 0.05).

Table 2. Susceptibility of SRCs to potato leafhopper and fruit damage caused by plum curculio and leafroller. (1994)

Cultivar	**% incidence PLH[2]**	**% fruit damage[1] PC**	**LR**
Golden	35.3 a[3]	11.5 a	4.0 a
Redfree	54.8 b	14.3 a	4.5 a
Freedom	52.4 ab	10.0 a	1.9 a
Liberty	47.9 ab	14.3 a	3.2 a
Jonafree	48.0 ab	12.8 a	3.6 a

[1] Numbers represent the mean of 2 scouting dates.
[2] Numbers represent the mean of 5 scouting dates
[3] Means in the same column followed by the same letter do not differ significantly according to Tukey-Kramer HSD (P = 0.05).

Not for Citation

Title: Pest Control on Dwarf Apples with WVU Containment Spray Systems

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Introduction

With a grant funded by the National Pesticide Impact Assessment Program, an over-the-row chassis and spray containment hoods for three-wire trellis and T-trellis plantings were constructed in 1991 and 1992, respectively. Previous research has focused on measurement of spray deposit and drift with these systems as compared to a conventional airblast sprayer. Research was initiated in 1993 to investigate pest control efficacy with containment spray systems.

Materials and Methods

Orchard plantings. Research was conducted at the WVU Experiment Farm in Kearneysville in a three-wire trellis and T-trellis dwarf apple orchard established in 1979. Trees were on M.9 rootstock and planted at a spacing of 12 ft between rows and 6 ft between trees within the row. A single row (50 trees) each of 'Red Delicious', 'York', and 'Golden Delicious' in the three-wire planting, and 'Red Delicious' and 'Golden Delicious' in the T-trellis planting were used to evaluate pest control efficacy. Each row was divided into six plots of eight or nine trees, which were alternately assigned to either the containment spray system or a conventional airblast sprayer.

Sprayers and spray applications. The three-wire containment spray system (Figure 1) was equipped with 20 hollow cone nozzles (10 D1-13, 8 D2-13, and 2 D3-13) which delivered a spray volume of 75 gal/acre at 250 psi and a travel speed of 1.75 mph. The T-trellis containment spray system (Figure 2) was equipped with 17 D1-13 hollow cone nozzles (9 on top boom and 4 on each of two lower booms) which delivered a spray volume of 50 gal/acre at 200 psi and a travel speed of 1.75 mph. The conventional airblast sprayer was a FMC Economist model DP300 which applied the same gal/acre as the containment spray systems on each of the trellis plantings. Spray was applied at 140 psi, with the fan operated at 2400 rpm while traveling at 2.2 mph. Five nozzles (1.0 disc, 2 whirl) and three nozzles per side were used for the three-wire trellis and T-trellis plantings, respectively.

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Materials (dates) applied for arthropod pest control included: Morestan (April 24), Sevin XLR Plus and Dimethoate (May 19), Guthion (June 2, July 29), and Lannate and Penncap-M (June 16, July 5, August 19, September 2).

Insect assessment. Insect data were taken from two trees in each of the three plots for each spray system (6 replications per treatment). Incidence of spirea aphid was determined by counting the number of aphids on the most infested leaf on each of 10 terminals per tree. Rose leafhopper and white apple leafhopper populations were determined by counting the number of nymphs on the underside of 25 leaves per tree. Incidence of spotted tentiform leafminer was determined by counting the number of mines observed per tree in 5 minutes. Leafhopper and leafminer populations were assessed in the periphery and center region of sample trees. At harvest for each variety, 100 fruit were sampled from each tree and evaluated for injury from fruit-feeding insects.

Results and Discussion

Three-wire trellis containment spray system. The containment spray system was comparable to the conventional airblast sprayer in the control of spirea aphid (Table 1), spotted tentiform leafminer (Table 3), and fruit-feeding insects (Table 4). Table 1 shows the spirea aphid population one day before and six days after control with Lannate. Even though there was no statistical difference between treatments, the airblast sprayer provided a greater reduction in the spirea aphid population than the containment sprayer. While incidence of leafmines and fruit injury was not statistically different between spray systems, levels were usually lower in the airblast sprayer treatment. Incidence of rose leafhopper and white apple leafhopper was either similar between spray systems or higher in the containment sprayer treatment (Table 2).

Previous studies measuring spray deposit revealed that the containment spray system delivered less spray deposit to the bottom of the leaf surface than the conventional airblast sprayer. Data presented here indicate a potential weakness of the containment spray system, especially against pests such as aphids and leafhoppers which occupy the underside of the leaf. It appears that increased pressure or air-assist will be necessary in order to maintain control of these pests comparable to the airblast sprayer.

T-trellis containment spray system. The containment spray system was less effective than the airblast sprayer in the control of spirea aphid (Table 5). By mid-June there is typically at least two feet of vertical shoot growth on the T-trellis, with aphids occupying the underside of the youngest leaves at the ends of these shoots. In order to achieve sufficient coverage of the underside of these leaves, spray would have to travel upward from the lower boom through the canopy. Poor control with the containment spray system is most likely due to the inability of spray delivered by the lower boom to penetrate sufficiently upward to reach the underside of the terminal leaves. Control of rose leafhopper and white apple leafhopper (Table 6), spotted tentiform leafminer (Table

7), and fruit-feeding insects (Table 8) was generally comparable between systems.

Incidence of rose leafhopper was found to be higher in the airblast sprayer treatment in the periphery of 'Red Delicious' trees on June 29 and on both varieties on August 26. There was no obvious explanation for this occurrence. Except for spirea aphid, the containment spray system appears to be a suitable replacement for the airblast sprayer for pest control in T-trellis plantings, while minimizing drift.

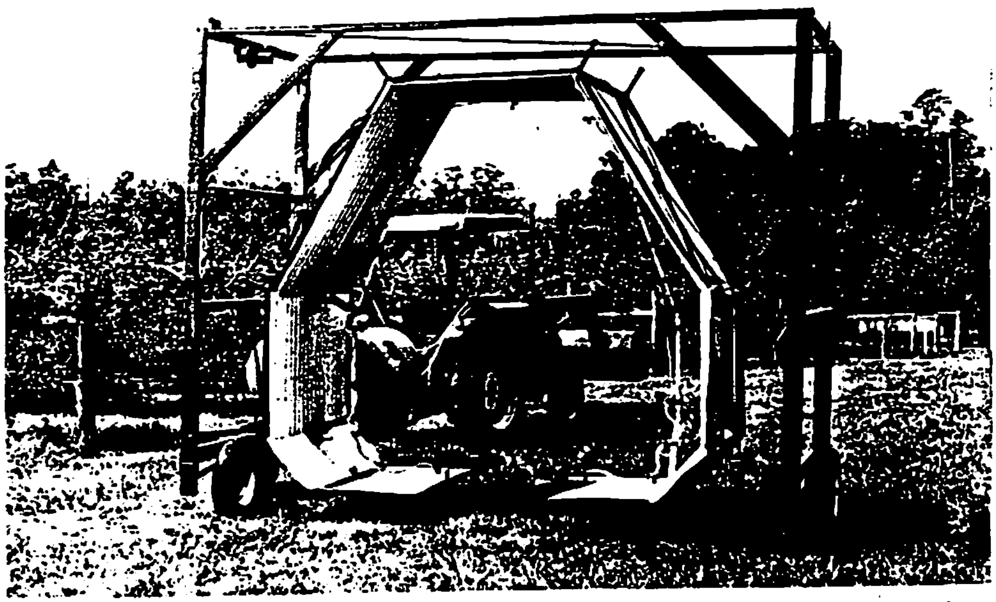

Figure 1. WVU containment spray system for three-wire trellis apples.

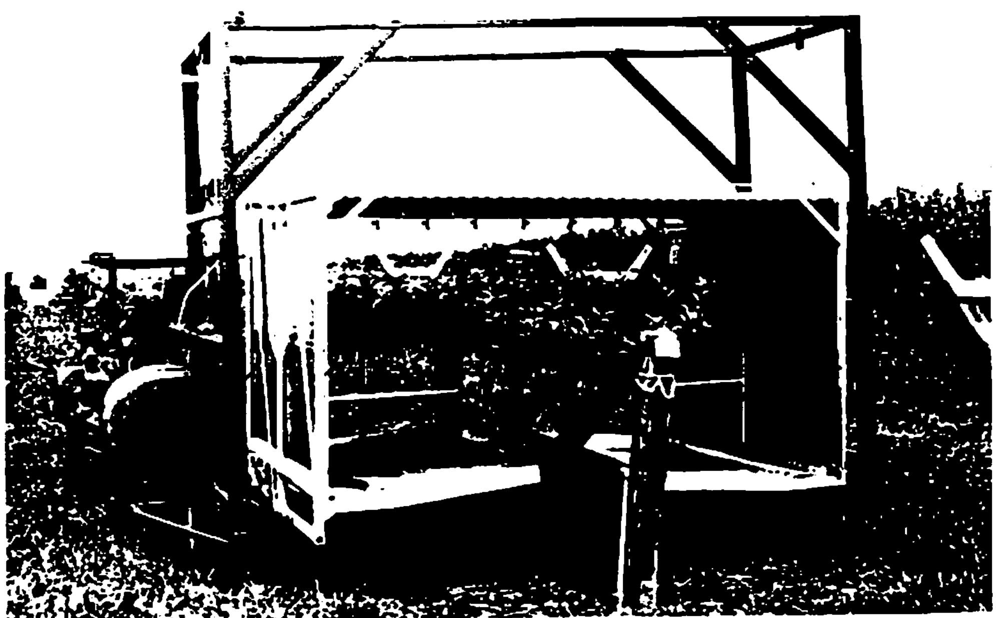

Figure 2. WVU containment spray system for T-trellis apples.

Table 1. Control of spirea aphid with containment and conventional airblast spray systems on three-wire trellis apples in 1993.

Spray System	Spirea aphids/most infested leaf/terminal		
	'Red Delicious'	'York'	'Golden Delicious'
June 15, 1993			
Containment	178.6 a	142.0 a	207.7 a
Conventional Airblast	186.6 a	182.4 a	259.6 a
June 22, 1993			
Containment	89.5 a	62.2 a	76.2 a
Conventional Airblast	78.5 a	48.8 a	37.5 a

Means in a given column at each date followed by the same letter are not significantly different (P = 0.05; Fisher's LSD).

Table 2. Control of rose leafhopper with containment and conventional airblast spray systems on three-wire trellis apples in 1993.

Spray System	Rose leafhopper nymphs/25 leaves					
	'Red Delicious'		'York'		'Golden Delicious'	
	Periphery	Center	Periphery	Center	Periphery	Center
June 29, 1993						
Containment	16.2 a	18.0 a	8.2 a	21.8 a	12.3 a	12.3 a
Conventional Airblast	8.2 a	12.0 a	6.7 a	8.7 a	13.7 a	12.2 a
July 8, 1993						
Containment	5.5 a	23.3 a	1.8 a	17.2 a	0.8 a	6.5 a
Conventional Airblast	0 b	1.2 b	0.7 a	0.7 b	0.2 a	0.5 b
August 26, 1993[a]						
Containment	0.7 a	6.3 a	1.2 a	4.2 a	0.8 a	3.5 a
Conventional Airblast	0.7 a	2.7 a	0.5 a	1.0 b	1.3 a	2.8 a

Means in a given column at each date followed by the same letter are not significantly different (P = 0.05; Fisher's LSD). [a]Count includes rose leafhopper and white apple leafhopper.

Table 3. Control of spotted tentiform leafminer with containment and conventional airblast spray systems on three-wire trellis apples in 1993.

	Leafmines/5 min on August 26, 1993					
	'Red Delicious'		'York'		'Golden Delicious'	
Spray System	Periphery	Center	Periphery	Center	Periphery	Center
Containment	11.3 a	14.0 a	16.3 a	28.5 a	12.2 a	17.3 a
Conventional Airblast	9.3 a	11.3 a	9.2 a	12.3 a	45.2 a	38.7 a

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

Table 4. Control of fruit-feeding insects with containment and conventional airblast spray systems on three-wire trellis apples in 1993.

Spray System	'Red Delicious'	'York'	'Golden Delicious'
% tarnished plant bug injury			
Containment	0.2 a	0.3 a	0.3 a
Conventional Airblast	0 a	0 a	0.3 a
% codling moth injury			
Containment	0.2 a	0.5 a	0.2 a
Conventional Airblast	0.2 a	0 a	0 a
% tufted apple bud moth and redbanded leafroller injury			
Containment	3.2 a	2.8 a	1.3 a
Conventional Airblast	0.7 a	1.5 a	2.0 a
% clean fruit			
Containment	96.5 a	96.3 a	98.2 a
Conventional Airblast	99.2 a	98.5 a	97.7 a

Means in a given column for each injury category followed by the same letter are not significantly different (P = 0.05; Fisher's LSD).

Table 5. Control of spirea aphid with containment and conventional airblast spray systems on T-trellis apples in 1993.

Spray System	Spirea aphids/most infested leaf/terminal	
	'Red Delicious'	'Golden Delicious'
June 15, 1993		
Containment	214.6 a	225.9 a
Conventional Airblast	299.0 a	207.8 a
June 22, 1993		
Containment	158.8 a	76.6 a
Conventional Airblast	66.4 b	23.7 b

Means in a given column at each date followed by the same letter are not significantly different (P = 0.05; Fisher's LSD).

Table 6. Control of rose leafhopper with containment and conventional airblast spray systems on T-trellis apples in 1993.

Spray System	Rose leafhopper nymphs/25 leaves			
	'Red Delicious'		'Golden Delicious'	
	Periphery	Center	Periphery	Center
June 29, 1993				
Containment	7.7 b	15.7 a	9.5 a	15.0 a
Conventional Airblast	12.8 a	16.2 a	10.7 a	13.0 a
July 8, 1993				
Containment	0.7 a	1.2 a	0.7 a	3.8 a
Conventional Airblast	0 a	0.5 a	1.0 a	0.8 a
August 26, 1993[a]				
Containment	1.5 b	2.0 a	1.7 b	1.7 a
Conventional Airblast	9.3 a	4.0 a	12.2 a	2.2 a

Means in a given column at each date followed by the same letter are not significantly different (P = 0.05; Fisher's LSD). [a]Count includes rose leafhopper and white apple leafhopper.

Table 7. Control of spotted tentiform leafminer with containment and conventional airblast spray systems on T-trellis apples in 1993.

	Leafmines/5 min on August 26, 1993			
	'Red Delicious'		'Golden Delicious'	
Spray System	Periphery	Center	Periphery	Center
Containment	13.7 a	10.7 a	26.8 b	20.8 a
Conventional Airblast	12.3 a	10.7 a	36.7 a	23.3 a

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

Table 8. Control of fruit-feeding insects with containment and conventional airblast spray systems on T-trellis apples in 1993.

Spray System	'Red Delicious'	'Golden Delicious'
% tarnished plant bug injury		
Containment	0 a	0.5 a
Conventional Airblast	0 a	0.2 a
% codling moth injury		
Containment	0.2 a	0.2 a
Conventional Airblast	0 a	0 a
% tufted apple bud moth and redbanded leafroller injury		
Containment	1.5 a	1.0 a
Conventional Airblast	1.0 a	0.7 a
%cleanfruit		
Containment	98.3 a	98.3 a
Conventional Airblast	98.7 a	99.2 a

Means in a given column for each injury category followed by the same letter are not significantly different (P = 0.05; Fisher's LSD).

Suppression of European Red Mite with Fluazinam

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The miticidal activity of the experimental fungicide fluazinam has shown promise a tool for suppressing European red mite (ERM) populations in apple. Although the effect of fluazinam on ERM is unknown, previous work (JFW) has shown that when used in a season-long fungicide program, it provides excellent control of ERM. This fungicide is effective against a wide range of diseases common to North Carolina, and thus could have a number of different use patterns in apple disease management programs. The purpose of this study was to determine the effectiveness of different fluazinam use patterns on suppression of European red mite and to determine its effect on different ERM life stages.

Materials & Methods

Field Studies: Studies were conducted at the Mountain Horticultural Crops Research Station, Fletcher, NC, using 15-yr-old 'Delicious' apple trees with a tree-row-volume of 225 gpa. Plots consisted of two 5-tree groups, and two trees in each group served as sample trees. Eight treatments were arranged in a randomized complete block design, and treatments consisted of different application timings of fluazinam and captan from petal fall (Pf) through 8th cover (8C). Application dates for Pf, 1C, 2C, 3C, 4C, 5C, 6C, 7C and 8C were 29 April, 12 and 25 May, 8 and 23 June, 8 and 21 July, and 4 and 18 August, respectively.

Treatments consisted of: 1) Fluazinam 500F (0.6 pt/100 gal) from Pf-8C; 2) Fluazinam 500F at Pf and 1C, followed by Captan 50W (2 lb/100 gal) from 2C-8C; 3) Captan 50W at Pf-2C, followed by Fluazinam 500F from 3C-8C; 4) Captan 50W from Pf-3C, followed by Fluazinam 500F from 4C-8C; 5) Captan 50W from Pf-8C plus Omite 30W (2 lb/100 gal) at 3C; 6) Captan 50W from Pf-8C plus Omite 30W (2 lb/100 gal) at 4C; 7) Captan 50W from Pf-8C; and 8) untreated (no fungicide). All treatments were treated with the same insecticides, including Imidan 50W (Pf, 1C), and Diazinon 50W (3C), and Guthion 50WP (5C). All applications were made with an airblast sprayer delivering 225 gpa.

ERM were monitored weekly from 3 May to 15 August by removing 10 leaves per sample tree, placing them through a mite brushing machine and counting the number of ERM eggs, motiles (immatures + adults) and *Amblyseius fallacis* (predator mite) under a stereo-microscope. In addition, populations of the predatory coccinellid *Stethorus punctum* were assessed weekly form 13 June to 15 August by conducting a 3-minute search near each sample tree and counting the number of adults and immatures. Cumulative mite days were calculated by multiplying the average mites per leaf between two sample dates times the number of days between sample dates. All data were analyzed by two-way ANOVA, and means were separated by LSD ($P = 0.05$).

Toxicity of Fluazinam to *S. punctum*. Because of the difficultly in separating the effects of fluazinam toxicity vs. differences in prey densities (REM) on populations of *S. punctum* in field studies, laboratory studies were conducted to determine the toxicity of fluazinam to *S. punctum*. For these studies, *S. punctum* adults and larvae were collected from ERM infested 'Delicious' trees that had not been sprayed with insecticides or miticides.

Twenty ml scintillation vials were filled with 0.5 ml of test solution, and vials were swirled until the solution dried such that the entire inner surface of vials were treated with test materials. Treatment solutions consisted of 1) 1 ml Fluazinam 500F/500 ml water; 2) 2 ml Fluazinam 500F/500 ml water; 3) water only; and 4) 0.04 ml Asana XL per 500 ml water. In addition, Tween X155 (0.08%) was added to all test solutions. After solutions had dried, either 5 *S. punctum* adults or 5 larvae were placed in vials, capped, and stored at approximately 24°C under a 16:8 L:D photoperiod for the duration of the bioassay. Mortality was recorded after 24 hr. After the 24 hr reading, individuals were removed from vials and placed on ERM infested leaves contained in sealed petri dishes. Mortality in petri dishes was recorded after 4 days. All data were subjected to a one-way ANOVA, and means were separated by LSD (P = 0.05).

ERM Laboratory Studies: To determine the effect of fluazinam on ERM, a number of laboratory bioassays were conducted. For all bioassays, ERM adults or immatures were placed on 3 cm leaf disks on top of moist cotton in petri dishes (9 cm diameter). Petri dishes were held at approximately 24°C under a 16:8 L:D photoperiod for the duration of the bioassay. For all bioassays, 5 adult or 5 immatures mites were placed on a single leaf disk and were considered replicates. For all experiments ERMs were collected from untreated 'Delicious' leaves the day of the experiment, and leaf disks used for bioassays were removed from untreated 'Golden Delicious' leaves.

Toxicity Studies. Three treatments were used. Treatment 1 (treated leaf, untreated mites) consisted of placing 5 adults or immature ERM on field-collected 'Golden Delicious' leaves (not treated with pesticides) that were dipped into a 1 ml Fluazinam 500F/500 ml water solution, allowed to air dry for 1 hr, and 3 cm leaf disks were removed and placed into bioassay chambers. Treatment 2 (untreated leaf, treated mites) consisted of a leaf disk from a leaf dipped into only water, and placing 5 adults or immature mites on that had previously been sprayed with a 1 ml Fluazinam 500F/500 ml water solution. Treatment 3 (untreated leaf, untreated mites) consisted of placing untreated mites on untreated leaf disks (both treated with only water prior to setup). Each leaf disk was examined at 1, 2, 3, 4 and 5 days after treatment and number of dead mites number leaving the leaf disk were recorded. Data were analyzed using a one-way ANOVA and means were separated by LSD (P = 0.05).

Ovicidal Studies. Two experiments were conducted to test ERM ovicidal properties of Fluazinam 500F. In experiment 1, field-collected 'Delicious' leaves (not treated with pesticides in the field) were dipped into either a solution of 1 ml Fluazinam 500F/500 ml water, or 2.4 gm Captan 50W/liter water. Leaf disks were removed from treated leaves, all motile mites removed from leaf disks, and disks were checked daily for 8 d for emergence of ERM larvae. In Experiment 2, field-collected 'Rome Beauty' leaves were dipped into either the above fluazinam or captan solutions, allowed to air dry, leaf disks removed, all eggs and motiles removed from leaf disks, and 10 ERM adult females placed on leaf disks for a 24 hr oviposition period. Number of eggs laid were recorded, and disks were checked daily for 8 d and number of ERM larvae hatching was recorded. Data transform using arcsin $\sqrt{x}$, subjected to a one-way ANOVA, and means separated by LSD (P = 0.05).

A third experiment with field-treated fluazinam leaves was conducted to further explore the ovicidal activity. Non-mite infested 'Rome Beauty' leaves were collected at 0, 1, 2 and 3-days after treatment with Fluazinam 500F (0.8 pt/100 gal) or Captan 50W (2 lb/100 gal). Leaf disks were removed and placed on moist cotton in bioassay chambers. Ten ERM adult females were placed on each of five leaf disks per fungicide treatment for a 24-h oviposition period. Mites were removed, number of eggs laid counted, and leaf disks checked daily to determine percentage of eggs hatching. Data transform using arcsin $\sqrt{x}$, subjected to a one-way ANOVA, and means separated by LSD (P = 0.05).

Results

Field Studies. ERM populations were relatively early in occurrence and high in intensity. Populations in the untreated peaked on 21 June at 149 mites per leaf (Fig. 1). Following the 21 June peak, populations decreased and fluctuated between 25 to 35 per leaf for three weeks, and then decreased to less than 7 per leaf thereafter. Cumulative mite days in the untreated reached 3,019.7 by 15 August.

Season total cumulative mite days, shown in Fig. 2, reflect the of overall mite pressure in the various treatments. The season-long fluazinam program and fluazinam from covers 3-8 had the lowest number of mite days. In addition, the benefit of the early season fluazinam applications (petal fall and 1C) in reducing overall mite intensity is well demonstrated in that cumulative mite days were significantly reduced below those in the untreated control. Treatments in which fluazinam applications were initiated at ERM densities of ca. 10 (6 June) or 50 (21 June) mites per leaf compared favorably to captan treatments which received Omite on these same dates (8 and 23 June, respectively). Based on counts taken after these applications, the initial application of fluazinam reduced ERM populations to the same level or lower than the Omite applications. Furthermore, the continued application of fluazinam the remainder of the season suppressed mites below those in treatments receiving the single Omite application.

Populations of the two mite predators *A. fallacis* and *S. punctum* were very low throughout this trial and had little influence on overall mite populations. *A. fallacis* populations did not appear until early July, and remained below 1 mite/leaf. *S. punctum* populations did not appear until mid June, and larval and adult numbers did not exceed 4 per 3 min search in any treatment on any sample

Toxicity of Fluazinam to *S. punctum*. Laboratory experiments demonstrated that *S. punctum* was highly tolerant of exposure to fluazinam. The 1 and 2 ml/500 ml rates of Fluazinam 500 tested are equivalent to 1.6 and 3.2 pts/100 gal, respectively, well above the field rate of 0.6 pt/100 gal. Mortality of adults and larvae did not differ from the water treatment at either the 24 or 120 hr evaluation (Table 1). In contrast, the Asana XL treatment of 0.08 ml/500 ml, which caused 100% mortality of adults and larvae at 24 hr, is equivalent to the recommended field rate of 2 oz/100 gal.

ERM Laboratory Studies (toxicity studies). Mortality of ERM adults treated with fluazinam or placed on fluazinam-treated leaves is shown in Table 2. In general, fluazinam appeared to exhibit minimal mortality on adults; mortality of adults placed on treated leaves was higher than the untreated only at the 2-day count, and topical treatment of mites had no mortality effect. However, placement of mites on treated leaf disks appeared to aggravate mites, as the percentage leaving disks was consistently higher than either topically-treated mites or non-treated mites placed on non-treated leaf disks, although these differences were not significant.

The response of immature ERM was similar to that observed with adult mites, but they appeared to be more sensitive to fluazinam. Initially, mortality of mites placed on fluazinam-treated leaf disks was higher than either topically-treated or untreated mites placed on untreated leaf disks (Table 3). At 4- and 5-day counts, mortality on treated leaf disks and treated mites was significantly higher than the untreated. In addition, at both 1- and 2-days after treatment, a significantly higher percentage of mites had left leaf disks in both fluazinam treatments compared with the untreated. However, these differences dissipated by 3-days post treatment, possibly reflecting satisfaction of an acclimation period by mites.

Ovicidal Studies. The toxicity of fluazinam to ERM eggs was evident in experiment 1 and 2 (Table 4). Results from experiment 1 demonstrates the toxicity of topical applications, while experiment 2 demonstrates eggs laid on fluazinam-treated leaf surfaces were nonviable compared with captan residues. Also of interest is that females laid significantly fewer eggs/female on fluazinam- compared with fluazinam-treated leaves. The ovicidal effects of fluazinam were also evident on field-treated leaves for at least 2 days after application (Table 5).

Summary

These studies demonstrate that fluazinam can play an important role in integrated mite management programs on apples. The repeated use of fluazinam initiated at a ERM threshold level of 7 mites per leaf provided excellent season-long control, and was superior to a single application of Omite. The residual activity of fluazinam against ERM appears to be relatively short; although a single early season application when mite populations were low delayed and reduced the intensity of populations, season-long control was not achieved. In addition, field and laboratory studies failed to detect an toxicity of fluazinam to *S. punctum*, the primary ERM predator throughout most of the mid and south Atlantic states. Laboratory studies suggest that the primary mode of action of fluazinam against ERM is ovicidal. Greater than 85% of eggs treated with Fluazinam 500 in the laboratory failed to hatch, while greater than 80% of eggs laid on 1-day-old field-treated leaves failed to hatch. Furthermore, fluazinam appeared to alter the behavior of mites, as both adults and immatures exhibited a greater propensity to leave fluazinam-treated leaf surfaces, and females laid fewer eggs on fluazinam- compared with captan-treated leaf surfaces.

Table 1. Mortality of *S. punctum* adults and larvae placed in scintillation vials treated with various concentrations of Fluazinam 500F and Asana XL, removed after 24 h and placed on ERM infested leaves.

Treatment	Concentration (ml/500 ml)	n	% Mortality 24 hr	120 hr	Total
			Adults		
Fluazinam 500	1.0	50	6.0(3.1)a	0.0	6.0(3.1)a
Fluazinam 500	2.0	50	2.0(2.0)a	0.0	2.0(2.1)a
Asana XL	0.08	50	100.0b	-	100.0b
Water	-	50	0.0a	0.0	0.0a
			Larvae		
Fluazinam 500	1.0	50	32.0(6.1)a	8.0(4.4)a	40.0(6.7)a
Fluazinam 500	2.0	50	32.0(6.1)a	10.0(4.5)a	42.0(6.3)a
Asana XL	0.08	50	100.0b	-	100.0b
Water	-	50	28.0(8.0)a	8.0(3.3)a	36.0(6.5)a

Means within the same column and life stage followed by the same letter are not significantly different by LSD ($P = 0.05$).

Table 2. Response of European red mite adults placed on fluazinam-treated or non-treated leaf disks ('Delicious' apple), or topically treated with fluazinam and placed on non-treated foliage. Leaves were dipped in solutions containing 1 ml Fluazinam 500/500 ml water.

Leaf treated	Mites treated	n	1-day	2-day	3-day	4-day	5-day
			% Mortality				
Yes	No	100	8.0(1.6)a	16.0(2.3)b	22.0(6.0)a	25.5(5.2)a	35.0(9.6)a
No	Yes	100	7.0(3.4)a	10.0(2.0)ab	18.0(2.0)a	30.0(4.8)a	37.0(4.7)a
No	No	100	2.0(1.2)a	7.0(1.9)a	13.0(1.9)a	20.0(4.3)a	33.0(5.3)a
			% Leaving disk				
Yes	No	100	17.0(6.4)a	33.0(11.7)a	45.0(12.4)a	49.0(9.3)a	55.0(10.2)a
No	Yes	100	6.0(3.5)a	15.0(1.9)a	29.0(3.4)a	30.0(3.5)a	36.0(1.6)a
No	No	100	6.0(2.6)a	10.0(2.0)a	33.0(5.7)a	37.0(5.0)a	36.0(1.6)a

Means within the same column and response category are not significantly different by LSD (P = 0.05).

Table 3. Response of immature European red mites placed on fluazinam-treated or non-treated leaf disks ('Delicious' apple), or topically treated with fluazinam and placed on non-treated foliage. Leaves were dipped in solutions containing 1 ml Fluazinam 500/500 ml water.

Leaf treated	Mites treated	n	1-day	2-day	3-day	4-day	5-day
			% Mortality				
Yes	No	95	9.5(2.5)b	16.3(4.1)a	38.0(3.5)b	55.5(5.9)c	62.0(6.2)c
No	Yes	100	2.0(1.1)a	12.0(2.8)a	20.0(2.8)a	36.0(3.6)b	38.0(6.2)b
No	No	90	5.4(0.8)ab	7.9(2.5)a	12.7(4.1)a	19.0(4.9)a	22.9(6.9)a
			% Leaving disk				
Yes	No	95	18.8(7.2)c	33.5(10.9)b	25.0(3.8)a	34.0(4.8)a	36.0(5.4)a
No	Yes	100	9.0(3.0)b	11.0(1.9)ab	20.0(2.8)a	21.0(1.9)a	39.0(1.0)a
No	No	90	1.9(1.8)a	5.8(3.3)a	13.0(2.6)a	20.6(4.2)a	33.8(4.8)a

Means within the same column and response category are not significantly different by LSD ($P = 0.05$).

Table 4. Ovicidal activity of Fluazinam 500 (2 ml/l) and Captan 50W (2.4 gm/l) to European red mite eggs. Egg-infested leaves (cv. 'Rome Beauty') were dipped into fungicide solutions in experiment 1, and females oviposited onto treated leaves in experiment 2.

	Experiment 1		Experiment 2		
Fungicide	n	% eggs hatching	n	% eggs hatching	No. eggs/female
Fluazinam 500	581	13.6(3.8)a	40	13.2(4.5)a	0.97(0.17)a
Captan	524	63.8(10.0)b	87	80.8(3.0)b	1.82(0.29)b

Means within the same column followed by the same letter are not significantly different by t-test ($P < 0.05$).

Table 5. Percentage of European red mite eggs hatching after females ovipositied on to leaf disks (cv. 'Rome Beauty) at various days after being sprayed in the field with Fluazinam 500 and Captan 50W.

		0-day		1-day		2-day	
Fungicide	Rate per 100 gal	n	% hatch	n	% hatch	n	% hatch
Fluazinam 500	0.8 pt	45	22.8(7.4)a	51	16.4(7.1)a	60	33.1(12.4)a
Captan 50W	2.0 lb	70	91.8(3.5)b	64	95.1(3.2)b	50	97.0 (1.8)b

Means within the followed by the same letter are not significantly different by t-test ($P < 0.05$).

Comparison of Large Plot Mating Disruption with IPM Treatments for Control of Tufted Apple Bud Moth in North Carolina

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Introduction

Due to increasing levels of resistance to organophosphate insecticides in tufted apple bud moth (TABM), there is a need to evaluate the effectiveness of alternative control practices which would reduce selection pressure for resistance. Pheromone mediated mating disruption of TABM has proven to be an effective alternative to conventional insecticide treatments under low density populations. However, it has had limited success in orchards in Henderson Co., the primary apple production region in North Carolina. Failures have been attributed to very high density TABM populations in Henderson Co. There are two generations of TABM in NC, with the first generation typically having lower numbers and causing less fruit damage than the second generation. Due to these factors mating disruption was directed at the first generation. Mating disruption may be a useful component to the IPM program already in place in NC, but more information must be obtained.

The purpose of these trials was to compare the efficacy of mating disruption to the standard IPM spray program for control of the first generation of TABM. In addition, TABM behavioral and trap placement information in pheromone treated and non-treated blocks was obtained.

Materials and Methods

The trials were conducted in three commercial orchards in Henderson Co. and one in Haywood Co. NC.

Hend-Mc: Three 5.5 acre blocks were utilized at this orchard. Blocks consisted of alternating rows of 20-year old 'Red delicious' and 'Golden Delicious' trees with an approximate height of 20 feet. There were 115 trees per acre. The orchard had a history of high levels of TABM insecticide resistance. There were nine trapping locations per block. A trapping location consisted of two TABM traps, one placed at 5-6 ft and the second at or near the top of the canopy.

Hend-Mar: Two blocks were utilized at this location. Blocks consisted of 13-year old 'Rome' trees approximately 15 feet in height. There were 145 trees per acre. The orchard had a history of high TABM populations. The Conventional block was four acres in size and Alternative I was six acres. There were three trapping locations per block.

Hend-NS: Two blocks were utilized at this location. Blocks consisted of 30-year old 'Golden Delicious' trees approximately 30 ft. in height. There were 75 trees per acre. The orchard had a history of moderate to high populations of TABM. The Conventional and Alternative I blocks were two and seven acres in size, respectively. There were two and five trapping locations in the Conventional and Alternative I block, respectively.

Haywood - F: Two five acre blocks were utilized at this location. The Conventional block consisted of 'Red Delicious', 'Golden Delicious', and 'Stayman' trees. Trees were approximately 20-years old, and 18-25 ft in height. There were 115 trees per acre. The Alternative II block consisted of 'Red Delicious' and 'Golden Delicious' trees 20-years old and 20 ft. in height. The orchard had a history of low to moderate population levels of TABM. Conventional and Alternative II blocks contained five trapping locations each.

Treatments: There were three different treatments in the experiment.

1-Conventional (IPM treatment) consisted of applications of Penncap-M or Lorsban at second, third, and fourth cover sprays. Penncap-M or Lorsban also were applied Mid and Late August against second generation TABM.

2-Alternative I consisted of an application of Asana to the orchard ground cover to reduce the over-wintering TABM larvae population, an application of Lorsban at petal fall, and an application of Penncap-M at first cover. Polyvinyl chloride (PVC) spiral pheromone dispensers containing a 50 mg load of *E* 11-14:OH and *E* 11-14:Ac in a 50:50 mixture, the pheromone blend identified for TABM (Hill et al. 1974),were used. At petal fall the dispensers (Ecogen Inc. Langhorne, PA) were hung in the upper third of the canopy, at a rate of 400 per acre.

3- Alternative II was the same as in Alternative I, but the Asana ground cover application was omitted. In Haywood-F: the first cover spray was also omitted.

Data Collection: Scentry wing traps were used and monitored weekly. Pheromone lures loaded with 10 mg of TABM pheromone were replaced every four to five weeks. Trap bottoms were replaced after 50 moths were trapped per week or as needed (Brown 1984). Trapping locations were positioned in the orchards to monitor 2 to 3 rows from each edge and the center of the block, depending on block size. In Hend-Mc a total of nine trapping stations per block were utilized to analyze edge effects.

Egg mass searches were performed during both generations. A one hour search per block was performed. At Hend-Mc and Hend-Mar, 0.5 hr. egg mass searches were conducted in the lower and upper canopy at each location. High searches were performed by climbing the trees, or from the top of a van, while low searches were performed from the ground.

Fruit damage assessment was conducted at the end of the first larval generation and at harvest. 100 fruit per tree were sampled, and damage was identified as first or second generation leafroller damage. At Hend-Mc and Hend-

Mar 1200 fruit per block were examined, at Hend-NS 600 fruit per block, and at Haywood-F 800 fruit per block. Hend-Mc fruit was harvested as 50 high and 50 low per tree.

Results and Discussion

Trap Catches: TABM pheromone trap catch and percent trap shutdown are shown for each farm in figures 1-4. Data presented from Hend-Mc is from four center block trapping locations.

Disruption of mating appeared to be most effective during the first three to four weeks of moth emergence, with high levels of percent trap shutdown. After this time there was a noticeable decline in percent shutdown, and in some cases zero percent shutdown. Hend-Mc Alternative I had lower trap catches and higher percent shutdown than did Alternative II for the majority of the first generation.

Egg Mass Counts: Egg mass counts were conducted as an alternate method of assessing mating disruption effectiveness. Table 1 displays the high and low cumulative egg mass counts from the first and second generation for each block. Higher numbers of first generation egg masses were found in the upper canopy. Which agrees with the findings of Meager and Hull (1987). Second generation data did not provide a clear indication of height preference in oviposition from the searched blocks. The only large reduction in egg mass number is observed in Hend-Mc Alternative I. It is important to note that in some mating disruption blocks a delay in oviposition was observed during the early part of the generation. This information, combined with percent trap shutdown data for the corresponding period, suggests that mating disruption was initially effective, but failed as time progressed.

Fruit Damage: Damage data presented in Table 2 is from the harvest evaluation. Hend-Mc and Hend-Mar both had higher levels of damage in mating disruption blocks compared to conventional treatments. Hend-NS and Haywood-F had similar levels of fruit damage in the conventional and alternative treatments.

Behavior and Trap Placement: By placing pheromone traps at two heights we were able to characterize male flight activity within the tree canopy. Figures 5a-8a show that moth trap catches during the first generation tended to be higher in the high traps. Trap catches were also greater in the high traps during the second generation; however, second generation populations were reduced overall, possibly due to high levels of rainfall during first generation larval development stage.

Figures 5b,5c-8b present percent trap shut down for the alternative treatment traps. The low traps exhibited higher percent trap shut down throughout the first generation. Reduction in percent trap shutdown for high traps occurred more rapidly than in low traps. Low traps followed similar trends in percent trap shutdown as high traps, but with less amplitude. These results suggest that high traps may be utilized as early warning systems in mating disruption blocks to prevent treatment control failures from occurring, although more research is necessary.

References

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Table 1. Number of TABM egg masses per one hour search in the upper and lower canopy.

