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PROCEEDINGS

CUMBERLAND - SHENANDOAH FRUIT WORKERS CONFERENCE

67TH ANNUAL MEETING

NOVEMBER 21-22, 1991

HARPERS FERRY, WEST VIRGINIA

The 67th meeting of the Cumberland-Shenandoah Fruit Workers Conference was hosted by the USDA-ARS, Appalachian Fruit Research Station, at the Cliffside Inn in Harpers Ferry, WV. The conference was held on Thursday and Friday, November 21-22, 1991, with 51 registered participants. Michael Glenn was the Program Chair; Bill Horton, Chaired the Horticulture Section; Mark Brown, Chaired the Entomology Section; and Tom van der Zwet, Chaired the Plant Pathology Section.

Two joint general sessions were held Thursday morning with these topics:

I - "Can We Live With Malling 9 and 26 Rootstocks?" Discussion Leader was Paul Steiner (MD), with participants Chris Walsh (MD) and Keith Yoder (VA).

II "Economics of Apple Processing Technology and Production Systems." Discussion Leader was Tara Baugher (WV) with participants Jayson Harper (PA) and Karen Burkhart (Knouse Foods, Inwood, WV).

Following lunch, a one-hour special session was arranged to discuss "The Future of the Cumberland-Shenandoah Fruit Workers Conference". Several aspects were discussed including meeting structure and poor attendance in recent years. It was suggested we consider the procedures used at the annual New England, New York, Canadian Fruit Pest Management Workshop which devotes 1 day to open discussion among all participants around a U-shaped table.

Following these sessions, three concurrent sessions were conducted with 8 papers presented in the Horticulture Session, 9 in Plant Pathology, and 10 in Entomology. In each session, there was considerable interaction and discussion. These paper and discussion sessions were continued Friday morning.

In the evening of November 21, the Mid-Atlantic Tree Fruit Publications Committee met to discuss the preparation of orchard monitoring and tree fruit production guides. The group reached a decision to begin work on a Mid-Atlantic Orchard Monitoring Guide to be available in 1993.

The business meeting was conducted Friday at 10:30 AM. Mike Glenn chaired the meeting. Brief reports were presented by each session chair. The deadline to receive papers for binding the reports was set for December 15, 1991, and the proceedings to be mailed by January 15, 1992.

The treasurer's report showed a balance from the 1988 (VA), 1989 (MD), and 1990 (NC) meetings of $594.58. With registration fees and coffee break expenses of this year's meeting, we carry a balance to date (Dec. 1) of $809.58. After preparation and mailing the proceedings, the final balance will be mailed to George Greene, (General Chairman - Pennsylvania) who will be the host for the 1992 meeting.

During the business meeting, and in follow-up to the special session on the future of the conference, lively discussions were held regarding all phases of our organization. Motions were made and accepted for two committees to report at the 1992 meeting: A Committee on Program Structure: Paul Steiner (MD), Dean Polk (NY) and Steve Miller (USDA), and a Committee to Explore Attendance by Chemical Consultants, Extension personnel, Scouts, Private Practioners, etc.: Ken Hickey (PA), Paul Steiner (MD), Turner Sutton (NC), Bob Horsburgh (VA), Dean Polk (NJ), Henry Hogmire (WV) and Tom van der Zwet (USDA).

<u>Future meeting schedule</u>:

1992 Pennsylvania

1993 West Virginia

1994 New Jersey & S. Carolina

1995 Virginia

1996 Maryland & Delaware

1997 North Carolina

1998 USDA

1999 PA (75th Anniv.)

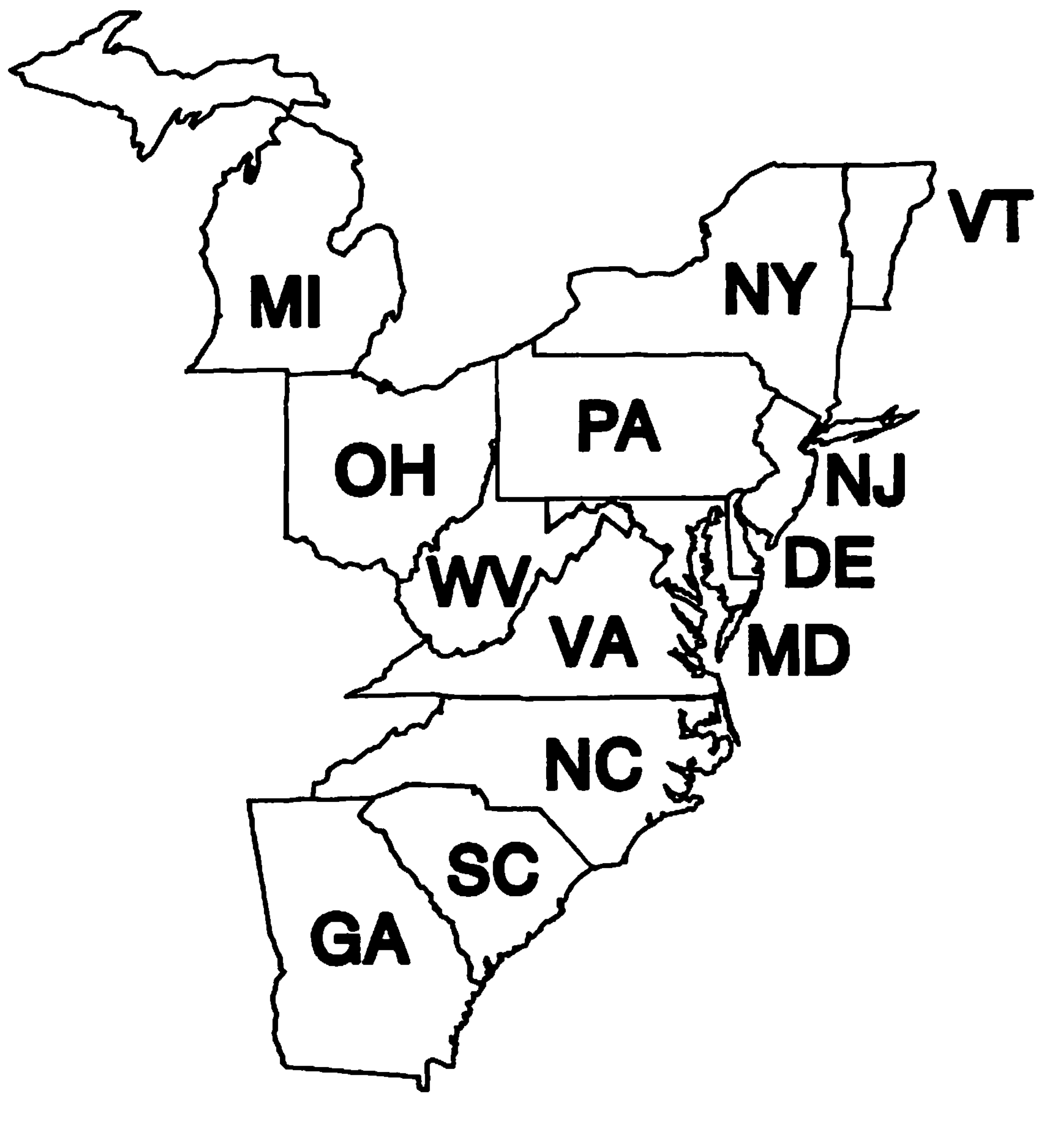
The meeting was adjourned at 12:15 PM.

Respectfully submitted,

Tom van der Zwet

Tom van der Zwet, Secretary

AREA REPRESENTED AT THE CUMBERLAND-SHENANDOAH FRUIT WORKERS CONFERENCE



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- Michael Glenn
- Bill Horton
- Stephen Miller
- Gary Puterka
- Jeffrey Schmitt
- Fumi Takeda
- Tom Tworkoski
- Tom van der Zwet

Kearneysville (WVU)
- Tara Baugher
- Alan Biggs
- Henry Hogmire
- David Leach
- Tim Winfield
- Roger Young

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- Kendall Elliot
- Morris Ingle
- Jim Kotcon
- Juanita Popenoe

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PLANT PATHOLOGY

ENTOMOLOGY

General Discussion Topic: 67th Annual Cumberland-Shenadoah Fruit Workers Conference,
Harper's Ferry, West Virginia, November 1991

Death of M-26 and M-9 Clonal Apple Rootstocks Following Scion Infections by *Erwinia amylovora*: A Potentially Serious Problem in the U.S.

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INTRODUCTION

The destructive nature of fire blight on apples and pears, caused by *Erwinia amylovora*, is well known. The disease kills blossoms, vegetative shoots, limbs and, sometimes, whole trees, causing losses that may not be recovered for many years. Recognition of blossom, canker, shoot and trauma blight as distinct phases of the disease, each with specific requirements for infection has enabled us to develop a more effective, focused approach to disease management [Steiner (1990), Acta Hort. 273:139-158]. Recently, a fifth phase, rootstock blight, has been observed in the Mid-Atlantic, Northeast, Midwest and Pacific Northwest areas. Although the specific details on the etiology of rootstock blight have yet to be fully characterized, the incidence and destructiveness of this phase has been cause for concern among both growers and researchers alike. The purpose of this discussion is to summarize several recent experiences with rootstock blight in the Mid-Atlantic area and elsewhere in an attempt to assess the risks and management options available.

ROOTSTOCK BLIGHT

Rootstock blight involves the internal secondary invasion, subsequent infection and death of susceptible apple rootstocks (or interstems) by *E. amylovora* following primary infections of scion blossoms or shoots while the intervening limb and trunk tissues remain symptomless. Death of the tree results from a girdling of the rootstock that may occur one to three months or more after symptoms of primary infection appear. At present, problems with two major clonal apple rootstocks, M-26 and M-9, and C-6, a clonal interstem, are best known. A third rootstock, Mark, is considered prone to this malady because of its M-9 parentage, but the incidence and severity of rootstock blight here has not been shown clearly.

ETIOLOGY OF ROOTSTOCK BLIGHT

Rootstock infections by *E. amylovora* have been often attributed to instances where the pathogen gains entry through trunk wounds (mechanical and insect related), burr knots (possibly also associated with insect damage), and infected root suckers. These instances, although infrequent and not well documented, are plausible given the known sensitivity of the M-26 and M-9 rootstocks. A much more common symptom pattern, however, has been observed where, in the absence of obvious wounds, burr knots and root sucker infections, the rootstock dies following primary blossom or shoot infections on the scion variety. While canker development and bacterial ooze can sometimes be found on the rootstock within a month after scion symptoms appear, many trees may appear healthy for several months before collapsing suddenly. In addition, where the rootstock girdling is only partially completed by late August to early fall, infected trees may show early fall red color in the foliage. One of the most interesting characteristics of rootstock blight is the fact that the bark of limbs and trunks between the primary scion strike and the rootstock remains symptomless, suggesting that the bacteria in these tissues are latent or simply in transit via the phloem enroute to the rootstock.

Evidence being developed at the University of Maryland strongly suggests that the progress of fire blight symptoms in vegetative tissues may be a function of the relative osmotic potential between host cell cytoplasm and the complex polysaccharide matrix of bacterial ooze in the intercellular spaces. Here, symptom development is most rapid in young, succulent vegetative tissues where the osmotic potential of the bacterial matrix may exceed that of the host cells. By contrast, the normal maintenance functions of more mature tissues which favor higher levels of soluble solids appear to confer resistance to further damage (=symptoms) by the pathogen, but apparently do not limit its spread. In addition, where the physiological status of mature tissues can be changed, allowing the bacteria access to the water and substances it requires for ooze formation, this simple resistance mechanism is breached and symptom development (=damage) occurs.

The presence and persistence of pathogenic isolates of *E. amylovora* in healthy bark tissues well in advance of symptoms is well known [Gowda & Goodman (1970), Pl. Dis. Rptr. 54:576, and Kiel & van der Zwet (1972), Phytopathology 62:39]. Indeed, the former report indicates that the transport of bacteria in these tissues occurs exclusively in the phloem. In our laboratory, a doubly marked streptomycin + rifampcin resistant isolate (courtesy, A. Jones, Mich. State Univ.) inoculated into a single shoot leaf tip of York and Red Delicious scions arrives in both M-26 and M-111 rootstocks within ca. two weeks, but early browning symptoms occur only in the bark tissues of M-26 rootstocks (experiments still in progress).

All of our results thus far, while tentative, suggest that the bacteria are transported quickly via the phloem through the more mature limbs and trunks of the scion variety into all rootstocks (including seedlings), but are capable of causing damage only in M-26 and M-9 rootstocks. Indeed, there are marked differences in the bark structure of these susceptible rootstocks compared with other, normally resistant rootstocks. That these differences are related to the levels of stored carbohydrates is suggested by the fact that both ooze and canker development can be induced in seedling rootstocks through the repeated stimulation of vegetative growth on the scion.

INCIDENCE OF ROOTSTOCK BLIGHT

Good documentation on the incidence of rootstock blight is lacking at this time for a variety of reasons: (1) the sporadic occurrence of fire blight; (2) the widespread use M-26 with blight susceptible scion varieties (Gala, Fuji, Braeburn, Empire, etc.) is a fairly recent change in orchard production practice; (3) rootstock symptoms may not be recognized for 1-12 months after primary infections; (4) late season symptoms are often misdiagnosed as those of collar rot; (5) not all trees on susceptible rootstocks that sustain primary scion infections succumb to rootstock blight; and, (6) growers sometimes simply remove the dead or dying trees, but do not inform research or extension workers attempting to chronicle such events.

Isolations from infected branches in several Maryland orchards in 1990 indicate that the bacteria move quickly through the scion well in advance of any visible symptoms, and may reach the rootstock within a few weeks (depending on distance between the strike and graft union). In one orchard, late blossom infections on Gala apples occurred 29 April and cool weather delayed symptom appearance until 26 May. Nevertheless, visible ooze and early canker development was detected in the M-26 rootstocks of some severely infected trees as early as 13 June, despite the fact that the central tree stem remained symptomless to the graft union. Other trees infected during the same 29 April event did not show cankering and tree death until late August and early September. Typically, trees dying in the late June to July period, collapsed suddenly while those that died in the late summer to early fall often showed early fall red color as the first symptom of decline. The grower severely pruned all infected trees and removed 250 of 600 (42%) in the block in 1990, some of which may have succumbed to collar rot (*Phytophthora cactorum*). In 1991, approximately 25% of the remaining trees were dead or dying by early September following an outbreak of shoot blight which appeared 21 May.

In fall of 1990, an orchard of Gala and Jonathan trees on M-26 in central Maryland and one of Gala on M-9 in western Maryland, which were not compromized by collar rot, lost ca. 10% of the trees following a rather minor epidemic of blight on secondary flowers 28 April. In the fall, the majority of these trees showed early red color in the scion canopy that was more or less proportional to the degree of girdling by blight cankers in the supporting rootstock (25-100%). In the spring of 1991, a few Gala trees in some orchards showed signs of early decline (poor foliage color, weak growth) and, subsequently, the development of a typical fire blight canker on the lower trunk extending upwards from the rootstock. These latter trees were completely killed by early July.

Dr. Keith Yoder (VPI & SU, personal communication) noted an unusual situation in Virginia in 1991 involving a high wind trauma blight incident in a 3-year-old Red Delicious (cv. Campbell Redchief on M-26 rootstock) planting. In this instance, a 50 mph wind (without rain) on 9 April (ca. 4 days into the bloom period) tattered foliage and blossoms. Based on the *MARYBLYT* (Version 3.0) predictive model, ca. 700-800 degree hours >65°F had accumulated since full pink when the wind storm occurred, constituting a trauma blight incident for which early symptoms developed about 23 days later. With the appearance of symptoms, the grower attempted to cut out all strikes, although some were missed. As is typical of fire blight on red delicious cultivars, the immediate damage was limited to only a few inches below each strike. By 24 July, the grower had flagged or removed 600 dead trees. At that time, we estimated another 300 trees might succumb by the end of summer based on the incidence of trees found with rootstock cankers in progress. In all cases, the internal bark of the scion trunk appeared healthy and symptomless. Based on the Maryland experience in 1990 and the incidence of scion blight in this orchard, it is not unreasonable to expect another 100 trees may decline and die in the spring of 1992.

ROOTSTOCK RISK ASSESSMENT

In the Virginia incident, the affected orchards comprised 44 acres planted at 1,500 trees per acre, so the overall potential loss of ca. 1,000 trees represented <1% of the tree population. In addition, because of the high planting density, the space opened by the killed trees can be easily filled by adjacent trees, minimizing the need for extensive replanting; the same may not be true for orchards with a wider spacing. In developing the documentation for the *MARYBLYT* forecasting system, the only fire blight epidemics involving normally resistant Red Delicious apples have been associated with a trauma event (hail, high winds, late frost of ≤ -2°C) when the cumulative degree hours >18°C after full pink was >200. The Virginia incident appears to be the first reporting significant tree loss with Red Delicious, attributed almost solely to the use of M-26 rootstocks. The risks for tree loss due to rootstock blight with resistant varieties such as Red Delicious, therefore, appear to be low with the possible exception of sites where trauma incidents might be common (e.g., >1 in 5 years?) during the bloom and early summer period. Given the extent of damage caused by various trauma events, it can be expected that late frost would result in more significant losses than either hail or wind, with the degree of loss associated with the latter injuries being related to the intensity/duration of the event.

The risks for tree loss due to rootstock blight with susceptible scion varieties on M-26 (and M-9), however, are considerably higher. This is because the conditions supporting fire blight blossom and shoot infections are common in most apple production areas and the general observation that there appears to be no relationship between the number of primary blight strikes per tree and the occurrence of rootstock blight. In addition, because of the inherent susceptibility of cultivars like Gala, Jonathan, Fuji, etc., the potential for secondary infections following even a minor trauma blight incident increases the tree loss risk.

The risks for tree loss as the result of rootstock blight can be reduced only by a rigorous management program for all phases of the disease: blossom, canker, shoot and trauma blight. Nevertheless, because of the rapid and extensive internal invasion of both susceptible and resistant limbs, trunks and rootstocks by the pathogen following primary infections, even the most rigorous removal of newly blighted tissues futile for trees on M-26 or M-9 rootstocks.

Can we control fire blight reliably enough to make the use of M-26 and M-9 apple rootstocks profitably? What are the alternatives?

HORTICULTURE

The Use of Beds to Attain Higher Density Orchards

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Most orchards in Pa. have uniform row spacings. The term "bed" in fruit production got its meaning from The Netherlands where from three to eight row beds have been researched and tried by growers. No equipment traveled between the rows in a bed and the beds were kept weed-free. Extensive research has been conducted in The Netherlands but beds have not been extensively used probably because most orchards have narrow spacings that are made possible by the use of M.9 rootstocks and very flat land. In Pa. wide weed-free beds would not be advisable since excessive erosion would often occur so Dutch style beds probably would not be workable.