		First Gen.			Second Gen.		
Orchard	**Trt**	**High**	**Low**	**Total 1st**	**High**	**Low**	**Total 2nd**
Hend Mc:	Conv.	18.9	8.6	27.5	13.6	16.4	30
	Alt I	6	3.7	9.7	18.4	10.4	28.8
	Alt II	19.1	8	27.1	21.6	10.8	32.4
Hend Mar:	Conv.	22	16(35)*	38(73)	42.4	84.8	127.2
	Alt I	20.6	10.7(45)	31(76)	30	69.2	99.2
Hend NS:	Conv.	--	7.8	7.8	--	13.9	13.9
	Alt 1	--	4.75	4.75	--	11	11
Haywood F:	Conv.	--	2.5	2.5	--	1.5	1.5
	Alt I	--	3.5	3.5	--	6.5	6.5

* 5/17 and 6/29 only low searches were performed numbers in () are the cumulative counts from those days and the totals

Table 2. Mean percent fruit damage (SEM) in IPM and mating disruption treated blocks.

Orchard	**Generation**	**Conventional**	**Alt I**	**Alt II.**
Hend Mc	1st	4.8 (1.00)	9.7 (0.87)	10.6 (1.47)
	2nd	4.7 (0.92)	3.3 (0.59)	6.6 (1.25)
	Combined	9.5 (1.62)	12.9 (1.38)	17.2 (1.95)
Hend Mar	1st	15.5 (1.8)	26.1 (2.6)	-----
	2nd	5.3 (0.3)	6.3 (1.5)	-----
	Combined	20.8 (1.74)	32.9 (2.9)	-----
Hend NS	1st	4.7 (1.3)	5.5 (1.5)	-----
	2nd	1.5 (0.8)	2.7 (0.7)	-----
	Combined	6.2 (1.8)	8.2 (1.9)	-----
Haywood F	1st	0.6 (0.3)	-----	0.9 (0.4)
	2nd	0.1 (0.1)	-----	0.1 (0.1)
	Combined	0.7 (0.3)	-----	1.0 (0.4)

Figure 1a. Hend Mc: TABM Trap Catch
Mean number of moths/trap/day

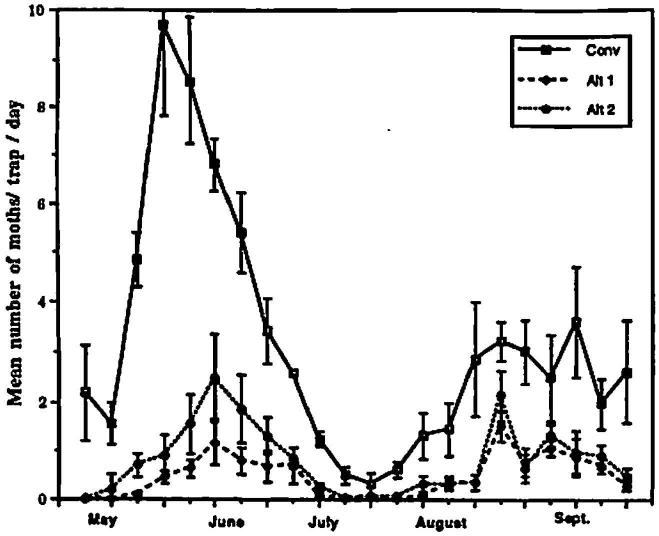


Figure 1b. Henderson MC: Percent Trap Shutdown

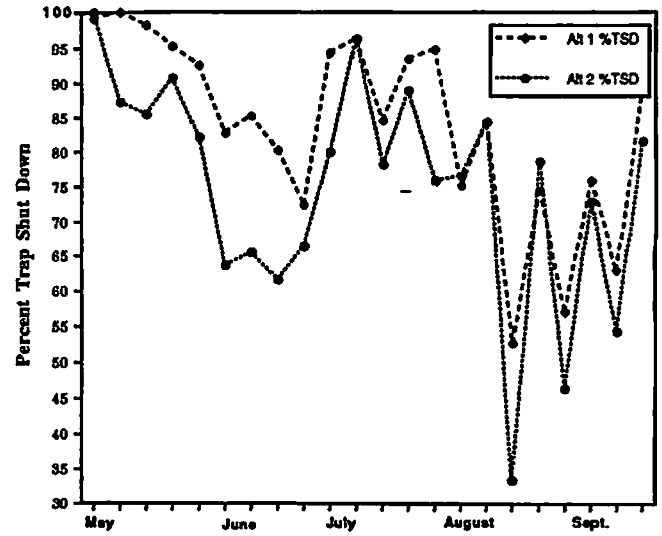


Figure 2a. Hend Mar: TABM Trap Catch
Mean number of moths/trap/day

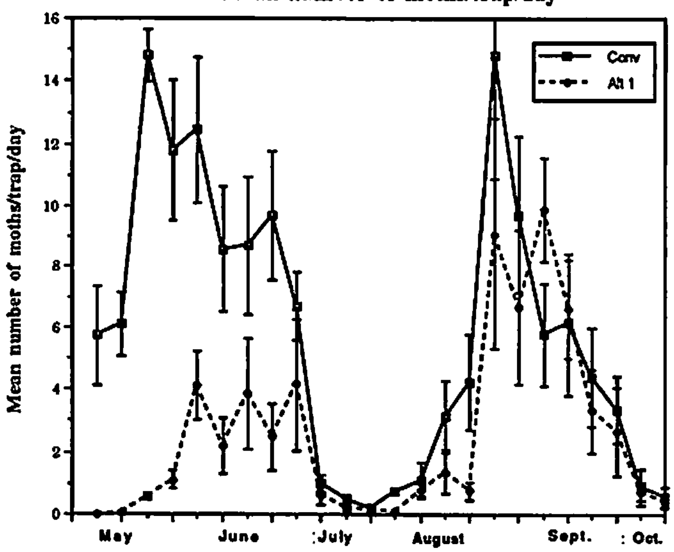


Figure 2b. Hend Mar: Percent Trap Shutdown

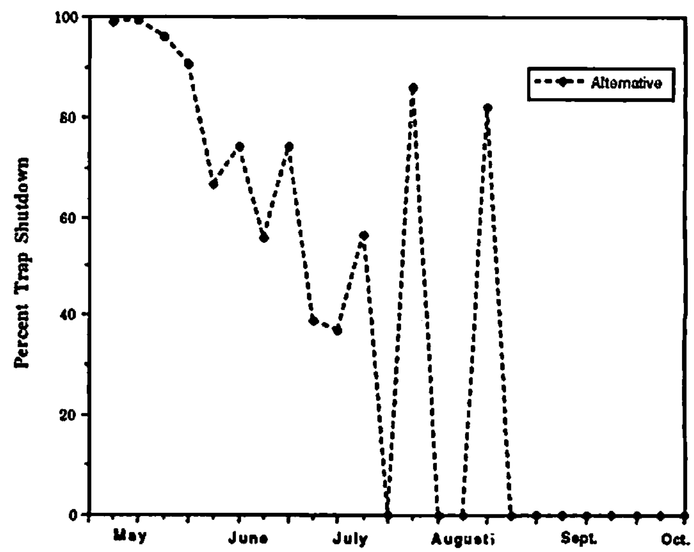


Figure 3a. Hend NS: TABM Trap Catch
Mean number of moths/trap/day

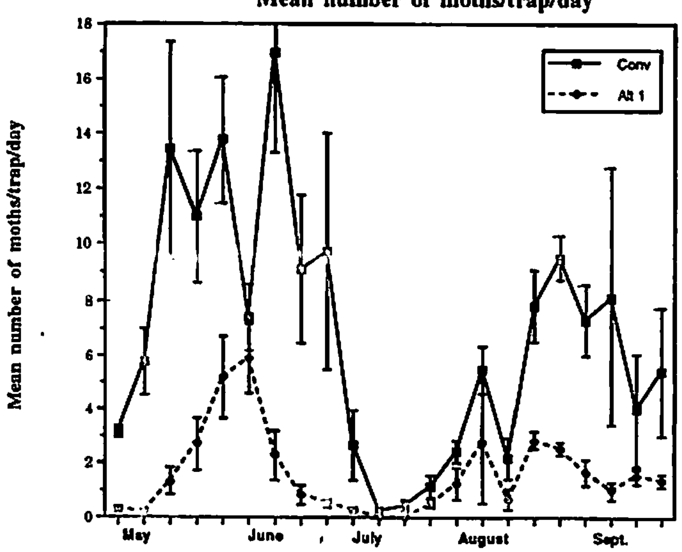


Figure 3b. Hend NS: Percent Trap Shutdown

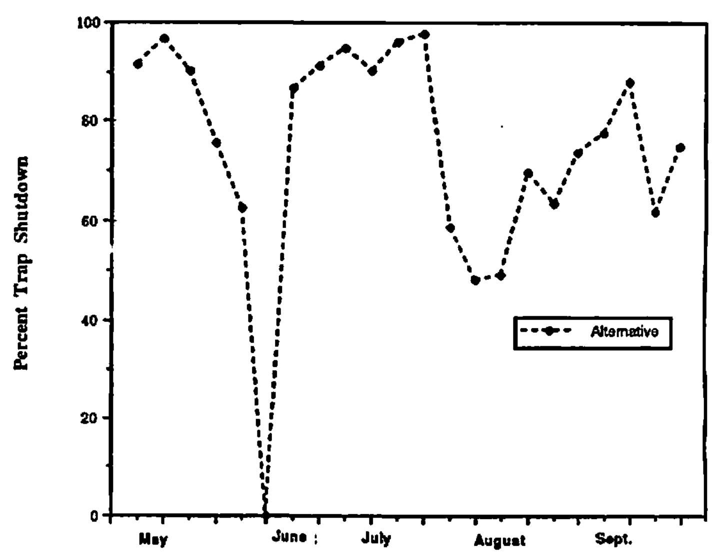


Figure 4a. Haywood F: TABM Trap Catch
Mean number of moths/trap/day

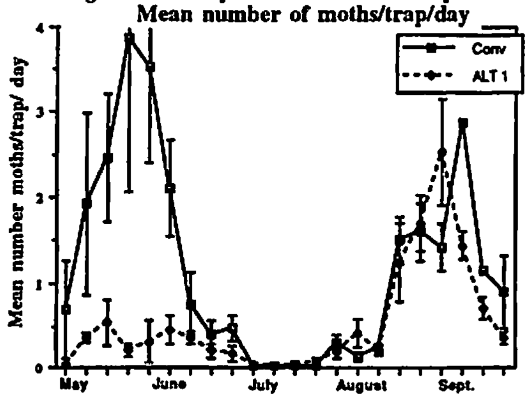


Figure 4b. Haywood F: Percent Trap Shutdown

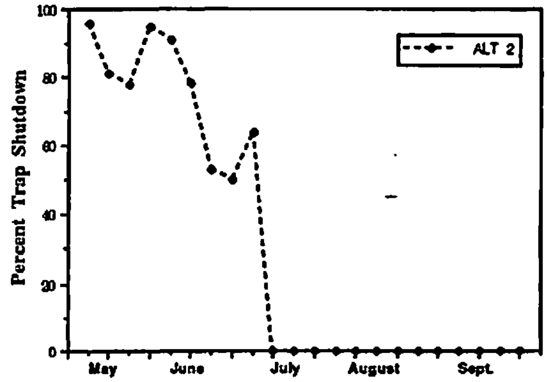


Figure 5a. Hend Mc: Conventional Block
TABM Trap Catches - High and Low

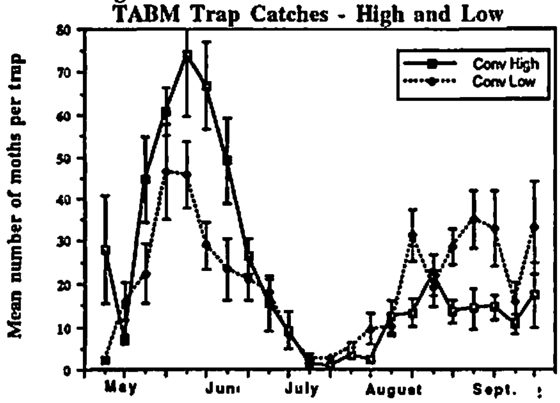


Figure 5b. Hend Mc: Alternative 1 Percent Trap Shutdown
High and Low

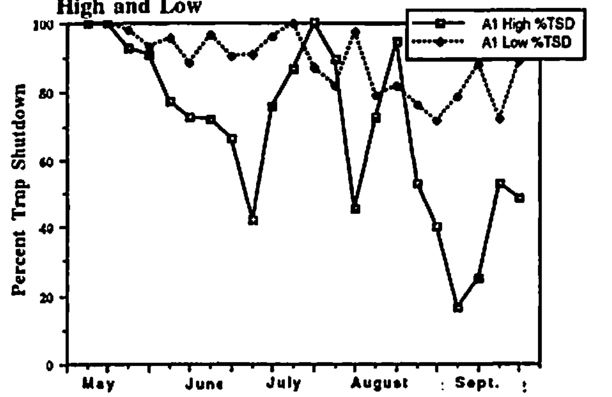


Figure 5c. Hend Mc: Alternative 2 Percent Trap Shutdown
High and Low Traps

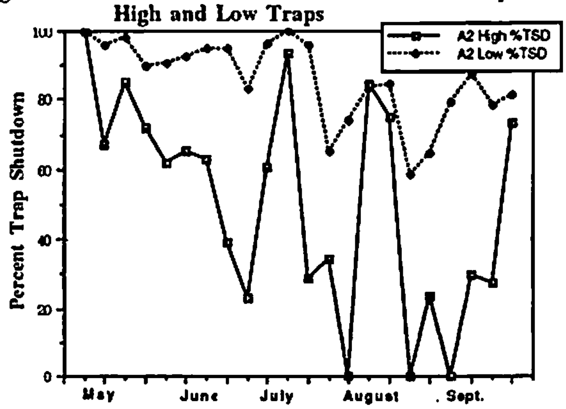


Figure 6a. Hend Mar: Conventional Block TABM Trap Catches - High and Low Traps

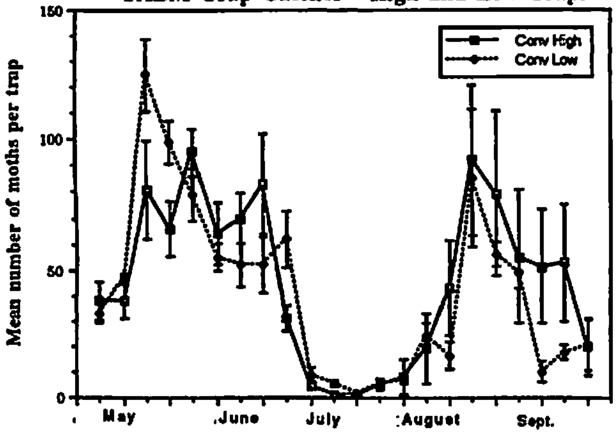


Figure 6b. Hend Mar: Percent Trap Shutdown High and Low Traps

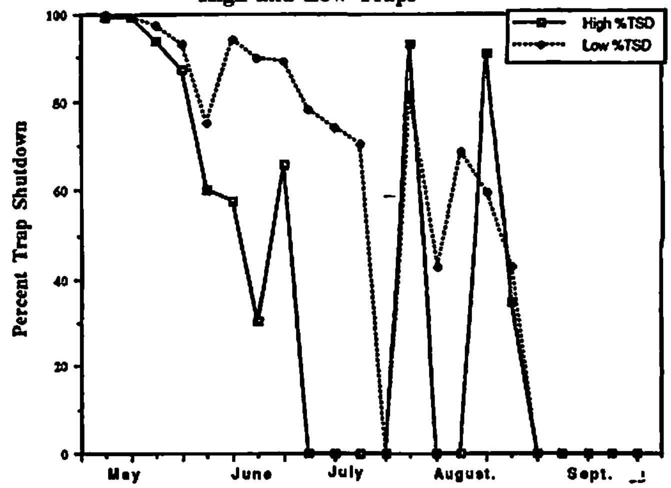


Figure 7a. Hend NS: Conventional Block TABM Trap Catch- High and Low Traps

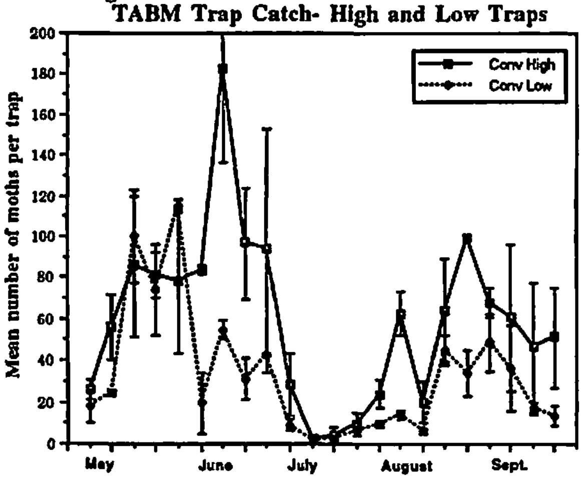


Figure 7b. Hend NS: Percent Trap Shutdown High and Low Traps

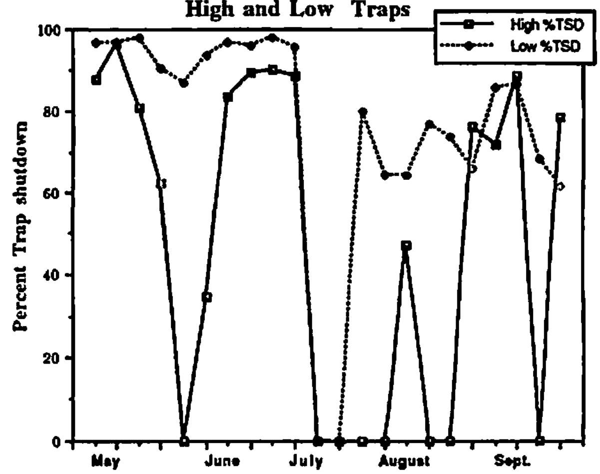


Figure 8a. Haywood F: Conventional block TABM Trap Catches - High and Low Traps

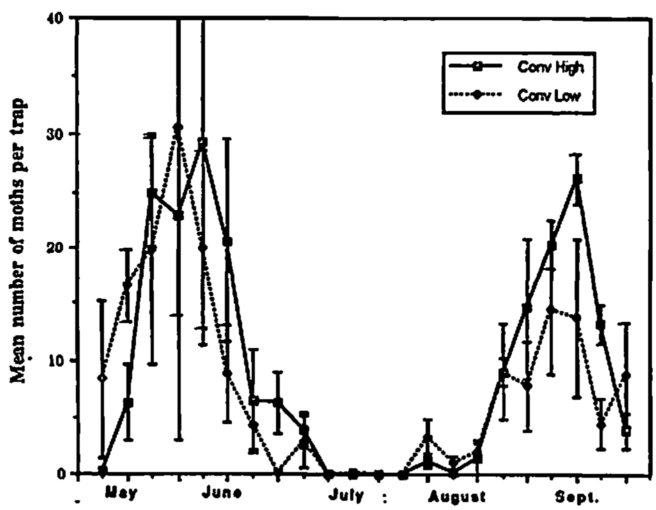
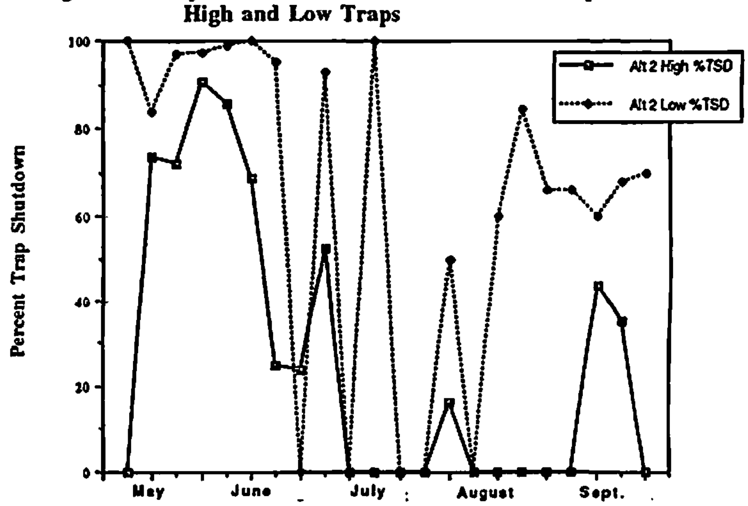


Figure 8b. Haywood F: Alternative 2 Percent Trap Shutdown High and Low Traps



Mating Disruption of Codling Moth and Leafrollers - 1994

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I. Introduction: The leafroller complex in the mid-Atlantic states includes several species, primarily variegated leafroller (VLR), *Platynota flavedana* (Clemens), tufted apple bud moth (TBM), *P. idaeusalis* Walker, and redbanded leafroller (RBL), *Argyrotaenia velutinana* (Walker). The leafroller complex is more diverse in our area than elsewhere in North America (Weires & Riedl 1992). Research has been performed on mating disruption for this complex in recent years (Pfeiffer et al. 1993); further results are reported here.

Codling moth (CM), *Cydia pomonella* (L.), has been the subject of mating disruption in Virginia since 1987; this work has become more intensive since 1989. Results have been promising to date. However, in some orchards damage has been higher than conventionally acceptable, especially in orchard edges. Further work is needed to determine how best to integrate mating disruption with chemical pest control.

II. Materials and Methods: Tyro Orchard - A 4-ha (10-acre) leafroller and CM disruption block was located in an orchard at Tyro (Nelson Co.). Shin-Etsu CM dispensers (Pacific Biocontrol, Davis CA) were placed on 19 April at the rate of 1000/ha (400/A). The pheromone blend contained in the dispensers was 192 mg of (*E,E*)-8,10-dodecadien-1-ol (63%)/ dodecenol (31%)/ tetradecenol (6%). Ecogen spiral dispensers (50 mg/dispenser) were placed at the same density on 12 May. The pheromone block was further subdivided into three pheromone treatments: Generic II, TBM and VLR blends. The control block was treated with conventional insecticide program. Four pheromone traps (Trécé Inc., P.O. Box 6278, Salinas, Ca.) each for VLR, TBM, RBL, OBL and CM were placed in the control block and monitored weekly. Two traps per leafroller species were placed in each pheromone treatment. This orchard has had low levels of CM damage historically. Damage was assessed periodically during the season. Harvest injury was assessed on 13 September on 200 fruit collected from each block center.

Batesville Orchard - Leafrollers and CM was the target of mating disruption in a 4-ha (10-acre) block, primarily `Winesap', at Batesville (Crown Orchard, Albemarle Co.). The control block, also primarily `Winesap'. was about 0.4 km (0.25 mi) away from the pheromone-treated block. The pheromone block was further divided into two 5-acre subplots, treated with Consep dispensers containing Generic II and VLR blends, placed at 500/ha on 6 June. Four pheromone traps for VLR, TBM, RBL, and CM were placed in the control block and checked weekly. Two traps per leafroller species were placed in each pheromone subplot. The grower agreed to refrain from all insecticide sprays after first cover until recommended otherwise. Harvest injury was assessed on 10 and 17 October.

Spring Valley - A 4-ha (10-acre) block at Spring Valley (Albemarle Co.) was treated with Shin-Etsu CM pheromone dispensers at 1000/ha on 21-22 April. Consep leafroller dispensers were placed on 1 June at the rate of 500/ha; half the acreage was treated with Generic II and half with VLR blends. A conventional insecticide program was followed through first cover. A control block of similar varietal representation was located about 50 m away. Four pheromone traps each for VLR, TBM, RBL, and CM were placed in the control block and monitored weekly. Two traps per leafroller species were placed in each pheromone subplot. Harvest injury was assessed on 4 September. At that time, 200 fruit of both `Red Delicious' and `Golden Delicious' were harvested both from the edge of each block.

Fincastle Orchard - A block near Fincastle (Botetourt Co.) was treated with Shin Etsu CM dispensers on 15 April, at 1000/ha. This block was 1.8 ha (4.5 acres), composed of `Red Delicious' (67%) and `Golden Delicious' (33%). Tree density was 325 trees/ha (130/acre). A standard insecticide program was followed through first cover, after which no further insecticides were applied unless conditions warranted them.

Hercon Generic II dispensers were place on 4 May at 1000/ha. The control block, of similar varietal composition, was about 0.4 km (0.25 mi) away from the block treated with pheromone; a conventional insecticide program was followed. Three pheromone traps each for VLR, TBM, RBL, and CM were placed in each block and monitored weekly. Harvest injury was assessed on 6 September, using 150 of both 'Golden Delicious' and 'Delicious' fruit, from each block center and edge (600 fruit per block).

Solenburger - A 25-acre processing orchard block was treated on 20 April with brown Shin-Etsu CM dispensers, and on 30 May was subdivided into 5-acre subplots and treated with the following blends: Consep VLR, Ecogen VLR, Ecogen Generic II, Ecogen TBM (high placement), Ecogen TBM (low placement); an untreated control block was nearby. CM and Ecogen dispensers were applied at 1000/ha (400/ha); Consep dispeners were applied at 500/ha (200/A). Three traps per species were placed in each 5-acre sub-plot. Effects of height of dispenser placement was made using TBM plots. Pheromone traps were placed on 12 ft. poles at 6 and 12 ft heights. Trap captures at different trap heights was compared in differing pheromone placement heights. On 2 September, 200 fruit from each block center and edge were collected. For the comparison of height effects, 150 high fruit and 150 low fruit were collected from each edge and center.

Glaize - A 25-acre block was treated with Shin-Etsu CM dispensers (1000/ha) on 28 April, and was divided into two sub-plots for leafroller disruption. Consep VLR dispensers were applied to 10 acres (500/ha) and 15 acres were treated with Ecogen TBM dispensers (1000/ha) on 26 May. Four pheromone traps per species were placed in each subplot. Damage was assessed on 2 September from 200 fruit collected from each plot center and edge.

III. Results and Discussion: Flight Data: Tyro trap data are summarized in Table 1. The VLR blend reduced captures more effectively than did either the TBM or Gen 2 blends. However, the VLR blend actually caused a 165% *increase* in the captures of RBL. This was not the case with either TBM or Gen 2 blends; Gen 2 caused total trap shutdown of RBL. Batesville trap data are summarized in Table 2. No blend caused total trap shutdown of any species. Gen 2 performed relatively poorly against RBL. The VLR blend caused about a 115% *increase* in RBL captures. Spring Valley trap data are summarized in Table 3. The VLR blend performed fairly well against both *Platynota* species; however, it caused a 470% *increase* in RBL captures. The Gen 2 blend performed well against TBM, moderately well against RBL, but poorly against VLR. At Fincastle (Table 4), Gen 2 worked fairly well against VLR, TBM and RBL.

Table 1. Trap data for Tyro orchard

	Pheromone Environment					
	Gen II			**TBM**		
	VLR	TBM	RBL	VLR	TBM	RBL
Cum. catch	2.5	0.5	0	8.5	0.5	0.5%
% shutdown	81.1	90.4	100	35.6	90.4	95.5
	VLR			**Control**		
	VLR	TBM	RBL	VLR	TBM	RBL
Cum. catch	0	0	18.5	13.2	5.2	11.2
% shutdown	100	100	(165% increase)	-	-	-

Table 2. Trap data for Batesville orchard

	Pheromone Environment								
	Gen II			VLR			Control		
	VLR	TBM	RBL	VLR	TBM	RBL	VLR	TBM	RBL
Cum. catch	8.5	4.5	34	3	7	46.5	71.5	68	40.5
% shutdown	88.1	93.4	16.0	95.8	89.7	(114.8% incr.)			

Table 3. Trap data for Spring Valley orchard

	Pheromone Environment								
	Gen II			VLR			Control		
	VLR	TBM	RBL	VLR	TBM	RBL	VLR	TBM	RBL
Cum. catch	27.0	1.0	4.0	1.5	3.5	115	30	47	24.5
% shutdown	10	97.8	83.7	95.0	92.6	(469.4% incr.)	-	-	-

Table 4. Trap data for Fincastle orchard

	Pheromone Environment					
	Gen II			Control		
	VLR	TBM	RBL	VLR	TBM	RBL
Cum. catch	0.7	3.0	3.7	34.0	41.7	37.3
% shutdown	97.9	92.8	90.1	-	-	-

Solenburger: Cumulative trap captures representing three traps per block are presented in Table 5. The treatments yielded the following % shutdown values for TBM: TBM (high) - 89.0; TBM (low) - 87.1; Ecogen VLR - 80.0; Consep VLR - 82.6; and Ecogen Gen 2 - 80.3. The following % shutdown values for RBL were obtained: TBM (high) - 62.4; TBM (low) - 89.7; Ecogen VLR - 8.2; Consep VLR - 99.1; and Ecogen Gen 2 - 90.0.

The effect of height of dispenser placement on trap captures of TBM both high and low in the tree are presented in Table 6. High dispensers more effectively reduced captures of TBM high in the tree. This effect is important given that somewhat more of the population is found higher in the tree. Low dispensers may have caused somewhat greater shutdown in low traps.

Table 5. Cumulative trap captures at Solenburger orchard.

	TBM (high)	TBM (low)	Ecogen VLR	Consep VLR	Ecogen Gen 2	Control
VLR	4	0	2	7	1	33
TBM	126	148	229	199	225	1,144
RBL	495	136	1,208	12	132	1,316

Table 6. Effect on tufted apple bud moth trap captures in high and low sections of trees, under conditions of high and low pheromone dispenser placement (numbers in parentheses denote % trap shutdown).

Trap height	High Dispensers	Low Dispensers	Control
High	27 (91.8)	81 (75.5)	331
Low	92 (63.6)	53 (79.0)	253
Totals	119 (79.6)	134 (77.1)	584

Glaize Orchard: Cumulative trap captures in four traps per block are presented in Table 7. Both pheromone blends gave good shutdown for both VLR, while only fair shutdown for TBM. The VLR blend had no effect on RBL, while the TBM blend gave fair shutdown.

Table 7. Cumulative captures at the Glaize orchard.

	Ecogen TBM	Consep VLR	Control
VLR	7	2	156
TBM	125	68	211
RBL	75	334	334

Damage data: During periodic assessments during the season, damage was low in most orchards. An important exception was the Solenburger orchard, where a severe control failure occurred in the first generation. This occurred for two reasons. First, dispensers were not placed before first male flight. Second, a very high population existed during the previous season because of pesticide resistance. This emphasizes the need to integrate mating disruption into a broader pest management program.

Tyro: From the center of each block, 200 fruit were collected from Ecogen TBM, VLR, Gen 2, and control blocks. No injury from CM, TBM/VLR, or RBL was detected. One fruit injured by plum curculio and 2 infested with San Jose scale were found in the control block.

Batesville: In a sample of 200 fruit from each block center (17 October), the following data were collected:

Table 8. Percent damaged fruit at the Batesville orchard (Consep dispensers).

Treatment	CM	*Platynota*	RBL	*Grapholita*
Gen 2	1	5	10	1
VLR	1(sting)	0	1	1
Control	0	0	1	0

Spring Valley: In a sample of 200 fruit from each block center (4 September), the following data were collected:

Table 9. Percent damaged fruit at the Spring Valley Orchard (Consep dispensers).

Treatment	CM	*Platynota*	RBL	*Grapholita*
Gen 2	1	2	0	0
VLR	1	0	0	2
Control	0	0	1	0

Fincastle: In a sample of 300 fruit from each block center and edge, the following injury was detected:

Table 10. Percent damaged fruit at the Fincastle orchard (Hercon dispensers).

Treatment		CM	*Platynota*	RBL
Gen 2	Edge	0	0	0
	Center	2	0	0
Control	Edge	0	0	0
	Center	0	0	0

Solenburger: In samples of 200 to 300 fruit from each block center and edge, no CM injury was detected. Severe damage from TBM was found, as follows:

Table 11. Percent damaged fruit at the Solenburger (Winchester) orchard.

	Ecogen TBM (high)	Ecogen TBM (low)	Ecogen VLR	Consep VLR	Ecogen Gen 2	Control
Edge	15.6	20.0	24.5	16.0	13.5	0.7
Center	17.7	16.3	15.5	4.5	2.0	0.0

In a comparison of high and low injury in trees with high versus low placement of Ecogen TBM pheromone dispensers, the injury presented in Table 12 was determined. Twice as much injury was found in lower parts of trees relative to high in the canopy.

Table 12. Effect on percentage of fruit damaged by tufted apple bud moth in high and low sections of trees, under conditions of high and low pheromone dispenser placement.

Fruit sample height	High Dispensers	Low Dispensers	Control
High	11.0	11.7	0.0
Low	22.3	24.7	0.5
Means	16.6	18.2	0.2

Glaize: In samples of 200 fruit from each block center and edge, no CM injury was detected. Damage from TBM was found, as follows:

Table 13. Percent damaged fruit at the Glaize (Winchester) orchard.

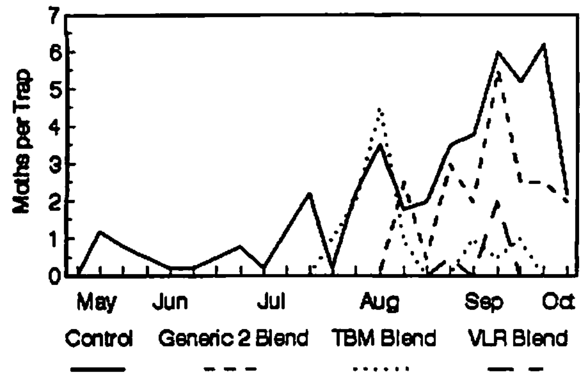
	Ecogen TBM	Consep VLR	Control
Edge	4.5	11.0	0.5
Center	4.0	5.5	0.0

IV. References Cited:

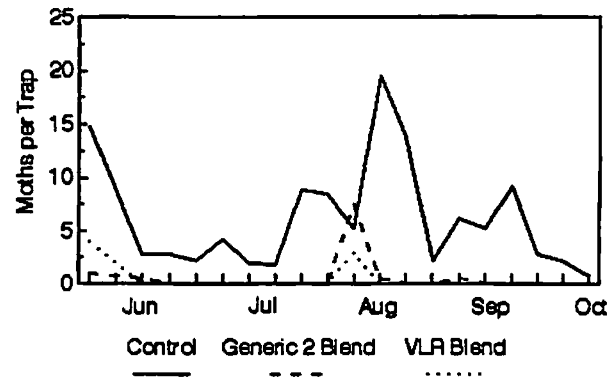
Pfeiffer, D. G., W. Kaakeh, J. C. Killian, M. W. Lachance, and P. Kirsch. 1993. Mating disruption to control damage by leafrollers in Virginia apple orchards. Entomol. Exp. Applic. 67: 47-56.

Weires, R. & H. Riedl. 1991. North American species. p. 413-434. *In* L. P. S. van der Geest & H. H. Evenhuis (eds). World Crop Pests. vol. 5. Tortricid Pests: Their Biology, Natural Enemies and Control. Elsevier, N.Y.