In a broader sense, beds for tree fruit production should simply be thought of as plantings with unequal row spacings. Beds in this broader sense have been around a long time. Some growers in Pennsylvania (ie M. E. Knouse) have alternated narrower rows, where no bin handling would occur, with wider rows where bin handling would occur. Thus, for example a row spacing of 20 feet might be standard in an orchard with uniform row spacings. However this 20 foot spacing could be alternated with 18 foot row-middles resulting in an average row spacing of 19 ft. This would result in 5% more rows and trees for a given width field.

With the desire of most Pennsylvania growers to use relatively wide row-middles for spraying and especially for bin handling, row spacing becomes a limiting factor in the design of moderately high density orchards. Thus, with growers desiring 6 to 8 feet for large equipment operation, significantly higher tree densities cannot be obtained. However,we could design "bed orchards" where a single, wide row-middle would be used for large sprayers and for bin handling. The bed itself could be designed with many row spacings and tree configurations. The bed could be designed with row spacings so that mowing could be done with a small tractor but no spraying would be done within the bed. Equipment used in Christmas tree plantations would be ideal. Alternatively, slightly wider row spacings, within the bed, would allow the use of both small compact sprayers and mowers. Six row beds of similar design have been used by some SC peach producers. Either of these arrangements would result in significantly higher tree densities and may be a workable plan so that growers can obtain higher tree densities while at the same time maintaining wide row-middles for large equipment. Listed below are some configurations, of various bed spacings, to attain higher densities than would be possible with uniformly wide row-middles between every row.

Table 1 Increase in tree density made possible by the use of beds. All measurements in feet.

Conventional planting			Bed planting specifications					
In row tree spacing	Row spacing	Trees /acre	In row tree spacing	Wide row spacing	In bed row spacing	No. of rows / bed	Trees /acre	Percent increase trees/acre
10	18	242	10	18	14	2	272	12.4
			10	18	14	3	284	17.4
			10	18	12	2	290	19.8
			10	18	12	3	311	28.5
14	22	141	14	22	18	2	156	10.6
			14	22	18	3	161	14.2
			14	22	16	2	164	16.3
			14	22	16	3	173	22.7

Obviously there are many, many tree arrangements possible and the ideal for any situation will depend on all the usual factors and on equipment width. The percentage increase in trees possible with this style beds is a function of:1) the ratio of the row widths within the bed to the row width between beds and 2) the number of rows in the bed.
Barritt recently reviewed the use of beds and proposed a formula to calculate tree density:"The calculation of tree density is straightforward with single-row plantings. However, with multi-row designs, the calculation of tree number per acre becomes more complicated. The following formula can be used to calculate tree density:

$$\text{Tree density (trees/acre)} = \frac{N\,(43{,}560)}{(A + B)\,D}$$

The variables in this formula are shown in Figure 1 and are defined as follows:

A - Alley width from trunk to trunk; the driveway for tractors and other equipment.

B - Bed width, the distance from one side of the bed to the other. It is the distance between the two rows of a double-row system or between the two outside rows of a three-row cr wider bed. For single rows B = 0.

D - Distance between trees within each row.

N - Number of rows within the bed. For single rows N = 1.

The number of square feet per acre (43,560) is also needed to calculate tree density when distance units are in feet."

This formula appears to be more complicated than necessary and the following more simple formula is proposed:

$$\text{Tree density (trees/acre)} = \frac{43560}{\left(\frac{A}{N}\right) B}$$

In this formula the following variables apply:

A - The distance from the trunk of the edge tree in one bed to the trunk of the tree in the similar position in the adjacent bed.

N - The number of rows in the bed.

B - The distance between trees in a row.

Summary

It appears that increasing tree density, up to a point, is advantageous in fruit production depending on a whole host of cultural, economic and grower specific factors. In the Mid-Atlantic area many growers wish to retain wide row-middles for bin handling and for the use of large sprayers. It appears that orchard production systems utilizing unequal row spacings (beds) may offer promise to allow growers to retain the use of large equipment while at the same time gain the advantages of higher density systems.

Reference

Barritt, B. H. 1990. Tree density and arrangement in high density orchards. Good Fruit Grower 41(16):4-8.

Not for Publication

THE EFFECT OF BEE-SCENT ON BISBEE RED DELICIOUS APPLES AND BOSC PEARS

by
Jerome L. Frecon and Stuart Race[1]

ABSTRACT

Research was conducted in 1990 and 1991 on Bosc pears and Red Delicious apples in Southern New Jersey to determine the effectiveness of Bee-Scent[2] an attractant reported to increase pear and apple set and yields. Under excellent conditions for pollination, Bee-Scent did not increase yields, fruit size, or seed count in either cultivar. Two applications of Bee-Scent reduced Bosc pear yields in 1991 when compared to an application of water only. Two applications of Bee-Scent reduced Bisbee Red Delicious yields in 1990 when compared to no applications, and in 1991 when compared to one application, a water application, and no applications.

INTRODUCTION

Bisbee Red Delicious is the most important apple cultivar in New Jersey. Red Delicious is more difficult to pollinate because of its peculiar flower structure. Roberts reported its upright stamens and spreading petals allowing foraging honey bees to extract nectar without collecting pollen.(1) Honey bees must visit the Red Delicious flower more often, therefore, facilitating pollination and subsequent fruit set. Bosc is the number one pear cultivar in the state. Pears do not yield well in New Jersey due to the low nectar content less attractive to foraging bees. Other environmental factors also influence fruit set, seed count, size and yield with both cultivars.

Mayer reported in Washington State that Bee-Scent, a bee attractant, increases foraging bees, and fruit set of apples, and pears.(2) He reported the product contains pheromones with naturally occurring scents that affect and modify insect behavior to lure and hold honey bees to blooming crops. Technical bulletins distributed by Scentry Inc. show increased yields with Bee-Scent on apples and Honey Dew melons at the recommended rate of 4.7 liters per hectare. The approximate cost of Bee-Scent at this rate is $61.75 per hectare.

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[2] A registered trademark of Scentry Inc.

The micro-climate in New Jersey is quite different than Washington State, and fruit yields are lower in New Jersey. The objective of this experiment was to evaluate the effectiveness of Bee-Scent in increasing yields of Bosc pear and Bisbee Red Delicious apples under New Jersey conditions.

MATERIALS AND METHODS

Six year old Bosc pear trees on domestic seedling rootstocks, and seven year old Bisbee Red Delicious trees on MM111 were sprayed with Bee-Scent in 1990 and again in 1991. The Bosc pear trees were planted 5.5 meters x 7.9 meters in a block owned by W.W. Heritage Sons, Inc. in Richwood, New Jersey. The Bisbee Red Delicious apple trees were planted 6.1 meters x 7.6 meters in a block owned by Wm. Schober and Sons, Inc. near Monroeville, New Jersey. Both blocks received normal care and attention during the two growing seasons of Bee-Scent applications.

Three treatments were replicated four times in a complete randomized block at both test sites in 1990. Four treatments were replicated four times in a complete randomized block at both sites in 1991. Treatments were similar at both sites in each year. In 1990, one treatment consisted of one application of Bee Scent at 4.7 liters per hectare when 20 % of the flowers were in full bloom. A second treatment was applied using the same rate at 20% full bloom and again at 100% full bloom. The same treatments were applied in 1991 except an additional treatment of water was included at 20 % full bloom. All treatments were applied with Solo Back-Pack mist blowers at a distance from the flowers to avoid dislodging floral parts. Active honey bee hives were rented and placed in the blocks at 3 hives per ten acres.

Data were collected and recorded on tree trunk diameter and height, fruit size, seed content, and yield. Observations were also recorded on bee activity, temperature, wind speed and rainfall.

RESULTS

Weather conditions were generally excellent for bee foraging during both seasons when treatments were applied, and during bloom. Bee activity was excellent at each site both years. Sub-freezing temperatures occurred one day after the first application in the Bosc tree block in 1990. Tire fires used for orchard heating, and freezing temperatures created variability of data in the Bosc block in 1990. Fruit set was severely reduced in this block.

Tree height was very uniform. Differences in trunk diameter were recorded and yield data was collected at harvest. Yield was calculated per centimeter of trunk diameter and is presented in Table 1.

Bee Scent Treatments	Yields in Kilograms/Centimeter of Trunk Diameter			
	Bosc Pears		Bisbee Red Delicious Apples	
	1990	1991	1990	1991
water only no BScent	----	8.10 a	----	4.29a
no water no BScent	2.68 ns	5.77 ab	2.07 a	3.45 a
one application	3.25	5.82 ab	1.82 ab	3.90 a
two applications	5.36	4.06 b	1.47 c	2.10 b

Mean separation by LSD at 5% level

No significant differences between treatments were recorded in Bosc pear yields in 1990. When two applications of Bee-Scent were applied at 20% and 100% full bloom, yields were reduced on Bisbee Red Delicious apples. In an effort to determine why this occurred a treatment with water only was included in 1991 at both the apple and pear test sites. Bosc pear yields were less in 1991 where two applications of Bee-Scent were made when comparing yields with trees where water only was applied. No differences were recorded in comparison to one or no applications of Bee-Scent and water on the Bosc trees. Two applications of Bee-Scent on Bisbee Red Delicious in 1991 reduced yields when compared to one application, no application, or an application of water only.

Apples and pears were sized in both 1990 and 1991. No significant differences were recorded in fruit size between treatments. Seed counts were taken from random samples of each size in 1990 and 1991. No difference in seed counts were recorded between treatments in 1990 and 1991. Bisbee Red Delicious apples averaged more seeds in 1991 than in 1990.

CONCLUSION AND DISCUSSION

Bee-Scent did not increase fruit yield or size in Bosc pears or Bisbee Red Delicious when applied at the recommended rate and timing in 1990 and 1991. Conditions for pollination and fruit set were considered near ideal except in the Bosc block in 1990. Honey bees were active with hives placed at a density common to Southern New Jersey orchards. In spite of these conditions the data indicated two applications of Bee-Scent had a deleterious effect on fruit yields of Bosc pears in 1991 and Bisbee Red Delicious in both 1990 and 1991. Wind and low humidity may desiccate stigmas thus the water application may offset this factor supporting the data of increased Bosc yields. However water did not help when Bee-Scent was applied twice.

Bee-Scent cannot be recommended to New Jersey fruit growers until further research from a similar climate demonstrates this material is effective in increasing fruit yields.

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A PROGRESS REPORT ON CONSUMER ATTITUDES TO DISEASE RESISTANT APPLE CULTIVARS - 1991

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Objectives: Determine if untrained taste testers could identify differences in apple quality between the sampled cultivars. Determine the acceptability of both named and unreleased cultivars. Determine if consumers would rate any cultivar significantly better than any other.

Untrained consumers evaluated five apple cultivars (*Malus domestica* Borkh., cvs Jonafree, Co-op 18, Liberty, and D-98-486 (all scab resistant) and Spur Red Delicious (Bisbee strain) to determine consumer opinion of cultivar attributes. The testing was done at a local apple festival (Terhune Orchards, Princeton, NJ) on September 28, 1991. The festival attracts between 14,000 to 15,000 people in one weekend, and therefore represents a good cross section of the population in that area. Red delicious was included as a standard, as was Liberty, since it had been tested in previous years. Fruit was prepared for testing just prior to the tasting procedure. Fruit was peeled, cored, and sliced with a hand crank apple peeler. Fruit was placed in a solution of ascorbic acid and water to retard discoloration. An evaluation scale was adapted from Dhanaraj et al. (1980), and previously used by ourselves in 1988 and 1989, Durner et al. (In Press). A 4 part questionnaire was developed which provided for background information of the participants, as well as three apple quality tests. Cultivars were assigned individual letter codes, and identified by code on the test instrument. Three cultivars only were randomly assigned to any one tester at a time for taste testing. All 5 cultivars were presented for the visual evaluation.

Test 1 was a quality evaluation where testers were asked to rate each sample for texture, juiciness, aroma, taste, and sweetness on a 3 choice scale ranging from less desirable at either end of the scale to optimum in the middle. If the taster felt that the sample fell in between the quality descriptions, they indicated that on the form. After evaluating for individual attributes, the tester was asked to rate the sample on an overall scale from excellent, very good, good, fair, or poor. Tasters took a bite of saltless cracker and a sip of water between each of the 3 samples in the first test, and between test 1 and test 2.

Test 2 was a comparative cultivar preference test. Each tester was given 3 randomly assigned sets of 3 cultivar slices each. Each set was treated independently by the tasters. Samples were tasted and ranked in comparison to one another as the best, acceptable, and worst. A saltless cracker and water were used after each set.

Test 3 was a visual rating of all 5 cultivars. Ratings were done on a 3 choice scale for color, shine, shape, and overall appearance for each cultivar. Statistical analysis of volunteer responses was performed by assigning numerical values to the various categorical answers. A total of 116 test questionnaires were completed by volunteers, of which 110 were analyzed. Ratings were subjected to a Kruskal-Wallis test (1952), non-parametric analysis. Cultivar means were separated with Miller's (1966) multiple comparison procedure for Kruskal-Wallis rank sums. Firmness and soluble solids data were analyzed with a one-way analysis of variance, and means separated with Fisher's protected LSD.

Taste Tester Profile Thirty-one percent of the testers were male, while 69% were female. Thirty-one percent of the testers were younger than 20 years; 15% were between the ages of 21 and 30; 31% were between 31 and 40; 12% were between 41 and 50, and 11% were 51 years or older. Fifty-seven percent of the testers earned less than $40,000.00 annually, while 43% earned more than that. Among the testers, 24% said they, on average, consumed less than one piece of fruit per day; 42% consumed one piece per day, and 34% consumed 2 or more pieces per day. Apples were most preferred by 45% of the testers; 24% preferred bananas, and 13% preferred grapes. The remaining 18% were equally divided in their preference of peaches, pears and oranges.

Result Summary All results are summarized in the tables below. In Test 1 all individual attributes were most favored if a 2 or close to 2 rating was given. The most desirable overall ratings were those closest to 1. Red delicious was not preferred for texture. All cultivars had a sufficient amount of juiciness, although Co-op 18 and Liberty were closest to optimum. No cultivar was perceived to have ideal aroma, but Co-op 18, Liberty, and Red Delicious were judged relatively equal in this attribute. Co-op 18 and Jonafree were most preferred for taste and sweetness. The overall evaluation of attributes showed that testers preferred Co-op 18 the most followed by Jonafree, D-98-486, and Liberty. Red Delicious was the least preferred cultivar.

In Test 2, a 3 way preference test, a 1 signified the most desirable, 2 was acceptable, and 3 was the worst choice. Co-op 18 received the best overall rating, followed by Jonafree, Liberty, D-98-486, and Red Delicious in that order.

The visual rating system used a 1 as the most attractive, 2 as fair, and 3 as poor. Jonafree was chosen the best for color, and shine. Jonafree and D-98-486 were preferred equally well for shape. Jonafree was most preferred in overall appearance, followed by D-98-486. The other 3 cultivars were equally rated for overall appearance.

Fruit quality attributes are listed in the last table. Co-op 18 and Liberty had the highest soluble solids and pressure levels. Pressure is reported in Newtons, which is equal to: Jonafree - 8.74Kg, Co-op 18 - 9.32Kg, Liberty - 9.28Kg, Red Delicious - 7.48Kg, and D-98-486 - 7.60Kg.

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1991 Lisa Taste Testing Results, Test 1

Cultivar	Texture	Juiciness	Aroma	Taste	Sweetness	Overall
Jonafree	2.08 b	2.13 a	1.40 b	1.85 b	1.80 ab	2.92 b
Co-op 18	1.92 c	2.02 ab	1.63 a	1.94 b	1.89 a	2.65 c
Liberty	1.91 c	2.03 ab	1.48 ab	1.63 c	1.64 cd	3.13 ab
Red Delicious	2.29 a	1.97 b	1.56 a	2.46 a	1.75 bc	3.19 a
D-98-486	1.94 c	1.89 b	1.46 ab	2.39 a	1.56 d	3.09 ab

1991 Lisa Taste Testing Results, Test 2

Cultivar	Overall Rating
Jonafree	1.69 c
Co-op 18	1.56 d
Liberty	2.13 b
Red Delicious	2.44 a
D-98-486	2.16 b

1991 Lisa Taste Testing Results, Test 3

Cultivar	Color	Shine	Shape	Overall
Jonafree	1.13 c	1.14 c	1.22 b	1.16 c
Co-op 18	1.93 a	1.72 a	1.46 a	1.72 a
Liberty	2.00 a	1.86 a	1.53 a	1.69 a
Red Delicious	1.63 b	1.78 a	1.56 a	1.50 a
D-98-486	1.49 b	1.29 b	1.27 b	1.39 b

1991 Lisa Taste Testing Results, Fruit Quality

Cultivar	Soluble Solids (Brix)	Firmness (N)
Jonafree	12.8 bc	85.7 a
Co-op 18	14.0 a	91.3 a
Liberty	13.7 ab	90.9 a
Red Delicious	12.2 cd	73.3 b
D-98-486	11.3 d	74.2 b

1991 Lisa Taste Testing Results, Taster Profile

Thirty-one percent of the testers were male, while 69% were female. Thirty-one percent of the testers were younger than 20 years, 15% were between the ages of 21 and 30, 31% were between 31 and 40, 12% were between 41 and 50, and 11% were 51 years or older. Fifty-seven percent of the testers earned less than $40,000.00 annually, while 43% earned more than that. Among the testers, 24% said they, on average, consumed less than one piece of fruit per day, 42% consumed one piece per day, and 34% consumed two or more pieces per day. Apples were most preferred by 45% of the testers, 24% preferred bananas, and 13% preferred grapes. The remaining 18% were equally divided in their preference of peaches, pears and oranges.

Title: Impact of Quality Factors on the Price Received for Processing Apples

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Abstract:

This study quantifies the discounts and premiums associated with various quality factors for processing apples. Doscounts and premiums were estimated using a hedonic price model estimates from quality data on 137 samples of three processing apple varieities (45 'York Imperial', 43 'Rome Beauty', and 49 'Golden Delicious'). Results indicate statisitically significant price discounts existed in the sample for apple size, bruise, bitter pit, decay, misshappen apples, and internal breakdown. Commonly cited defects such as insect damage and apple scab did not cause sinificant price discounts.