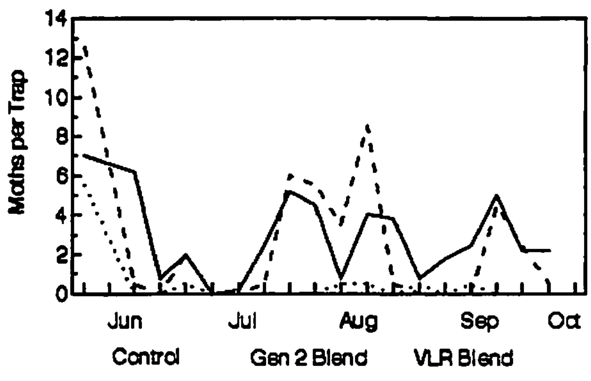
Variegated Leafroller Flight Activity
Tyro Orchard - 1994



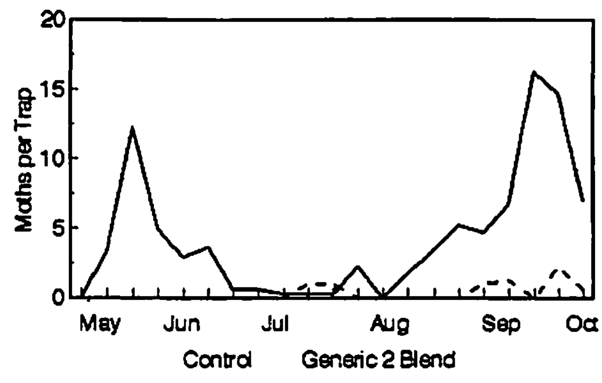
Variegated Leafroller Flight Activity
Crown Orchard - 1994



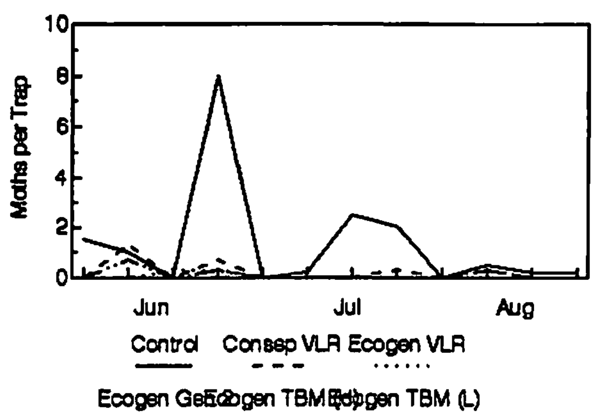
Variegated Leafroller Flight Activity
Spring Valley - 1994



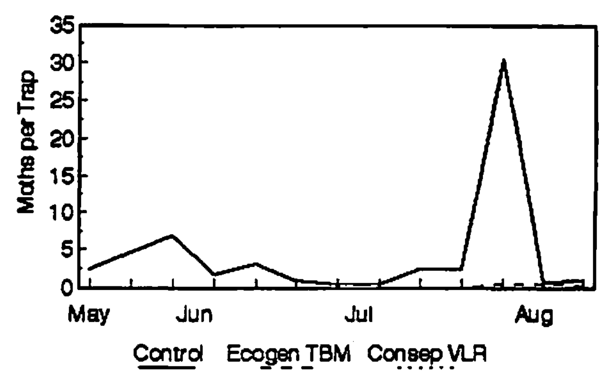
Variegated Leafroller Flight Activity
Fincastle - 1994



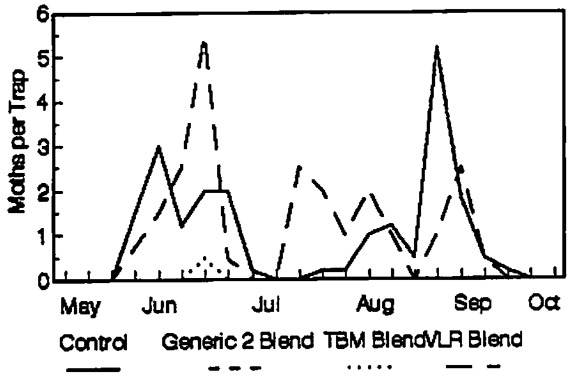
Variegated Leafroller Flight Activity
Solenburger Orchard - 1994



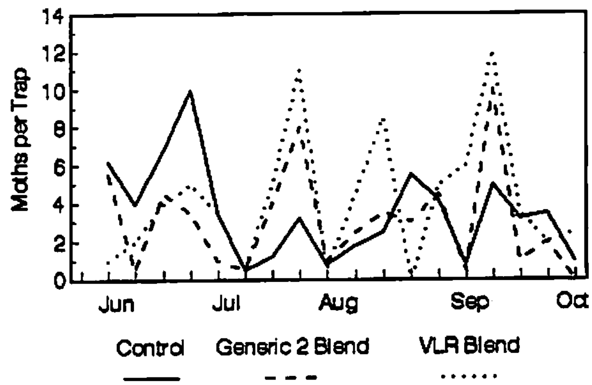
Variegated Leafroller Flight Activity
Glaize Orchard - 1994



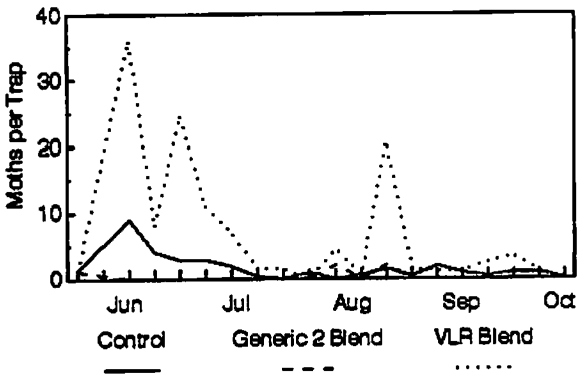
Redbanded Leafroller Flight Activity
Tyro Orchard - 1994



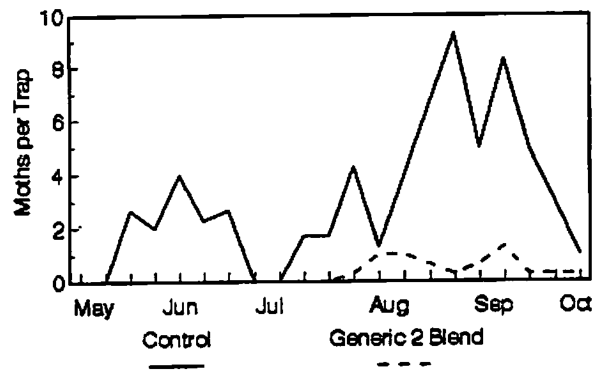
Redbanded Leafroller Flight Activity
Crown Orchard - 1994



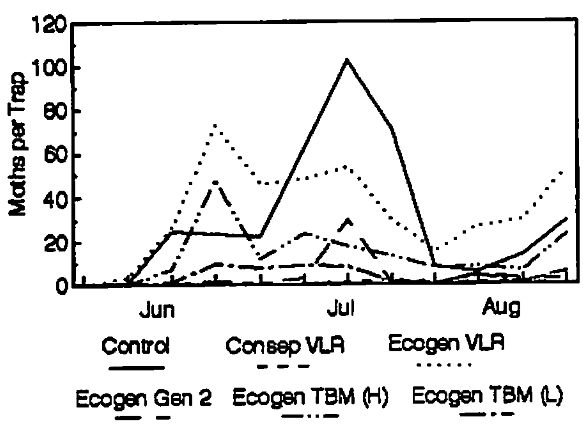
Redbanded Leafroller Flight Activity
Spring Valley - 1994



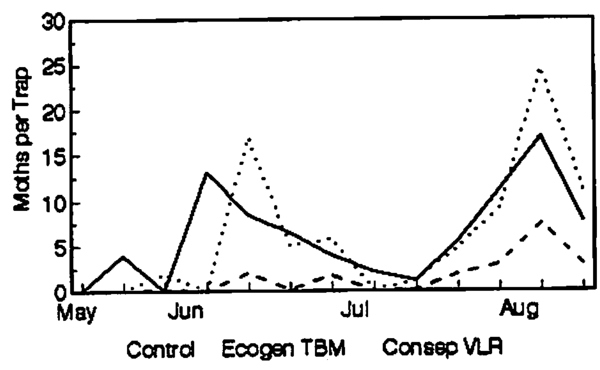
Redbanded Leafroller Flight Activity
Fincastle - 1994



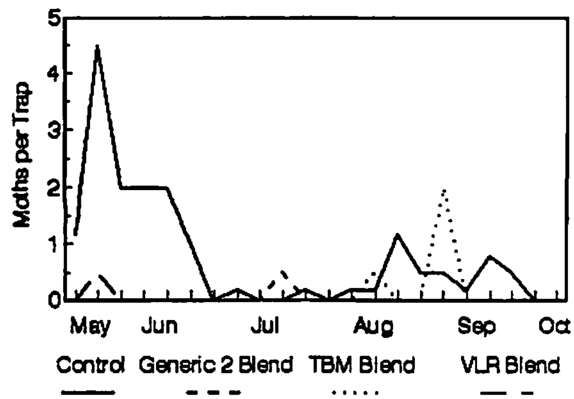
Redbanded Leafroller Flight Activity
Solenburger Orchard - 1994



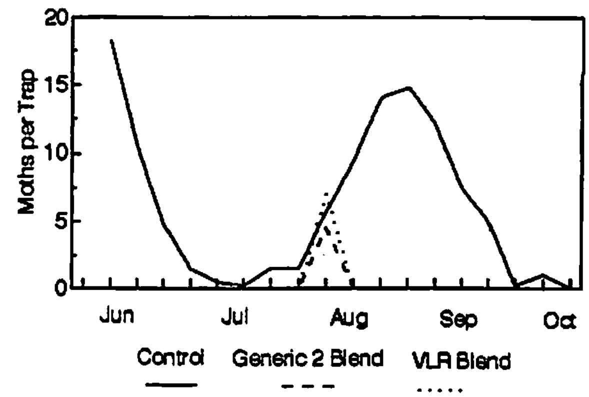
Redbanded Leafroller Flight Activity
Glaize Orchard - 1994



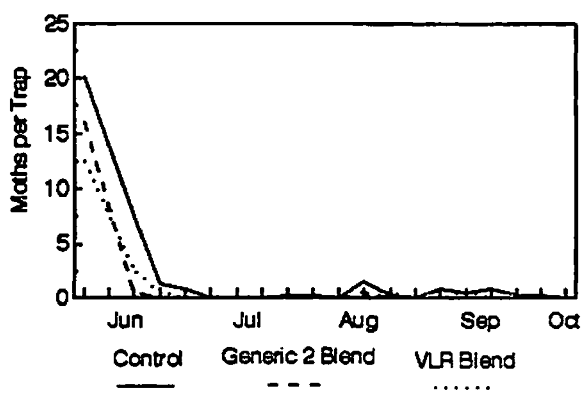
Tufted Apple Bud Moth Flight Activity
Tyro - 1994



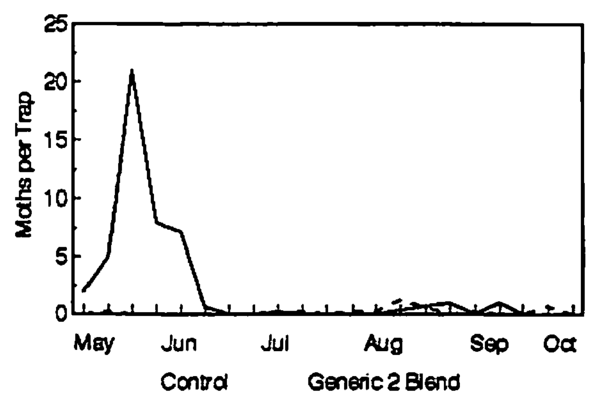
Tufted Apple Bud Moth Flight Activity
Crown Orchard - 1994



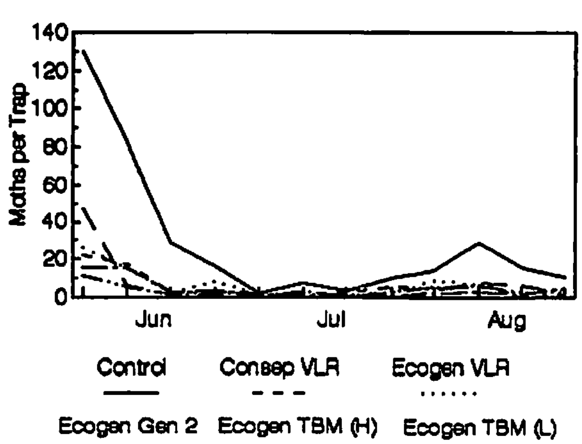
Tufted Apple Bud Moth Flight Activity
Spring Valley - 1994



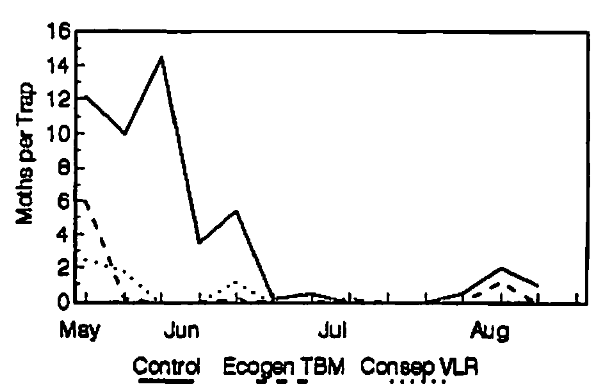
Tufted Apple Bud Moth Flight Activity
Fincastle - 1994



Tufted Apple Bud Moth Flight Activity
Solenburger Orchard - 1994



Tufted Apple Bud Moth Flight Activity
Glaize Orchard - 1994



Garden Tortrix Flight Activity in Leafroller Pheromone-Permeated Orchards

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Introduction: In 1994, moths superficailly resembling miniature obliquebanded leafroller (OBL), *Choristoneura rosaceana* (Harris), were collected in pheromone traps for tufted apple bud moth (TBM), *Platynota idaeusalis* Walker, in northern Virginia. This was considered unusual because these moths were often in very high numbers, especially in orchards permeated with pheromone of variegated leafroller, *P. flavedana* (Clemens). The sex pheromone of TBM is *E*11-14:Ac/*E*11-14:OH (50:50) (Bode et al. 1973, Hill et al. 1974); the pheromone of VLR has been reported as *E*11-14:OH/*Z*11-14:OH (90:10) (Hill et al. 1977).

Identification and Biology: Specimens were sent to Dr. Richard L. Brown (Mississippi State University) for identification. The moths were identified as *Ptycholoma peritana* (Clemens), commonly known as garden tortrix. The pheromone for this species in not described (Arn et al. 1992). It somewhat resembles a miniature OBLR; Atkins (1958) described it as similar to orange tortrix, *Argyrotaenia citrana* (Fernald). Powell (1964), including it in the genus *Clepsis*, described it as "a small, widespread, common moth having tan forewings marked by a dark brown transverse band and outer costal spot, and gray hindwings." The forewings are 4.7-6.7 mm in the male, 5.4-7.3 mm in the female. There is no costal fold. It was considered by Powell to be "the most widespread tortricine species in North America", with considerable geographic variation. It is distributed from southern Canada at least to northern Mexico, and from throughout the eastern U.S. through California. Although common, Powell (1964) commented on the scarcity of published information on this species' biology.

Covell (1984) described the coloration of garden tortrix as orange-yellow, with a "blackish subapical spot at costa and oblique median band that narrows below costa." The species was illustrated in a color plate, although adults actually are more yellow brown than depicted, and the subapical spot is less dark.

It apparently feeds on dead leaf material. The number of generations varies geographically. In San Diego, moths fly in all months, with continuous flight from mid-March to early October. In San Francisco, there are two main periods of flight activity. It has caused damage in strawberry plantings and citrus orchards where fruit come in contact with the ground or weeds; in high populations, larvae may damage living parts of plants (Powell 1964). In such serious situations, fruit as high as 5 ft have been damaged (Atkins 1958). It has also been a pest of lima beans (Atkins 1958). Given the wide range of host plants on which this species may feed, tree fruit crops could probably be fed upon by garden tortrix under the proper circumstances.

Behavior in VLR Mating Disruption Blocks: Although garden tortrix was collected primarily in pheromone traps for TBM, the highest captures of garden tortrix were obtained in orchard blocks permeated with the sex pheromone of VLR (Table 1). This phenomenon is not currently explained. However, elevated captures of other tortricids caused by permeation with an "alien" pheromone has been reported previously. Redbanded leafroller responded in this manner to the pheromone of VLR (Pfeiffer et al. 1993), and oriental fruit moth, *Cydia molesta* (Busck) to dodecenyl acetate (Rothschild 1974).

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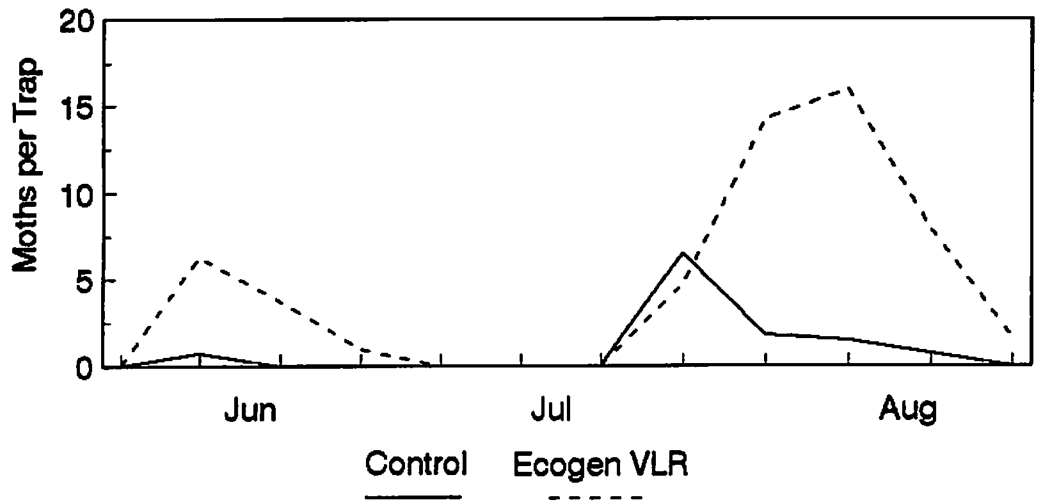
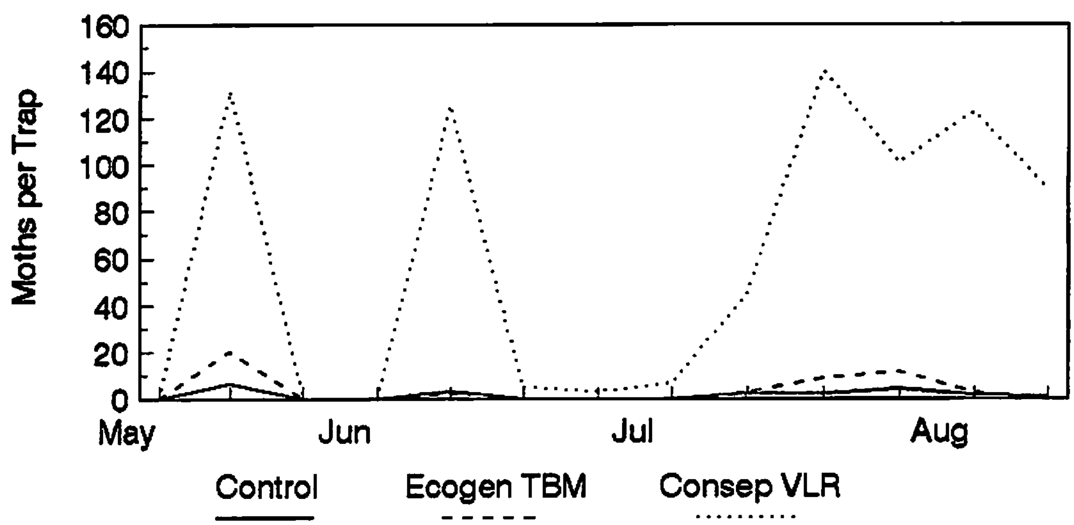
Table 1. Captures of garden tortrix in two orchards in northern Virginia permeated with sex pheromones of variegated leafroller and tufted apple bud moth.

	Control	Ecogen TBM	Consep VLR	Ecogen VLR
Solenburger	46	5	2	48
Glaize	81	198	3,241	

Garden Tortrix Flight Activity
In Ecogen VLR versus Control Blocks
Solenburger Orchard - 1994



Garden Tortrix Flight Activity
Glaize Orchard - 1994



Small Plot Comparisons of Pheromone Blends for the Leafroller Species Complex: Ecogen Regional Study - 1994

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I. Introduction: The diversity of leafrollers affecting apple in the mid-Atlantic region is greater than in many other areas (Weires & Riedl 1991). The most important leafroller species are variegated leafroller (VLR), *Platynotaflavedana* (Clemens), tufted apple bud moth (TBM), *P. idaeusalis* Walker, redbanded leafroller (RBL), *Argyrotaenia velutinana* (Walker), and to a lesser extent, obliquebanded leafroller (OBL), *Choristoneurarosaceana* (Harris). Mating disruption can be an effective control for this complex (Pfeiffer et al. 1993), but may be cost-prohibitive unless a single set of dispensers can be made to disrupt the entire complex. Small plots are useful in comparing relative efficacy of blends in disrupting orientation of male moths (Pfeiffer et al. 1993), although insufficient to prevent injury. The following small plot study was performed in 1994 as part of a regional study comparing leafroller pheromone blends.

II. Materials and Methods: Two proposed generic blends were provided in spiral dispensers by Ecogen (50 mg/dispenser), along with spirals containing the blend for VLR, the most important species in central Virginia, for use as a standard. Generic II was composed of *E*11-14:OH, *Z*11-14:Ac, and *E*11-14:Ac (30:40:30). Generic III included the same components in a proportion of 40:20:40. The overlap of these blends with those of the four main leafroller species in our region can be determined in Table 1.

The study was performed twice, the first starting on 10 May (covering 11 weeks, the period of the first generation of VLR and TBM and second generation of RBL) and the second starting on 4 August (covering 10 weeks, most of the period of the second VLR and TBM generations and third generation of RBL). Each of these studies included four replications, two each in orchards in Roseland and Tyro (Nelson Co.). Plots were 30 x 30 m, and were separated by 20 m buffers. Each replication (block) contained an untreated plot. One pheromone trap each for VLR, TBM, RBL and OBL (Traps supplied by Ecogen, lures by Trécé) was placed in the center of each plot and were monitored weekly. New plots were used and treatment positions re-randomized for the second trial. The relative positions of the pheromone traps for each species within a plot were determined randomly.

III. Results and Discussion: Both generic blends performed well against all species; The VLR blend caused substantial trap shutdown for both VLR and RBM, but did not reduce captures of RBL or OBL. In fact, captures of RBL were elevated in VLR-treated plots during the first placement, a phenomenon noted earlier.

Table 1. Pheromone blends for four leafrollers of apple orchards in mid-Atlantic states, with compositions of two experimental generic blends.

	Species				Generic Blend	
Component	VLR	TBM	RBL	OBL	II	III
*E*11-14:Ac	-	50	3	4.8	30	40
*Z*11-14:Ac	-	-	37	90.2	40	20
*E*11-14:OH	90	50	-	-	30	40
*Z*11-14:OH	10	-	-	5.0	-	-
12:Ac	-	-	60	-	-	-

Table 2. Cumulative moth captures per trap, and associated trap shutdown, for four leafroller species in small plots treated with two generic blends and variegated leafroller pheromone blend (% shutdown is reduction in catch relative to control).

	Pheromone Environment							
	Gen II				Gen III			
	VLR	TBM	RBL	OBL	VLR	TBM	RBL	OBL
Cum. catch	1	3	0	1	3	2	0	0
% shutdown	99.0	97.3	100	83.3	97.0	98.2	100	100
	VLR				Control			
	VLR	TBM	RBL	OBL	VLR	TBM	RBL	OBL
Cum. catch	1	13	157	2	99	111	68	6
% shutdown	99.0	88.3	(231% increase)	66.7	-	-	-	-

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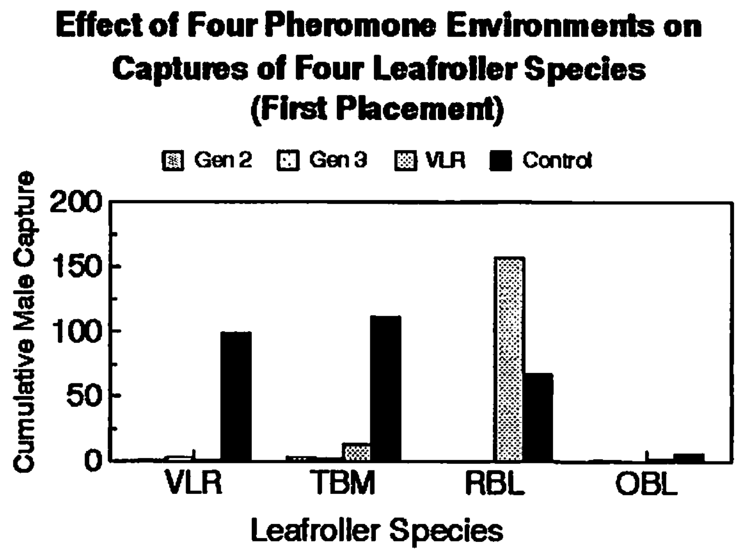
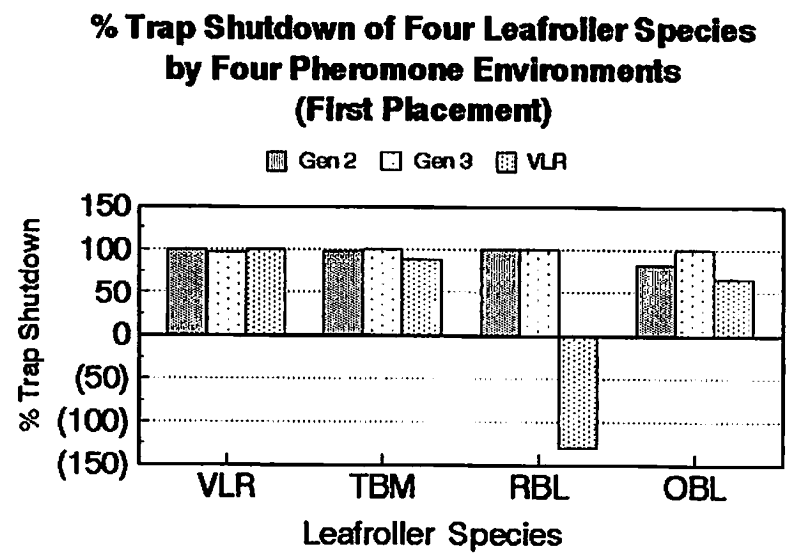
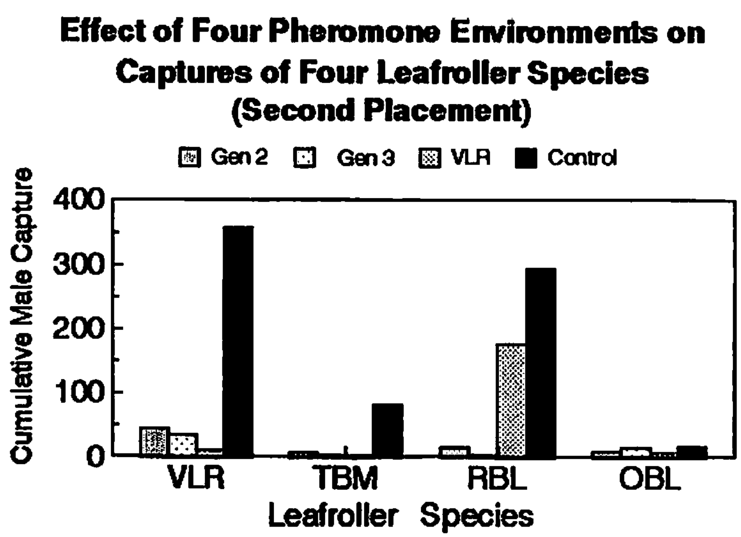
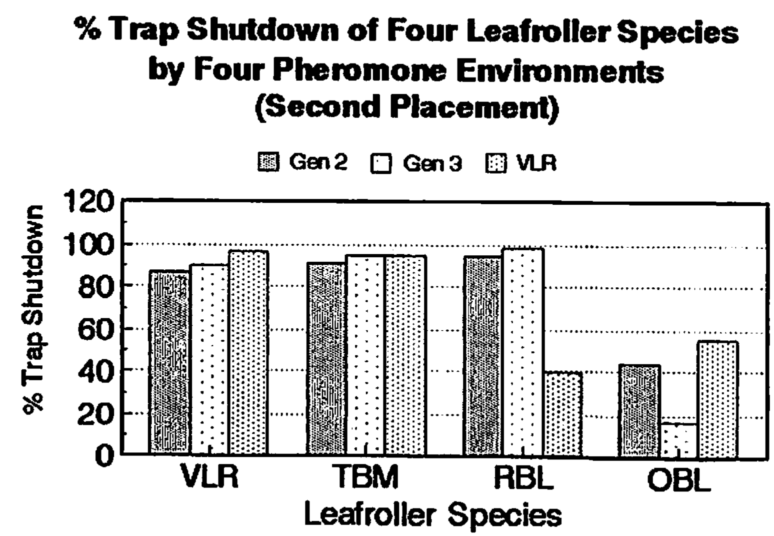

Effect of Four Pheromone Environments on Captures of Four Leafroller Species (First Placement)
Gen 2
Gen 3
VLR
Control
Cumulative Male Capture
200
150
100
50
0
VLR
TBM
RBL
OBL
Leafroller Species


% Trap Shutdown of Four Leafroller Species by Four Pheromone Environments (First Placement)
Gen 2
Gen 3
VLR
% Trap Shutdown
150
100
50
0
(50)
(100)
(150)
VLR
TBM
RBL
OBL
Leafroller Species


Effect of Four Pheromone Environments on Captures of Four Leafroller Species (Second Placement)
Gen 2
Gen 3
VLR
Control
Cumulative Male Capture
400
300
200
100
0
VLR
TBM
RBL
OBL
Leafroller Species


% Trap Shutdown of Four Leafroller Species by Four Pheromone Environments (Second Placement)
Gen 2
Gen 3
VLR
% Trap Shutdown
120
100
80
60
40
20
0
VLR
TBM
RBL
OBL
Leafroller Species

Mating Disruption of Grape Berry Moth and Redbanded Leafroller in Virginia Vineyards - 1993

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I. Introduction: Mating disruption has been performed for grape berry moth since 1990. Most work done previously in this system has been performed in vineyards in New York and other northern areas (Dennehy et al. 1990, Trimble et al. 1991). The technique has worked fairly well in Virginia but with some exceptions that confirm the need for regional testing.

Both single and two component dispensers provided effective control of GBM (Pfeiffer & Wolf 1992). Z-11-tetradecen-1-yl acetate (Z11-14:Ac) is the lesser component in the two-component GBM dispenser. Z11-14:Ac is a major pheromone component of redbanded leafroller (RBL), an occasional pest in vineyards in our region (Jubb 1975, Pfeiffer & Schultz 1986). Our laboratory has achieved successful mating disruption of RBL using this component alone (Pfeiffer et al. 1991). Perhaps by using the two component dispenser, control of more than one pest could be achieved. Further research using the commercial dispenser was suggested by Pfeiffer & Wolf (1992).

II. Materials and Methods: In 1994, three blocks were treated with Shin Etsu dispensers at the full label rate of 400 dispensers per acre (1000/ha). Each dispenser contained 69 mg of Z-9-dodecen-1-ylacetate (90%)/ Z-11-tetradecen-1-yl acetate (10%). A 10-acre block at Rapidan River Vineyard (Madison Co.) consisted of 'Riesling' vines; a 5-acre block at Redlands Vineyard (Albemarle Co.) of 'Cabernet Franc' and 'Chardonnay', and a 5-acre block at Ladd Vineyard (Augusta Co.) of 'Concord' vines. Dispensers were placed on 20 May at Rapidan River, 8 June at the Ladd vineyard and 25 May at Redlands. Each block was associated with a conventionally treated control block of similar varietal composition.

All blocks were adjacent to mixed deciduous woodland. Three commercially available pheromone traps were placed in each block and monitored weekly to determine disruption of orientation to point sources of pheromone. Damage by the first generation of GBM was assessed by counting the percent infested clusters in at least 200 clusters in two rows each at block edges and middles. Percent infested clusters were determined periodically in June, July and August.

Percent infested berries were estimated by retrieving 20 clusters from each block edge and center, and separating individual berries for examination in the laboratory. Harvest dates were 26 August at Rapidan River, 2 September at Redlands and 7 September at Ladd.

III. Results and Discussion: Trap captures of GBM were almost totally eliminated in all pheromone-treated vineyards. However, GBM flight activity as reflected in pheromone trap catches, was low in all blocks in 1994. RBL captures were almost totally suppressed in GBM pheromone-permeated blocks at both Rapidan River and the Ladd vineyard.

Early season percent cluster data indicated successful control. At Rapidan River on 19 July, counts of percent infested clusters in the center and edge of the pheromone-treated block were 8.0% and 58%, respectively, and in the control block center and edge, 3.5% and 14.5%, respectively. At Redlands on 1 August, counts of percent infested clusters in the center and edge of the pheromone-treated block were 3.0% and 26.5%, respectively, and in the control block center and edge, 14.0% and 33.0%, respectively. At Ladd on 13 July, counts of percent infested clusters in the center and edge of the pheromone-treated block were 1.0% and 27.5%, respectively, and in the control block center and edge, 0.5% and 5.5%, respectively. On

19 August at this vineyard, counts of percent infested clusters in the center and edge of the pheromone-treated block were 0% and 43.0%, respectively, and in the control block center and edge, 1.5% and 53.5%, respectively.

At Rapidan River, harvest injury from GBM in the center and edge of the pheromone-treated block was 0.9% and 1.2%, respectively, and in the control block center and edge, 1.6% and 1.5%, respectively. RBL injury was not detected.

At Redlands, percent injured berry data for the harvest samples are as follows: Pheromone block center and edge were 0.1% and 0.4%, respectively (2409 and 1553 berries). The control contained 0.1% and 0.8% injured berries in the center and edge, respectively (2213 and 2045 berries). RBL injury was negligible at Redlands.

At Ladd, the pheromone block center and edge were 6.8% and 21.6% (789 and 830 berries); in the control, 14.5% and 9.6%, respectively (828 and 938 berries). The Ladd block is a high risk site, with a history of high GBM injury (Pfeiffer & Wolf 1991, 1992). The need for border row sprays is demonstrated by these data. A similar vineyard but in normally lower risk surroundings, Banjo Shack, contained 14.4 and 14.9% in the center and edge (724 and 790 berries). GBM appeared to be unusually severe in 1994; this is reflected in damage counts at the Banjo Shack block. RBL injury was negligible at Ladd.

Mating disruption continued to provide control of GBM. Damage was higher in the edge of both pheromone-treated and conventionally managed blocks, as in past years. Based on trap catch data and limited injury data, the two-component pheromone dispenser for GBM may also provide control for RBL. Further work on reproduction by RBL in GBM-treated vineyards is planned.

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Control of Spotted Tentiform Leafminer with Agri-Mek and Vydate

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APPLE: *Malus* X *domestica* `Delicious'
Spotted tentiform leafminer (STLM): *Phyllonorycter blancardella* (F.)

APPLE, LEAFMINER TRIAL, 1994: A trial for control of STLM was conducted in a `Delicious' orchard at Lovingston (Nelson Co.). Agri-Mek (abamectin; 17.0 fl. oz./100 gal) was compared with Vydate L (oxamyl; 80 fl. oz. form./100 gal.), a standard insecticide for STLM, and an untreated control. A light-weight oil (Peptoil, 1 gal/A; Drexel, Memphis TN) was added to the Agri-Mek spray. Application was made with a truck-mounted Durand-Wayland airblast sprayer on 29 June at the rate of 60 gal./A. Each treatment was applied to four replications, each consisting of a plot of 5 rows by 9 trees (24.4 m x 27.4 m). Pretreatment examination of trees on 23 June revealed that sap-feeder mines of the second generation were present and approximately evenly spread over the orchard; this is confirmed by the "old tissue feeder" count on 20 July (Table 1). Counts were made on four trees in the middle row of each plot. On 20 July (toward the end of the second STLM generation), a timed count was made on each sample tree, visually searching each tree for sap feeder mines, active tissue-feeder mines, and old tissue-feeder mines. On 2 September (reflecting the third STLM generation), 20 leaves were collected from each of the four sample trees per plot, and counts of the three STLM categories were made. In addition, active tissue feeder mines were opened to detect parasites.

On 20 July (almost a month post-treatment), sap feeder mines were reduced by a similar degree by both Agri-Mek and Vydate, the standard. Active tissue feeder mines (containing either tissue feeding larvae or pupae) were also not significantly different in the two chemical treatments; both were lower than the control. There were no differences among treatments in old tissue feeder mines; this reflects the lack of pre-treatment differences among plots.

On 2 September, there were no longer any differences in sap feeder mines. By this time, the single application of insecticides exerted no control of the new STLM cohort. Trees treated with Agri-Mek contained significantly fewer active tissue-feeder mines than the control. Vydate, the standard, was intermediate in effect, significantly different from neither Agri-Mek nor the control. Old tissue feeder mines were significantly fewer in both insecticide treatments, lowest in Agri-Mek-treated plots.

Naked pupae of *Sympiesis* spp. as well as the white cocoons of *Pholetesor* spp. were found, but in densities too low to justify further analysis. Two *Sympiesis* pupae (one each in Vydate and control plots) and one *Pholetesor* cocoon (in the control) were found.

In conclusion, when STLM sap feeder mines of the second generation were treated, Agri-Mek controlled STLM to an equivalent degree as a standard pesticide for this pest, Vydate, during the treated generation. By the end of the following generation, Agri-Mek treated trees still contained lower numbers of tissue feeding mines, although neither insecticide exerted any control of new sap feeder mines.

Table 1. Average numbers[1] of spotted tentiform leafminer following applications of Agri-Mek and Vydate.

Material, lb AI/A	Mines per 3-min. count (20 July)			Mines per 20 leaves (2 Sept.)		
	Sap-feeders	Active Tissue-feeders	Old Tissue-feeders	Sap-feeders	Active Tissue-feeders	Old Tissue-feeders
Agri-Mek 0.0125 lb	7.6a	5.0a	20.2a	17.2a	1.3a	2.8a
Vydate 0.75 lb	8.2a	5.5a	19.4a	23.3a	2.6ab	13.9b
Control	21.8b	14.7b	19.0a	26.0a	4.4b	29.6c

[1]Data transformed for analysis $[(x+0.5)^{0.5}]$. Numbers in a column followed by the same letter are not significantly different (Duncan's multiple range test, $P \leq 0.05$).

Control of European Red Mite on Grapevines with Kelthane and Vendex

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GRAPE: *Vitis vinifera* 'Mourvèdre'
European red mite (ERM): *Panonychus ulmi* (Koch)

GRAPE, ACARICIDE TRIAL, 1994: A comparison of acaricide efficacy against European red mite (ERM) was conducted at Horton Vineyard, Orange Co. Kelthane 50W (dicofol; 2.5 lb. form./100 gal) and Vendex 50W (fenbutatin-oxide; 2.0 lb. form./100 gal) were applied to seven and six grapevines, respectively, on 25 July and 1 August. Seven unsprayed vines were used as a control. Applications were made with a Kioritz backpack sprayer. Pre- and post-treatment counts were made on four leaves per vine. Pre-treatment counts were made on 19 July; post-treatment counts were made on 27 July, 1, 8, 16, 26 August, 2, 9, 16, 26 September, and 1 October. Véraison was estimated by the grower to have occurred on 20 July. The harvest date for this variety was about September 30.

ERM populations had started to increase appreciably only within a week before the pretreatment count date. Plots showed no pretreatment differences in ERM densities (Table 1). Two days after the first application, both acaricides reduced ERM densities to a similar degree, though not to the degree seen after a week, and especially to the degree seen after the second application. Kelthane and Vendex controlled ERM to a similar degree throughout the study. ERM densities on control vines remained above the economic threshold for the entire period.

The equivalent level of control afforded by these acaricides is important given the increasing severity of ERM in vineyards in the region, and the lack of alternative products for eastern vineyards. Furthermore, Vendex is often regarded as acting against mites relatively slowly; this might cause growers to rely more heavily on other acaricides. The similarity in effect shown by this study will facilitate resistance management of ERM.

Table 1. Average numbers[1] of European red mites on grapevines (four leaves per vine,four replications) following applications of Kelthane and Vendex.

Material, AI/100L	ERM per Leaf							
	19 Jul	27 Jul	1 Aug	8 Aug	16 Aug	19 Aug	26 Aug	2 Sep
Kelthane 50W 150.6 g	21.6a	10.7a	5.1a	0.7a	5.9a	2.5a	1.1a	2.7a
Vendex 50W 120.2 g	30.6a	12.6a	5.0a	0.0a	0.0a	0.1a	0.1a	1.2a
Control	19.9a	25.3b	25.4b	18.1b	32.2b	17.5b	27.6b	29.4b

[1]Data transformed for analysis $[(x+0.5)^{0.5}]$. Numbers in a column followed by the same letter are not significantly different (Duncan's multiple range test, $P \leq 0.05$).

Relationship of European Red Mite Populations and Yield and Quality of 'Mourvèdre' Grapevines

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A comparison of the effect of European red mite (ERM) feeding on fruit quality and yield was conducted at Horton Vineyard, Orange Co. A range of mite-days was achieved by applying different acaricidal treatments on selected vines. Kelthane 50W (dicofol; 2.5 lb. form./100 gal) and Vendex 50W (fenbutatin-oxide; 2.0 lb. form./100 gal) were applied to seven and six grapevines, respectively, on 25 July and 1 August. Seven unsprayed vines were used to assure a relatively high number of mite-days. Applications were made with a Kioritz backpack sprayer. Pre- and post-treatment counts were made on four leaves per vine. Pre-treatment counts were made on 19 July; post-treatment counts were made on 27 July, 1, 8, 16, 26 August, 2, 9, 16, 26 September, and 1 October.

ERM populations had started to increase appreciably only within a week before the pretreatment count date. In the vineyard described above, ERM populations were counted on four leaves per vine at about weekly intervals from the onset of mite activity (in mid-July) until harvest (October 1). Mites were counted under a binocular dissecting microscope. Véraison was estimated by the grower to have occurred on 20 July. Grapes used in this experiment were harvested on 29 September (most vines were harvested on 1 October by the grower).

Mite-days were calculated using the following equation:

$$[(\text{day } 1 + \text{day } 2)/2] * \text{no. of days between sampling dates.}$$

Mite-days were summed over the entire sampling period to yield cumulative mite-days used in the harvest evaluations.

At harvest, four clusters were taken from each vine. After cluster weights were obtained, ten berries were removed from each cluster and combined into a sample for determination of soluble solids, pH, total titratable acidity, and berry weight. The rest of the clusters were frozen for later examination of phenolics and color characteristics (these will be reported later).

Combined berry samples were crushed in stomacher bags and the resulting juice allowed to settle. Soluble solids were determined using a temperature-compensated refractometer. A pH meter was used to measure pH of each sample. The titration method described by Zoecklein et al. (1990) was used to determine total titratable acidity, titrating the sample to a pH of 8.2.

Regression analysis was used to examine the relation between cumulative mite days and the various berry characteristics. No significant relationship existed between ERM infestation and soluble solids, pH, TTA, berry weight or cluster weight. Pending results of further comparisons, these results would have important ramifications on vineyard pest management. According to this study, feeding by ERM had no effect on grape quality or yield. Therefore ERM should not be a major concern to growers. It should be noted that substantial ERM populations existed during this study. Cumulative mite-days reached ca. 5,000 per leaf. Populations usually remained between 20-30 per leaf during this study, mainly during the period from véraison through harvest, when berries are the main sink for photosynthates. However, more extensive leaf bronzing has been seen in other vineyard situations. Further work is needed on higher ERM densities, as well as on the effect of early season ERM populations (effects on vegetative growth, etc.).

The action threshold currently recommended for commercial vineyards in Virginia is "Only if mites exceed 5/leaf (10/leaf on *labrusca* types), and more than minor bronzing occurs" (Pfeiffer et al. 1994). The results of this study indicate that that threshold is too conservative. The effect of ERM appears to be less pronounced on grape quality and yield than that of other tetranychid species. McNally & Farnham (1985) found that Willamette mite, *Eotetranychus willamettei* Ewing, reduced soluble solids of both `Chenin blanc' and `Zinfandel' grapevines, though not suppressing yield per vine. Damage was primarily associated with mid- to late-season feeding. Welter et al. (1989b) reported that Willamette mite reduced soluble solids during the first year of infestation. After an infestation of 2 years, total fruit weight per vine was reduced by 17.9% and mean berry size was reduced by 8% at 1,308 mite-days, a fraction of the mite-days obtained in the present study. Soluble solids was not reduced in the second year of that study.

Welter et al. (1991) found that `Zinfandel' vines required 2 years to recover from high levels of Willamette mite feeding. For vines with the highest level of mite feeding (1,347 mite-days), yield per vine was reduced by 14.9% in the first year of recovery. There were no differences in vegetative growth. The effect of feeding by Willamette mite, while more dramatic than ERM, is nevertheless less damaging than Pacific spider mite, *Tetranychus pacificus* (McGregor). Feeding by the former species is considered to prevent more serious feeding by the latter (English-Loeb & Karban 1988).

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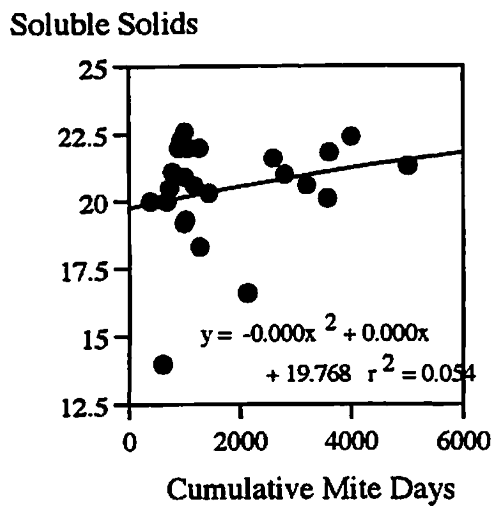
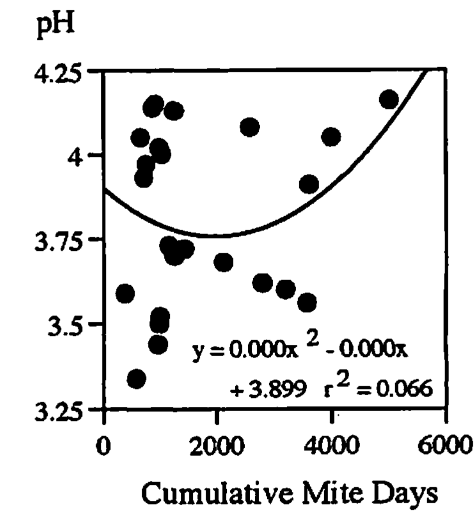
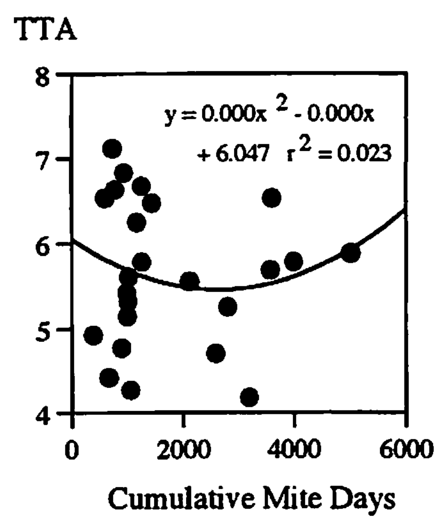
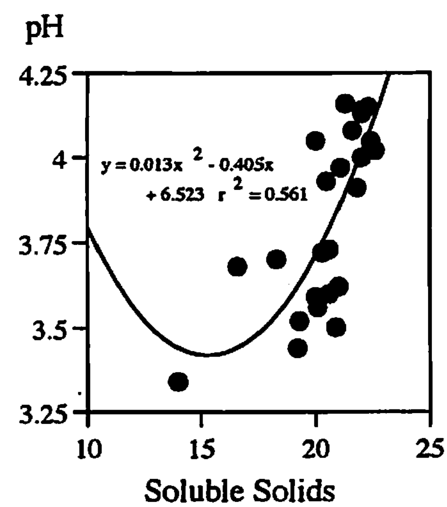
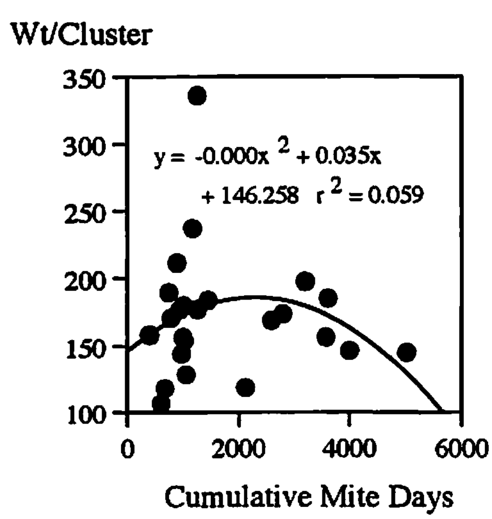
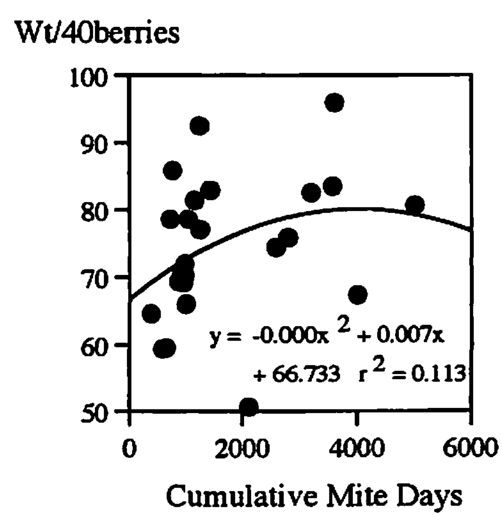

Soluble Solids
25
22.5
20
17.5
15
12.5
y = -0.000x 2 + 0.000x
+ 19.768 r 2 = 0.054
0
2000
4000
6000
Cumulative Mite Days


pH
4.25
4
3.75
3.5
3.25
y = 0.000x 2 - 0.000x
+ 3.899 r 2 = 0.066
0
2000
4000
6000
Cumulative Mite Days


TTA
8
7
6
5
4
y = 0.000x 2 - 0.000x
+ 6.047 r 2 = 0.023
0
2000
4000
6000
Cumulative Mite Days


pH
4.25
4
3.75
3.5
3.25
y = 0.013x 2 - 0.405x
+ 6.523 r 2 = 0.561
10
15
20
25
Soluble Solids


Wt/Cluster
350
300
250
200
150
100
y = -0.000x 2 + 0.035x
+ 146.258 r 2 = 0.059
0
2000
4000
6000
Cumulative Mite Days


Wt/40berries
100
90
80
70
60
50
y = -0.000x 2 + 0.007x
+ 66.733 r 2 = 0.113
0
2000
4000
6000
Cumulative Mite Days

Impact of Low Spray Mating Disruption Programs on Aphidophagous Populations in Apple Orchards-1994

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Blacksburg VA

I. Introduction: Mating disruption is currently more expensive than conventional control methods in apple orchards. To help promote acceptance of this method, it is necessary to evaluate the impact of mating disruption on the arthropod community of orchards. The evaluation of potential effects such as higher populations of natural enemies, and slowing the rate of development of resistance may help to persuade growers to adopt this technique (Brunner 1991).

Natural enemies can be used to help control aphid populations in apple orchards. Natural enemy populations tend to vary with the environment and management practices used. The use of mating disruption often allows for substantial decrease of sprays which often kill beneficials. For example, using mating disruption in apple orchards may decrease post bloom pesticide applications from once every two weeks to two applications per season (Pfeiffer et al. 1993). This may allow beneficial populations to rise in the orchard.

II. Materials and Methods: Two blocks in each of two orchards, located in Fincastle (fifth year of mating disruption) and Tyro (third year of mating disruption), were sampled weekly for the presence of aphids and predators. Sampling will continued while aphids were present in the orchards. One block in each be orchard will under mating disruption for codling moth and leafrollers; this block is matched with a conventionally managed block in the same orchard

Six trees were sampled weekly in each block. Ten terminal growth shoots were examined on each tree, and the presence of aphids was noted. If aphids were present, the shoot was collected and inspected for predators in the lab. The number of leaves in each colony collected was also recorded. When evaluating sample means a confidence interval was determined using an alpha level of 0.05.

III. Results and Discussion: The sampling method used was targeted at gathering information on aphid populations and predators that usually live in the aphid colonies. Predaceous larvae, including syrphid, chrysopids, hemerobiids, coccinellids, and cecidomyiids were among the expected insects. Table 1 shows the total number of predators and aphid colonies observed in the orchards. Almost twice as many predators were observed in the Fincastle pheromone block relative to the Fincastle control block. These results were expected in a low spray block versus a conventionally managed block. The total number of predators in the Tyro pheromone block, 26, was less than the total found in the control block, 35. Even though the pheromone block has undergone disruption for 3 years, a possible explanation for the larger number of predators collected in the control block could be due to the location. The Tyro pheromone block is adjacent to a conventional managed orchard and hay fields. These environments might have reduced likelihood of immigration of predatory insects to the pheromone block.

Figures 1-4 show the mean number of aphid colonies and predators found in the orchards over time. In the Fincastle pheromone block, aphid populations peaked shortly before the predator population (Figure 1). The aphids were controlled by their natural enemies in this block possibly in combination with declining host vigor. In the Fincastle control block, Tyro control block and the Tyro pheromone block the predators population did not rise in response to the aphid population. In the control blocks, this may be due to the higher insecticide input (Figure 2 & 3). Again, as mentioned above, location may have played a role in the predator y populations of the Tyro pheromone block (Figure 4).

Figures 5-8 show the mean number of aphid colonies and the mean number of leaves per colony over time. Overall the mean number of leaves per colony increased with the number of colonies per tree. Figure 9 shows the linear relationship found between the mean number of leaves per colony and the mean number of colonies per tree. The r^2 value indicated an apparent simple linear relationship between the number of aphid colonies per tree and the mean number of leaves per colony. This relationship is independent of block management.

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Pfeiffer, D. G., W. Kaakeh, J. C. Killian, M. W. Lachance & P. Kirsch. 1993. Mating disruption to control damage by leafrollers in Virginia apple orchards. Entomol. Exp. Appl. 67: 47-56.

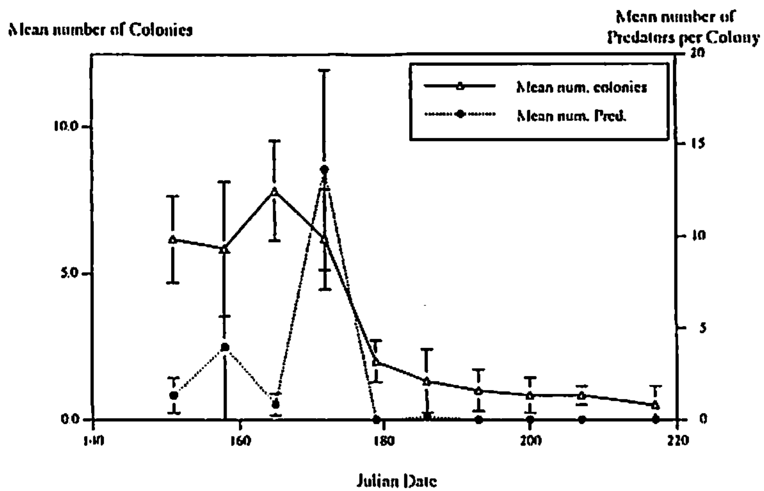

Figure 1. Mean number of colonies and mean number of predators per colony versus Julian date. Fincastle Pheromone Block. (Bars are 95% CI)

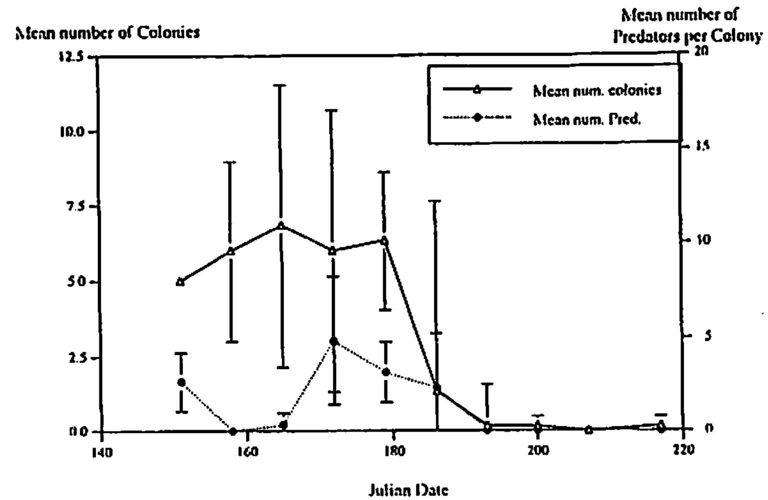

Figure 2. Mean number of colonies and mean number of predators per colony versus Julian date. Fincastle Control Block. (Bars are 95% CI)

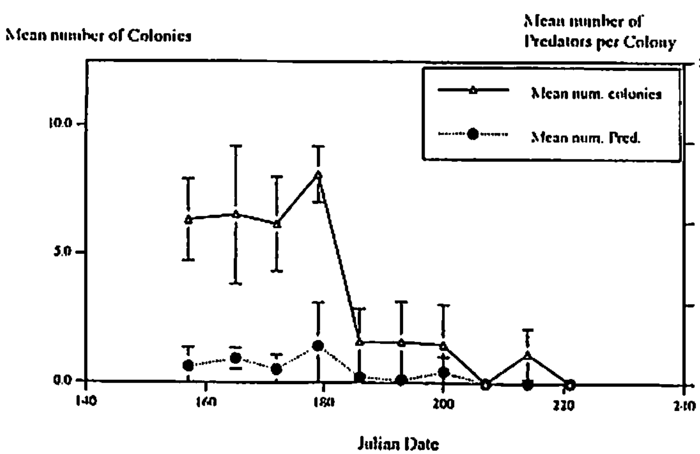

Figure 3. Mean number of colonies and mean number of predators per colony versus Julian date. Tyro Control Block. (Bars are 95% CI)

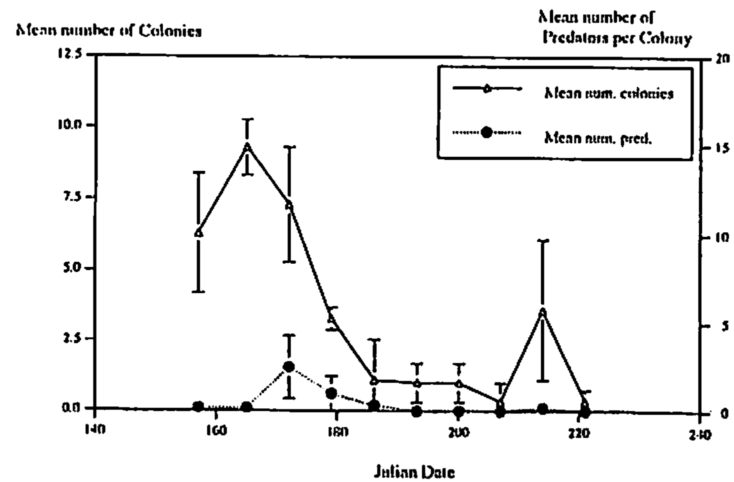

Figure 4. Mean number of colonies and mean number of predators per colony versus Julian date. Tyro Pheromone Block. (Bars are 95% CI)

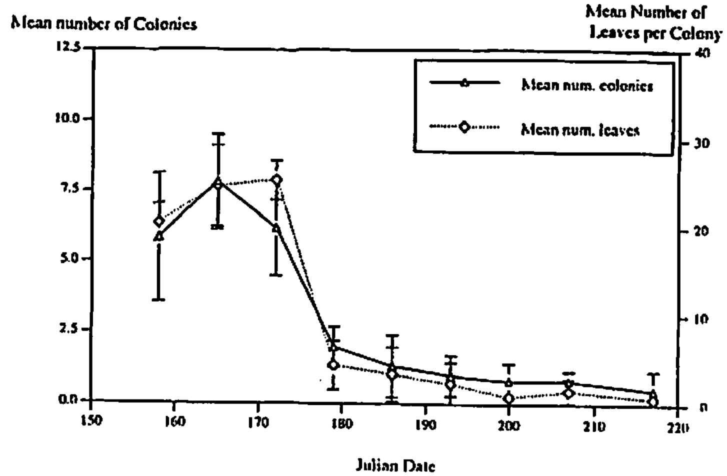

Figure 5. Mean number of colonies and mean number of leaves per colony versus Julian date. Fincastle Pheromone Block. (Bars are 95% CI)

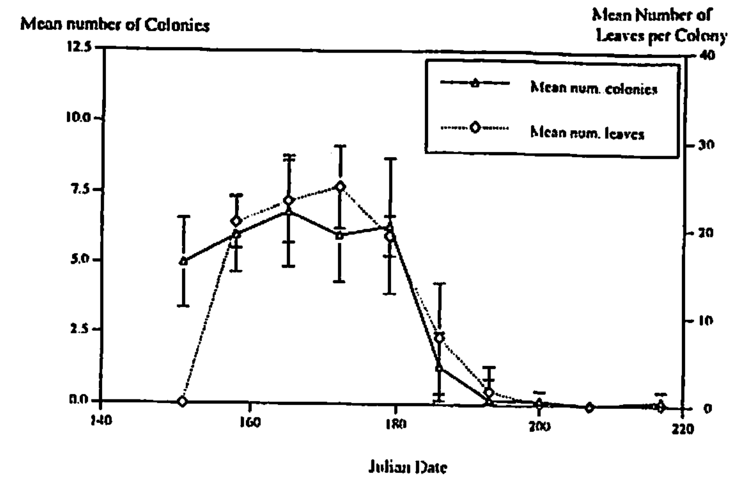

Figure 6. Mean number of colonies and mean number of leaves per colony versus Julian date. Fincastle Control Block. (Bars are 95% CI)

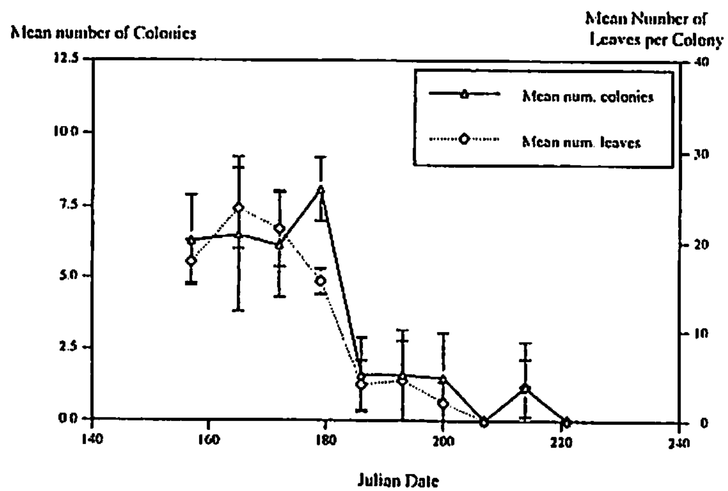

Figure 7. Mean number of colonies and mean number of leaves per colony versus Julian date. Tyro Control Block. (Bars are 95% CI)

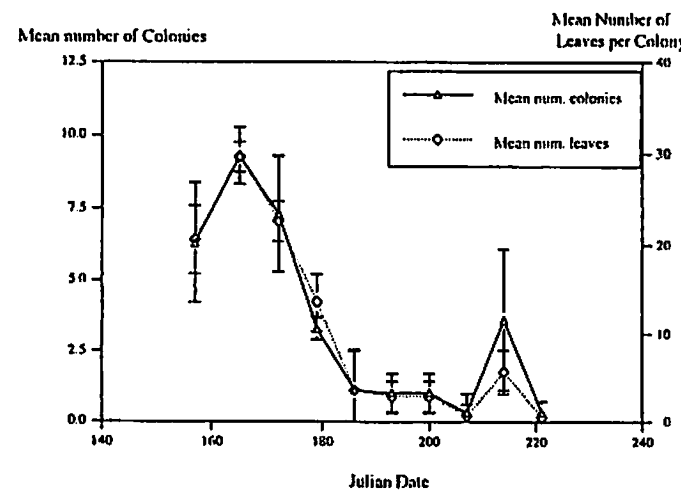

Figure 8. Mean number of colonies and mean number of leaves per colony versus Julian date. Tyro Pheromone Block. (Bars are 95% CI)

Table 1. Aphids and Predators observed in 1994.

Aphid Data	Tyro		Fincastle	
	Pheromone	Control	Pheromone	Control
#of colonies	203	199	196	195
#leaves	614	559	499	585
Syrphid Eggs	22	13	50	34
Syphid Larvae	3	3	13	5
Lacewing Eggs	35	0	2	1
Lacewing Larvae	8	2	7	9
Cecidomyiid Larvae	0	7	69	10
Coccinellid Adult	4	5	7	7
Coccinellid Larvae	0	0	0	1
Anthocorids	11	17	14	35
Thrips	0	1	10	0
Total Predators	26	35	120	67

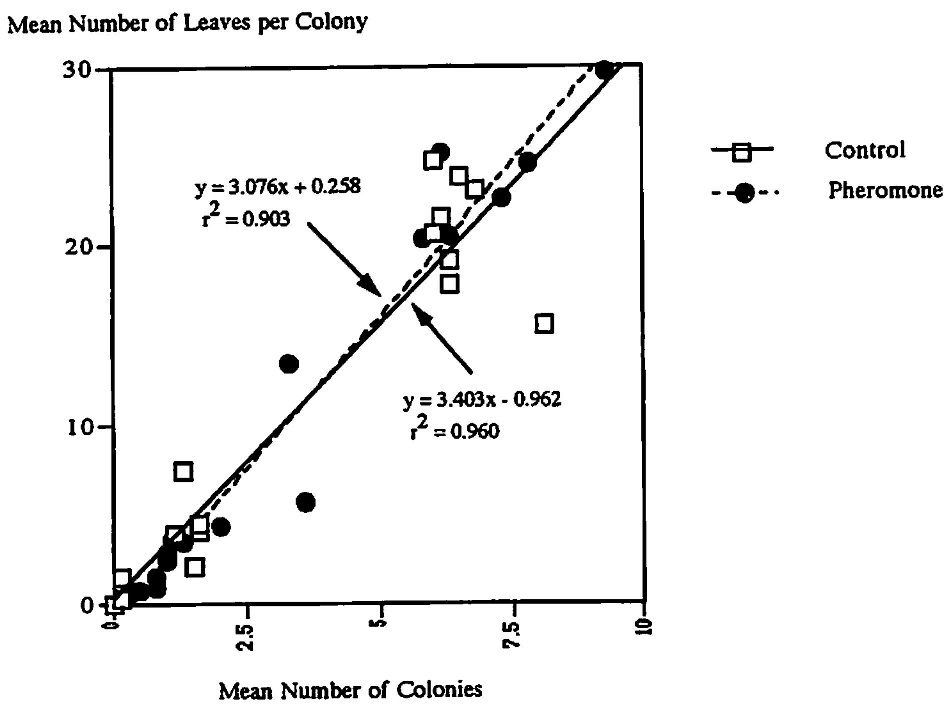

Figure 9. Mean number of colonies versus Mean number of leaves per colony. Fincastle and Tyro Blocks.

Mite Populations in Mating Disruption versus Conventionally Managed Apple Orchards

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I. Introduction: The European red mite (ERM), *Panonychus ulmi* (Koch), is a major pest in apple orchards, and is often difficult to manage. Natural enemies of the ERM may help maintain populations below a damaging threshold. ERM predators in the mid-Atlantic region include: *Stethorus punctum* (LeConte), *Amblyseius fallacis* (Garman), *Zetzellia mali* (Ewing), predatory mirids, *Leptothrips mali* (Fitch), and *Orius insidiosus* (Say) (Hull & Horsburgh *In press*). Natural enemy populations tend to vary with the environment and management practices used. The use of mating disruption usually allows for substantial decrease of sprays which often kill these beneficials. For example, using mating disruption in apple orchards may decrease post bloom pesticide applications from once every two weeks to two applications per season (Pfeiffer et al. 1993). This may allow beneficial populations to rise in the orchard.

Mating disruption is currently more expensive than conventional control methods in apple orchards. To help promote acceptance of this method, it is necessary to evaluate the impact of mating disruption on the arthropod community of orchards. The evaluation of potential effects such as higher populations of natural enemies, and slowing the rate of development of resistance may help to persuade growers to adopt this technique (Brunner 1991).

II. Methods and Materials: In 1994, mites were monitored in four orchards: Fincastle (fifth year of mating disruption), Tyro (third year of mating disruption, Spring Valley (fourth year of mating disruption) and Crown (sixth year of mating disruption). A pheromone treated block and a conventionally managed block were monitored in each orchard. Mites were sampled weekly. Four samples of twenty leaves were collected in each block. The leaves were run through a mite brushing machine, and the numbers of ERM, ERM eggs, apple rust mites, and predatory mites was recorded. The average numbers of ERM and ERM eggs present was determined with a 95% confidence interval. Cumulative mite days were determined based on the weekly mean of four ERM samples.

III. Results and Discussion: Mite days for each orchard block were determined using the following formula: ((Mean number of $ERM_{(Sample\ 1)}$ + Mean number of $ERM_{(Sample\ 2)}$) / 2)* Number of days between samples. Cumulative mite days for each orchard are displayed in figure 1. The Fincastle and Tyro orchards accumulated more mite days than either Crown or Spring Valley. It looks like the only time there was a significant difference in cumulative mite days between blocks, the pheromone block was lower. The Fincastle pheromone accumulated 275 mite days; while the Fincastle control block accumulated 820. The lower accumulation of mite days in the pheromone block indicates that natural enemies may be controlling populations of ERM. The cumulative mite days for Tyro pheromone(1027) were similar to those of the control (939). Even though the pheromone block has undergone disruption for 3 years, a possible explanation for the lower cumulative mite days in the control block could be due to the location. The Tyro pheromone block is adjacent to a conventional managed orchard and hay fields. These environments might have reduced likelihood of immigration of predatory insects to the pheromone block. The cumulative mite days in the Spring Valley and Crown orchards were low (less than 80). The values for the pheromone and control blocks were similar in both of these orchards. Due to mite populations in these orchards were very low, predatory populations may have not built up in the pheromone blocks due to lack of food.

Figures 2-5 show ERM/leaf over time for each orchard. ERM populations never reached above threshold in the Spring Valley and Crown orchards (Figures 2& 3). In the Fincastle block the ERM population was larger in the control block (Figure 4). The mite predators in the Fincastle block were not sampled, but they might have help to keep the ERM populations down. Threshold populations were reached in both of the Tyro blocks (Figure 5). Again, as mentioned above, the predatory populations of the Tyro pheromone block may be influenced by a lack of available immigrants.

IV. References Cited:

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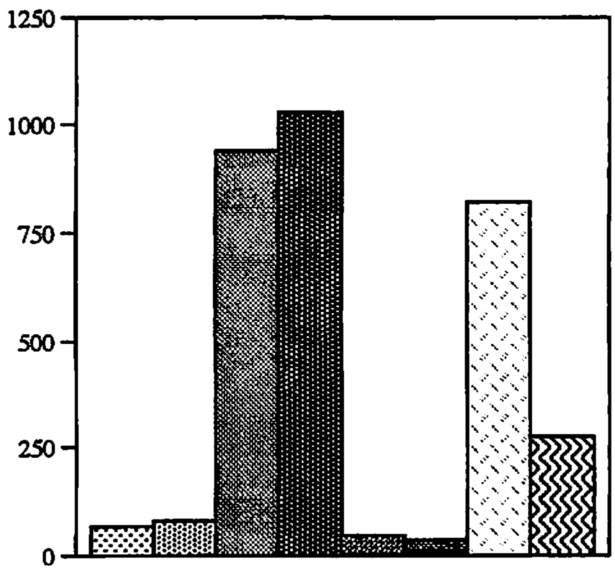
Pfeiffer, D. G., W. Kaakeh, J. C. Killian, M. W. Lachance & P. Kirsch. 1993. Mating disruption to control damage by leafrollers in Virginia apple orchards. Entomol. Exp. Appl. 67: 47-56.

Cumulative Mite Days



Spring Valley Pheromone
Spring Valley Control
Tyro Control
Tyro Pheromone
Crown Control
Crown Pheromone
Fincastle Control
Fincastle Pheromone

Figure 1. Cumulative ERM days in 1994.

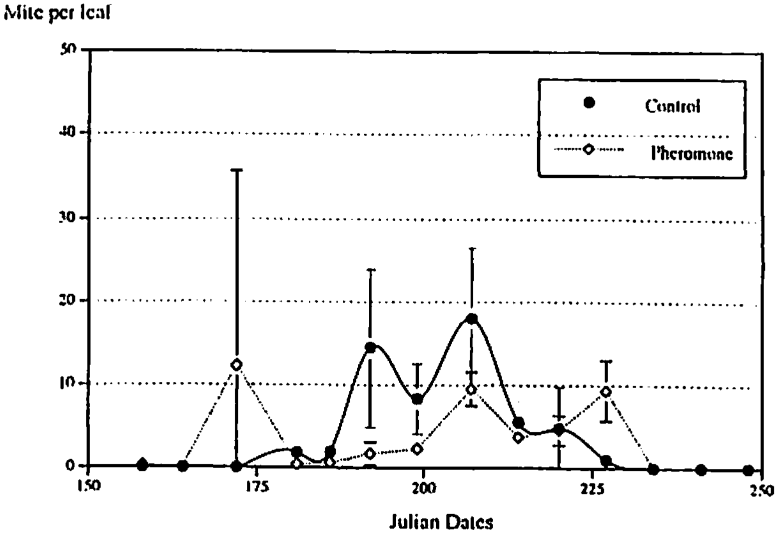


Figure 2. Tyro mite data (mites per leaf)

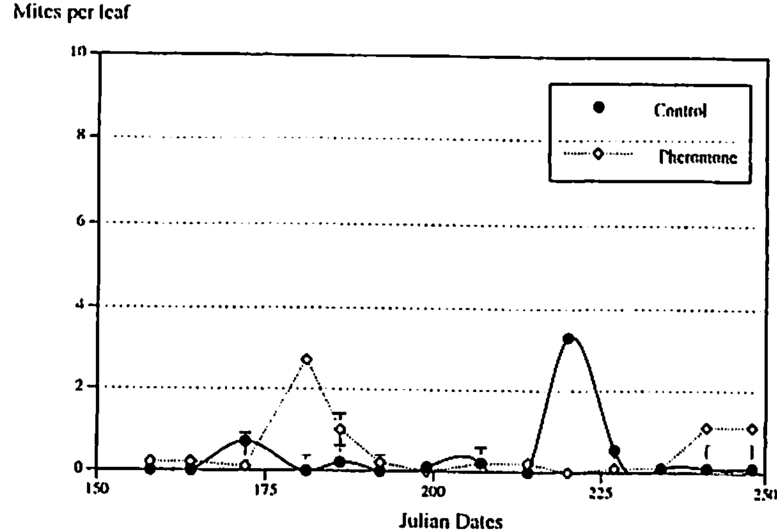


Figure 4. Crown mite data (mites per leaf)

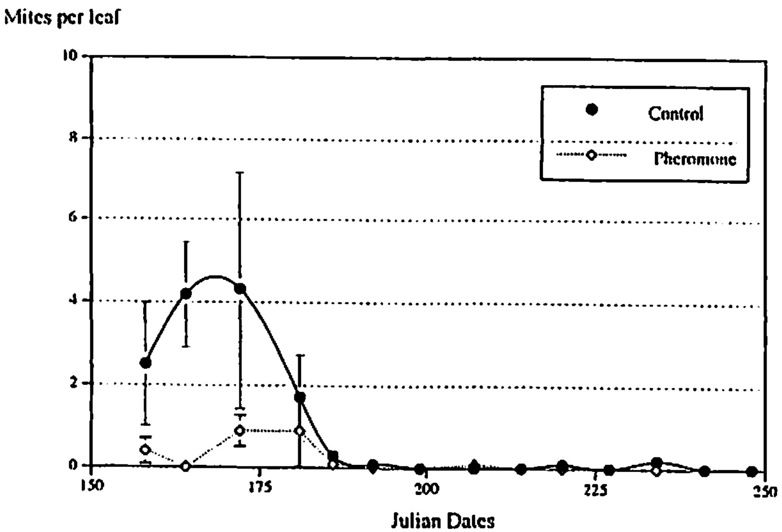


Figure 3. Spring Valley mite data (mites per leaf)

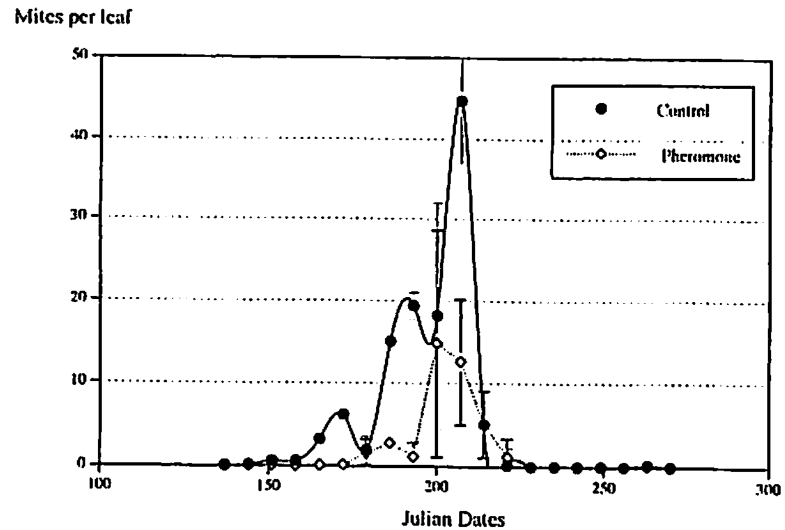


Figure 5. Fincastle mite data (mites per leaf)

The Effect of a Low Spray Mating Disruption Program Upon Virginia Apple Orchards Arthropod Communities

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Cumberland-Shenandoah Fruit Workers Conf. Proc. 69th (1994)

ABSTRACT Arthropod communities were studied in four Virginia orchards by pitfall sampling. Each orchard had a block undergoing a low-spray mating disruption program and a corresponding conventionally control block. In 1992 orchards, which had been managed through the use of mating disruption for three years and over, populations of arthropods and Shannon-Weiner diversity indicies were higher in the pheromone than the control block. Orchards sampled in 1993 showed the same trend. Cluster analysis and principle component analysis was performed. It provided insight on which taxa are influencing factors in particular orchard arthropod communities. In summary, orchards undergoing a mating disruption program may increase their arthropod community diversity. As a result, populations of benefical insects may also increase.

Introduction:

Insecticides have been used as a principle means of pest control in apple orchards throughout the United States for many years. Recently several important pest species, such as codling moth (*Cydia pomonella* (L.)) and redbanded leafroller (*Argyrotaenia velutinana* (Walker)) have shown indications of becoming resistant to various insecticide sprays (Varela et al. 1993). Resistance is already a problem for tufted apple bud moth and variegated leafroller. These and other tortricid pests are subjects of research on a technique called 'mating disruption'

The purpose of this research was to investigate the effect mating disruption has had upon the populations of various arthropod assemblages in different orchards undergoing a low spray mating disruption IPM program. The use of a low spray mating disruption IPM program has allowed apple growers to reduce the amount of insecticides they apply to their orchard, thereby permitting populations of natural enemies to increase. While natural enemies may not completely control all pest populations they will greatly control populations of secondary pests and partially control populations of primary pests.

Brown and Adler (1990), Oatman et al. (1964), Skånkland (1980), Hagley et al. (1977, 1980) and Cleaveland and Hamilton (1958) just to name a few, have all studied various orchard arthropod communties. Even with a large amount of research focusing on arthropod communities in apple orchards none has been performed on how mating disruptions will effect these arthropod communities

Methods and Materials:

Pitfall sampling:

Pitfall traps were used to sample the various arthropods occurring in the ground cover. It is a commonly accepted technique in monitoring arthropod communities, especially carabids. This is due largely to the ease of setup and large catches that result (Topping & Sunderland 1992).

Pitfall traps were constructed of 270 ml plastic Solo® cups. The first cup had drain holes place in its base and side, before being placed in the soil. A second cup was then placed inside the first cup and made level with the soil surface. Morrill (1975) suggested the use of similar parts. While this trap is different from Morrill's design, it was very inexpensive to construct. Three bamboo rods, approximately 7 cm, were then placed in the soil, surrounding the cups. These supported a plastic petri dish, which served as a lid to prevent rain and debris from entering the trap. The lids were 3 cm above the lip of the cups. Stones were placed on the lids, preventing them from being blown off. The traps were then filled with 3 cm of a 4%

formalin solution. The formalin acts as both a killing agent and a deterrent for small rodents from eating the contents of the trap (Bell, 1990). The cups were arranged so that two traps were adjacent to each other. This provided a larger opening for the arthropods to enter. The traps were located approximately 0.5 m from the base of the tree and were in line with the tree row. This avoided the problem of orchard machinery destroying the traps. A total of six trapping stations were located in each orchard studied. The traps in each orchard were evenly distributed so that they would collect over the widest possible area. This was done so no particular habit was biasedly sampled. Pitfall traps were checked at approximately weekly intervals to retrieve the contents and replace the formalin solution. The content of the traps were placed in plastic tubes for travel and storage until sorting and identification.

Orchards:

The orchards studied were located in two regions of Virginia. Two orchards, Daleville and Fincastle, were located on the western side of the Blue Ridge in Botetourt County. The other two orchards, Tyro and Spring Valley, were located on the eastern side of the Blue Ridge in Nelson County and Albemarle County, respectively. Each orchard contained a five acre (Daleville and Fincastle) or a ten acre (Tyro and Spring Valley) pheromone treated block and conventionally treated control of approximately the same area. The Daleville, Fincastle and Spring Valley orchards were composed of 'Delicious' and 'Golden Delicious' varieties on M11 root stocks. Tyro orchards were composed of 'Delicious', 'Golden Delicious' and 'Lodi' varieties. A majority of the trees in the orchards were 5 m tall.

Environments surrounding the orchards varied. Both Tyro orchards, Daleville control and Fincastle control were surrounded by other orchards and fields. The Daleville pheromone was surrounded by both a wood lot and a abandoned orchard. The Fincastle pheromone orchard was surrounded by either pasture land and woods. The Spring Valley orchards were bordered by woods and a farm road.

The duration of time each of orchards had been placed under a low spray mating disruption program varied. The Daleville and Fincastle orchards had undergone a total of four and three years, respectively by 1992, the first year of the study. The Spring Valley orchard had undergone three years of disruption by 1993. The only year it was sampled. Mating disruption at the Tyro orchard was initiated in 1992.