Introduction

The value of processing apples, as with most agricultural commodities, is influenced by the interaction of many factors. Unlike fresh market apples, where color, crispness, and flavor are the dominant factors in consumer acceptance (Manalo), apple processors are more concerned with fruit size and quality characteristics which influence the amount of trim waste. At present, inspection procedures classify processing apples according to grade (U.S. #1 (up to 5% trim waste), U.S. #2 (up to 12% trim waste), ciders, and culls) and size (greater than 2.75 inches in diameter, 2.5 to <2.75 inches, 2.25 to <2.5 inches, and less than 2.25 inches). The inspection certificate received by the producer, however, does not give much feedback as to the observed causes of downgrades. If producers had access to this type of information, orchard management practices could be targeted to reduce specific defects and improve overall apple quality or reduce input intensity and lower production costs.. Knowledge of the value of specific quality attributes is essential to producers in making economic management decisions and allocating limited resources. Dissatisfaction with the the present grading procedures for apples is evidenced by the pricing structures used by apple processors. To counter the shortcomings of the present procedures, new grading systems have been proposed by Russo and Rajotte for fresh market apples and by Johnson, Wood, and Mattus for processing apples. Attempts by Baugher et al. and Greene have been made to put revised versions of each system to a practical test.

When a problem involves product heterogeneity, like the case of processing apples differentiated by size and grades, it has been suggested that researchers take a product characteristics approach to the analysis (Ladd and Martin). This approach embodies the view first proposed by Lancaster of a product as a collection of characteristics. In this situation, products are valued for their utility-bearing characteristics and prices vary depending on the amounts of each characteristic contained in the product (Lucas). One method of analyzing this type of problem is through the estimation of hedonic price functions. Hedonic price functions are regressions of price received as a function of its quality attributes (Lucas). Recent examples of the estimation of hedonic price models for agricultural products include those for livestock (Schroeder et al.; Mintert et al.; Bailey, Peterson, and Brorsen), rough rice (Brorsen, Grant, and Rister), and cotton (Ethridge and Davis).

Data

With the cooperation of Knouse Foods Cooperative, Inc., 137 samples of processing apples representing three of the major processing varieties were taken from loads of apples delivered at harvest in the fall of 1990. These included 49 samples of 'York Imperial', 43 of 'Rome Beauty', and 45 of 'Golden Delicious'. An inspector of the Federal State Inspection Service graded the apples and indicated the specific causes of downgrades. The apples were weighed by grade and size as well as by specific quality defect. Apples were valued using Knouse Foods price schedule, which is similar to those used by most apple processors, which takes into account fruit size and USDA grade. Processing considerations have lead Knouse to pay according to a four tier price scale in which large U.S. #1 (2.75"+) apples receive a premium, medium U.S. #1 (2.5" to <2.75") receive a lower price, and all other apples (small U.S. #1, all U.S. #2, and cider apples) receive a much lower "juice" price (cull apples are worth nothing and are discarded). The price schedule for the three processing varieties is listed in Table 1.

Apple Quality Factors

In this study, apples were inspected on the basis of size and by the presence of various quality defects. In the 137 samples analyzed, nine types of quality defects were observed across the three processing varieties. These defects included misshapen fruit, hail damage, trim bruise, decay, scab, insect damage, York spot, bitter pit, and internal breakdown. With the exception of decay and internal breakdown (along with certain types of insect damage) which cause the apples to be classified as culls, the presence of any of these defects cause the affected fruits to be downgraded to U.S #2 or ciders, which means they receive the juice price (Table 1). Seven of these defects were observed in the samples of 'York Imperial' and five in 'Rome Beauty' and 'Golden Delicious'. Descriptive statistics for the apple processing data for each of the quality factors is given by variety in Table 2.

Size breakdown was determined by running the sample over standard sizing chains. Size is important in processing apples because large apples have less a smaller percentage of waste (peel and core) than smaller apples. Some of the factors which influence fruit size include variety, rootstock, fertility, crop load, and water availability. In the sample, 51% of the apples by weight fell into the 2.75" and up size class, 39% were in the 2.5" to <2.75" range, 9% fell in the 2.25" to <2.5" class, and less than 1% were less than 2.25" in diameter. Size varied greatly between the three varieties with over 72% of 'Rome Beauty' apples falling in the 2.75" and up class compared to only 49% of 'York Imperial' and less than 35% of 'Golden Delicious'.

Misshapen apples are those that cannot be cored or peeled properly with machine operation. Misshapen fruit is most often the result of poor pollination. Because most apple varieties are not self-fertile, they require cross-pollination from other apple varieties. Poor pollination can be caused by a number of factors including an insufficient number of compatible pollinizers in the orchard, insufficient number of bees for pollination, or poor weather conditions. In the sample, 0.6% of the fruit by weight was downgraded because it was misshapen. In the sample, misshapen fruit was most common in 'Golden Delicious' and least common in 'York Imperial'.

Hail damage can be of two types, only one of which causes fruit to be downgraded. Hail marks which are superficial and will be removed by peeling are ignored. Apples with old hail marks with healed, broken skin and dry, corky tissue are downgraded to ciders. In the sample, less than one-tenth of one percent of the apples by weight had hail damage which caused them to be downgraded to ciders. Hail damage varied between the three varieties from none in the 'York Imperial' to 0.2% in the 'Rome Beauty'.

Trim bruise is a defect which is scored on a waste basis. For U.S #1 apples, up to 5% trim waste is acceptable. From a pricing standpoint only the U.S. #1 standard is important because trim waste in excess of 5% causes the apples to be downgraded and receive the juice price (Table 1). Trim bruise in excess of 5% averaged 1.13% by weight across all the samples. There were no downgrades for trim bruise in 'Rome Beauty', but an average of over 1.5% of apples by weight were discounted for both 'York Imperial' and 'Golden Delicious'.

Decay or rotting of apples in the orchard is known as bitter rot, black rot, or white rot depending on the causal organism. In storages, blue mold and alternaria rot are the chief diseases which cause decay in apples. In the sample, decay averaged 0.139% of the apples by weight. 'York Imperial' had the least decay at 0.092% and 'Golden Delicious' had the most at 0.164%.

Apple scab is Pennsylvania's most important apple disease. Cool, wet springs help foster the development of the apple scab fungus, which initially attacks young leaves and can infect the fruit at anytime during its development. The severity of scab infections can be reduced by applying fungicides at regular intervals throughout the season, with the most critical time being from bud emergence to petal fall. Apple scab can cause both yield and quality losses. Severe infection of the fruit stem can cause fruit drop, while the disease on the fruit causes lesions, which on heavily infected fruit may result in misshapen fruit or cracking. In the sample, less than 0.2% of the apples by weight were downgraded due to scab. No scab was observed in any of the 'Rome Beauty' samples. The samples of 'York Imperial' had an average of 0.05% scab by weight and 'Golden Delicious' had 0.5% on average.

Insect damage can be caused by any number of insect pests. In Pennsylvania, the most serious insect pest of fresh market apples is the tufted apple bud moth. Generally, bud moth injury does not reduce the grade of processing apples, but it can affect the storability of affected apples by promoting decay. Codling moth is a potentially more serious pest in processing apples because the damage caused results in the classification of the affected apples as culls. In the sample, less than 0.03% of the apples by weight were downgraded because of insect damage. Insect damage was only evident in samples of 'York Imperial'.

York spots or corking are dead areas in the flesh of apples that start to develop early in the season and are related to low levels of calcium. By harvest the spots can be up to one-quarter of an inch in diameter and if they are close to the surface of the apple they result in a depressed area over the spot. York spot was found only to a limited extent in the samples of 'York Imperial'.

Bitter pit is a physiological disorder of apples in which discolored corky areas form beneath the skin in the flesh of the apple. Bitter pit is caused by calcium deficiency, often brought on by moisture stress. Bitter pit caused downgrades in 0.5% of the apples by weight. The samples of 'Rome Beauty' had the most bitter pit at 1.3% by weight, while none was found in any of the samples of 'Golden Delicious'.

Internal breakdown is characterized by the breaking down and browning of the interior of the apple. It is most often associated with the end of storage life in apples, but can occur earlier following water core (a physiological disorder associated with advancing maturity of apples), freezing, severe bruising, or as the result of certain growing, handling, or storage practices. Any apples showing internal breakdown are downgraded to culls. Internal breakdown was present only in some samples of 'Rome Beauty' apples.

Procedures

Hedonic price functions are regressions of the form (Lucas):

$$P_i = f(V_{i1}, \ldots, V_{iJ} ; u_i)$$

where P_i is the observed price of commodity i, V_{ij} is the amount of quality factor j per unit of commodity i, and u_i is the disturbance term. This type of model could be derived from a mathematical programming model by assuming that for the case of apple processor they choose apples which maximize profit subject to their production technology and a cost constraint. For commodities that are continuously variable with respect to quality characteristics, this interpretation implies a linear model for the hedonic function (Ladd and Martin). Because the data set used in this study contains only cross-sectional data, no adjustments for price differences over time are required. The estimated processing apple hedonic price equation is a linear function of:

$$P_{Apples} = f(\text{variety, size, fresh market bruise, defects}; u_i)$$

where the effect of the 3 varieties, 4 size classes, presence of more than 10% bruise (fresh market bruise standard for the premium price class), and 9 quality defects will be considered.