Statistics:

Several different statistical methods were employed to analyze the pitfall capture data. The first was the total abundance of individuals collected. Taxa richness was then determined. It indicates the total number of individual taxa collected. The information theory diversity statistic, Shannon-Wiener (1948), was used to determine species diversity in each orchard

The Shannon-Wiener evenness (J') of a community was also calculated for each community. Evenness is defined as the distribution of n individuals among the s taxa/species.

Horn's index of community similarity was used to compare different blocks. Cluster analysis and principle component analysis was used to determine overall block relationships. (Ludwig and Reynolds 1988, Brower et al. 1990).

Results & Discussion:

Taxa diversity and similarity:

Daleville orchard:

The pheromone blocks differed the most between years. In 1992 the pheromone block totals were 792 individuals and 71 taxa while in 1993 the totals were 2054 individuals 96 taxa (Table 1). The 1992 control block collected 331 individuals and 36 taxa while in 1993, 679 individuals in 54 taxa were collected. For both years, the pheromone block had the highest index of diversity. In the pheromone block the index was 1.26 and 1.35 for 1992 and 1993, respectively. For the control block the diversity index was 0.8 in 1992 and 1.09 in 1993. The J' (0.68) was the same for both years in the pheromone blocks. In the control, the J' increased from 0.51 in 1992 to 0.63 in 1993. After determining Student's t for both blocks, it was determined that the pheromone and control blocks had statistically different H' for both years (Table 1). The pheromone and control block's H' were also compared between the same year (Table 2). Both years demonstrated highly significant differences between blocks, i.e. the H' was different between the pheromone and control blocks in 1992 and 1993. Horn's index of similarity $\left(R_0\right)$ was also calculated. Rejmánek's correction factor was used in determination of the R_0 for between block comparisons in the same year. The R_0 for the pheromone comparison was 0.8. The control had a much lower R_0 of 0.41. The R_0 was low for the comparison between blocks in both 1992 and 1993. The 1992 blocks had a similarity of 0.42 while the 1993 blocks had a similarity of 0.45. All of these indicies indicated that for the Daleville pheromone block, mating disruption is increasing populations and diversity of arthropods.

Fincastle orchard:

The control blocks differed the most between years. In 1992 the control block totals were 276 individuals and 53 taxa while in 1993 the totals were 601 individuals and 56 taxa (Table 1). The 1992 pheromone block collected 633 individuals and 75 taxa while in 1993, 816 individuals in 80 taxa were collected. H' was consistent between all blocks. In the pheromone block the index was 1.44 and 1.47 for 1992 and 1993, respectively. For the control block the diversity index was 1.30 in 1992 and 1.44 in 1993. The evenness (0.77) was the same for both years in the pheromone blocks. In the control, the J' increased from 0.75 in 1992 to 0.82 in 1993. After determining Student's t for both blocks, it was determined that the pheromone and control blocks had statistically different H' for both years (Table 1). The pheromone and control block's H' were also compared between the same year (Table 2). Both years demonstrated significant differences between blocks, i.e. the H' was different between the pheromone and control blocks in 1992 and 1993. Horn's index of similarity $\left(R_0\right)$ was calculated. Rejmánek's correction factor was used in determination of the R_0 for between block comparisons in the same year. The R_0 for the pheromone comparison was 0.61. The control had a higher R_0 of 0.66. The 1992 blocks had a similarity of 0.61 while the 1993 blocks had a similarity of 0.70.

These Horn indicies indicate that populations and species present in the Fincastle blocks changed from year to year. Even with this lower similarity the other diversity indicies point to mating disruption as the factor increasing populations and diversities of arthropods present in apple orchards.

Tyro orchard:

The control blocks differed the most between years. In 1992 the control block totals were 80 individuals and 31 taxa while in 1993 the totals were 170 individuals 48 taxa (Table 1). The 1992 pheromone block collected 156 individuals and 44 taxa while in 1993, 244 individuals in 49 taxa were collected. H' was consistent between all blocks. In the pheromone blocks the index was 1.44 and 1.33 for 1992 and 1993, respectively. For the control block the diversity index was 1.34 in 1992 and 1.45 in 1993. The J' for the pheromone block was 0.87 in 1992 while in 1993 it was 0.78. In the control, the J' decreased from 0.90 in 1992 to 0.86 in 1993. After determining Student's t for both blocks, it was determined that the pheromone and control blocks had statistically different H' for both years (Table 1). The pheromone and control block's H' were compared between the same year (Table 2). Both years demonstrated significant differences between blocks, i.e. the H' was different between the pheromone and control blocks in 1992 and

1993. Horn's index of similarity $\left(R_0\right)$ was also calculated. Rejmánek's correction factor was used in determination of the R_0 for between block comparisons in the same year. The R_0 for the pheromone comparison was 0.64. The control had a lower R_0 of 0.51. The 1992 blocks had a similarity of 0.42 while the 1993 blocks had a larger similarity of 0.45.

The Tyro orchard reversed several diversity indicies from 1992 to 1993. I believe a large factor for this is the number of year in which a low spray mating disruption program had been implemented there. The communities in the pheromone block had not had significant enough time to rebound from years of insecticide spraying. The large Horn index between treatment for both 1992 and 1993 (Table 2) also supports this belief.

Spring Valley orchard:

The Spring Valley orchard was sampled only during 1993 and therefore no comparisons can be made with the previous year. In 1993, although, 927 individuals were collected from 61 taxa from the pheromone block and 831 individuals and 64 taxa were collected in the control block (Table 1). The H' and J' was higher in the pheromone than the control. H' and J' was 1.28 and 0.72, respectively, for the pheromone and 1.16 and 0.65, respectively for the control (Table 1). Student's t was calculated between blocks and it was determined that the H' was significantly different between the orchards (Table 2). Horn's index was calculated to be 0.80 between blocks (Table 2). Table 9 lists all taxa collected, excluding carabids, in the Spring Valley orchard.

This orchard did not follow the expected change in arthropod fauna. Both had a large number of taxa and relatively high Shannon-Wiener indicies. Horn's index (Table 2) indicated a large amount of similarity between treatments. Due to the above factors, one can not make an easy analysis of these blocks. These blocks were studied for only one year. Possibly with another year of research more accurate conclusion may be made.

Tables 3 lists all of the carabids collected in both years.

Multivariate Analysis:

Cluster Analysis:

Figure 1 shows the cluster analysis of all orchards and blocks for both years regarding the taxa data. The Spring Valley blocks group out first. Then the 1993 Daleville control (DC '93) and 1993 Fincastle control (FC '93) group together. After which the 1993 Fincastle pheromone (FP '93)and the Spring Valley (SV) orchards all group together to form one cluster. The two Daleville pheromone (DP) blocks cluster together. The 1992 Daleville control (DC '92) , 1992 Fincastle control (FC '92) and 1993 Fincastle pheromone (FP '93) all form one cluster. The Tyro (T) orchard groups out according to year and then forms one cluster. There are a total of four individual clusters at 30% similarity. Figure 2 shows the cluster analysis of all orchards and blocks for both years regarding taxa data but excluding the Spring Valley data. The results are very similar to the previous analysis but now FP '92 groups with the FP '93, DC '93 and FC '93 cluster.

Figure 3 is a dendogram showing the clustering of the 1992 taxa data. The DP and FP form one cluster. The DC and FC form another cluster and TP and TC form the third cluster.

Figure 4 is a dendogram showing the clustering of the 1993 taxa data. The FP, DC and FC form one cluster. Spring Valley and Tyro orchard formed a second cluster and third cluster, respectively. Daleville pheromone forms the last, singular, cluster. There is a total of four clusters at 50% similarity and three clusters at 40% similarity. Figure 7 is another dendogram of the 1993 taxa data. The Spring Valley data has been removed so one can compare it to the 1992 taxa dendogram (Figure 3). The clustering is identical to Figure 4, except the removal of Spring Valley.

Figure 1 and 2 clearly show the strong relationship between the Tyro blocks. Secondly, the Daleville pheromone blocks are closely related. When the Fincastle, Spring Valley and Daleville control blocks are compared they all group together. This is largely due to high very populations of a few common insect between them.

The analysis of the 1992 data revealed expected results (Figure 3). This grouping supported the hypothesis that mating disruption alters the arthropod community in apple orchards. The analysis of the 1993 data was less clear (Figures 4 & 5). This year the Fincastle grouped with the Tyro orchard rather than the Daleville. This is largely due to a few common species shared between them. These species were in high enough population to change the relationship of the blocks.

Principle Component Analysis:

Two principle component analysis graphs were done for each analysis. This was done so the relationship of the blocks can be shown in three dimensions rather than two. The second and third principle components (second and third dimensions) in the analysis together can add an addition 30% to the variability. If the third principle component is not graphed some of the possible relationships that do exists might not be shown.

Figures 6 and 7 represent the PCA of all taxa collected for both years, in all orchards. In figure 6 two clusters are visible. The first contains DP '92, DC '92, FP '92, FC '92 and DP '93. The second contains both 1993 Fincastle blocks, all of the Tyro blocks, both Spring Valley blocks and DC '93. In Figure 7 three clusters are identifiable. The first cluster includes the Daleville pheromone block in 1992 and 1993. The second includes both the 1992 Fincastle blocks and DC '92. The third contains all of the Tyro blocks, both Spring Valley blocks, both 1993 Fincastle blocks and DC '93.

Figures 8 and 9 represent the PCA of all taxa collected in 1992. In figures 8 and 9 three individual groups can be seen. One contains both Tyro blocks. The second includes both Fincastle blocks and Daleville control. Daleville pheromone remains by itself for the third group.

Figure 10 and 11 represent the PCA of all taxa collected in 1993. In figure 10 two clusters can be seen. The first cluster includes both Tyro blocks, Spring Valley, and Fincastle blocks and Daleville control. The second cluster only includes the Daleville pheromone block. In figure 11 three cluster are visible. The Fincastle, Tyro and the Daleville control block all comprise the first cluster. Both Spring Valley blocks form the second cluster. Daleville pheromone, singularly, make the third cluster.

Figures 6 and 7 show the same grouping as seen in the cluster analysis. The two Daleville pheromone blocks are quite remove from the other orchards. The close relationship between the Tyro blocks is also shown. Figures 8, 9, 10 and 11 relay the similarity between the 1992 and 1993 blocks, respectively. The same relationships as seen in figure 6 and 7 are also shown in these figures.

The multivariate analysis, I believe, shows the close relationships of the various blocks independent of year but dependent on management practicies.

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Table 1. Diversity and Similarity Indicies. Includes all taxa.

Statistics	Daleville				Fincastle			
	Pheromone		Control		Pheromone		Control	
	1992	1993	1992	1993	1992	1993	1992	1993
Total number of individuals	792	2054	331	679	633	816	276	601
Total number of taxa	71	96	36	54	75	80	53	56
Shannon-Wiener	1.26	1.35	0.80	1.09	1.44	1.47	1.30	1.44
Maximum Shannon-Wiener	1.85	1.98	1.56	1.73	1.88	1.90	1.72	1.75
Shannon-Wiener evenness	0.68	0.68	0.51	0.63	0.77	0.77	0.75	0.82
Student's *t*	44.73		75.78		12.69		24.11	
Degrees of Freedom	1068		549		1270		410	
Horn's index of Similarity	0.80		0.41		0.61		0.66	

Table 1 cont. Diversity and Similarity Indicies. Includes all taxa.

Statistics	Tyro				Spring Valley†			
	Pheromone		Control		Pheromone		Control	
	1992	1993	1992	1993	1992	1993	1992	1993
Total number of individuals	156	244	80	170	-	927	-	831
Total number of taxa	44	49	31	48	-	61	-	64
Shannon-Wiener	1.44	1.33	1.34	1.45	-	1.28	-	1.16
Maximum Shannon-Wiener	1.64	1.69	1.49	1.68	-	1.79	-	1.81
Shannon-Wiener evenness	0.87	0.78	0.90	0.86	-	0.72	-	0.65
Student's *t*	9.84		5.56		-		-	
Degrees of Freedom	273		124		-		-	
Horn's index of Similarity	0.64		0.51		-		-	

† Spring Valley orchard was sampled only in 1993

Table 2. Student's *t*, degrees of freedom and Horn's index of Similarity between the Pheromone and Control orchards, for all taxa, within the same year.

Statistics	Daleville		Fincastel		Tyro		Spring Valley†	
	1992	1993	1992	1993	1992	1993	1992	1993
Student's *t*	122.03	127.23	24.03	12.24	4.89	11.43	-	49.82
Degrees of Freedom	529	891	405	1204	131	311	-	1733
Horn's index of Similarity	0.42	0.45	0.61	0.70	0.80	0.74	-	0.80

† Spring Valley orcard was sampled only during 1993.

Table 3. Total list of all Carabidae species collected.

Species	Total '92	Total '93	All Total
Abacidus sculptus LeConte	0	1	1
Agonum melanarium Dejean	0	1	1
Agonum placidum (Say)	0	1	1
Agonum punctiforme (Say)	3	1	4
Agonum retractum LeConte	1	0	1
Amara aenea DeGeer	5	0	5
Amara aeneopolita Casey	0	1	1
Amara cupreolata Putz.	1	8	9
Amara exarata (Dejean)	0	1	1
Amara familiaris Duft	9	5	14
Amara impuncticollis Say	2	0	2
Amara littoralis Mannerheim	6	22	28
Amara pennsylvanica (Hayward)	0	1	1
Amphasia interstitialus Say	0	44	44
Anisodactylus furvus LeConte	12	96	108
Anisodactylus harrisi LeConte	2	81	83
Anisodactylus ovularis Casey	3	0	3
Anisodactyus nigerrimus Dejean	48	69	117
Anisodactylus rusticus Say	0	2	2
Anisodactylus sanctaecrucis	0	1	1
Anistotarsus terminatus Say	1	0	1
Apenes lucidula (Dejean)	0	1	1
Bradycellus badipennis	0	3	3
Bradycellus congener LeConte	2	0	2
Bradycellus insulus (Casey)	1	0	1
Calathus gregarious (Say)	7	18	25
Calsoma scrutator Fabricius	0	1	1
Carabus webbi Bell	0	1	1
Chlaenius emarginatus Say	26	31	57
Cymindis americana Dejean	0	1	1
Cymindis complanata Dejean	0	1	1
Cymindis limbata (Dejean)	0	2	2
Dicaelus dilatus Say	0	3	3
Dicaelus elongatus Bonelli	29	166	195
Dicaelus furvus Dejean	1	1	2
Dicaelus purpuratus Bonelli	0	2	2
Dromius piceus Dejean	0	1	1
Galerita bicolor Drury	29	64	93
Harpalus caliginosus Fabricius	0	17	17
Harpalus erythropus Dejean	21	338	359
Harpalus fulgens Csiki	5	0	5
Harpalus herbivagous Say	1	8	9
Harpalus longicollis LeConte	51	131	182
Harpalus pensylvanicus DeGeer	68	1137	1205
Harpalus somnulentus Dejean	2	0	2
Lebia viridis Say	0	2	2
Notiobia nitidipennis (LeConte)	2	7	9
Notiobia terminatus (Say)	4	0	4
Notiophilus semistriatus Say	1	1	2
Platynus cincticollis (Say)	0	1	1
Platynus decentis (Say)	0	2	2
Pterostichus coracinus Newman	105	44	149
Pterostichus lucablandus (Say)	27	291	318
Pterostichus mutus (Say)	13	1	14
Pterostichus tristis Dejean	0	1	1
Scarites subterraneus Fabricius	14	11	25
Selenophorus opalinus Leconte	1	0	1
Stenolophus conjunctus (Say)	0	1	1
Stenolophus rotundatus LeConte	0	3	3
Trichotichnus dichrous (Say)	0	21	21
Xestonotus lugubris Dejean	0	1	1
Number of Individuals	503	2649	3152
Number of Species	33	50	61

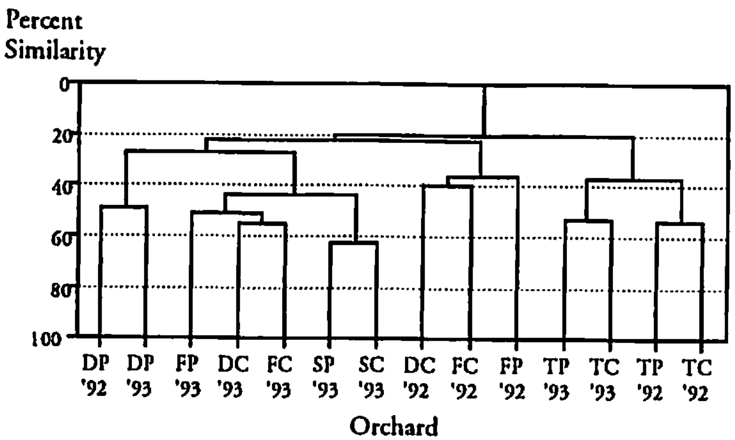

Figure 1. Dendogram of all taxa collected in all orchards during both years. Clustering is by the group - average stradegy. (D-Daleville, F-Fincastle, T-Tyro, S-Spring Valley, P-Pheromone, C-Control)

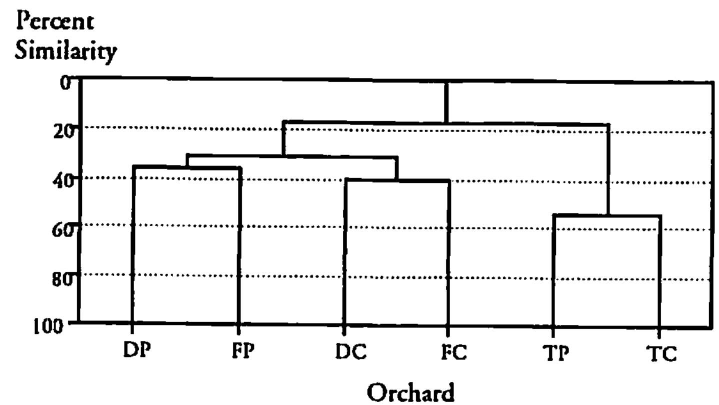

Figure 3. Dendogram of all taxa collected in all orchards during 1992. Clustering is by the group - average stradegy. (D-Daleville, F-Fincastle, T-Tyro, S-Spring Valley, P-Pheromone, C-Control)

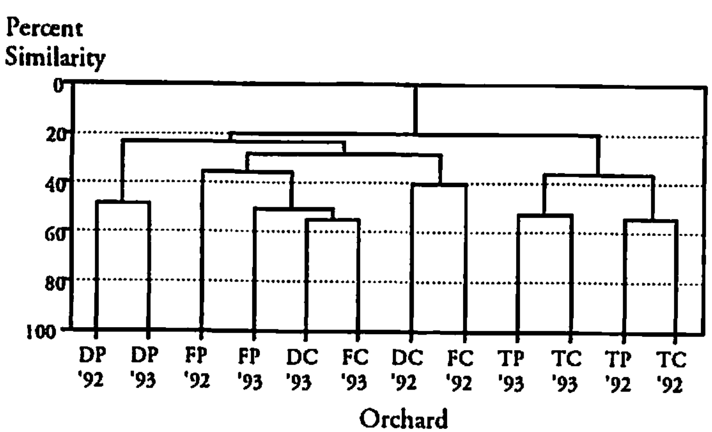

Figure 2. Dendogram of all taxa collected in all orchards during both years. Spring Valley data was excluded. Clustering is by the group - average strategy. (D-Daleville, F-Fincastle, T-Tyro, P-pheromone, C-Control)

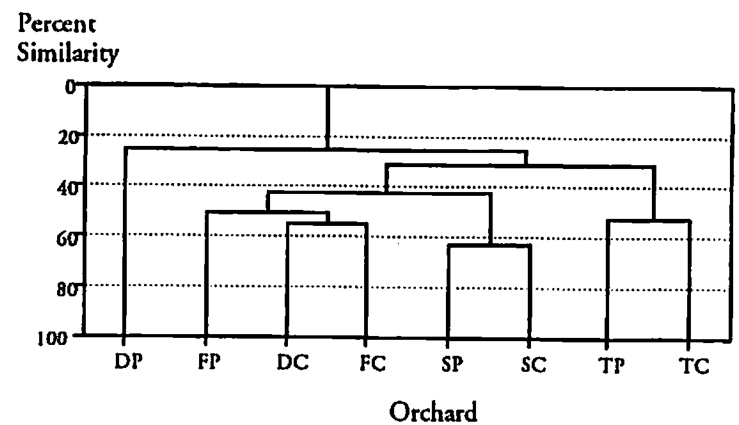

Figure 4. Dendogram of all taxa collected in all orchards during 1993. Clustering is by the group - average strategy. (D-Daleville, F-Fincastle, T-Tyro, S-Spring Valley, P-Pheromone, C-Control)

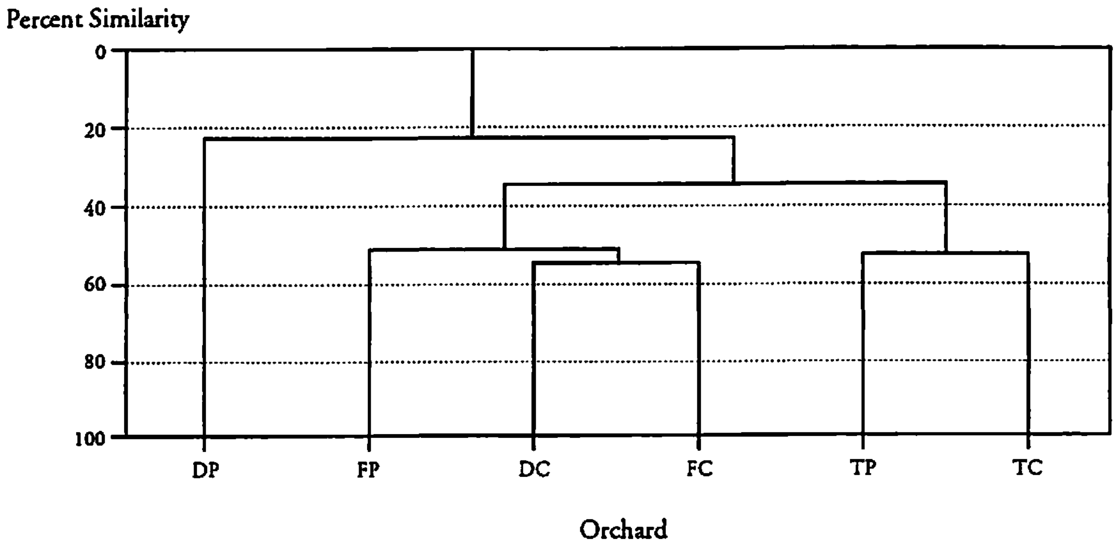

Figure 5. Dendogram of all taxa collected in all orchards during 1993. Spring Valley data was excluded. Clustering is by the group - average strategy. (D-Daleville, F-Fincastle, T-Tyro, P-Pheromone, C-Control)

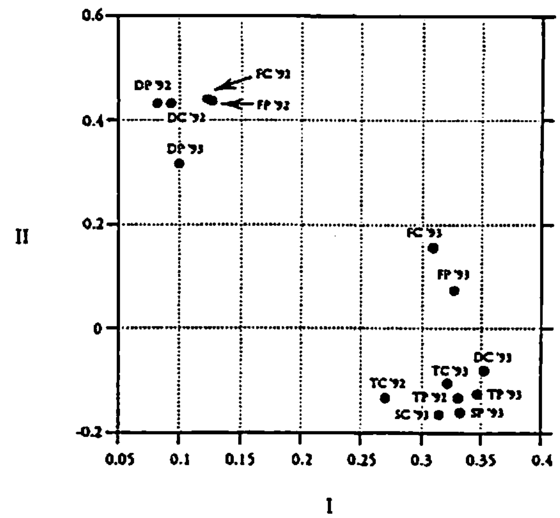

Figure 6. Principle component analysis of all taxa collected for all orchards in 1992 and 1993. (D-Daleville, F-Fincastle, T-Tyro, S-Spring Valley, P-Pheromone, C-Control)

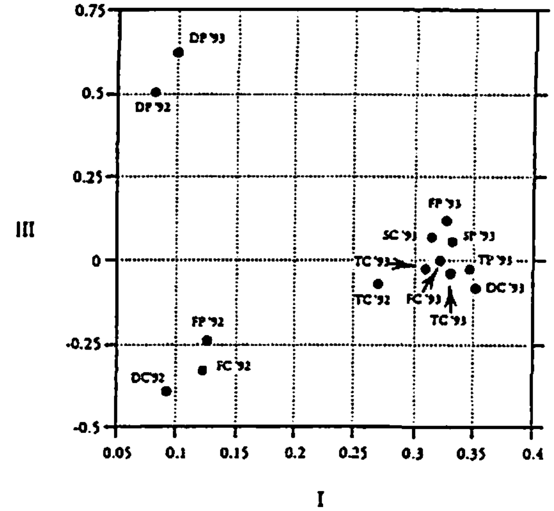

Figure 7. Principle component analysis of all taxa collected for all orchards in 1992 and 1993. (D-Daleville, F-Fincastle, T-Tyro, S-Spring Valley, P-Pheromone, C-Control)

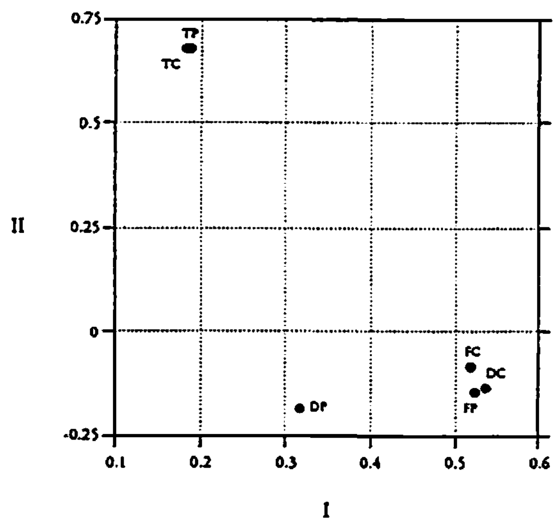

Figure 8. Principle component analysis of all taxa collected in 1992. (D-Daleville, F-Fincastle, T-Tyro, P-Pheromone, C-Control)

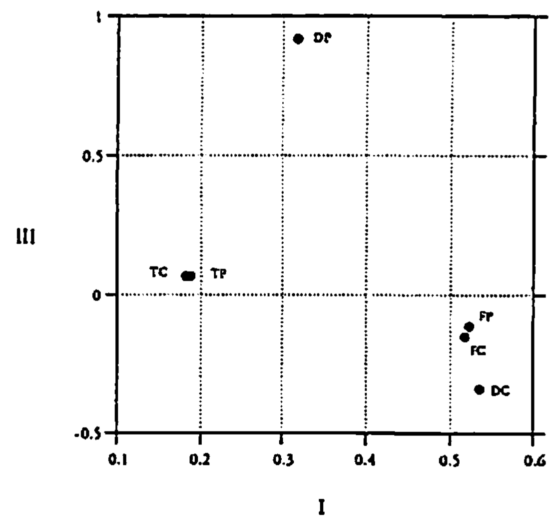

Figure 9. Principle component analysis of all taxa collected in 1992, (D-Daleville, F-Fincastle, T-Tyro, P-Pheromone, C-Control)

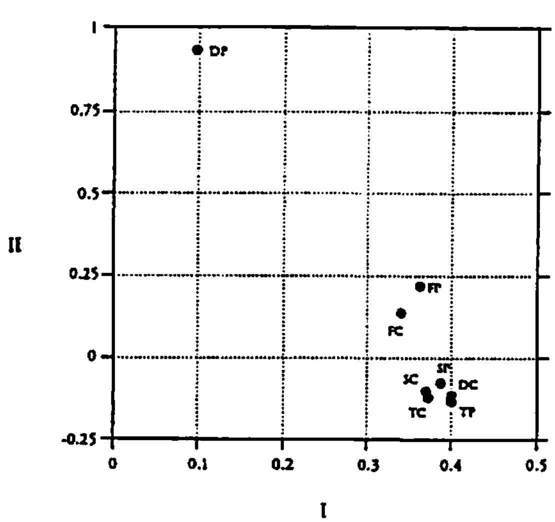

Figure 10. Principle component analysis of all taxa collected in 1993. (D-Daleville, F-Fincastle, T-Tyro, S-Spring Valley, P-Pheromone, C-Control)

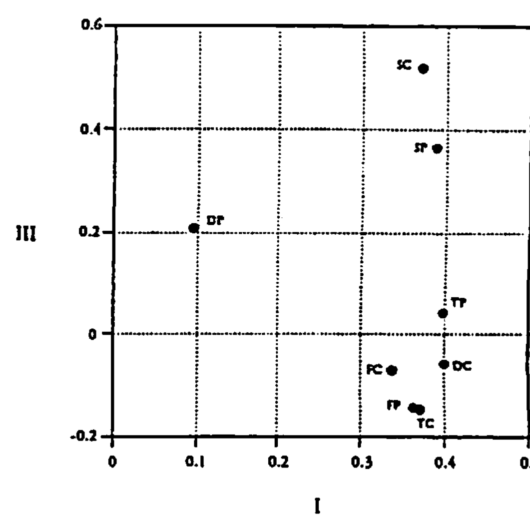

Figure 11. Principle component analysis of all taxa collected in 1993. (D-Daleville, F-Fincastle, T-Tyro, S-Spring Valley, P-Pheromone, C-Control)

Release Rates of Codling Moth and Leafroller Pheromone Dispensers

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I. Introduction: Mating disruption in apple orchards has been shown to be effective in controlling the codling moth (CM), *Cydia pomonella* (L.) and leafrollers such as the variegated leafroller (VLR), *Platynota flavedana* (Clemens), the tufted apple bud moth (TBM), *P. idaeusalis* Walker, and the redbanded leafroller (RBL), *Argyrotaenia velutinana* (Walker) (Pfeiffer et al. 1993a,b). Pheromone dispensers must have several properties for mating disruption to work: (1) the dispenser must contain the proper blend of pheromone components: (2) the dispenser must release these components effectively; and (3) the proper number of dispensers must be placed in the orchard. Weight measurement of dispensers can give an estimation of how well a dispenser releases its pheromone components.

II. Materials and Methods: Ten dispensers of each design (Generic 2, Generic 3, VLR, TBM, CM red, and CM clear) were attached to 1.25 inch galvanized staples on two 1.5m by .75m plywood boards. Leafroller dispensers were of the spiral design, loaded with 50mg AI. Generic 2 was composed of E11-14:Ac (30%), Z11-14:Ac (40%), E11-14:OH (30%). Generic 3 was composed of E11-14:Ac (40%), Z11-14:Ac (20%), E11-14:OH (40%). VLR was composed of E11-14:OH (90%), Z11-14:OH (10%). TBM was composed of E11-14:Ac (50%), E11-14:OH (50%). Codling moth dispenser design was a 20cm polyethylene tube sealed at each end, also known as the rope design. These were loaded with 165mg AI. Components of the CM dispensers were: E,E-8,10-dodecadien-1-ol (52.9%), dodecanol (29.7%), tetradecanol (6.0%), inert ingredients (11.4%). Each board had 15mm holes drilled above and below each staple to enhance air flow across the dispensers. The boards were suspended from a tree, and dispensers were removed and weighed on weekly intervals for 21 weeks (147 days). Leafroller dispensers were provided by Ecogen and CM dispensers were provided by Pacific Biocontrol.

III. Results and Discussion: <u>Leafroller dispensers</u>: These dispensers were made to last for 70 days. For days 0-70, all leafroller dispensers provided a nearly linear rate of pheromone release (Figs. 1-4). Using confidence intervals with $\alpha = .05$, there is no statistically significant difference between the Generic 3 and TBM dispensers. The VLR dispenser had the greatest release rate, while the Generic 2 dispenser had the smallest release rate (Fig.9).

For days 70-147, the release rates gradually leveled out (Figs. 1-4). Using confidence intervals with $\alpha = .05$, there is no statistically significant difference between the Generic 2, Generic 3, and TBM dispensers. The VLR dispenser again had the greatest release rate (Fig.10).

One limitation of using weight loss to determine pheromone release rates is that the dispenser may interchange water molecules for pheromone molecules (Bierl-Leonhardt 1982). Another limitation is that there is no way to determine the ratio of components emitted from the dispenser. Weight measurements in this experiment did show that dispensers released their contents at a relatively constant rate up to a certain point, where the release rate leveled out.

After ten to twelve weeks, it appears that no leafroller dispenser would be able to maintain adequate release rates to allow effective mating disruption. If dispensers were placed in early May to disrupt first generation mating, they may not provide protection for the entire growing season. Therefore, two applications of dispensers may be required to effectively protect the crop. An alternative would be to produce long-life dispensers which should last from early May through late August.

Codling moth dispensers: These dispensers were made to last for 90 days. For days 0-91, the CM dispensers provided a nearly linear rate of pheromone release (Figs. 5-6). Using confidence intervals with $\alpha = .05$, there is no statistically significant difference between the CM red and CM clear dispensers (Fig. 7).

For days 91-147, the release rates gradually leveled out (Figs. 5-6). Using confidence intervals with $\alpha = .05$, there is statistically significant difference between the two dispensers. The CM red dispenser had the greater release rate (Fig. 8).

The CM red dispenser did not level out until around day 120, and thus should provide better coverage than CM clear if only one application is made. The CM red dispenser apparently would provide protection for the entire growing season.

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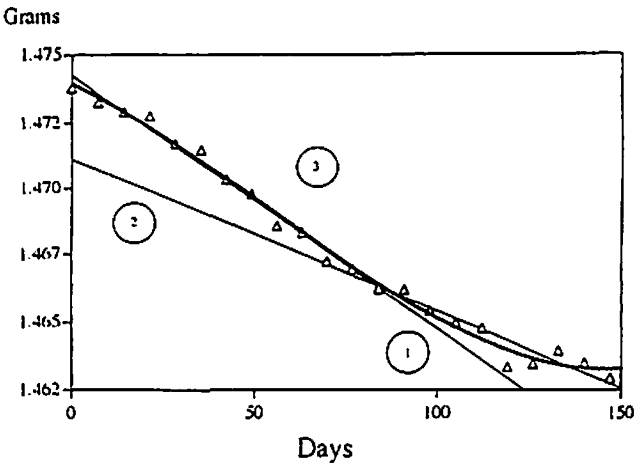
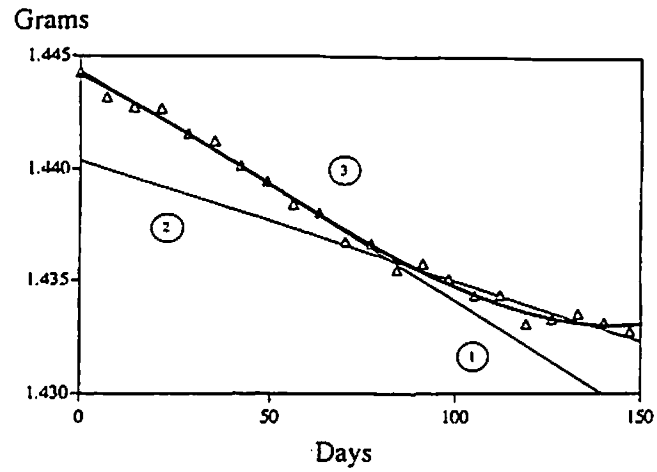
Figure 1. Generic 2 Dispenser Release Rate.



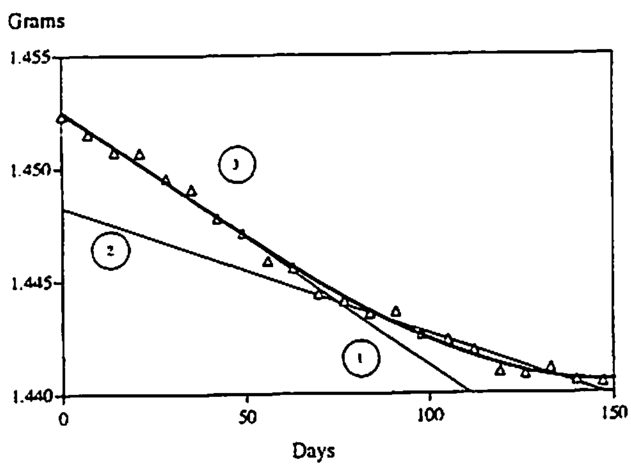
1. Day 0-70 $y = -9.5026E-05x + 1.4743E+00$ $r^2 = 9.7561E-01$
2. Day 70-147 $y = -5.7058E-05x + 1.4711E+00$ $r^2 = 9.2946E-01$
3. Day 0-147 $y = 3.7078E-09x^3 - 5.8323E-07x^2 - 6.7049E-05x + 1.4740E+00$ $r^2 = 9.9255E-01$

Figure 2. Gen 3 Dispenser Release Rates.



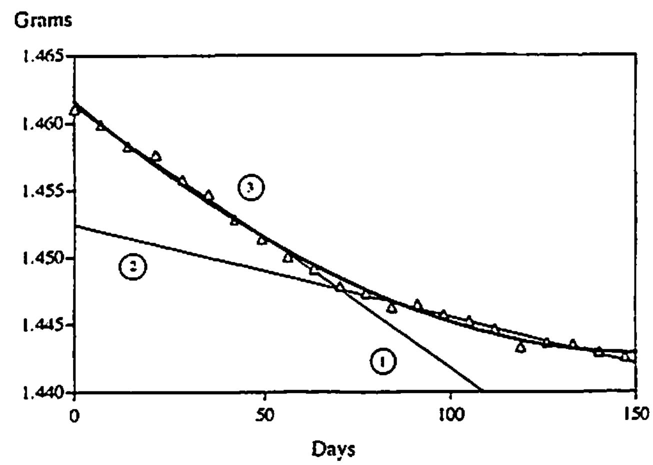
1. Day 0-70 $y = -1.0281E-04x + 1.4444E+00$ $r^2 = 9.8290E-01$
2. Day 70-147 $y = -5.4026E-05x + 1.4404E+00$ $r^2 = 9.2332E-01$
3. Day 0-147 $y = 3.4262E-09x^3 - 4.4926E-07x^2 - 8.3943E-05x + 1.4442E+00$ $r^2 = 9.9316E-01$

Figure 3. TBM Dispenser Release Rates.



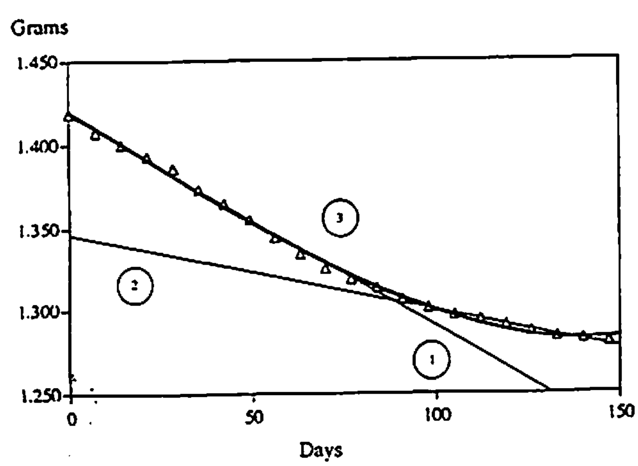
1. Days 0-70 $y = -1.1306E-04x + 1.4526E+00$ $r^2 = 9.8747E-01$
2. Days 70-147 $y = -5.5814E-05x + 1.4483E+00$ $r^2 = 9.5129E-01$
3. Days 0-147 $y = 2.3816E-09x^3 - 1.7139E-07x^2 - 1.0724E-04x + 1.4525E+00$ $r^2 = 9.9424E-01$

Figure 4. VLR Dispenser Release Rates.