Results

The estimated coefficients for the processing apple hedonic price model are presented in Table 3. The coefficients represent the premiums or discounts (in $/unit/cwt.) associated with each quality factor. Of the fifteen quality factors considered in the model, eleven have estimated coefficients significantly different

from zero at the 5% level and fourteen are of the expected sign. The high R^2 and significant F statistic indicate that a large proportion of the observed variation in price is explained by the model. In order to avoid a singular matrix, no dummy variable was used for 'York Imperial' and the variable for the 2.5"to <2.75" size class was dropped from the model . By dropping the 2.5" to <2.75" class, the premium associated with large apples (2.75" and up) and the discounts associated with small apples (less than 2.5") were determined.

As expected from knowledge of the price structure detailed in Table 1, significant price discounts exist when marketing either 'Rome Beauty' ($2.14/cwt.) or 'Golden Delicious' ($1.17/cwt.) apples for processing. If the 'York Imperial' remains the benchmark on which other processing varieties are judged, the discounts associated with other varieties will continue. This premium may influence producers to maintain present 'York Imperial' acreage in the short run or replant with 'York Imperial' in the long-run. The apple producer in making replanting decisions, however, must also consider yield potential, size breakdown, and marketing alternatives. Varieties such as 'Rome Beauty' and 'Golden Delicious' are dual purpose varieties, meaning they can be sold on the fresh or processing markets, while the 'York Imperial' is strictly a processing apple. In addition, the widespread use of 'Golden Delicious' as a pollinizer for other apple varieties will see its continued use as a processing variety despite its lower relative price.

The dummy variable for fresh market bruise (FRESHBRUZ =1 if fresh market bruise is greater than 10%, 0 otherwise), in conjunction with the size variables, attempts to quantify the discount that would change the sample of either 'York Imperial' or 'Golden Delicious' from the "premium" price class to the "regular" price class (see Table 1). The discount of $0.83/cwt. is a significant incentive to try and keep fresh market bruise within the 10% tolerance. In the data set, however, only 4% of the samples had fresh market bruise which exceeded this tolerance.

Discounts for defects were significant for five of the nine defects observed. The discounts varied from a low of $0.057 for each percent change in bitter pit to a high of $0.164 for decay. Other defects with significant discounts were misshapen apples ($0.122 per one percent change), trim bruise ($0.087), and internal breakdown ($0.109). Because decay and internal breakdown are normally storage related defects, producers who deliver their crop at harvest to the processor would be less concerned about these quality factors. Those who store apples for later sale should balance the higher prices of later delivery not only with the cost of storage, but also with the possible discounts associated with these types of storage related defects and loss of weight due to shrinkage. For the producer delivering at harvest, therefore, only three defects are of interest: misshapen apples, bitter pit, and trim bruise. No significant discounts were found for such intensively managed defects as apple scab and insect damage. This indicates that additional efforts to manage these factors would not improve the price received. Whether the present level of management for insects and scab is excessive can not be answered with this data, only that additional efforts will not improve net returns. Defects associated with hail and York spot were not found to have significant discounts for the small number of observations and limited range in the sample.

The most important factor in the processing apple hedonic price equation was size. As is readily apparent from the three step price classification, medium and large U.S. #1 apples are given higher processing prices while small apples, regardless of grade, are paid much lower juice prices. For each one percent increase in the weight of apples less than 2.25" in diameter, price fell by $0.131 per cwt. A discount of $0.038/cwt. applies for a one percent increase in apples 2.25 to <2.5" in diameter. Conversely, a premium of $0.014/cwt. was found to apply for each one percent increase in apples larger than 2.75" in diameter.

The value of the individual quality factors per cwt. of apples is given in Table 4. The value of the quality factors were calculated by using the mean values from Table 2 with the estimated coefficients for the hedonic price model to arrive at the value per cwt. From this it can be seen how the premiums and discounts associated with size dwarf the other quality factors, none of whose discounts amount to more than $0.10 per cwt for each one percent change. Because most management practices apply to the treatment of an orchard block rather than to a cwt. of apples, the discounts were also calculated on an acre basis in Table 5. One hundred cwt. increments are used in Table 5 to cover a wide range of orchard productivities. As would be expected, the value of the discounts per acre increases as yields increase. Although the estimation of the costs of managing the individual quality factors has not been undertaken in the present paper, the magnitude of losses due to certain of the quality factors indicates the potential for increasing net returns by reducing their occurrence.

Summary and Implications

The purpose of this study was to quantify the discounts and premiums associated with various quality factors for processing apples. This type of information will be used to help apple producers prioritize management practices and allocate limited resources. Discounts and premiums were estimated using a hedonic price model estimated from quality data collected on 137 samples of three processing apple varieties (45 'York Imperial', 43 'Rome Beauty', and 49 'Golden Delicious'). Results indicate statistically significant price discounts existed in the sample for apple size, bruise, bitter pit, decay, misshapen apples, and internal breakdown. Commonly cited defects such as insect damage and apple scab did not cause significant price discounts. These results indicate that cultural factors including pruning, fertility, thinning, and pollination may merit more consideration in producing quality processing apples than additional efforts at insect or disease management. As evidenced by discounts for fresh market and trim bruise, decay, and internal breakdown, improved post-harvest handling and storage management techniques for growers or processors who store fruit.may also be of value. Attention to improving quality will not only improve the prices received by the producer for the raw product, but will also improve processing efficiency.

By linking quality discounts and premiums with the costs of managing specific quality factors, management practices and resources can be more efficiently allocated by the grower. Economic decisions regarding management practices affecting quality attributes should be evaluated on the basis of their cost per marginal unit of control relative to the associated marginal returns (Grant, Rister, and Brorsen). A marginal approach is necessary because absolute control of the causes of poor quality is generally recognized as infeasible due to the diminishing marginal productivity of additional levels of inputs, which at some point will cause the cost associated with an additional unit of management to exceed its benefit. The next step in this research will be to identify the potential causes of processing apple defects and identify alternative management practices and their costs of implementation.

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Table 1. Price Schedule for Processing Apples, 1990[1]

Apple Variety, Grade, and Size	$/Cwt.
Premium[2,3] York Imperial	
U.S. #1, 2.75" up	12.00
U.S. #1, 2.5" to <2.75"	9.50
Others[4]	4.75
Regular York Imperial	
U.S. #1, 2.75" up	11.00
U.S. #1, 2.5" to <2.75"	9.00
Others[4]	4.75
Premium[2,3] Golden Delicious	
U.S. #1, 2.75" up	11.00
U.S. #1, 2.5" to <2.75"	8.75
Others[4]	4.75
Regular Golden Delicious	
U.S. #1, 2.75" up	9.25
U.S. #1, 2.5" to <2.75"	7.25
Others[4]	4.75
Firm[3] Rome Beauty	
U.S. #1, 2.75" up	9.50
U.S. #1, 2.5" to <2.75"	7.50
Others[4]	4.75

Notes:

[1] Knouse Foods Cooperative, Inc., Final 1990-91 Apple Prices (6/26/91)

[2] To receive the premium price classification, the apples must have no more bruise than allowed in a U.S. #1 fresh market apple (10%) and be 90% U.S. #1, 2.25" up.

[3]To receive the premium or firm classification the apples must must pressure test at 16 psi or greater. For the present analysis, a pressure test of 16 psi or higher was assumed for all the samples.

[4]Others include U.S. #1 less than 2.25", U.S. #2, and ciders. Culls are discarded.

Table 2. Descriptive Statistics for the Processing Apple Data

Variable[1]	All Apple Varieties Mean	Std. Dev.	York Mean	Rome Mean	Golden Mean
PRICE	8.837	1.071	9.927	8.646	8.250
FRESHBRUZ	0.038	0.188	0.022	0.000	0.082
MISSHAPEN	0.574	1.306	0.021	0.402	1.234
HAIL	0.096	0.557	0.000	0.238	.0600
TRIMBRUZ	1.126	2.414	1.533	0.000	1.737
DECAY	0.139	0.716	0.092	0.160	0.164
SCAB	0.169	0.831	0.051	0.000	0.426
INSECT	0.028	0.233	0.085	0.000	0.000
YORKSPOT	0.009	0.107	0.028	0.000	0.000
BITTERPIT	0.521	1.690	0.379	1.263	0.000
BREAKDOWN	0.158	0.694	0.000	0.502	0.000
VERY SMALL	0.380	0.989	0.593	0.181	0.358
SMALL	9.458	8.682	10.863	3.721	13.202
MEDIUM	38.967	17.129	39.299	24.009	51.789
LARGE	51.195	23.577	49.245	72.089	34.651

Notes:

[1]The variables are defined as follows:

PRICE = sample price ($/cwt.)
FRESHBRUZ = proportion of samples with >10% bruise by fresh market standards
MISSHAPEN = percent of fruit by weight downgraded because it was misshapen
HAIL = percent of fruit by weight downgraded because of hail damage
TRIMBRUZ = percent of fruit by weight downgraded because of trim bruise
DECAY = percent of fruit by weight downgraded because of decay
SCAB = percent of fruit by weight downgraded because of scab
INSECT = percent of fruit by weight downgraded because of insect damage
YORKSPOT = percent of fruit by weight downgraded because of York spot
BITTERPIT = percent of fruit by weight downgraded because of bitter pit
BREAKDOWN = percent of fruit by weight downgraded because of internal breakdown
VERY SMALL = percent of apples less than 2.25" in diameter
SMALL = percent of apples 2.25" to <2.5" in diameter
MEDIUM = percent of apples 2.5" to <2.75" in diameter
LARGE = percent of apples greater than 2.75" in diameter

Table 3. Processing Apple Hedonic Price Model

Independent Variable[1]	Estimate[2]
Intercept	9.924* (.244)
ROME	-2.138* (.108)
GOLD	-1.170* (.109)
FRESHBRUZ	-0.832* (.202)
MISSHAPEN	-0.122* (.032)
HAIL	-0.030 (.064)
TRIMBRUZ	-0.087* (.016)
DECAY	-0.164* (.050)
SCAB	-0.084 (.054)
INSECT	-0.062 (.154)
YORKSPOT	0.123 (.336)
BITTERPIT	-0.057* (.022)
BREAKDOWN	-0.109* (.053)
VERY SMALL	-0.131* (.040)
SMALL	-0.038* (.008)
LARGE	0.014* (.003)

$R^2 = .873$ $\bar{R}^2 = .857$ $F = 55.39$

Notes:

[1]See Table 2 for a description of the quality variables. In addition:

ROME = 1 if the apple variety is 'Rome Beauty', 0 otherwise
GOLD = 1 if the apple variety is 'Golden Delicious', 0 otherwise

The intercept value is based on the variety 'York Imperial' and the 2.5"-2.75" size class.