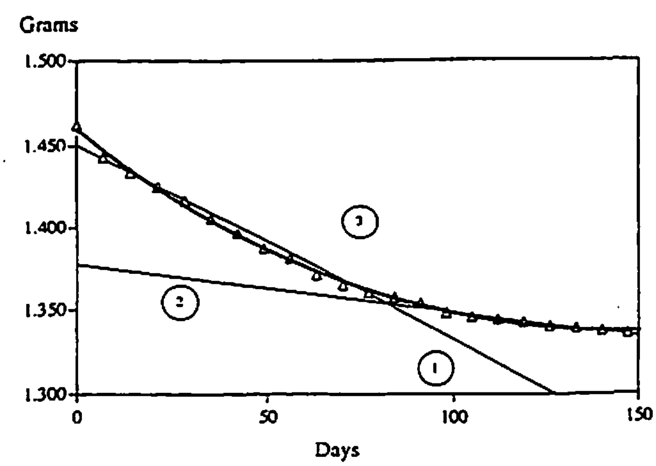
1. Day 0-70 $y = -1.9465E-04x + 1.4612E+00$ $r^2 = 9.9605E-01$
2. Day 70-147 $y = -0.000x + 1.452$ $r^2 = 0.960$
3. Day 0-147 $y = 2.5028E-10x^3 + 7.3152E-07x^2 - 2.4005E-04x + 1.4616E+00$ $r^2 = 9.9479E-01$

Figure 5. CM Red Dispenser Release Rates.



1. Days 0-91 $y = -1.2760E-03x + 1.4181E+00$ $r^2 = 9.9528E-01$
2. Days 91-147 $y = -4.6362E-04x + 1.3464E+00$ $r^2 = 9.8209E-01$
3. Days 0-147 $y = 3.1273E-08x^3 - 2.0445E-06x^2 - 1.3042E-03x + 1.4192E+00$ $r^2 = 9.9783E-01$

Figure 6. CM Clear Dispenser Release Rates.



1. Day 0-91 $y = -1.1796E-03x + 1.4506E+00$ $r^2 = 9.7419E-01$
2. Day 91-147 $y = -2.8831E-04x + 1.3773E+00$ $r^2 = 9.5283E-01$
3. Day 0-147 $y = -1.2784E-08x^3 + 9.1922E-06x^2 - 1.9133E-03x + 1.4603E+00$ $r^2 = 9.9814E-01$

Figure 7. Release rates of codling moth dispensers, day 0-91.

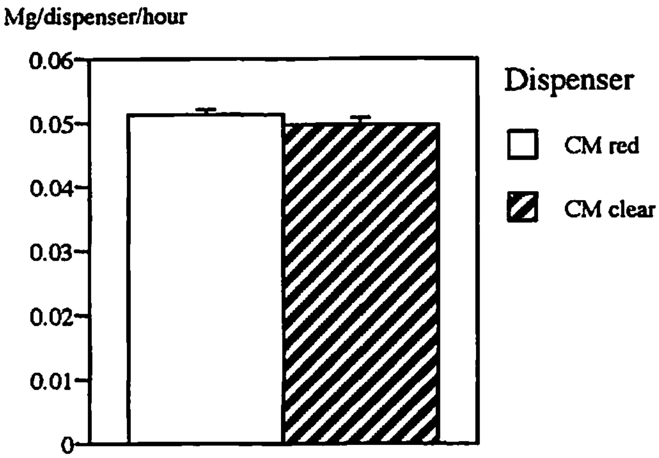


Figure 8. Release rates of codling moth dispensers, day 91-147.

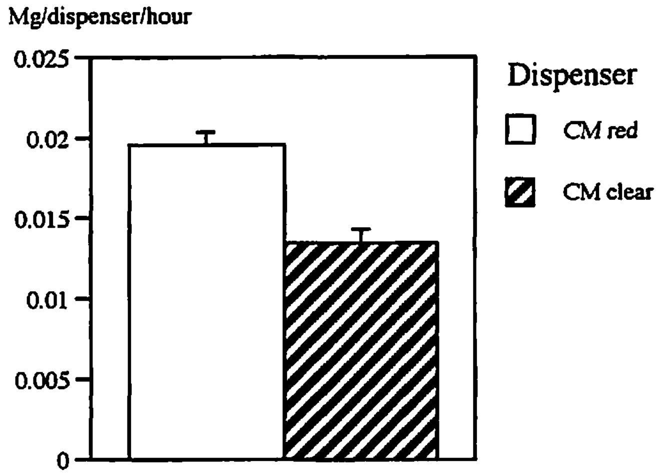


Figure 9. Release rates of leafroller dispensers, day 0-70.

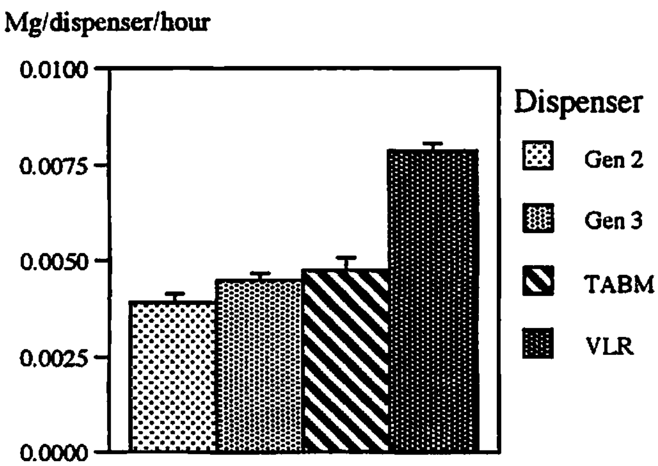
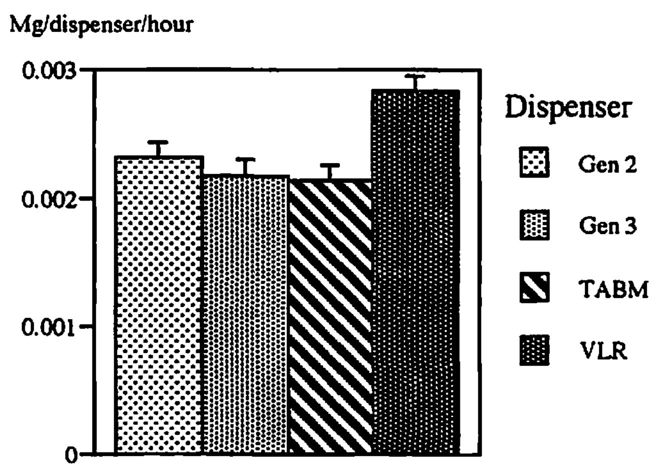


Figure 10. Release rates of leafroller dispensers, day 70-147.



Burr Knot Borer Activity and Control by Mating Disruption in 'Gala' Apples - 1994

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I. Introduction:

Synanthedon scitula (Harris), commonly known as the dogwood borer (DB), is a relative newcomer to the list of indirect pests of apple (Riedl et al. 1985, Warner & Hay 1985). It bores into and develops within burr knots which are primarily adventitious root primordia. 'Gala' is somewhat unique among apple varieties in that the trunk (scion) tends to form burr knots. The semi-dwarfing M26 rootstock to which 'Gala' are often grafted also has a tendency to form burr knots. Consequently, the problem of burr knot borers becomes amplified.

Engelhardt (1946) reported DB as having the broadest host range of any member in the family Sesiidae. It is a primary pest of flowering dogwood (Taft et al. 1991), and a secondary pest of many hardwood trees and shrubs including oak, beech, birch, hickory, pecan, cherry, mountain ash, and willow. It ranges from southeastern Canada and New England, west to Ohio and Minnesota, and south to Texas. A single, protracted generation is thought to occur (Potter & Timmons 1983, Riedl et al. 1985, Warner & Hay 1985). However, some studies show two flight peaks; the phenological significance is unclear (Potter & Timmons 1985). Larvae overwinter in galleries beneath the tree bark.

As the popularity of 'Gala' continues to increase, so too will the problem of burr knot borers. Chronic infestations may cause a decline in vigor and yield, occasionally killing the tree. Due to difficulties involved in controlling any borer, mating disruption may be the most viable and economical means of control. Mating disruption has been shown by feiffer et al. (1991), to be more effective than standard insecticides for control of lesser peachtree borer (LPTB), *Synanthedon pictipes* (Grote and Robinson). There are no commercial pheromones presently available for control of DB, but the similarity in pheromone composition of the peachtree borer (PTB), *Synanthedon exitiosa* (Say), to a complex of sesiids that includes DB, may offer a ready alternative. Mating disruption is now registered for PTB control.

II. Materials and Methods:

The pheromone-treated area consisted of a 2-ha (5-acre), rectangular block of 'Gala' located in Piney River (Nelson County); it was bordered on two sides by apple and two sides by pasture. Ropes (Pacific Biocontrol, Davis CA) containing the sex pheromone of PTB [(Z,Z)-3,13-ODDA], were placed on 22 April 1994 at the rate of 250/ha. The control area was another 2-ha, rectangular block of 'Gala' adjacent to the pheromone-treated block; it was bordered on three sides by apple and one side by pasture. Both blocks were treated with a conventional spray program.

In our 1993 study (Killian & Pfeiffer 1993), DB appeared to show a preference for traps baited with lilac borer (LB), *Podosesia syringae* (Harris), pheromone [(Z,Z)-3,13 ODDA], over those baited with DB pheromone [(*E*,Z)-2,13-ODDA/(Z,Z)-3,13-ODDA (100:1)], so as a means for determining disruption, three commercially available pheromone traps for LB were placed in each block. In addition, three traps for DB were placed in the control block. Septa were replaced on 23 June. All traps were checked weekly and adults removed.

In an effort to clarify further the phenology of DB, two LB pheromone traps were placed approximately 100 yards apart in each of two non-orchard environments: a residential area and a hardwood forest (both in Stafford County). Four traps were placed in Mountain Cove Orchard (Nelson County), and represented nonburr knot forming varieties of apple including 'Golden Delicious', 'Fuji', 'Sunrise', 'Red Delicious' and 'Ginger Gold'.

Damage was evaluated between 23-24 June and again between 16 Sept and 1 Oct by searching 100 tree trunks per block (10 groups of 10 trees, the groups spread uniformly in the block) for infested (as indicated by the presence of frass, exuviae or larvae) and non- infested burr knots. All pupal exuviae and larvae were counted and removed.

III. Results and Discussion:

Flight data: Catch data for male DB in DB and LB traps from the control block at Piney River are shown in Fig. 1. Flight occurred from May to October with large peaks in flight activity in late May - early June, and again in early - mid-August. In Michigan, emergence starts in mid-June, peaking in mid-July, and ending in September (Riedl et al. 1985; Howitt 1993). In Ontario, activity extends from late June until early August (Warner & Hay 1985). Snow et al. (1985) reported multiple generations of DB with the first generation occurrence in April-May (in Georgia). However, there are cases of univoltine sesiids exhibiting a bimodal emergence pattern, e.g., grape root borer (Snow et al. 1991).

A comparison of 1994 DB captures with those of 1993 is shown in Fig. 2. The 1994 population appears to be more evenly distributed throughout the season than the 1993 population which shows one large peak in mid-July - early August. Our results support the existence of a single, protracted generation.

DB captures from the residential, hardwoods, and mixed apple environments are shown in Fig. 3. In both the residential and hardwoods environment, DB captures peaked in early June and then ceased. DB captures in the mixed apple environment peaked in mid-May and then again in late July. This data is consistent with that of Potter and Timmons (1983) who provided evidence suggesting that an early flight peak was indicative of DB emergence from dogwood, while the larger, late-summer flight peak reflected infestation of apple (and possibly other hosts).

Suppression of DB males to LB pheromone traps in the treatment block was 99.3%; one male was captured on 19 August and one on 26 August.

Damage data: Number of burr knots per 10 trees, and percent infestation as indicated by the presence of frass, exuviae, and larvae for early-season and late-season counts are presented in Table 1. Average number of burr knots infested in the control and treatment blocks for the early-season count was 22.5 and 16 percent, respectively. Average number of burr knots infested in the control and treatment blocks for the late-season count was 38 and 37.4 percent, respectively. Although overall infestation of burr knots by DB in 1994 is less, relative to late-season counts made in 1993 (68.5 and 64.1 for the control and treatment block, respectively), the amount of damage is too great to consider the PTB pheromone an effective agent for mating disruption of DB. Further testing with dispensers of the appropriate DB blend appears to be in order.

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Taft, W.H., D.S. Smitley, and J.W. Snow. 1991. A Guide to the Clearwing Borers (Sesiidae) of the North Central United States. North Central Regional Publication No. 394.

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Table 1. Number of burr knots in 2 m of trunk, % burr knots with frass, % burr knots with exuviae, and % burr knots with larvae.[1]

Jun 23-24:

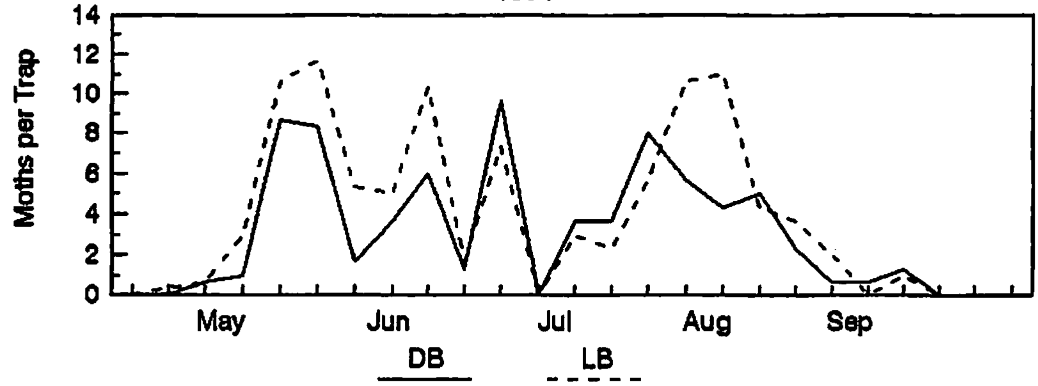
		% burr knots		
Treatment	Burr knots /10 trees	Frass	Exuviae	Larvae
Control:	50.5 (13.5)	22.5 (7.0)	3.9 (3.6)	2.4 (2.1)
Pheromone:	42.0 (12.5)	16.0 (6.8)	2.6 (2.3)	0.7 (1.2)

Sep 16 - Oct 1:

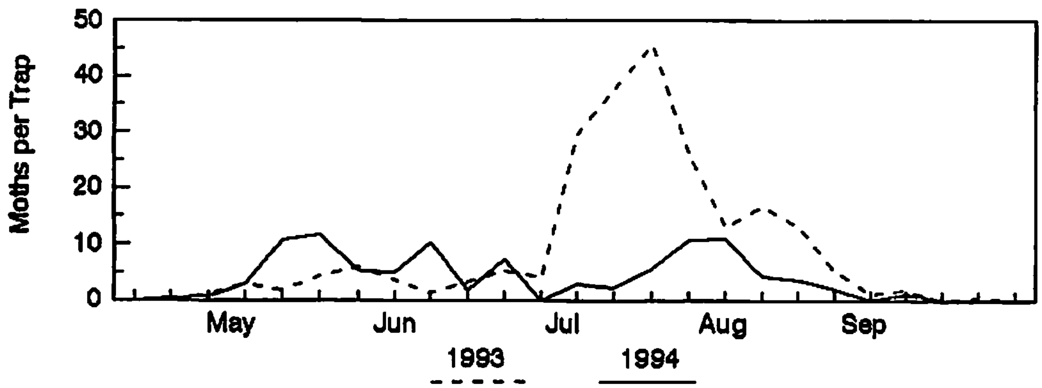
		% burr knots		
Treatment	Burr knots /10 trees	Infested	Exuviae	Larvae
Control:	91.6 (22.9)	38.0 (17.6)	2.3 (2.0)	14.5 (8.9)
Pheromone:	93.6 (28.0)	37.4 (9.6)	3.2 (2.5)	10.5 (6.3)

[1]Counts based on 10 groups of 10 trees each. Numbers in parentheses represent standard errors.

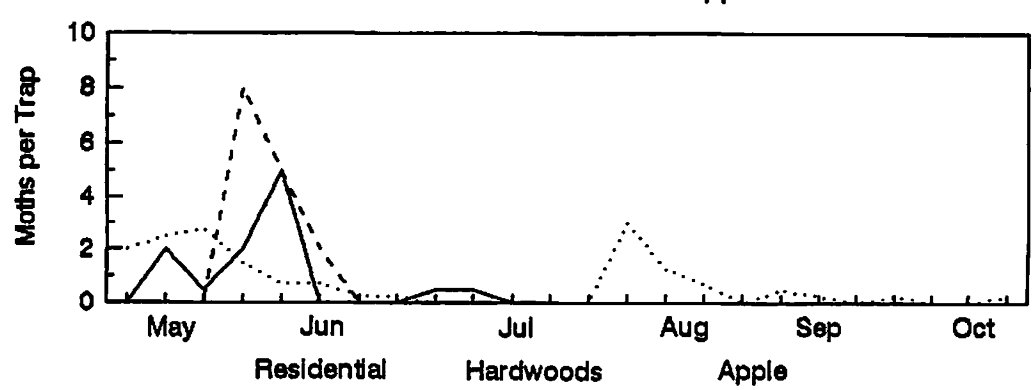
Dogwood Borer Captures in Piney River Orchard
Lilac Borer versus Dogwood Borer Traps
1994



Dogwood Borer Captures in Piney River Orchard
1993 and 1994



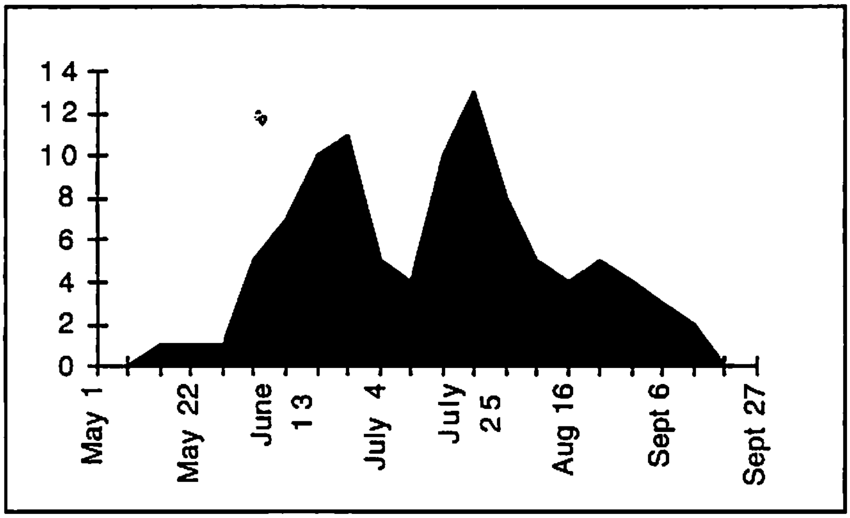
Dogwood Borer Captures
In Residential vs Hardwood vs Mixed Apple Block



Key Pests of North Jersey IPM Program 1994

K.Petersen and D. Polk
Rutgers Cooperative Extension

Codling Moth (CM)- Codling Moth was a problem pest this year that required frequent insecticide applications in most orchards. In twenty weeks of scouting, CM was above threshold ten of the twenty weeks. Threshold in NJ is 5 per week.



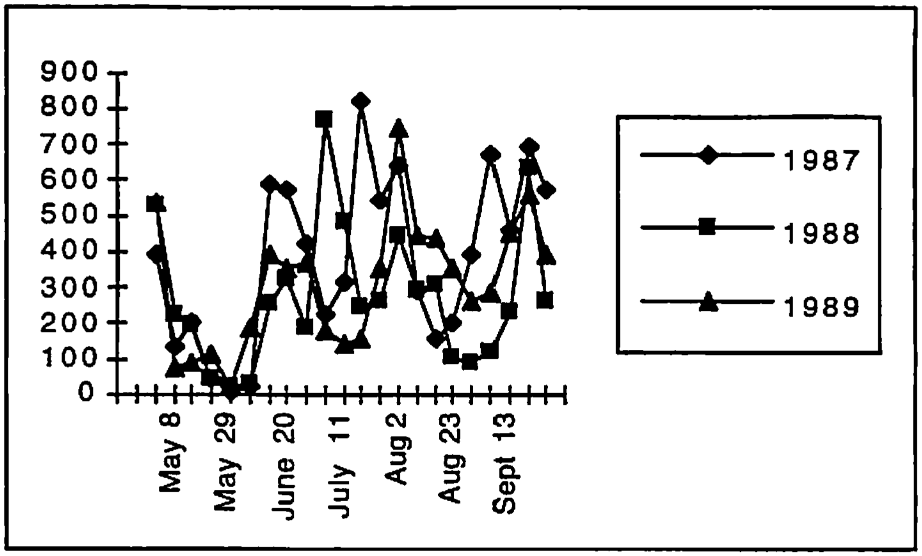
Oriental Fruit Moth (OFM)- Because of the severe winter in North Jersey this past year, the peach crop was non- existent. In the first week in June there were farms in four counties that had an outbreak of what looked like CM larvae boring into apples. After further examination by rearing larvae in the lab and netting the limbs to capture the adult moths, it was identified as OFM.

Fire Blight- For the third straight year, fireblight continued to be a problem on many farms. Because the weather in North Jersey was ideal for fireblight infection most of the summer, we had infections well into late July. As a result several growers lost blocks of trees up to an acre.

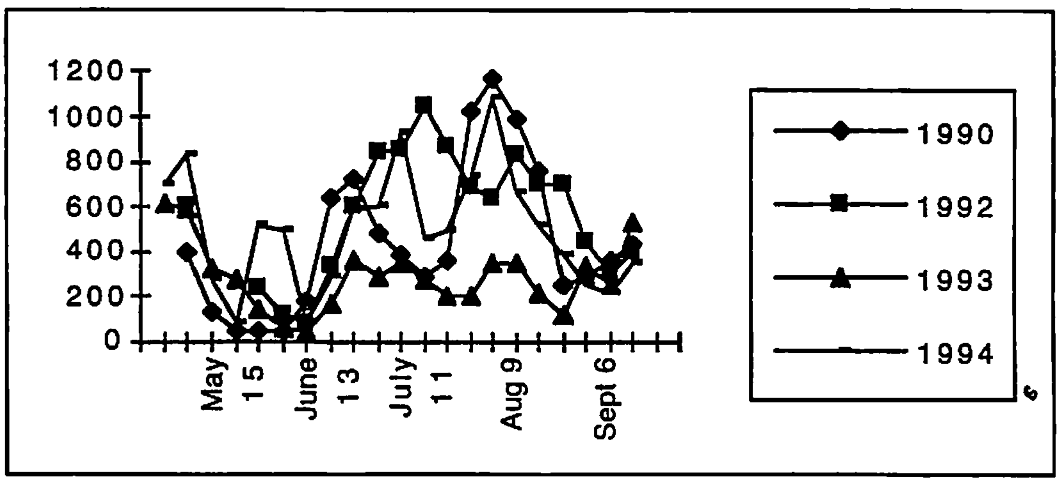
Leafminers (STLM)- Spotted Tentiform Leafminer populations have steadily increased in numbers over the last 7 years. This problem is amplified in North Jersey as Vydate doesn't seem to control the first generation effectively resulting in the use of harsher insecticides such as Lannate or pyrethroids later in the season. As these products kill beneficial predator populations, mites can became a problem.

Below are two graphs showing leafminer trap count averages since 1987. Notice that in the early years the graph shows nice generation peaks and valleys. In the later years, the second and later generations overlap, thus leading to a more sustained high population.

1987-1989
Leafminer populations



1990- 1994
Leafminer populations



There was also a "mystery" leafminer that didn't cause any economic damage to apple trees, but was prevalent enough throughout 3 counties that it did raise some interest. At first it was found in late July- early August on first year unsprayed trees, but then at the same orchard found on sucker growth of productive trees. After looking at several other locations, and seeing significant populations, cocoons were collected and reared. The insect was preliminarily identified as *Lyonetia specullela,* but has since been identified as *L. prunifolia.* It has been found over the past several years in Adams County PA, and The Kearneysville Station in West Virginia.

Key Pests of Peaches and Nectarines in South Jersey in 1994

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Background:

The Rutgers Cooperative Extension fruit integrated pest management program consists of a complete delivery program - scouting, sampling, and recommendations. Each farm is visited every week, traps are checked, and half the peach blocks are scouted. The scouts are usually college students hired in May for the duration of the summer break. The scouts are trained in pest identification and scouting techniques by the statewide IPM agent and the program associate. After the scout's visit the program associate checks the orchards and the scout's report and makes a recommendation based on the findings.

The following is a summary of the key pest problems found during the 1994 season in 32 commercial peach orchards in South Jersey.

Key Insect Pests:

Tufted apple budmoth (TABM) is a well-known and economically important pest in apple and has been for many years. Five years ago we first found TABM injury on Redhaven peaches in one South Jersey orchard. In the last four years TABM has become the most economically important pest in commercial peach production. The feeding is typically in the stem end where the fruit presses against the branch. As on apples, the feeding is on the surface, but if the peach pit splits the larva will go inside the fruit and will be considered an "internal worm" by the buyer. The stem-end feeding is difficult to see in the field. Feeding is also found where two fruit hang next to each other or where a leaf rests close to the skin of the peach.

At first it was found in the Burlington-Gloucester-Cumberland area where TABM was a pest in apple. This year TABM was just as serious in the Camden-Atlantic area where few apples are grown. First generation trap counts in the C-A area peaked sharply and nearly twice as high as the B-G-C area.

This year first generation TABM trap counts peaked in early June. Second generation peaked in early August. First generation feeding was seen on Redhaven at 1.5% field count as early as June 30. Postharvest counts showed TABM injury on all 32 IPM farms, up to 12% injury in some early varieties with a season average of 4-5%.

Several factors increase the frequency of TABM injury. Low volume sprayers are not applying insecticide evenly over the whole tree, especially in the tight stem-end/branch area of the fruit. Lannate is not used in June and July due to fear of mite build-up. Little or no Penncap M is used in May and June due to growers wishing to avoid accidental bee kill while weeds or nearby crops are in bloom. Most growers use Imidan and Guthion which do little to control TABM. TABM injury generally tapers off at the end of the season when growers begin to use Lannate and Penncap-Lannate combinations in August.

Our catfacing insect complex includes stink bugs, tarnished plant bugs, and false chinch bugs. Stink bugs (SB) show up first during prebloom and are present all season around 1 or 2 SB per 50 sweeps. Tarnished plant bugs (TPB) show up when the weather gets a little warmer, around bloom, increasing in late May and peaking in July. Average count is 2-4 TPB per 50 sweeps. A high count is usually 15 TPB per 50 sweeps, but one farm this year had 52 TPB in 50 sweeps. False chinch bugs (FCB) show up in late May and increase quickly in hot weather. Most farms with weedy groundcover reached 26-30 FCB per 50 sweeps in July.

Catfacing injury occurs throughout the season: at shuck split stage when the fruit grows out from the protection of the shuck; mid-season especially in warm, rainy weather when weeds like clover and vetch are flowering and growing rapidly; and during the pre-harvest period when fruit-laden branches are hanging low into the high weeds and the preharvest intervals of insecticides limit the control choices. Postharvest counts showed 2-4% catfacing injury this year.

Oriental fruitmoth counts started out very high this year in all southern counties, up to 340 moths/trap/week in late June. Due to bad economic situations (hail) in some areas, some growers let pest control lapse. Flags were found late June to early July. Trap counts remained around 30-40 moths/trap/week on about half the farms. Threshold for OFM is 6-8 moths/trap/week.

OFM injury was seen on two hail-hit farms on 11% of the fruit in late June. One non-hail farm had 1% injury in one sample only. Another non-hail farm had 1% injury in a Jersey Queen block on August 11. One week later the same block had 2.5% injury.

Excellent OFM control is achieved in our program using a degree-day (DD) model. The clock starts at first moth catch, usually pink bud stage. First insecticide for OFM is applied at 200 DD base 45, usually early petal fall. Second OFM spray is applied at another 200 DD, usually shuck split. On the farms that followed these recommendations, counts remained below threshold for the entire season and no postharvest injury was seen.

In addition to an increase in OFM incidence on peach, we are also beginning to find OFM injury in apples. We suspect organophosphate resistance. This summer we began a study to test for Guthion resistance in Gloucester County. Results were inconclusive.

In the past we have found that mites are economically important in peach, not because the mites decrease tree vigor or fruit growth (we have never seen mites affect peach this way), but because high mite levels cause discomfort and itching for the farmworkers. Workers in some cases refused to thin or pick the crop where mites were a problem.

First European red mites were seen in late May. First Two-spotted mites were seen in early July. More mites were found on nectarines, due to the use of prebloom pyrethroids for aphid control and other insecticides used at petal fall and shuck split for thrip control. Mites in general were not a problem in peach this year. No counts exceeded thresholds. Highest counts were 6-7 mites/leaf. One grower, with a history of high mite counts and trees stressed this year by low nitrogen levels, sprayed Apollo in June when mites reached 2-3 mites/leaf. All mites on this farm were gone by July.

Thrips are also an up-and-coming peach/nectarine pest in South Jersey. Most of our injury occurs while the fruit is still in shuck. In previous years, injury on some farms has exceeded 50% on nectarines. This year, early season thrip injury was also seen on peaches. Postharvest counts were 2-20% injury in affected blocks this year.

Green peach aphids were present mid-May through June. All counts stayed below thresholds.

Japanese beetles were present early July to early August, feeding mostly on leaves. In the third week in July, first Japanese beetle feeding was seen on Redhaven Special and Ernie's Choice. By Loring season the beetles had moved on.

San Jose Scale was present in small areas of two farms in 1993 and 1994. This unusual problem developed due to poor spray coverage, poor timing, and poor choice of chemicals used by these two growers. Scale is not a problem for most commercial growers.

Key Disease Problems

Phytopthora caused severe tree loss in South Jersey in mid-May. Cold wet soil, combined with other stress factors such as winter injury, nematodes, and peachtree borer injury, made the peach trees extremely susceptible to the Phytopthora fungus. Large areas of heavy or poorly drained soil were affected. Nearly every tree in one ten-acre block was killed. Another grower lost one-third of his trees over the entire farm.

Brown rot was heavy on blocks hit by hail. Regardless of spray program, hail-hit peaches showed up to 10% brown rot by first picking.

On farms without hail damage, brown rot was also a concern. The hot, rainy weather of July and August washed off non-systemic fungicides and caused rapid fruit growth during final swell. Brown rot first showed on Harvester, Harbrite, and Redhaven varieties around July 20. Growers started using Orbit fungicide in the preharvest period last year, and most growers credit Orbit for keeping brown rot under control this year under extreme disease pressure. Postharvest (in bin) counts showed 1-2% brown rot on the shoulders and seams of the fruit. Counts in the field were higher. Some rot is left on the tree or thrown on the ground.

Peaches sold well this year and storage rots were not a problem for most growers.

Fusicoccum canker is a problem we still don't have a handle on. Fussicoccum shows up late April to mid-June. Usually heaviest on early varieties such as Garnet Beauty, fussicoccum was present at some level in all blocks. This year, in addition to early varieties, Redhaven, Redhaven Special, Salem, Jersey Glo, Jersey Queen, and Autumn Glo were affected heavily. Fall applications of copper seem to help, and summer sprays of Tenncop for bacterial spot help somewhat, but no treatment seems to bring the problem below economic levels.

Bacterial spot is a problem every year in our area. Bacterial spot is worse on sandy soil. Infections appeared on leaves in late May and early June. Fruit infections appeared by late June. The hot, rainy weather in July increased leaf spots. Postharvest counts stayed around 2-3%, not as severe as most years.

Rusty spot was not an economic problem this year. First infections showed up June 4 on Autumn Glo, Redhaven, and Jersey Glo. No blocks went over 2% injury. None of our growers used Nova as a preventative this season.

Peach scab affected very few farms this year. Three farms had scab infections on fruit. The problem for two of these growers, the same two growers who had San Jose Scale on peach, was caused by poor spray coverage and poor chemical choices. Another grower had a localized problem in one nectarine variety. Those nectarines have been frozen for possible future testing for fungicide resistance.

In the past, after crop losses to killing spring frost, growers got into trouble with peach scab by not spraying during the year of the loss and not taking preventative measures, i.e. Bravo or Benlate/Topsin, the following year. Because of the losses due to hail this season, I suspect peach scab will be a problem on some farms in 1995.

Other Key Problems

The most important economic problem was not a "pest" at all, but the weather. A severe hail storm hit a broad band of farmland in South Jersey in late May. Several other smaller hail storms hit the area over the next six weeks. Eighteen of 32 fruitgrowers in our program received some hail damage. Twelve of those 18 growers suffered severe damage. Some growers lost 90-100% of the fruit on every tree to the hail. A few peach growers simply walked away after the storm. Some used a reduced spray program. Others used a regular spray program, thinned damaged fruit, and hoped for the best.

Having large areas of unsprayed or lightly sprayed peaches increased the pest pressure this year, especially with insects that can move from farm to farm. OFM and TABM counts remained high all season. High numbers of insects will be over-wintering in the hail-hit blocks, and next year's initial populations will be high. In addition to the previously discussed problem of peach scab pressure on next year's crop, brown rot/blossom blight pressure will be heavy on hail blocks. Many brown rot infected peaches are hanging on the tree. Brown rot cankers have formed on the wood and an abundance of mummies will remain on the tree to bloom of next year.

Because of the poor financial condition many growers were in after the hail storm, most could not afford the chemicals to make the PTB trunk spray this fall or nematode treatments if necessary. These conditions will add to the tree stress that affects tree loss.

On some farms leaves looked yellow due to low nitrogen levels in early May. On May 5 young leaves were "small, narrow, and yellowish with purple/pink spots" as reported by one scout. Peach tree roots did not take up the nitrogen fertilizer in the cold, wet spring soil. A near rainless June aggravated the problem in young blocks. By pit-hardening stage most trees had recovered.

Many split pits were present in peaches this season, up to 32% in some early varieties. The surprise was seeing 5-12% split pits in some late varieties. Rio-oso-gem had 7% split pits on the tree on August 18. This translated to 12% split pits at harvest at the end of the month. The excess rain in July and August accounted for most of the splitting.

Summary:

1994 was a moderate year for biological pests in South Jersey peach and nectarine orchards. The severe hail caused great economic loss on many farms. For these growers and their neighbors 1995 will hold greater challenge to be prepared for overwintering pest populations in order to provide quality fruit for their buyers.

Ecological Approaches to Peach Integrated Pest Management In New Jersey
Mating Disruption , Ground Cover Manipulation, and Nematode Use - 1994

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Introduction:

Peach IPM in New Jersey has focused on insect and disease monitoring, along with plant fertility and nematode detection over the past eight years. While maximizing fruit quality has been a principle objective, minimizing pesticide use has also been a concern. Reductions in pesticide use have been largely with insecticides and miticides. Recent developments such as the lengthening of reentry intervals for some pesticides, the establishment of new worker protection standards, and increased pesticide costs have made growers more receptive to new technologies that can reduce pesticide use.

Farmworker exposure to pesticides and worker reentry intervals are concerns that farmers have to deal with on an increasing basis. This is especially true in fruit and vegetable crops which require intensive hand labor. Peaches require hand labor in 3 extended time periods during the season: pruning during the spring, hand thinning during May and early June, and picking from late June through early September. Minimizing insecticide use during these periods decreases farmworker exposure, and makes it easier for the grower to conform to pesticide regulations regarding reentry times, worker exposure, and preharvest intervals.

New Jersey growers make weekly applications for control of oriental fruit moth and several catfacing insect species. Peachtree borers and lesser peachtree borers are targeted in 2 June treatments and/or in a single post harvest application. Control of lesser peachtree borers and peachtree borers is not adequate at the present time. Control consists of spraying insecticides (endosulfan, chlorpyrifos) in the fall with a handgun or airblast sprayer. Even with annual control measures, limbs and entire trees continue to be lost from each of these 2 insects.

This project is a long term effort that focuses on alternative and new technology to further reduce organophosphate, carbamate and synthetic pyrethroid use in peach and nectarine orchards. Efforts have dealt with mating disruption of multiple pest species, use of insect parasitic nematodes, manipulation of existing ground cover. The project is a component of the peach IPM program which also utilizes a degree day driven model for oriental fruit moth control, intensive pest monitoring, plant parasitic nematode management, weed management, and the maintenance of proper plant nutrition.

Objectives:

1) Establish a multi-component approach to alternative pest control through mating disruption, nematode use, and ground cover management practices.

2) Investigate the effectiveness of each of the above components by themselves, as well as how they perform together in an integrated approach . Investigate the combined effect of mating disruption on three individual pests - oriental fruit moth, lesser peach tree borer, and peach tree borer.

3) Demonstrate these management practices to commercial growers with on farm plots, meetings and news articles.

Methods:

Mating disruption and ground cover plots-

Twenty four acres were selected on a 110 acre peach farm. The blocks were surrounded on the north and west by other peaches, on the east by woods, and on the south by apples and newly planted peaches. All peach varieties in the experimental section were late varieties consisting of 'autumnglo,' 'rio-oso-gem,' 'encore' and 'blake.' Trees were planted at a density of 140 trees per acre. Late varieties were chosen so that they would be exposed to all 4 generations of oriental fruit moth and other fruit pests, and be exposed to the maximum number of pesticide applications. Two varieties (autumnglo, and rio), consisting of approx. 12 acres were used for the treatment site. The other two varieties were used for a grower standard (check) comparison. Mating disruption pheromone twist tie dispensers were obtained from Biocontrol Limited, Davis, CA (Qld, Australia). Dispensers were placed in the orchard on 4/29 and 5/2/94 at the rate of 5 dispensers per tree (3 OFM, 1 LPTB, 1 PTB), or approx. 700 dispensers per acre. Buffer areas were created on three sides of the experimental area consisting of an additional 3 rows with mating disruption dispensers (approx. 60 feet wide). Buffer rows were sprayed on the grower's normal spray schedule, along with his other acreage and the check varieties being monitored. The blocks used as treatments areas in 1994 were also treated in 1993 with peach tree borer mating disruption dispensers at one dispenser per tree.

In order to help manage catfacing insects such as tarnished plant bugs, and stink bugs, all broad leaf weeds and legumes were removed from the treatment area. An application of clopyralid (DowElanco) @ 6.4 oz of formulated product (77.6 ml ai)/A plus 2,4-D (Rhone-Poulenc) Formula 40 @ 32 oz of formulated product (530.4 ml ai)/A was made on June 7, 1994. Application was made with a sprayer operating at 40 psi using two offset drop nozzles covering a swath of 17 feet.