[2]Standard errors are in parentheses and asterisks denote significance at the 5% level.

Table 4. Value of Apple Processing Quality Factors ($/cwt.)

Variable	All Apple Varieties ($/cwt.)	Apple Variety: York Imperial ($/cwt.)	Rome Beauty ($/cwt.)	Golden Del. ($/cwt.)
FRESHBRUZ	-0.03	-0.02	0.00	-0.07
MISSHAPEN	-0.07	0.00	-0.05	-0.15
HAIL	0.00	0.00	-0.01	0.00
TRIMBRUZ	-0.10	-0.13	0.00	-0.15
DECAY	-0.02	-0.02	-0.03	-0.03
SCAB	-0.01	0.00	0.00	-0.04
INSECT	0.00	-0.01	0.00	0.00
YORKSPOT	0.00	0.00	0.00	0.00
BITTERPIT	-0.03	-0.02	-0.07	0.00
BREAKDOWN	-0.02	0.00	-0.05	0.00
VERY SMALL	-0.05	-0.08	-0.02	-0.05
SMALL	-0.36	-0.41	-0.14	-0.50
LARGE	0.72	0.69	1.01	0.49
PRICE (estimated)	$8.86	$9.93	$8.42	$8.26

Note: For a description of the variables see Table 2.
Values calculated using the means from table 2 and the coeffiecents of the model listed in table 3.
Italicized variables were not found to be statistically different from zero at the 5% level of significance

Table 5. Value of Apple Processing Quality Factors ($/acre)

Variable	Yield 100 cwt./A ($/acre)	 200 cwt./A ($/acre)	 300 cwt./A ($/acre)	 400 cwt./A ($/acre)	 500 cwt./A ($/acre)
FRESHBRUZ	-$3.16	-$6.32	-$9.48	-$12.65	-$15.81
MISSHAPEN	-$7.00	-$14.01	-$21.01	-$28.01	-$35.01
HAIL	-$0.29	-$0.58	-$0.86	-$1.15	-$1.44
TRIMBRUZ	-$9.80	-$19.59	-$29.39	-$39.18	-$48.98
DECAY	-$2.28	-$4.56	-$6.84	-$9.12	-$11.40
SCAB	-$1.42	-$2.84	-$4.26	-$5.68	-$7.10
INSECT	-$0.17	-$0.35	-$0.52	-$0.69	-$0.87
YORKSPOT	$0.11	$0.22	$0.33	$0.44	$0.55
BITTERPIT	-$2.97	-$5.94	-$8.91	-$11.88	-$14.85
BREAKDOWN	-$1.72	-$3.44	-$5.17	-$6.89	-$8.61
VERY SMALL	-$4.98	-$9.96	-$14.93	-$19.91	-$24.89
SMALL	-$35.94	-$71.88	-$107.82	-$143.76	-$179.70
LARGE	$71.67	$143.35	$215.02	$286.69	$358.37

Note: For a description of the variables see Table 2.
Per acre figures calculated using the discounts/premiums associated with all apple varieties in Table 4.
Italicized variables were not found to be statistically different from zero at the 5% level of significance

Automated Inspection of Produce

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Abstract

Research in the Departments of Agricultural Engineering, Mechanical Engineering, and Horticulture at The Pennsylvania State University is emphasizing the development of an automated inspection system using digital images and artificial intelligence techniques. The use of both color and monochromatic systems provides much promise for the development of automated inspection stations. A primary consideration is that the system must be inexpensive enough to be attractive as an alternative to manual inspection. Beginning in 1989, two computer vision systems were procured and installed. Procedures are being developed for evaluating size, shape, color, and some defects in apples, potatoes, and mushrooms. Significant research thresholds have been achieved in the application of color vision systems to fruit and vegetable inspection. Techniques are also being established for using statistical extraction procedures and "neural networks" for enumerating "quality" features. Work is continuing on the incorporation of these algorithms and techniques into an automated inspection station.

Introduction

The inspection and grading of produce by hand is a labor intensive and subjective task. Human inspection involves viewing the product and assigning quality scores for defective or undesirable items. In addition to being costly, this method is highly variable and decisions are not always consistent between "inspectors" or "graders" or from day-to-day. Recently there has developed an increasing awareness of the difficulty of hiring seasonal personnel who are adequately trained and willing to undertake the tedious task of inspection. In this context, inspection refers to the assignment of a "grade" category based on a sample of fruit or vegetables. This inspection is not intended to be real-time sorting or separation.

When making inspection decisions, factors such as size, shape, cleanliness, maturity, injury or damage, external defects, and disease must be taken into account. The inspection and grading process is based on standards such as the United States Department of Agriculture Standards for Grades of Potatoes (United States Department of Agriculture, 1972). These standards are useful in identifying general grade categories but do not always provide sufficient information for the packer or processor to be able to properly reward producers for quality products. An objective measurement of the surface quality of a given

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lot of produce would be very useful. In order to assign the correct quality score, the operator must have information about physical quality parameters and the way in which the various parameters combine to affect the overall quality or grade.

Ongoing research at The Pennsylvania State University, University Park, PA USA, uses "computer vision" or "machine vision" for evaluating quality parameters such as size, shape, surface defects and injuries. This method allows cameras to take pictures of an object as it passes on a conveyor belt or freely falls through air. These pictures are then "digitized" and stored in a computer. Computer programs or algorithms are used to evaluate the quality parameters. A quality "score" can be calculated based on the combination of measured parameters. Information concerning the quality "score" is further processed by the same computer system using procedures commonly referred to as "artificial intelligence", "expert systems", or "neural networks".

Although many Agricultural Engineers are currently using machine vision and artificial intelligence approaches to automation and robotic problems, the approach being taken at The Pennsylvania State University has the following distinguishing features.

1. Major effort is devoted to inspection rather than sorting applications.
2. Apples, potatoes, and mushrooms are being studied simultaneously.
3. Both color and monochromatic vision systems are being used.
4. Both "MS-DOS" and "Macintosh" computer platforms are being used.
5. Machine vision and artificial intelligence concepts are being combined.
6. A statistical approach is being taken towards feature recognition.
7. In the color system, the HSI rather than RGB domain is being used.

Although not intended to be an exhaustive survey, the reader is referred to the following related works dealing with machine vision applications. Marchant, et. al, 1988, and McClure, 1988 report work dealing with computer vision sorting of potatoes. Sarker and Wolfe, 1985, Rehkugler and Throop, 1985, Tang et. al, 1989, Taylor and Rehkugler, 1985, and Wright et. al, 1984 all report on machine vision techniques applied to sorting and grading of fruit and vegetables. More recently, Searcy and Reid, 1989, Dowell, 1990, Delwiche et. al, 1990, and Shearer and Payne, 1990 discuss the use of color systems for automated sorting of fruits and vegetables. The reader is also referred to the list of Penn State publications which is appended to this report.

Automated Inspection Research Station

Both "386 MS-DOS" and "Apple Macintosh" computers are being used in conjunction with commercial color and monochromatic frame grabber boards. The "MS-DOS" machine is used with a color vision system and the "Macintosh" system is used with a monochromatic vision system. Preliminary trials use the color system for developing inspection algorithms for apples and potatoes and the monochromatic system for mushrooms.

Color System

The configuration of the color inspection station is shown in Figure 1. The camera for generating the color image signals is a Sony XC-711 CCD color camera which provides three separate RGB signals. It has 510(H) x 492(V) pixel elements and a horizontal resolution of 320 TV lines. A D.O.Industry 18-105mm F2.5 TV zoom lens is mounted on the camera . The image is digitized by a Data Translation DT2871 color image frame grabber and stored in three of four 512 x 512 x 8 bit frame buffers on board in either RGB or HSI (Hue, Saturation, and Intensity) formats with software selection and hardware conversion. There is 1MB (four buffers) of on-board memory. A grabber captures and displays color images at 30 frames per second. The digitized image is displayed on a Sony PVM-1342Q Trinitron color RGB high resolution monitor (600 TV lines horizontal) for viewing the image during the research development stage.