Orchard monitoring was carried out once per week starting on 5/27/94. Four samples each were taken in each the treatment and grower standard areas. Each sample consisted of a 10 tree sample in which 100 fruit was sampled for catfacing insect injury, oriental fruit moth stings, plum curculio scars, leafroller feeding, and Japanese beetle injury. Trees were sampled for the presence of fruit moth flagging, phytophagous mites, and mite predators. The presence of tarnished plant bugs, stink bugs, and false chinch bugs in the trees was examined with beating tray samples. The grower was advised to stay on his normal spray program in the check blocks, but was advised to spray the treatment blocks only if injury was threatened. Since the trees were pruned during the first OFM flight, insecticide was used on all areas to control the first brood. Tufted apple budmoth, which also required insecticide treatments was present in all blocks during August. All blocks were treated with chorpyrifos in early September for peachtree and lesser peachtree borer control. Therefore mating disruption treatments for borers became "treatments plus a grower standard" compared to the grower standard alone.

Six pheromone traps each for oriental fruit moth, and the 2 species of borers were placed on a diagonal line starting from the edge of the treatment and check areas, and extending to the other side of the monitored areas. A total of 18 traps were placed in each of the 2 sections. Two additional trapping stations for each of the three species were added to the grower standard (check) blocks late in the season on the side furthest away from the treatment blocks. Thus, a total of 42 traps were used. Traps were monitored once per week for the purposes of 1) monitoring insect emergence, 2) monitoring any migration of males, or implied migration of females into the treated blocks, and 3) as a partial measure of dispenser effectiveness as indicated by trap shut down in the treated areas.

Trees were marked and numbered, 100 each in each variety (total = 400), and were used for monitoring lesser borer and peach tree borer emergence. Pupal cases were counted and removed on each marked tree on 6/18,20, 7/8,11, 8/9,12, and on 9/27-29.

Nematode plots-

A 3 acre block of peaches, var. 'Jim Dandee' was used for the test. A total of 200 trees were marked and numbered in a totally randomized design. Insect parasitic nematodes were applied in a dilute application with a handgun at 200 psi to all tree bases and Cytospora cankers of

100 test trees. A commercial strain of *Steinernema carpocapsae* was used at the rate of 1.5 billion per 100 gal or 30 million nematodes per tree. (Biosis, Lesco Vector TL). Nematodes were applied at dusk on 7/17 and 18, which was between the first and second lesser peachtree borer flights, but about one third of the way through the peachtree borer flight. Pupal case counts were taken on each marked tree on 7/21 and 9/29. The grower followed his normal spray program throughout this block for the entire season, except no post harvest application of chlorpyrifos was used for borer control during 1994.

Results:

Mating disruption and ground cover management-

Trap captures of oriental fruit moth in the check blocks were quite low, possibly due to inferior dispensers. However almost complete trap shut down was achieved, except during one point during the third flight peak on Aug 5. No flags were seen in the treated blocks while a very low number were present in the standard check blocks. No fruit injury was present in either the treatment or standard check blocks.

Lesser peachtree borer traps were almost completely shut down, but did have up to .5 moths per trap avg during some weeks. No differences in pupal case counts were present for the second generation, the only generation that would have been affected by the mating disruption treatments.

Peachtree borer pheromone traps were completely shut down, although the flight was light as indicated by traps in the control blocks. Pupal case counts showed differences principally in the September count. Since the same area had been treated during 1993, a 74% reduction was attributed to this treatment (Table 1).

Catfacing insects found in the ground cover remained at similar levels in both treatment and check areas throughout the growing season. No differences in sweep counts except on Aug 19 when slightly more false chinch bugs were present in the standard blocks. Similar amounts of injury from catfacing insects were seen in both blocks.

Tufted apple budmoth feeding remained very low in both blocks, but was numerically higher in the pheromone treated blocks during the second generation. Two sprays were applied specifically for this pest during August.

Grower insecticide use in the treatment blocks was roughly 50% of that used in the standard blocks. Fourteen alternate middle insecticide applications were used in the standard blocks (Table 3), while 7 applications were made in the treatment area, or 3.16 lb ai compared to 1.34 lb ai.

Nematode Trial -

No differences in moth emergence were seen in the second lesser peachtree borer flight. Differences were seen in peachtree borer emergence (Table 2). A 66% reduction in emergence was seen as reflected by pupal case counts on 29 Sept.

Table 1. Pooled pupal case counts from mating disruption vs. grower standard treatments.

	Peachtree Borer				Lesser Peachtree Borer			
Treatment	20 Jun	11 Jul	12 Aug	27 Sep	20 Jun	11 Jul	12 Aug	27 Sep
Mating Disruption	0.15a	0.05a	0.06a	0.18b	0.25a	0.26a	0.12a	0.70a
Grower Standard (Check)	0.05b	0.03a	0.11a	0.69a	0.34a	0.20a	0.20a	0.67a

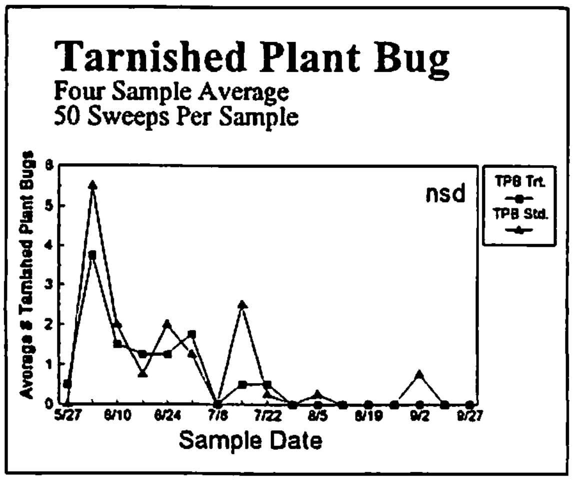
Table 2. Pupal case counts from nematode treatment trial.

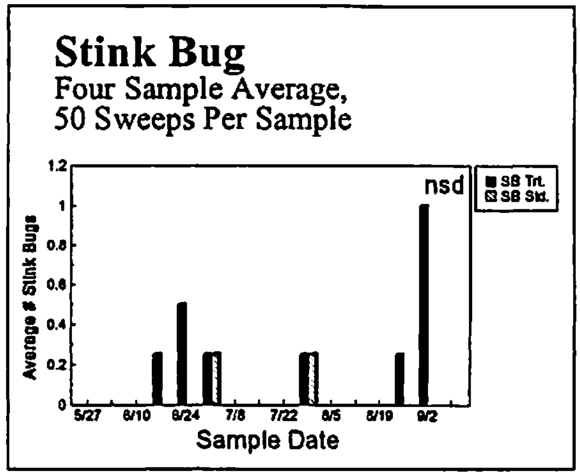
	Peachtree Borer		Lesser Peachtree Borer	
Treatment	21 Jul	29 Sep	21 Jul	29 Sep
Nematode	0.18a	0.09b.	0.53a	0.92a
Untreated Control	0.20a	0.27a	0.45a	0.99a

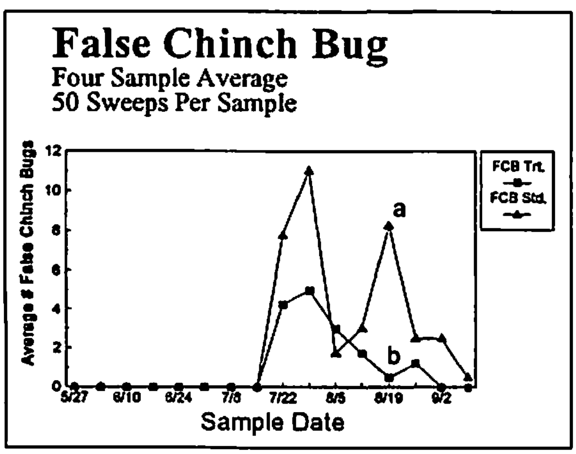
Table 3. Insecticide Use Per Acre - 1994

	Standard	Treatment
No. of Appl.	14	7
Lb. Form. Insecticide	7.5	3.5
Lb. Active Ingredient	3.16	1.34

Catfacing Insect Population Records:







1994 Peach Insecticide Evaluation Results

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Peach producers in South Carolina face problems from several insects that attack the fruit throughout the season. The hemipteran catfacing insects such as the tarnished plant bug and the stink bug complex are primarily early season pests beginning at petal fall. The plum curculio is a problem during the early season (petal fall) and again during the middle portion of the season. This pest is becoming more common in South Carolina. White peach scale can be a problem, especially when producers rely on a pyrethroid spray program. From three to four generations occur annually. Green June beetles can be a problem at harvest, especially for growers producing peaches for the baby food industry. Both Gerber and Heinz have banned the use of Sevin as a pre-harvest control for green June beetles. Our evaluations of insecticides focused on two areas: 1) Full Season control; 2) Pre-Harvest Green June Beetle Management.

Materials and Methods: The trials were conducted in an orchard located on the Simpson Agricultural Research Farm near Pendleton, South Carolina. The orchard is a mix of 'Blake' and 'Cresthaven' cultivars. Plots were three rows wide and seven trees long. The rows are 25 feet wide and the trees are 12.5 feet apart. All applications were made with a Meyers Mity Mist airblast sprayer calibrated to deliver 70 gallons per acre finished spray material. To minimize drift the outer rows were sprayed from the outside towards the center and both sides of the center row were sprayed. All trees in the orchard received fungicide sprays. The untreated check received no insecticide sprays, but did receive a full season fungicide program. The following treatments were applied during the full season spray program:

1.	Ambush 2EC	0.1 lb ai/A	Petal Fall - 8th Cover
2.	Ambush 2EC	0.1 lb ai/A	Petal Fall, 1st Cover
	Imidan 70WP	1.4 lb ai/A	2nd - 8th Cover
3.	Penncap M	0.5 lb ai/A	Petal Fall, 1st, 4th, 5th Cover
	Guthion 35WP	0.875 lb ai/A	2nd, 3rd, 6th - 8th Cover
4.	Asana XL 0.66 EC	0.025 lb ai/A	Petal Fall - 8th Cover
5.	Penncap M	0.5 lb ai/A	Petal Fall, 1st - 3rd Cover
	Sevin XLR	1.0 lb ai/A	4th and 5th Cover
	Asana XL 0.66 EC	0.025 lb ai/A	6th - 8th Cover
6.	Untreated Check (Fungicide Only)		

The phenology of the orchard was as follows: Pink, 15 March; Full Bloom, 29 March; Petal Fall, 31 March; Shuck Off, 12 April. Insecticide sprays were applied on the following dates: Petal Fall, 31 March; Shuck Off (1st Cover), 12 April; 2nd Cover, 21 April; 3rd Cover, Skipped; 4th Cover, 19 May; 5th Cover, 1 June; 6th Cover, 13 June; 7th Cover, 23 June; 8th Cover, 7 July.

Data were collected from the three center trees of the center row. A random sample of one-half bushel of fruit was picked from each of the three trees for evaluation of insect damage. Each fruit was inspected for any type of surface damage. All types of damage were recorded. The fruit were then cut in half to detect any larvae within the fruit. The fruit evaluation was conducted on 18-19 July.

Plum curculio populations were monitored with the Tedders' trap. Fifteen traps were located in our research orchard. Nine traps were located in one small orchard in the area and seven traps in another. Most of the traps were spaced at random around the outer edges of the orchards.

To evaluate Green June Beetle control all plots except the check were sprayed with Ambush on 20 July ("7-days before harvest"). The "4-day before harvest" treatments were applied on 25 July. The following treatments were applied during the Green June Beetle test:

1.	Ambush 2 EC	0.1 lb ai/A	7 days before harvest
2.	Pyrellin EC	2 pt product/A	4 days before harvest
3.	Lannate 90 SP	0.9 lb ai/A	4 days before harvest
4.	Admire 2F	0.03 gm ai/liter finished spray	4 days before harvest
5.	Admire 2F	0.05 gm ai/liter finished spray	4 days before harvest
6.	Untreated Check		

Evaluation of green June beetle activity was made by carefully approaching a peach tree and then tapping individual scaffold limbs with a wooden pole. This disturbed any beetles feeding on the fruit causing them to take off. Since green June beetles usually feed *en masse*, jarring a limb produces an obvious mass take-off. Data were collected just prior to application of the 4-day Pre-Harvest treatment (25 July) and again at 1-day and 3 days following this treatment. Rain prevented collection of data 2-days after treatment. The data express the numbers of mass take-offs per tree as individual limbs were jarred. Due to the wet season and early maturity of the fruit there was more than the average amount of fruit decay present resulting in good numbers of green June beetles. By the third day after application the check trees did not have much fruit remaining on them. This may have resulted in a lower level of infestation on the checks.

Rainfall during the 1994 season was erratic. Conditions were quite dry during April and May. Monthly rainfall was as follows: March, 8.37 inches; April, 2.86 inches; May, 1.92 inches; June, 5.77 inches; July, 6.07 inches.

Results: The data for the full season spray program are presented in Table 1. Catfacing damage was divided into two categories, early (deep depressions) and late (shallow depressions). Plum curculio damage was rated as surface scarring and larvae inside the fruit. Other unidentified surface feeding damage was also scored. Scale damage, expressed as red measles-like spots on the fruit surface, was also scored. There was some "red spot" present in the orchard as well. Every attempt was made to separate scale damage based on a small white spot in the center of the red spot. All treatments provided significantly better control of damage when compared to the check. There was very heavy insect pressure on the untreated checks.

Table 1. Percent injury by various insects following a full season spray program. Means followed by the same letter do not significantly differ (P = 0.05, LSD)

Treatment	Rate lb ai/A	Timing	Catface Early	Catface Late	Plum Curculio Scar	Plum Curculio Larva	Surface Feeding	Scale Damage
Ambush	0.1	Full Season	1.20 b	0.00 b	0.00 b	2.20 b	0.00 b	7.40 b
Ambush Imidan	0.1 1.4	PF, 1st 2 - 8	2.80 b	1.60 b	0.00 b	2.00 b	0.00 b	7.80 b
Penncap M Guthion	0.5 0.875	PF, 1, 4, 5 2, 3, 6 - 8	1.40 b	0.80 b	0.00 b	0.20 b	1.20 b	2.40 b
Asana XL	0.025	Full Season	0.60 b	0.00 b	0.00 b	0.80 b	2.00 b	5.60 b
Penncap M Sevin XLR Asana XL	0.5 1.0 0.025	PF, 1 - 3 4, 5 6 - 8	1.20 b	1.00 b	0.40 b	1.60 b	0.80 b	1.40 b
Check	--	--	24.00 a	14.00 a	19.40 a	71.00 a	21.80 a	16.40 a
		LSD (0.05)	7.64	6.54	6.26	12.00	4.04	7.24

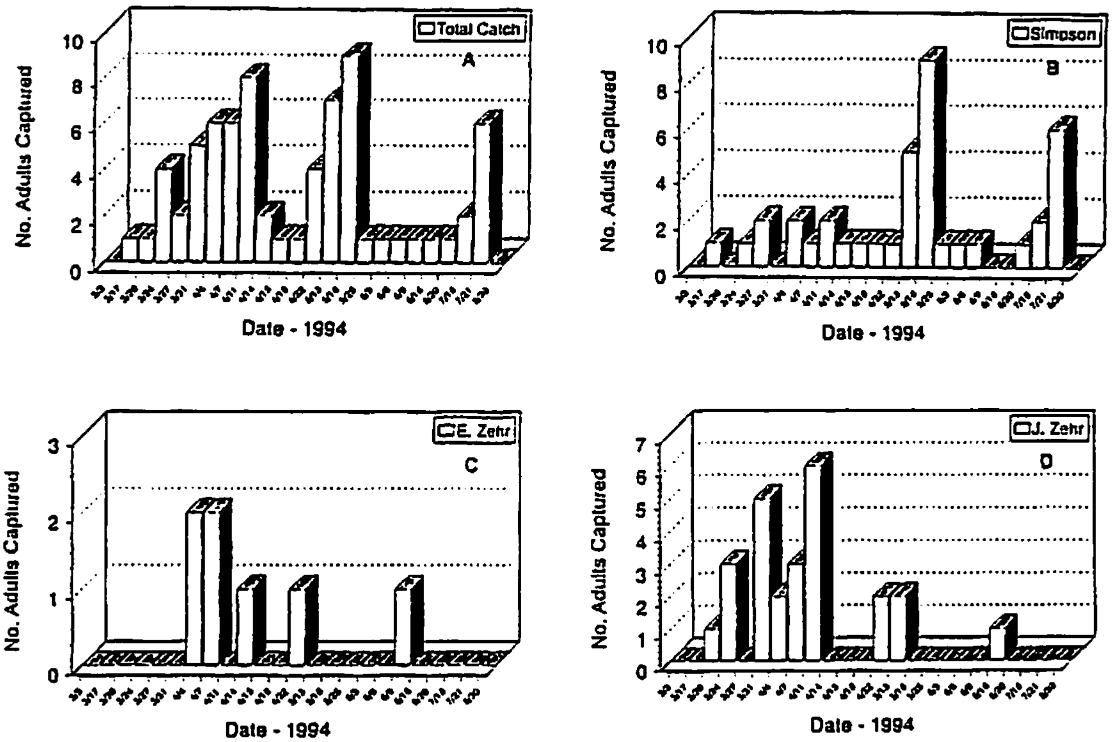
The results of the plum curculio trapping are shown in Figure 1. The traps appeared to detect the initial movement into the orchards as well as adult emergence during the season. Additional work is needed to determine the best placement of traps in an orchard.

The green June beetle population was quite active in the orchard. Numerous clusters of beetles were present on damaged fruit. Due to earlier than normal maturity, the normal pre-harvest fungicide program was not applied to the orchard. Considerable fruit had dropped by the initiation of this trial. The beetle population was fairly uniform prior to pesticide application on 25 July (Table 2). Ambush, applied on 20 July, did not provide adequate control of green June beetles. Pyrellin EC provided some reduction in beetle numbers, but not adequate for commercial control. Both rates of Admire provided good control of green June beetles. Residue analysis is being conducted. This will determine whether Admire has a future as a pre-harvest application for green June beetle control.

Table 2. Green June beetle flight activity from trees treated with various pre-harvest insecticides. Means followed by the same letter do not significantly differ (P = 0.05, LSD).

Treatment	Rate lb ai/A	Timing (days before harvest)	Pre-treat (4 days before harvest)	1 day post-treatment	3 days post-treatment
Ambush	0.1	9	2.07 ab	1.67 b	2.00 a
Pyrellin EC	2 pt prod/A	4	2.17 ab	1.73 b	1.87 b
Lannate	0.9	4	2.07 ab	1.20 bc	0.93 bc
Admire	0.03 gm ai/liter finished spray	4	1.33 b	0.53 c	0.53 c
Admire	0.05 gm ai/liter finished spray	4	1.47 ab	0.90 bc	0.93 bc
Check	–	–	2.93 a	3.09 a	2.20 a
		LSD (0.05)	1.48	1.02	1.04

Figure 1. Plum curculio trap catches: A - Total catch from all locations; B - Catch at the Simpson Agricultural Research Station orchard; C - Catch at the E. Zehr location; D - Catch at the J. Zehr location. Location C was a well maintained orchard. Location D was in the second year of management following several years of no management.



Effect of Fluazinam Fungicide on Mite Populations

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In the past, apple producers have had the ability to use certain fungicides, such as Dikar, that provided good disease control and also provided suppression of mites. This allowed producers to reduce production costs by eliminating or reducing miticide applications. The loss of these materials has proven costly from a mite management standpoint. Recent research with fluazinam has shown that it is effective for a number of apple diseases and also has mite suppressive activity.

Materials and Methods: Ten- to 15-year-old 'Golden Delicious' cv. apple trees at the Simpson Agricultural Experiment Station, Pendleton, South Carolina were sprayed with fungicides beginning at green tip for control of leaf and fruit diseases. Fungicide treatments were applied to single trees replicated four times in a randomized complete block design. The fungicides were applied by a handgun spraying until runoff (~1.5 gallons/tree). The fungicide treatments are shown in Table 1.

Table 1. Fungicide treatments and application dates.

Treatment	Rate/100 gal	Application Dates
Fluazinam 500L	284 ml	green tip, 21 Mar; tight cluster, 28 Mar; full pink, 4 Apr; petal fall, 11 Apr; cover sprays, 18 & 27 Apr, 10 & 24 May, 7 & 21 Jun, 6 & 21 Jul, 3 Aug
Fluazinam 500L	189 ml	" "
Fluazinam 75SDG	189 g	" "
Fluazinam 75SDG	126 g	" "
Dithane M-45 + Nova	1.0 lb + 1.5 oz	green tip, 21 Mar; tight cluster, 28 Mar; full pink, 4 Apr; petal fall, 11 Apr; cover sprays, 18 & 27 Apr
Topsin M + Captan 50W	3.0 oz + 2.0 lb	cover sprays, 10 & 24 May, 7 & 21 Jun, 6 & 21 Jul, 3 Aug
Check (insecticide only)	--	

Insecticides were applied separately by airblast sprayer. The insecticide treatments are shown in Table 2.

Table 2. Insecticide program for the fluazinam evaluation trials.

Treatment	Rate/100 gallons	Application Dates
Lorsban 4E	1 pt	28 Mar
Guthion 50W	0.5 lb	19 Apr
Imidan 50W	1.0 lb	3 & 13 Apr
Penncap M	2 pt	27 May, 22 Jun, 6 & 20 July,
Sevin 80W	1.25 lb	20 Jul, 2 & 16 Aug

Rainfall was light during the 6-week period just before bloom, but was above normal in March, June, July, and August. Monthly rainfall totals were: 7.45, 2.42, 1.80, 7.60, 6.70, and 7.25 inches for the March to August period.

In late June, a rating of mite populations was made. Ten leaves were selected at random from each tree. The leaves were returned to the laboratory and brushed with a leaf brushing machine. Counts of motile mites were made and are shown in Table 3.

Table 3. Mite counts taken in late June. The population was a mix of twospotted spider mites and European red mites. Means followed by the same letter do not significantly differ (P = 0.05, LSD).

Treatment	Rate/100 gal	Average number of mites/leaf
Fluazinam 500L	284 ml	0.06 c
Fluazinam 500L	189 ml	0.00 c
Fluazinam 75SDG	189 g	0.00 c
Fluazinam 75SDG	126 g	0.75 c
Dithane M-45 + Nova Topsin M + Captan 50W	1.0 lb + 1.5 oz 3.0 oz + 2.0 lb	16.75 b
Check (insecticide only)	--	56.00 a
	LSD (0.05)	6.72

Fluazinam provides excellent control of mites when used in a full season program. Additional mite counts were not taken due to the rainfall in July and August.

APPLE: Malus domestica Borkhauser,
'Spur Red Delicious'
Honey bee (HB): Apis mellifera Linnaeus
Bumble bee (BB); Bombus spp.
White apple leafhopper (WALH); Typhlocyba pomaria McAtee
Apple aphid (AA); Aphis pomi DeGeer
Spirea aphid (SA); Aphis spiraecola Patch
Redbanded leafroller (RBLR); Argyrotaenia velutinana (Walker)
Tufted apple budmoth (TABM); Platynota idaeusalis (Walker)
Codling moth (CM); Cydia pomonella (L.)
Spotted tentiform leafminer (TLM); Phyllonorycter blancardella (F.)
Rosy apple aphid (RAA); Dysaphis plantaginea (Passerini)
Predator (COCC); Coccinellidae
Predator (CHRY); Chrysopidae
Predator (Spid); Arachnida
European red mite (ERM); Panonychus ulmi (Koch)
Gypsy moth (GM); Lymantria dispar (L.)
Green fruitworm (GFW); Lithophane antennata (Walker)

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INSECTICIDE EVALUATION, 1994: This experiment was conducted in a 3.8 acre (1.54 ha) block of 17 year old Spur Red Delicious trees on 111 rootstocks. The experimental design was a randomized complete block and treatments consisted of five pesticides and a water control. There were four replicates of each treatment and the control and each replicate consisted of three adjacent trees in a row. Data was only taken on the center tree in each replicate. Treatments were applied with an airblast sprayer at 300 psi and calibrated to deliver a 6X concentrate spray of 50 gal/acre (76.6 liters/ha) = 300 gpa dilute equivalent. The materials evaluated were CGA215944 50W, 54.97 gm/acre (22.17 gm/ha); Omite 30W, 5 lb/acre (.92 Kg/ha); NTN 33893, 4.8 oz/acre (57.45 cc/ha); RH-5992 70W, 0.43 oz/acre (4.92 gm/ha); Guthion 50W 1.5 lb/acre (275.36 g/ha) + Lannate LV, 4.5 pt/acre (861.74 cc/ha); and water 50 gal/acre (76.60 liters/ha).

Data on pollinating insects associated with each replicate in the NTN 33893 and the Guthion 50W + Lannate LV (standard program) plots was collected in two post-treatment (22 Apr and 25 Apr) counts. The treatments were applied on 21 Apr. Data was converted to square root of X + .5 for analysis and back transformed data is presented. Data on relative humidity, temperature, wind direction and number of pollinators present visiting each of three sectors (NE, NW, S) of each replicate tree is presented for 25 Apr. The data is the result of a three minute observation period in which the observer visually scanned the sector of the tree canopy and noted the number of pollinators observed, and then added the number of pollinators flying into the area during the remainder of the three minute observation period. Bloom on the trees was uneven and notes on the bloom are included with the 22 Apr data. Analysis of the data by compass sector and by treatment revealed no significant differences between the number of honey bees or bumble bees on the NTN 33893 or the Guthion 50W + Lannate LV treated trees.

Because of protocols established for each material in the experiment, treatment application dates varied and are presented in a table.

Treatments	Dosage/ acre	Dosage/ hectare	Treatment application dates 21 Apr	9 May	23 May	25 May	10 Jun	13 Jun	15 Jul
CGA 215944 50WP	54.79 gm	22.17 gm	-	x	-	x	x	-	x
Omite 30WP	5 lb	0.92 kg	-	x	-	x	x	-	x
NTN 33893	4.8 fl oz	57.45 cc	x	x	-	x	x	-	x
RH 5992 70WP	0.43 oz	4.92 gm	-	-	x	-	-	x	x
Guthion 50W + Lannate LV	1.5 lb + 4.5 pt	275.36 g + 861.74 cc	x	x	-	x	x	-	x
Water	50 gal	76.60 l	-	x	-	x	x	-	x

Data on insect pests was collected on 15 Apr, 24 May, 8 Jun, 1 Jul, 7 Jul, 12 Jul, 14 Jul, 19 Jul, and 27 Jul. Data on phytophagous mites and their predators was gathered by visually examining 10 leaf samples from each replicate and recording the number of motile mites present on each sampling date. Rates are the same as shown in the data tables.

No significant differences were observed in the numbers of pollinators visiting the apple trees on 22 Apr. However, it was apparent that trees with the most bloom were visited by the most honey bees during the pre-treatment (22 Apr) count. Data from the second post-treatment (25 Apr) count was analyzed by treatment and compass sector observed. The only significant differences between treatments revealed by the analysis were for bumble bees in the southern sector. Here bumble bees were more numerous on trees in the standard Guthion-Lannate treatment than on the NTN 33893 plot. The numbers of bumble bees observed were so few that more detailed experimentation would be required before firm conclusions on the validity of this significance could be shown. No solitary bees were observed on 25 Apr in either plot. Average temperature, relative humidity and cloud cover during the 4 Apr count was 63F (17.2C), 33%, and 15% respectively.

	22 Apr - Bees/3 min [1,2]			25 Apr - Bees/3 min [1,2]					
				NE		NW		S	
Treatment [3]	HB	BB	SB	HB	BB	HB	BB	HB	BB
NTN 33893 4.8 fl oz/A	5.98	0.36	0.70	3.82	0.00	2.58	0.43	3.66	0.00 b
Guthion 50W 1.5 lb/A+ Lannate LV 4.5 pt/A	10.92	0.36	0.49	4.81	0.00	7.39	0.20	6.15	0.70 a

[1] Numbers in the same column followed by the same letter are not significantly different, p = .05, DMRT.
[2] Data transformed to square root of X + .5 for analysis. Backtransformed data is presented.
[3] Rates are the same as shown in the data tables.

There were significantly more TLM present on the RH-5992 treatment on 3 Jun than on the others while the NTN 33893 replicates had the least. Also on that date RH-5992 had significantly more of the AA-SA complex present while the fewest were present on the NTN 33893 and Guthion + Lannate plots. By 9 Jun significance in the TLM numbers had disappeared but NTN 33893 and Guthion + Lannate plots still had significantly fewer of the AA-SA complex on them. The 16 Jun data revealed that significantly fewer WALH were present on the NTN 33893, RH-5992 and Guthion + Lannate plots than on the other two treatments and water control plots. Also on 16 Jun significant differences in the AA-SA complex were again detected with the fewest being found on the Guthion Lannate plots and the most on the Omite 30W treatment. Although the numbers were extremely small on 24 Jun, significantly more TABM were present on the CGA 215944 plots than on any other of the treatments or the control. On 1 Jul no significant differences between any treatments or the control were detected, however, by 7 Jul significantly more TLM were present on the CGA 215944 plot than on any other plot. Significant differences in the TLM populations were again found on 14 Jul when more TLM were present on the CGA 215944 and Omite 30WP plots than any of the other treatments or the control. Also on 14 Jul significantly more RBLR were found in the Omite 30W and RH-5992 plots than on the other treatments or the control. The fewest RBLR were present on the control and the Guthion + Lannate treatment on 14 Jun. All treatments reduced TLM populations significantly when compared to the control on 19 Jul, 27 Jul, and 3 Aug. Although ERM and predators of mites were evaluated on each sampling day they were never present in significant numbers on any of the plots or the control in this experiment and no significant differences were found. No phytotoxic effects on foliage or fruit were observed in this experiment. Harvest data on insect injury to fruit is presented in tabular form.

SPUR RED DELICIOUS

			3 Jun						9 Jun					
Treatment	Dosage/ acre	Dosage/ hectare	WALH /leaf	TLM /leaf	AA /min	RAA /min	RBLR /min	TABM /min	WALH /leaf	TLM /leaf	AA /min	RAA /min	RBLR /min	TABM /min
CGA 215944 50WP	54.79 gm	22.17 gm	0.13	0.08 cd	3.58 ab	0.00	0.00	0.08	0.00	0.05	6.50 a	0.08	0.17 a	0.00
Omite 30WP	5 lb	0.92 kg	0.05	0.20 bc	2.83 ab	0.08	0.00	0.00	0.05	0.25	8.42 a	0.00	0.00 b	0.08
NTN 33893	4.8 fl oz	57.45 cc	0.08	0.03 d	0.00 b	0.00	0.17	0.08	0.03	0.05	1.58 b	0.00	0.00 b	0.00
RH-5992 70W	0.43 oz	4.92 gm	0.15	0.40 a	4.75 a	0.67	0.00	0.00	0.05	0.18	5.58 ab	0.00	0.00 b	0.00
Guthion 50W +	1.5 lb +	275.36 g +	0.00	0.05 cd	0.75 b	0.00	0.08	0.00	0.03	0.00	2.42 b	0.00	0.00 b	0.00
Lannate LV	4.5 pt	861.74 cc												
Water	50 gal	76.60 l	0.13	0.30 ab	2.83 ab	1.75	0.80	0.00	0.10	0.33	4.50 ab	0.92	0.00 b	0.00

			16 Jun					24 Jun			
Treatment	Dosage/ acre	Dosage/ hectare	WALH /leaf	TLM /leaf	AA /min	RBLR /min	TABM /min	WALH /leaf	TLM /leaf	AA /min	TABM /min
CGA 215944 50WP	54.79 gm	22.17 gm	0.13 a	0.03	5.33 ab	0.00	0.08	0.50	0.03	5.33	0.17 a
Omite 30WP	5 lb	0.92 kg	0.05 ab	0.08	6.83 a	0.00	0.00	0.00	0.00	7.50	0.00 b
NTN 33893	4.8 fl oz	57.45 cc	0.00 b	0.00	2.08 bc	0.17	0.00	0.03	0.18	4.92	0.00 b
RH-5992 70W	0.43 oz	4.92 gm	0.00 b	0.10	3.42 abc	0.00	0.00	0.03	0.08	4.83	0.00 b
Guthion 50W +	1.5 lb +	275.36 g +	0.00 b	0.00	0.75 c	0.00	0.00	0.00	0.00	4.42	0.00 b
Lannate LV	4.5 pt	861.74 cc									
Water	50 gal	76.60 l	0.10 ab	0.00	4.92 abc	0.25	0.00	0.05	0.13	4.00	0.00 b

			1 Jul						7 Jul					
Treatment	Dosage/ acre	Dosage/ hectare	WALH /leaf	TLM /leaf	AA /min	RAA /min	RBLR /min	TABM /min	WALH /leaf	TLM /leaf	AA /min	RAA /min	RBLR /min	TABM /min
CGA 215944 50WP	54.79 gm	22.17 gm	0.35	0.03	2.58	0.00	0.00	0.08	0.25	0.25 ab	0.08	0.25	0.00	2.00
Omite 30WP	5 lb	0.92 kg	0.08	0.03	0.67	0.00	0.00	0.17	0.25	0.08 b	0.33	0.25	0.00	0.25
NTN 33893	4.8 fl oz	57.45 cc	0.00	0.00	0.83	0.00	0.08	0.08	0.25	0.00 b	0.00	0.67	0.00	0.00
RH-5992 70W	0.43 oz	4.92 gm	0.50	0.00	2.92	0.00	0.00	0.08	0.25	0.10 b	0.42	0.00	0.00	0.50
Guthion 50W +	1.5 lb +	275.36 g +	0.03	0.03	3.83	0.00	0.00	0.08	0.25	0.00 b	0.00	1.67	0.00	3.25
Lannate LV	4.5 pt	861.74 cc												
Water	50 gal	76.60 l	0.25	0.08	0.25	0.00	0.00	0.00	0.25	0.40 a	0.33	0.50	0.00	0.75

Data converted to square root of X + .5 for analysis. Back transformed data tabulated. Numbers in the same column followed by same letter not significantly different, p = .05, DMRT.

SPUR RED DELICIOUS

Treatment	Dosage/ acre	Dosage/ hectare	14 Jul WALH /leaf	14 Jul TLM /leaf	14 Jul RBLR /min	14 Jul TABM /min	19 Jul WALH /leaf	19 Jul TLM /leaf	19 Jul TABM /min	19 Jul CM/50 apples	19 Jul ERM /leaf
CGA 215944 50WP	54.79 gm	22.17 gm	0.25	0.38 a	0.25 ab	0.17	0.25	0.08 b	0.83	1.50	0.00
Omite 30WP	5 lb	0.92 kg	0.25	0.23 ab	1.08 a	0.08	0.25	0.03 b	1.00	1.50	0.03
NTN 33893	4.8 fl oz	57.45 cc	0.25	0.00 b	0.25 ab	0.17	0.25	0.00 b	0.42	2.00	0.00
RH-5992 70W	0.43 oz	4.92 gm	0.25	0.10 b	1.08 a	0.00	0.25	0.00 b	0.75	0.75	0.00
Guthion 50W +	1.5 lb +	275.36 g +	0.25	0.00 b	0.00 b	0.00	0.25	0.00 b	0.33	0.00	0.00
Lannate LV	4.5 pt	861.74 cc									
Water	50 gal	76.60 l	0.25	0.08 b	0.17 b	0.00	0.25	0.20 a	1.25	1.25	0.0

Treatment	Dosage/ acre	Dosage/ hectare	27 Jul WALH /leaf	27 Jul TLM /leaf	27 Jul TABM /min	27 Jul ERM /leaf	3 Aug WALH /leaf	3 Aug TLM /leaf	3 Aug AA /min	3 Aug TABM /min	18 Aug ERM /leaf
CGA 215944 50WP	54.79 gm	22.17 gm	0.25	0.00 b	0.33	0.15	0.25	0.43 a	0.33	0.00	0.00
Omite 30WP	5 lb	0.92 kg	0.25	0.00 b	0.42	0.05	0.25	0.00 b	0.83	0.33	0.00
NTN 33893	4.8 fl oz	57.45 cc	0.25	0.00 b	0.17	0.23	0.25	0.00 b	0.08	0.00	0.02
RH-5992 70W	0.43 oz	4.92 gm	0.25	0.00 b	0.33	0.08	0.25	0.03 b	0.25	0.08	0.02
Guthion 50W +	1.5 lb +	275.36 g +	0.25	0.00 b	0.17	0.05	0.25	0.00 b	0.08	0.08	0.00
Lannate LV	4.5 pt	861.74 cc									
Water	50 gal	76.60 l	0.25	0.05 a	0.83	0.13	0.25	0.30 a	0.42	0.67	0.02

Data converted to square root of X + .5 for analysis. Back transformed data tabulated. Numbers in the same column followed by same letter not significantly different, p = .05, DMRT.

PREDATORS - SPUR RED DELICIOUS

			8 Jun				9 Jun		16 Jun	
Treatment	Dosage/ acre	Dosage/ hectare	SPA /min	COCC /min	CHRY /min	CM/50 apples	COCC /min	CHRYE /min	COCC /min	CHRYE /min
CGA 215944 50WP	54.79 gm	22.17 gm	0.08	0.83	0.00	0.00	1.33	0.00	1.50	0.00
Omite 30WP	5 lb	0.92 kg	0.00	1.50	0.08	0.00	3.00	0.00	0.00	0.00
NTN 33893	4.8 fl oz	57.45 cc	0.00	0.08	0.17	0.25	0.17	0.17	0.00	0.00
RH-5992 70W	0.43 oz	4.92 gm	0.00	0.33	0.08	0.00	1.50	0.00	0.00	0.50
Guthion 50W +	1.5 lb +	275.36 g +	0.08	0.00	0.17	0.00	0.00	0.00	0.00	0.00
Lannate LV	4.5 pt	861.74 cc								
Water	50 gal	76.60 l	0.00	3.42	0.08	0.00	0.83	0.08	0.00	0.00

			1 Jul					7 Jul		14 Jul		3 Aug
Treatment	Dosage/ acre	Dosage/ hectare	CHRYE /min	CHRYL /min	COCC /min	LM /min	OI /min	COCC /min	CHRY /min	CHRY /min	SPID /min	CHRY /min
CGA 215944 50WP	54.79 gm	22.17 gm	0.33	0.17	0.00	0.00	0.00	0.08	0.08	0.58	0.25	0.42
Omite 30WP	5 lb	0.92 kg	0.67	0.00	0.17	0.00	0.00	0.25	0.08	0.83	0.00	0.50
NTN 33893	4.8 fl oz	57.45 cc	0.58	0.08	0.42	0.00	0.00	0.33	0.08	1.25	0.42	0.58
RH-5992 70W	0.43 oz	4.92 gm	0.25	0.00	0.00	0.42	0.00	0.17	0.08	0.67	0.17	0.17
Guthion 50W +	1.5 lb +	275.36 g +	0.25	0.00	0.00	0.00	0.00	0.00	0.08	0.67	0.17	0.00
Lannate LV	4.5 pt	861.74 cc										
Water	50 gal	76.60 l	0.33	0.17	0.00	0.00	0.08	0.08	0.00	0.50	0.50	0.50

Data converted to square root of X + .5 for analysis. Back transformed data tabulated. Numbers in the same column followed by same letter not significantly different, p = .05, DMRT.

% INSECT INJURY TO HARVESTED FRUIT (SPUR RED DELICIOUS)
125 apples/replicate (500 apples/treatment)
September 21, 1994

Treatment	Dosage/ acre	Dosage/ hectare	RBLR	TABM	CM	GFW	TPB	GM
CGA 215944 50WP	54.79 gm	22.17 gm	0.6	6.2	0.2	0.0	0.2	0.0
Omite 30WP	5 lb	0.92 kg	1.0	10.4	0.4	0.2	0.2	0.2
NTN 33893	4.8 fl oz	57.45 cc	1.0	10.6	0.8	0.2	0.0	0.0
RH-5992 70W	0.43 oz	4.92 gm	0.6	7.0	0.4	0.8	0.2	0.2
Guthion 50W +	1.5 lb +	275.36 g +	0.0	6.6	0.0	0.2	0.0	0.0
Lannate LV	4.5 pt	861.74 cc						
Water	50 gal	76.60 l	1.2	7.6	0.2	0.0	0.4	0.4

APPLE: Malus domestica Borkhauser
'Red Delicious', 'Golden Delicious', 'York
White apple leafhopper (WALH); Typhlocyba pomaria McAtee
Apple aphid (AA); Aphis pomi DeGeer
Spirea aphid (SAA); Aphis spireecula Patch
Rosy appld aphid (RAA); Dysaphis plantaginea Passerini
Tufted apple budmoth (TABM); Platynota idaeusalis (Walker)
European red mite (ERM); Panonychus ulmi (Koch)
Spotted tentiform leafminer (STLM); Phyllonorycter blancardella (F.)
Codling moth; Cydia pomonella (L.)
Black hunter thrips (LM); Leptothrips mali (Fitch)
Predator (SP); Stethorus punctum (LeConte)
Fall cankerworm (CW); Alsophila pometaria (Harris)
Green fruitworm (FW); Lithophane antennata (Walker)
Gypsy moth (GM); Lymantria dispar (Linnaeus)

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APPLE, EFFICACY OF SEVIN XLR PLUS A STANDARD (GUTHION 50W + METHOMYL L) 1994: This experiment was conducted in a 20 year old orchard at the Center that was comprised of 9 rows (31 tree) rows running in a North-South configuration. Tree spacing was 24 ft (7.32 meters) in the row and 30 ft (9.14 m) between rows. There were three rows of Golden Delicious, four of Red Delicious and four rows of York trees in the block. The block was divided into thirds across all three varieties to obtain large plots of approximately 1.5 acres (0.61 ha) each. Four trees of each variety in each plot were selected at random for purposes of data generation. Treatments assigned to the plots were 1. Sevin XLR plus 16 oz/A (191.5 cc/ha); 2. Sevin XLR plus 32 oz/A (383 cc/kg); 3. Guthion 50W 1.5 lb/A (275.96 g/ha) + Lannate L 48 oz/A (574.49 cc/ha). The Guthion/Lannate combination served as a standard for comparative purposes in this test. All plots were sprayed on 19 May and 10 Jun and 15 Jul with an airblast sprayer calibrated to deliver 50 gpa (76 l/ha) (6X concentrate) at 300 psi and a ground speed of 2.5 mph (4.02 kg/ha).

Insect and mite predators and pests were counted (approximately weekly) and the results tabulated by the following units (per 3 minute observation: TABM, RAA, AA-SA); (per 10 leaves: WALH, STLM, ERM). Data were tabulated (zero presence instances omitted) and the results analyzed to indicate significant differences between treatments and between cultivars. Apples that fell to the ground in the pre-harvest interval were gathered and examined on Aug 3. These data are presented as number of damaged apples per treatment for each pest. At harvest 125 apples were picked and examined for insect injury. In some cases where there were not 125 apples on any given replicate trees, additional fruit from other replicates from the same treatment was harvested to bring the total number per replicate to 125. Data is presented as percent of fruit damaged by each pest. There were many more drop apples on the York variety when examined on 3 Aug (1069 compared to 158 on Red Delicious and only 15 on Golden Delicious). Examination of the dropped apples on York and analysis of the data revealed that there were significant differences between the three treatments but only for TABM damage. The standard Guthion + Lannate treatment gave superior control of TABM when compared to the low rate (16 oz/A) of Sevin XLR but not when a comparison with the higher rate (32 oz/A) was made.

Data collected on 20 Apr and 28 Apr indicated a general light presence of the green apple aphid-spirea aphid complex, rosy aphid, gypsy moth, cankerworm, spotted tentiform leafminer and redbanded leafroller as well as a few beneficial species including Stethorus punctum LeConte and Leptothrips mali Ewing across the three varieties in the experimental orchard. Twelve days after the 19 May treatment application (1 Jun) significant differences in the TABM population between treatments were found on the York cultivar with more larvae being found on the low rate sevin plot than either the higher sevin rate or the standard Guthion + Lannate plots. On 6 Jun differences in the AA-SA populations were apparent on York trees with both rates of sevin providing superior control to the standard treatment. Rosy aphid, again on Yorks, were present in significantly greater numbers on both of the sevin plots than on the standard treatment plot when counts were made on 16 Jun. This date was six days after the second application of treatments (10 Jun). By the end of the month (30 Jun) differences in AA-SA populations were evident for all three treatments on York variety with the fewest being present on the low rate of sevin and the greater number being found on the standard treatment. By 7 Jul on both Red Delicious and York cultivars control of AA-SA was significantly better on both sevin treatments than on the standard treatment. From this and the earlier counts it is evident that sevin XLR plus reduced AA-SA populations on York to lower levels than did the standard Guthion + Lannate application. Eleven days after the third treatment application (26 Jul) there were significantly fewer ERM on both sevin plots than on the standard. However, the reverse was true with TABM and STLM where the standard provided superior control to either rate of sevin treatments.

GOLDEN DELICIOUS

Treatment	Rate	1 Jun WALH/ leaf	1 Jun TLM/ leaf	1 Jun AA/ min	1 Jun RAA/ min	1 Jun RBLR/ min	9 Jun TLM/ leaf	9 Jun AA/ min	9 Jun RAA/ min	16 Jun TLM/ leaf	16 Jun AA/ min
1. Sevin XLR plus	0.5 lb ai/A	0.00	0.08	4.67	1.67	0.08	0.03	3.67	1.67	0.03	0.00
2. Sevin XLR plus	1.0 lb ai/A	0.05	0.08	4.00	0.50	0.00	0.05	5.67	1.50	0.03	0.83
3. Guthion 50W + Lannate 1.8L	0.75 lb ai/A + 10.8 oz ai/A	0.03	0.15	1.75	1.42	0.08	0.00	2.58	1.92	0.00	0.17

Treatment	Rate	22 Jun TLM/ leaf	22 Jun AA/ min	30 Jun WALH/ leaf	30 Jun TLM/ leaf	30 Jun AA/ min	30 Jun ERM/ leaf	30 Jun RBLR/ min	30 Jun TABM/ min
1. Sevin XLR plus	0.5 lb ai/A	0.00	0.08 b	0.03	0.05	7.83	0.00	0.08	0.08
2. Sevin XLR plus	1.0 lb ai/A	0.00	1.58 a	0.00	0.10	2.58	0.03	0.00	0.00
3. Guthion 50W + Lannate 1.8L	0.75 lb ai/A + 10.8 oz ai/A	0.03	1.33 a	0.03	0.03	1.42	0.00	0.08	0.00

Treatment	Rate	7 Jul WALH/ leaf	7 Jul TLM/ leaf	7 Jul AA/ min	7 Jul ERM/ leaf	7 Jul RBLR/ min	7 Jul TABM/ min	7 Jul CHRY/ min	12 Jul ERM/ leaf
1. Sevin XLR plus	0.5 lb ai/A	0.00	0.03	0.00	0.00	0.00	0.08	0.00	0.00
2. Sevin XLR plus	1.0 lb ai/A	0.00	0.15	0.00	0.00	0.08	0.33	0.08	0.03
3. Guthion 50W + Lannate 1.8L	0.75 lb ai/A + 10.8 oz ai/A	0.20	0.03	0.08	0.03	0.00	0.17	0.33	0.00

Treatment	Rate	14 Jul WALH/ leaf	14 Jul TLM/ leaf	14 Jul TABM/ min	14 Jul CHRY/ min	26 Jul TLM/ leaf	26 Jul ERM/ leaf	26 Jul TABM/ min	26 Jul CHRY/ min
1. Sevin XLR plus	0.5 lb ai/A	0.03	0.23	0.08	0.00	0.15	0.03 b	0.25	0.25
2. Sevin XLR plus	1.0 lb ai/A	0.00	0.18	0.17	0.17	0.08	0.00 b	0.25	0.00
3. Guthion 50W + Lannate 1.8L	0.75 lb ai/A + 10.8 oz ai/A	0.05	0.10	0.17	0.17	0.18	0.18 a	0.00	0.08

Data converted to square root of X + .5 for analysis. Back transformed data tabulated. Numbers in the same column followed by the same letter not significantly different, p = .05, DMRT.

GOLDEN DELICIOUS

		10 Aug				18 Aug
Treatment	Rate	WALH/ leaf	TLM/ leaf	TABM/ min	GAA/ min	ERM/ leaf
1. Sevin XLR plus	0.5 lb ai/A	0.00	0.05	0.00	0.00	0.00
2. Sevin XLR plus	1.0 lb ai/A	0.00	0.15	0.00	0.23	0.00
3. Guthion 50W + Lannate 1.8L	0.75 lb ai/A + 10.8 oz ai/A	0.00	0.07	0.00	0.08	0.07

RED DELICIOUS

Treatment	Rate	1 Jun WALH/ leaf	1 Jun TLM/ leaf	1 Jun AA/ min	1 Jun RAA/ min	1 Jun RBLR/ min	1 Jun TABM/ min	9 Jun WALH/ leaf	9 Jun TLM/ leaf	9 Jun AA/ min	9 Jun RAA/ min	16 Jun TLM/ leaf	16 Jun AA/ min	16 Jun RAA/ min
1. Sevin XLR plus	0.5 lb ai/A	0.05	0.10	1.00	0.17	0.58	0.08	0.00	0.33	3.00	0.75	0.45	2.75	0.50
2. Sevin XLR plus	1.0 lb ai/A	0.00	0.15	2.67	0.92	0.17	0.08	0.00	0.28	1.50	0.33	0.18	1.75	0.30
3. Guthion 50W + Lannate 1.8L	0.75 lb ai/A + 10.8 oz ai/A	0.08	0.08	0.67	0.75	0.00	0.00	0.03	0.15	1.67	1.00	0.08	0.00	0.00

Treatment	Rate	22 Jun TLM/ leaf	22 Jun AA/ min	22 Jun RAA/ min	30 Jun WALH/ leaf	30 Jun TLM/ leaf	30 Jun AA/ min	30 Jun ERM/ leaf
1. Sevin XLR plus	0.5 lb ai/A	0.05	3.58	0.00	0.03	0.23	2.50	0.00
2. Sevin XLR plus	1.0 lb ai/A	0.05	2.25	0.25	0.03	0.05	4.17	0.08
3. Guthion 50W + Lannate 1.8L	0.75 lb ai/A + 10.8 oz ai/A	0.05	6.08	0.00	0.08	0.00	6.25	0.00

Treatment	Rate	7 Jul WALH/ leaf	7 Jul TLM/ leaf	7 Jul AA/ min	7 Jul ERM/ leaf	7 Jul TABM/ min	7 Jul CHRY/ min	12 Jul ERM/ leaf	12 Jul CM/ apple
1. Sevin XLR plus	0.5 lb ai/A	0.03	0.08	0.00 b	0.00	0.58	0.25	0.03	0.03
2. Sevin XLR plus	1.0 lb ai/A	0.08	0.00	0.00 b	0.15	0.67	0.83	0.00	0.00
3. Guthion 50W + Lannate 1.8L	0.75 lb ai/A + 10.8 oz ai/A	0.05	0.08	1.83 a	0.13	0.17	0.50	0.00	0.00

Treatment	Rate	14 Jul WALH/ leaf	14 Jul TLM/ leaf	14 Jul TABM/ min	14 Jul CHRY/ min	26 Jul TLM/ leaf	26 Jul ERM/ leaf	26 Jul TABM/ min	26 Jul CHRY/ min
1. Sevin XLR plus	0.5 lb ai/A	0.00	0.30	0.25	0.00	0.33	0.00	0.42	0.08
2. Sevin XLR plus	1.0 lb ai/A	0.00	0.33	0.08	0.17	0.20	0.08	0.33	0.25
3. Guthion 50W + Lannate 1.8L	0.75 lb ai/A + 10.8 oz ai/A	0.03	0.05	0.00	0.42	0.20	0.20	0.00	0.08

Data converted to square root of X + .5 for analysis. Back transformed data tabulated. Numbers in the same column followed by the same letter not significantly different, p =.05, DMRT.

RED DELICIOUS

Treatment	Rate	10 Aug WALH/ leaf	TLM/ leaf	GAA/ min	TABM/ min	18 Aug ERM/ leaf
1. Sevin XLR plus	0.5 lb ai/A	0.02	0.07	0.23	0.08	0.00
2. Sevin XLR plus	1.0 lb ai/A	0.00	0.12	0.14	0.08	0.02
3. Guthion 50W + Lannate 1.8L	0.75 lb ai/A + 10.8 oz ai/A	0.02	0.15	0.08	0.00	0.02

YORK

Treatment	Rate	1 Jun WALH/ leaf	1 Jun TLM/ leaf	1 Jun AA/ min	1 Jun RAA/ min	1 Jun TABM/ min	9 Jun TLM/ leaf	9 Jun AA/ min	9 Jun RAA/ min	9 Jun TLM/ leaf	16 Jun AA/ min	16 Jun RAA/ min
1. Sevin XLR plus	0.5 lb ai/A	0.05	0.08	3.25	0.25	0.42 a	0.13	9.42	0.08 b	0.13	10.00 a	0.08
2. Sevin XLR plus	1.0 lb ai/A	0.05	0.05	3.25	0.33	0.00 b	0.10	7.25	0.08 b	0.05	8.67 a	0.00
3. Guthion 50W + Lannate 1.8L	0.75 lb ai/A + 10.8 oz ai/A	0.00	0.08	1.67	0.67	0.00 b	0.00	3.17	1.00 a	0.03	0.17 b	0.08

Treatment	Rate	22 Jun TLM/ leaf	22 Jun GAA/ min	30 Jun WALH/ leaf	30 Jun TLM/ leaf	30 Jun AA/ min	30 Jun ERM/ leaf
1. Sevin XLR plus	0.5 lb ai/A	0.10	9.25	0.00	0.00	0.42 a	0.03
2. Sevin XLR plus	1.0 lb ai/A	0.03	9.42	0.03	0.03	4.75 b	0.35
3. Guthion 50W + Lannate 1.8L	0.75 lb ai/A + 10.8 oz ai/A	0.03	8.50	0.00	0.03	0.42 b	0.25

Treatment	Rate	7 Jul WALH/ leaf	7 Jul TLM/ leaf	7 Jul AA/ min	7 Jul ERM/ leaf	7 Jul TABM/ min	7 Jul CHRY/ min	12 Jul ERM/ leaf	12 Jul CM/ apple
1. Sevin XLR plus	0.5 lb ai/A	0.03	0.00	0.00 b	0.00	0.58	0.17	0.08	0.25
2. Sevin XLR plus	1.0 lb ai/A	0.00	0.03	0.00 b	0.53	0.75	0.42	0.30	0.00
3. Guthion 50W + Lannate 1.8L	0.75 lb ai/A + 10.8 oz ai/A	0.08	0.05	5.08 a	1.93	0.25	1.17	2.38	0.00

Treatment	Rate	14 Jul WALH/ leaf	14 Jul TLM/ leaf	14 Jul TABM/ min	14 Jul CHRY/ min	26 Jul TLM/ leaf	26 Jul ERM/ leaf	26 Jul TABM/ min	26 Jul CHRY/ min
1. Sevin XLR plus	0.5 lb ai/A	0.00	0.15	1.00	0.33	0.33 a	0.50 b	0.42 a	0.00
2. Sevin XLR plus	1.0 lb ai/A	0.03	0.23	0.42	0.08	0.18 ab	2.65 b	0.25 ab	0.00
3. Guthion 50W + Lannate 1.8L	0.75 lb ai/A + 10.8 oz ai/A	0.05	0.10	0.00	0.33	0.05 b	10.30 a	0.00 b	0.08

Data converted to square root of X + .5 for analysis. Back transformed data tabulated. Numbers in the same column followed by the same letter not significantly different, p =.05, DMRT.

YORK

Treatment	Rate	10 Aug				18 Aug
		WALH/ leaf	TLM/ leaf	GAA/ min	TABM/ min	ERM/ leaf
1. Sevin XLR plus	0.5 lb ai/A	0.05	0.05	0.30	0.23	0.12
2. Sevin XLR plus	1.0 lb ai/A	0.00	0.16	0.00	0.00	0.11
3. Guthion 50W + Lannate 1.8L	0.75 lb ai/A + 10.8 oz ai/A	0.05	0.00	0.00	0.08	0.00

Observations were begun in the experimental orchard in advance of actual commencement of this experiment on April 20. On four randomly selected trees in each designated treatment area the following insects were recorded.

Treatment and rate	Insect totals on 4 replicate trees per treatment				
	COCC	TLM	AA (colonies)	GML	WALH
Sevin XLR plus 16 oz/A	1	4	9	1	0
Sevin XLR plus 32 oz/A	0	1	0	0	1
Guthion 50W 1.5 lb/A + Lannate L 3 pt/A	0	0	5	1	0

Observations continued and approximately 1 week later (4/28/94) the following data was recorded by designated treatment block and by variety.

Treatment and rate	Golden Delicious									Red Delicious							
	LH /10	AA /3	RA /3	GM /3	STLM /10	STLM /3	RBLR /3	CM /3	LR /3	AA /3	RA /3	GM /3	STLM /10	STLM /3	RBLR /3	CM /3	LMA /3
Sevin XLR plus 16 oz/A	0	10	0	1	0	1	0	3	1	10	2	2	0	0	0	0	7
Sevin XLR plus 32 oz/A	1	26	0	0	0	2	0	1	0	22	1	3	0	0	0	0	0
Guthion 50W 1.5 lb/A + Lannate L 3 pt/A	0	4	0	3	1	2	6	0	0	9	1	2	1	0	1	1	1

DROP APPLES AND INSECT DAMAGE ON YORK - 8/3/94 [1,2]

Treatment and rate	Number of drops/tree	RBLR	TABM	CM	GFW
Sevin XLR plus 16 oz/A	100.50	3.75	13.50	0.25	0.33
Sevin XLR plus 32 oz/A	100.75	2.00	3.50	0.00	0.00
Guthion 50 W 1.5 lb + Lannate L 3 pt/A	66.00	0.50	1.00	0.25	0.25

[1] Data transformed to X + .5 for analysis. Back transformed means tabulated above.

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

% INSECT INJURY TO HARVESTED FRUIT (RED DELICIOUS)
125 apples per replicate (500 apples/treatment)
September 21, 1994

	Rate						
Treatment	lb ai/acre	gm ai/ha	RBLR	TABM	CM	GFW	GM
Sevin XLR plus	0.5	183.51	1.4	8.8	0.8	0.4	0.4
Sevin XLR plus	1.0	367.14	0.6	6.2	0.2	1.0	0.2
Guthion 50W +	0.75 +	275.35 +	0.0	1.8	0.0	0.4	0.2
Lannate 1.8L	0.68	123.91					

% INSECT INJURY TO HARVESTED FRUIT (YORK)
125 apples per replicate (500 apples/treatment)
September 21, 1994

	Rate								
Treatment	lb ai/acre	gm ai/ha	RBLR	TABM	CM	RAA	GFW	GM	TPB
Sevin XLR plus	0.5	183.51	0.6	4.4	1.6	0.2	0.1	0.2	0.0
Sevin XLR plus	1.0	367.14	0.6	3.2	0.8	0.0	0.0	0.2	0.0
Guthion 50W +	0.75 +	275.35 +	0.2	1.6	0.8	0.6	0.0	0.6	0.4
Lannate 1.8L	0.68	123.91							0.2

% INSECT INJURY TO HARVESTED FRUIT (GOLDEN DELICIOUS)
125 apples per replicate (500 apples/treatment)
September 21, 1994

	Rate						
Treatment	lb ai/acre	gm ai/ha	RBLR	TABM	CM	GFW	GM
Sevin XLR plus	0.5	183.51	0.4	3.2	1.0	0.8	0.2
Sevin XLR plus	1.0	367.14	0.8	3.0	0.8	0.4	0.4
Guthion 50W +	0.75 +	275.35 +	0.0	2.0	0.0	0.6	0.2
Lannate 1.8L	0.68	123.91					

APPLE Malus domestica Borkhauser 'Empire'
European red mite (ERM); Panonychus ulmi (Koch)
European red mite eggs (ERME); Panonychus ulmi (Koch)
Twospotted spider mite (TSM); Tetranychus urticae Koch
Twospotted spider mite eggs (TSME);
Tetranychus urticae Koch
Predator mite (ZM); Zetzellia mali (Ewing)
Phytoseiid mite (P); Phytoseiidae
Predator adult (SPA); Stethorus punctum (LeConte)
Insidiosus flower bug (OI): Orius insidiosus (Say)
Green lacewing (CHRY); Chrysopidae
Spiders (SPID); Arachnida
Tufted apple budmoth (TABM); Platynota idaeusalis (Walker)

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MITICIDE EVALUATIONS, 1994: Miticides were applied to five year old 'Empire' apple trees on MM111 rootstocks. The trees were planted 20 ft (6.10 m) apart in the row and 24 ft (7.32 m) between the rows. Each replicate consisted of three adjacent trees in a row and all data was collected from the center tree in each replicate.The pH of the Kelthane treatment was adjusted to 6.5 with the addition of Latron 44. In all three treatments (Vydate 3 pt/acre (574.47 cc/ha); Kelthane 50W 55.8 oz/A (640.19 g/ha) + Latron 44 3 pt/A (574.74 cc/ha); Omite 6E 30 oz/A (369.12 cc/ha) and a water control in the experiment and each treatment was replicated four times. The replicates were arranged in a randomized block design. Treatments were applied with a handgun to runoff at 300 psi pump pressure. Treatment dates were 16 Jun, 24 Jun, 6 Jul. Mite samples (20 leaves/tree) were collected weekly and counted microscopically following the Henderson-McBurnie method. Data was converted to log X+1 for analysis by Duncan's Multiple Range Test. Predators were counted on each replicate tree during a three minute visual search. Data was also converted to log X + 1 for analysis.

A week after spraying (23 Jun) data analysis revealed no significant differences in mite populations between any of the treatments and the water control and a second treatment was applied (24 Jun). Data taken on 5 Jul showed differences in ERM and TSM and TSME populations on analysis with all three treatments being superior to the control for ERM suppression. However, Vydate did not differ from the control insofar as TSM and TSME numbers were concerned but both the Kelthane and Omite treatments were superior to the control. A third treatment was applied on 6 Jul and by 11 Jul differences were apparent in ERME and TSM numbers. All treatments significantly depressed TSM numbers when compared to the control, but with ERME significance of the Vydate treatment was not evident. By 15 Jul all three miticides were superior to the control for ERM and ERME suppression and both Omite and Kelthane were superior to the control and Vydate for TSM control. By 18 Jul the only significant differences detected were that both Omite and Kelthane were superior to Vydate and the water control. This condition remained unchanged in the data collected on 25 Jul. By 2 Aug evidence of significant control of ERM by all three acaricides was evident but for TSM only the Kelthane and Omite outperformed the control and Vydate treatments. No significant differences in ZM or P populations between treatments and the control were revealed by analysis of data from leaf brushing of samples in this experiment.

Data on predators per 3 minute visual examination per replicate was also collected and analyzed on 7, 27, and 30 Jun; 5, 11, 15, 18 and 25 Jul; and 2, 10 Aug. Significant differences in predators present between the treatments and the control were few. However, on 11 Jul there were more TABM present on the Vydate treated trees than on the other treatments or the control. Data taken on 15 Jul on analysis revealed significantly more spiders to be present on the Vydate and control plots than on the trees in the other two treatments. Also, on 2 Aug significantly fewer SPA and SPL were present on the Kelthane + Latron and Omite 6E plots than on the other treatment or the water control. By 15 Aug the data revealed that there were fewer predator mites on the Kelthane + Latron and Omite plots than on the other two treatments; however, the number of predators present was small.

MITES AND MITE PREDATORS PER LEAF - EMPIRE VARIETY

Treatment and rate	23 Jun					30 Jun					5 Jul					
per 300 gallons	ERM	ERME	TSM	TSME	PHYTO	ERM	ERME	TSM	TSME	ZM	ERM	ERME	TSM	TSME	ZM	PHYTO
1. Water	1.59	11.48	1.88	1.39	0.17	0.81	1.47	1.63	0.77	0.00	0.82 ab	5.00	2.31 a	0.92 a	0.26	0.37
2. Vydate 2L 3 pt/A	1.64	11.68	0.71	0.41	0.06	0.93	2.57	1.69	0.53	0.06	1.52 a	5.41	1.38 a	1.18 a	0.12	0.00
3. Kelthane 50W 55.6 oz/A + Latron 44 3 pt/A	1.41	19.61	1.34	0.29	0.06	0.36	4.37	0.18	0.06	0.00	0.24 b	5.35	0.11 b	0.00 b	0.00	0.00
4. Omite 6E 30 oz/A	1.61	11.68	0.52	0.44	0.06	0.27	2.79	0.61	0.17	0.12	0.24 b	2.19	0.23 b	0.00 b	0.06	0.06

Treatment and rate	11 Jul						15 Jul					
per 300 gallons	ERM	ERME	TSM	TSME	ZM	PHYTO	ERM	ERME	TSM	TSME	ZM	PHYTO
1. Water	0.22	1.39 ab	1.55 a	0.32	0.15	0.06	1.11 a	1.29 a	1.81 a	0.56	0.17	0.22
2. Vydate 2L 3 pt/A	0.06	1.90 a	0.60 ab	0.00	0.00	0.00	0.37 b	0.15 b	1.23 a	0.00	0.00	0.06
3. Kelthane 50W 55.6 oz/A + Latron 44 3 pt/A	0.00	0.36 b	0.00 b	0.00	0.00	0.00	0.00 c	0.00 b	0.00 b	0.06	0.00	0.00
4. Omite 6E 30 oz/A	0.00	0.32 b	0.00 b	0.06	0.00	0.00	0.00 c	0.06 b	0.15 b	0.00	0.00	0.00

Treatment and rate	18 Jul					25 Jul					
per 300 gallons	ERM	ERME	TSM	TSME	ZM	ERM	ERME	TSM	TSME	ZM	PHYTO
1. Water	0.30	1.51 a	0.51	0.46	0.23	0.37	1.21 a	0.98	0.47	0.23	0.17
2. Vydate 2L 3 pt/A	0.41	0.99 a	0.26	0.39	0.00	0.54	2.34 a	0.71	0.64	0.22	0.17
3. Kelthane 50W 55.6 oz/A + Latron 44 3 pt/A	0.00	0.17 b	0.00	0.15	0.00	0.06	0.12 b	0.00	0.00	0.00	0.00
4. Omite 6E 30 oz/A	0.06	0.24 b	0.00	0.00	0.00	0.06	0.06 b	0.00	0.00	0.00	0.00

Treatment and rate	2 Aug						10 Aug					15 Aug					
per 300 gallons	ERM	ERME	TSM	TSME	ZM	PHYTO	ERM	ERME	TSM	TSME	ZM	ERM	ERME	TSM	TSME	ZM	P
1. Water	0.32 b	1.81	0.54 b	0.12	0.33	0.18	0.41	0.60	0.27	0.00	0.11	0.11	0.75	0.53	0.33	0.29 a	0.12 ab
2. Vydate 2L 3 pt/A	1.05 a	2.15	1.60 a	0.39	0.11	0.17	0.40	0.83	0.22	0.00	0.00	0.11	0.47	0.76	0.15	0.06 ab	0.39 a
3. Kelthane 50W 55.6 oz/A + Latron 44 3 pt/A	0.12 b	0.33	0.06 b	0.24	0.00	0.00	0.06	0.80	0.06	0.06	0.00	0.12	0.15	0.23	0.11	0.00 b	0.00 b
4. Omite 6E 30 oz/A	0.15 b	0.32	0.06 b	0.29	0.00	0.00	0.12	0.77	0.11	0.00	0.06	0.06	0.29	0.30	0.06	0.00 b	0.00 b

Data converted to square root of X + .5 for analysis. Back transformed data tabulated. Numbers in same column followed by same letter not significantly different.

PREDATORS OF MITES/3 MINUTE OBSERVATION [1, 2] - EMPIRE VARIETY

Treatment and rate per 300 gallons	7 Jun SPA	7 Jun SPL	7 Jun OI	27 Jun SPA	27 Jun SPL	27 Jun OI	27 Jun CHRY	30 Jun SPA	30 Jun SPL	30 Jun OI	30 Jun CHRY
1. Water	2.13	0.50	0.00	0.41	3.29	0.68	1.71	0.73	1.63	0.19	2.84
2. Vydate 2L 3 pt/A	2.13	0.00	0.19	0.00	1.45	0.57	1.21	0.19	1.00	0.19	1.63
3. Kelthane 50W 55.6 oz/A + Latron 44 3 pt/A	2.56	0.19	0.00	0.00	5.28	0.19	1.21	0.78	2.22	0.41	4.05
4. Omite 6E 30 oz/A	0.97	0.00	0.00	0.19	3.16	1.06	2.31	0.19	1.45	0.00	3.16

Treatment and rate per 300 gallons	5 Jul SPA	5 Jul SPL	5 Jul COCC	5 Jul OI	5 Jul CHRY	5 Jul CM	11 Jul COCC	11 Jul OI	11 Jul CHRY	11 Jul SPID	11 Jul TABM	15 Jul SP	15 Jul OI	15 Jul CHRY	15 Jul SPID	15 Jul TABM
1. Water	0.42	0.00	0.00	0.32	2.66	0.32	0.00	0.19	1.55	0.68	0.00 b	0.32	0.57	1.21	0.19 ab	0.00
2. Vydate 2L 3 pt/A	1.21	0.63	0.00	0.19	1.52	0.00	0.00	0.00	2.13	0.00	0.86 a	0.19	0.00	2.31	0.68 a	0.00
3. Kelthane 50W 55.6 oz/A + Latron 44 3 pt/A	0.57	0.32	0.19	0.19	3.79	0.00	0.00	0.00	4.81	1.00	0.00 b	0.00	0.00	2.08	0.00 b	0.19
4. Omite 6E 30 oz/A	0.19	0.19	0.19	0.19	3.53	0.19	0.57	0.00	4.69	0.19	0.19 b	0.57	0.00	3.56	0.00 b	0.00

Treatment and rate per 300 gallons	18 Jul OI	18 Jul CHRY	25 Jul SPA	25 Jul OI	25 Jul CHRY	25 Jul SPID	25 Jul COCC	2 Aug SPA	2 Aug OI	2 Aug CHRY	2 Aug SPID	2 Aug SPL	2 Aug COCC	10 Aug SPA	10 Aug OI	10 Aug CHRY
1. Water	0.19	0.73	1.11	0.19	0.00	0.00	0.00	0.42 ab	0.00	1.52	0.86	0.57 ab	0.42	0.00	0.57	0.86 ab
2. Vydate 2L 3 pt/A	0.19	1.21	0.68	0.00	0.00	0.41	0.00	1.59 a	0.00	0.57	0.19	2.03 a	0.00	0.19	0.00	0.00 c
3. Kelthane 50W 55.6 oz/A + Latron 44 3 pt/A	0.00	0.42	0.00	0.19	0.57	0.19	0.19	0.00 b	0.41	1.63	0.00	0.00 b	0.42	0.00	0.00	1.45 a
4. Omite 6E 30 oz/A	0.32	0.19	0.57	0.00	0.00	0.19	0.00	0.00 b	0.00	0.86	0.42	0.00 b	0.68	0.00	0.00	0.19 bc

Treatment and rate per 300 gallons	15 Aug SPA	15 Aug OI	15 Aug CHRY
1. Water	0.73 ab	0.68	0.41
2. Vydate 2L 3 pt/A	1.63 a	0.19	0.00
3. Kelthane 50W 55.6 oz/A + Latron 44 3 pt/A	0.19 b	0.42	0.00
4. Omite 6E 30 oz/A	0.00 b	0.42	0.00

1 Numbers in the same column followed by the same letter are not significantly different, $p = .05$, DMRT.
2 Data converted to log $X + 1$ for analysis. Back transformed data is tabulated.

APPLE (Malus domestica Borkhauser 'York')
Tufted apple budmoth (TABM);
Platynota idaeusalis (Walker)

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APPLE, GROUND APPLICATION OF ASANA VS. TABM, 1994: On 5 May 1994, the ground area under the drip line of three one acre plots of mature 'York' apple trees were sprayed by a cooperating commercial orchardist with a LV 320 sprayer, operating at 2.5 mph (4.02 km/hr). All nozzles except the bottom two on each side were shut off. The two active nozzles on each side were fitted with a #6 disk and re-directed so the spray covered the surface from the trunk to the drip line of the tree. The pump pressure was adjusted to 300 psi and the airblast fan of the sprayer was shut off. This sprayer set up delivered 125 gallons per acre (GPA) (191.49 liters/ha). The three plots were sprayed with the following materials: treatment #1, control (no ground spray); treatment #2, Asana 14 oz/acre (160.63 g/ha) + Kinetic 1 pt/acre (191.5 liter/ha); treatment #3, Asana 14 oz/acre (160.63 g/ha). Ten trees were selected at random from each plot and designated as replicates in each plot for data generation. On 26 May the area under each tree was visually searched for three minutes and the number of live larvae found per tree recorded. The ground under the trees was virtually covered by a combination of Virginia creeper (Parthenocissus quinquefolia), poison ivy (Rhus radicans), and wild oats (Avena fatua).

Both the Asana alone and the Asana-Kinetic combination significantly reduced the numbers of live TABM under the trees. Harvest data on injury by RBLR and TABM indicated that the ground treatments in the spring reduced TABM injury to fruit at harvest. RBLR injury was apparently not influenced by the treatments.

Ground Cover Observation Under Trees, 26 May 1994

	Rate		TABM larvae/3 min observation/tree [1,2]	
Treatment	acre	hectare	Converted mean	Arithmetic mean
Control	none	none	1.33 a	1.60
Asana + Kinetic	14 oz + 1 pt	160.63 g + 191.5 l	0.00 b	0.00
Asana	14 oz	160.63 g	0.21 b	0.27

[1] Data converted to square root of X + .5 for analysis, back transformed data presented.

[2] Numbers in the same column followed by the same letter are not significantly different ($p > .0001$, DMRT).

% Fruit Damaged by TABM at Harvest (500 apples/treatment)

	Rate			
Treatment	acre	hectare	% Fruit damaged	Injured apples/treatment
Control	none	none	0.4	6.0
Asana + Kinetic	14 oz + 1 pt	160.63 g + 191.5 l	0.8	2.6
Asana	14 oz	160.63 g	0.2	1.4

[1] Data converted to square root of X + .5 for analysis, back transformed data presented.

APPLE: Malus domestica Borkhauser 'York'
Redbanded leafroller (RBLR); Argyrotaenia velutinana (Walker)

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COMPARISON OF 1993 AND 1994 RBLR PHEROMONE LURES, 1994: In the spring of 1994 redbanded leafroller moths were monitored as a part of a large experiment in which four commercial apple orchard blocks were sprayed with several different insecticide treatments. The traps were monitored weekly and the number of male RBLR moths captured was recorded on each date. Pheromone baits or lures manufactured by Ecogen, Inc/Scentry Division, 2005 Cabot Blvd W., Langhorne, PA 19047 were obtained commercially from Pest Management Supply, Inc., 311 River Drive, Handley, MA 01035. All lures, including those used by the grower, were kept refrigerated until placement in traps in the orchard. It soon became apparent that the 1994 lures were not attracting moths satisfactorily. This was obvious since moths could be observed at rest on foliage and bark in the orchards being monitored. Fortunately, one of the grower-cooperators (Edwards) had erected a trap baited with a 1993 RBLR lure in the same orchard (Beverly Orchard) adjacent to the experimental plots. This trap provided comparative data for the 1994 experimental plot trap and lure and continued to capture male RBLR moths throughout the 1994 season. The supplier of the 1994 lures was notified of the problem and provided new lures that were installed before the 27 Jun count. The new lures also were from Ecogen and bore the code No. L112. The new lures also did not capture the number of moths expected in a heavy RBLR population. Another comparison between the 1993 and 1994 lures was made in the Brown Orchard where trapping from 9 May to 6 Sep showed the 1993 lures to be far superior. In the Fruit Hill orchard the grower used a 1993 lure that remained in the orchard for the entire season (6 May - 5 Aug). This lure continued to capture male moths throughout this period.

1993 vs 1994 RBLR Pheromone Lures

Solenberger [1] (Beverly Orchard)				Solenberger [2] (Fruit Hill Orchard)		Brown Orchard		
1993 Lure		1994 Lure		1993 Lure			1993 Lure	1994 Lure
Date	Moths	Date	Moths	Date	Moths	Date	Moths	Moths
3/25	0	--	--	--	--	--	--	--
3/28	2	--	--	--	--	--	--	--
4/1	3	--	--	--	--	--	--	--
4/4	120	--	--	--	--	--	--	--
4/6	56	--	--	--	--	--	--	--
4/8	25	--	--	--	--	--	--	--
4/11	20	4/11	1	--	--	--	--	--
4/13	35	--	--	--	--	--	--	--
4/15	35	--	--	--	--	--	--	--
4/18	50	4/18	1	--	--	--	--	--
4/22	36	--	--	--	--	--	--	--
4/25	16	4/25	0	--	--	--	--	--
4/28	24	--	--	--	--	--	--	--
5/2	28	5/2	0	--	--	--	--	--
5/6	25			5/6	9	--	--	--
--	--	--	--	--	--	5/9	1	0
5/10	15	--	--	5/12	34	5/16	0	0
5/16	0	5/16	0	5/19	1	5/23	0	0
5/24	0	5/23	0	5/25	0	5/30	0	1
5/31	0	5/30	0	6/1	0	6/6	0	0
6/7	0	6/6	0	6/8	2	6/13	6	0
6/13	1	6/13	0	6/14	0	6/20	29	1
6/20	14	6/20	0	--	--	6/27	16	2
6/27**	37	6/27*	1	6/23	13	--	--	--
7/5**	31	7/5*	0	6/30	3	7/5	30	0
7/12**	35	7/11*	1	7/8	3	7/11	1	0
7/18**	22	7/18*	0	7/15	3	7/18	9	0
7/25**	10	7/25*	0	7/21	2	7/25	2	0
8/5**	50	8/1*	0	7/28	2	8/1	3	0
--	--	8/8*	1	8/5	2	8/8	5	0
--	--	8/15*	0	--	--	8/15	17	0
--	--	8/22*	20	--	--	8/22	11	1
--	--	8/27*	15	--	--	8/29	38	2
--	--	--	--	--	--	9/6	32	1
--	--	--	--	--	--	9/12	17	0
--	--	--	--	--	--	9/19	21	0
--	--	--	--	--	--	9/26	1	0
--	--	--	--	--	--	9/30	0	0

[1] Trap located adjacent (100 yd) to Virginia Tech trap in same orchard.
[2] Same 1993 lure through entire season.
* Trap baited with replacement lure provided by manufacturer (same lure 6/27-8/29).
** Lure changed, identical 1993 lure to that used earlier.