The image acquisition, processing and analysis are supported by an Everex Step 80386/25 MHz desktop computer. It is equipped with an Intel 80387/25 MHz math coprocessor, 2MB RAM memory and 128K RAM Cache for fast computation. A 16 bit Paradise VGA card and a Zenith VGA flat screen monitor are used for graphic and text information about images. The AURORA subroutine library supports the DT2871 color image frame grabber. This subroutine library provides basic functions for image acquisition and processing. A DT2858 Image Frame Processor is used to perform some image processing functions by hardware. This allows relatively high speed image processing. The direct connection of the DT2858 frame processor board to the DT2871 frame grabber overcomes the slowness of the image data transfer via the computer bus, and hence, enhances the speed of the processing for the DT2858 supported functions. The Microsoft C programming lanquage is used for function calls and program development and will eventually be used for mechanical sorter controls.

Color is a very important attribute for grading fruits and vegetables. Many machine vision applications have been limited because of the inability of previous systems to recognize color as humans perceive it. Color video information is generally displayed as combinations of red, green and blue light. Humans do not perceive color as combinations of red, green and blue but as exhibiting three distinct attributes, namely, hue, intensity, and saturation. These three attributes are independent of each other. Hue represents the true color, red, orange, yellow. Saturation represents the dilution of hue with white. Intensity represents the relative brightness or the shade of gray. With the advent of image grabber boards which can convert the RGB format to the HSI format in real time, many exciting possibilities exist in the area of sorting and grading of fruits and vegetables.

Monochromatic System

A monochromatic inspection station is being developed primarily for mushroom inspection. A Macintosh II CI computer is being used as the primary computational facility in this station. A QuickCapture frame grabber card, manufactured by Data Translation acquires the images for the mushrooms. Image analysis routines for processing the captured image have been extracted from the United States National Institute of Health's Image 1.6 program, which provides Pascal source code files. Currently, source code for the routines of interest is being customized to this particular application. An algorithm to acquire the image and quantitatively analyze the information contained in the image is being written. The next step will be to develop an expert system, using C library functions, to compare the image to a set of qualitative and quantitative inspection criteria and assign an inspection grade to the mushroom sample.

Lighting structure and material handling

Good illumination of the objects is essential to a vision system. For vision inspection, a lighting scheme should provide uniform illumination and exposure features on the surfaces of the product. A lighting system for fruit, vegetable, and mushroom inspection is being used as shown in Figure 1. The system has a hemicylindrical lighting chamber made by lattice-patterned sheet metal 60 cm in diameter. The interior surface of the chamber is painted flat white to provide diffuse light reflection. The product is placed on a V-trough (120 degree) at the bottom center of the chamber. Four fluorescent light tubes are placed inside the chamber and directed towards the cylindrical surface. This lighting scheme provides uniform illumination on the product surface without glare. One window is open on each side (120 degrees apart) of the cylindrical chamber for allowing cameras to observe the product in the trough. The cameras can see about 70% of the product surface. More than 70% of the object's surface and more accurate observation of length and width information can be achieved by rotating the product in the trough and taking multi-images. The rotation can be achieved automatically by placing two parallel belts moving axially along the chamer at different speeds in the trough .

Methodology

Automated inspection of fruits and vegetables requires image processing, feature extraction or recognition, and grade determination. A general procedure for inspection and grading shown in Figure 2 includes both low level and high level image processing. A knowledge-based model structure is being developed and used to supervise image processing and grading decisions. Low level image processing performs primitive processing on the image including filtering, gray-level thresholding, enhancement and basic segmentation. This processing is to obtain a clear image in a desired form and expose features for feature extraction. High-level image processing performs tasks of segmentation and merging, feature identification and extraction, and feature information compression. Based on the feature extracted, image interpretation and grade decisions for some products and conditions can be made at this level. A knowledge-based control structure provides a supervisor mostly for high-level image processing. Heuristic and basic rules can help with feature extraction and recognition. Fast and accurate results can be obtained by choosing shortcuts, eliminating redundant processing and dynamically changing program behavior by applying proper rules in the control strategy.

Work on automated inspection has been on-going at the Pennsylvania State University since 1989. Brief examples will be given of progress being made on the development of methodology for inspecting apples, potatoes, and mushrooms.

Apples

Apple grades are established based on parameters such as size, shape, maturity, color, and defects. Preliminary efforts in the inspection of apples have been devoted to the evaluation of color as an indication of apple maturity. Conventionally, color is reported in percentages. In manual inspection, the color of Golden Delicious for U.S. Extra Fancy and U.S. Fancy must have 75% or more of the apple surface showing white or light green predominating over green. Manual inspection of color is a very subjective procedure.

The DT2871 image grabber converts RS-170/RGB video signals from digitized red, green and blue values in to 256 values of hue, 256 values of saturation, and 256 values of intensity (HSI). In that Hue represents the "true color" of an object, the subjective evaluation of color in manual inspection of apples can be eliminated by analysis of a hue histogram. The hue histogram of an image is the distribution of hue values of pixels in the image. For Golden Delicious apples the hue values fall in the 30 to 46 range. For a green apple 75% or more of the hue values lie in the 41-46 range. For a nearly mature apple, 75% or more of the hue values lie in the 38-41 range and for a yellow mature apple, 75% or more of the hue values lie in the 32-37 range. A statistical analysis of hue information can then match the apple to one of the four USDA grades for color.

An object can be isolated using a multilevel hue threshold. For Golden Delicious apples this threshold lies within the 30-46 hue range. A blue background was chosen since its hue values lie in the 168-172 range. The hue range for background was very different from the hue range of the apple so that the image of the apple can be easily segmented. With hue segmentation the size of the apple can be calibrated by taking the sum of all pixels in the 30-46 range. An example of normalized hue histograms is shown in Figure 3. These histograms have been normalized to eliminate the effect of size of the apples. As can be clearly seen in Figure 3, hue histograms provide an excellent technique for determining maturity (color) levels for apples.

Work is continuing on the characterization of shape and defects in apples. Preliminary results indicate a high correlation between apple shapes detected by the computer vision system and by manual inspection. It is also possible to detect selected surface defects such as russeting, cuts, and punctures with the automated system. Bruising continues to be a difficulty parameter to correctly evaluate.

Potatoes

Grade evaluation for a potato must take into account such parameters as size, shape, disease, mechanical injury, greening,and cracks. Initial efforts at establishing a methodology for automated inspection of potatoes have concentrated on the development of techniques for detecting greening, a condition which results when potatoes are exposed to sunlight prior to being harvested.

Color representation in the hue domain provides unique identification of color. Detection of greening of potatoes has also been studied by using hue histogram information. It has been found that hue values for the greening part of potatoes falls within 31 to 45 although the hue value for pure green is around 85. Hue histograms for good and greened potatoes as averaged over 30 and 40 samples are given in Figure 4. These histograms have been normalized to account for varying sizes of potatoes. Hue histogram values have been treated as features to distinguish greening from non-greening potatoes. Notice that the hue 31 to 45 in Figure 4 have a higher magnitude for the greening than non-greening potatoes. One method for identifying greening is by using direct thresholding over the hue histogram for green values in the range of 31 to 45. The size or area of greening on a potato can be determined from the number of pixels obtained from the thresholding. Results show that the method is simple and fast. However, the presence of noise can affect the determination of the greening size for some black spot pixels may fall in the same range of green hue.

Another method used for greening detection is statistical discriminant analysis. It is expected that clusters between good and greening potatoes in the feature space are separable. Figure 5 shows a two-dimensional feature plot of the clusters of green and non-green sample potatoes. It is found that the two clusters for green and non-green potatoes are primarily separable in the feature space. By training with examples, the discriminant program can generate criteria for separating the clusters and classifying the new samples. Tests of the method of discriminant analysis have been performed by taking hue histogram as features and training the programs by samples. Results from using linear discriminant function analysis show 100% correctness of the determination of the greening and non-greening clusters. Results from nearest neighbors show about 99% correctness for non-greening and 85% correctness of greening determination varying in thresholding values applied. Further study of greening determination will concentrate on the optimal feature or hue range selection so that efficient and fast processing can be achieved through the minimum number of hue features and maximum ability of greening detection.

Mushrooms

For mushrooms, the primary inspection objective is to develop a rule base of inspection criteria based on standards currently used at mushroom production facilities. This would include size, shape, color, and cap openness. The initial step in mushroom grading has been to determine a criteria for "color" evaluation. Intensity histograms are currently being studied to determine what constitutes a fresh or degraded mushroom. Normalized histograms in Figure 6 depict the intensity levels (monochromatic) of the top view of a mushroom. The mushroom depicted on day 1 was freshly cut, and hence shows a peak toward the bright (white) end of the intensity scale. As the mushroom degrades, brown or gray areas begin to appear, and the mushroom begins to take on a darker cast. This is shown as a shift to the right and a reduction in the peak as depicted on day two and day three histograms. This method appears to be very promising for color grading using a monochromatic system.

Conclusions

The use of both color and monochromatic vision systems provides much promise for the development of automated inspection stations. The anticipated outcome of this research will be the development of inspection equipment that can be readily transported between fruit and vegetable packing and processing facilities. A primary consideration is that the system must be inexpensive enough to be attractive as an alternative to manual inspection. Speed of image acquisition and processing is a secondary consideration since only a sample is being evaluated rather than a mass of fruits or vegetables at a particular location.

The next stages of this research will continue to emphasize the development of statistical algorithms and procedures in the HSI domain. Primary emphasis is currently being placed on the integration of various features into the assignment of an overall "quality" grade. Statistical feature extraction and neural network techniques are being compared for suitability for assignment of the overall grade..

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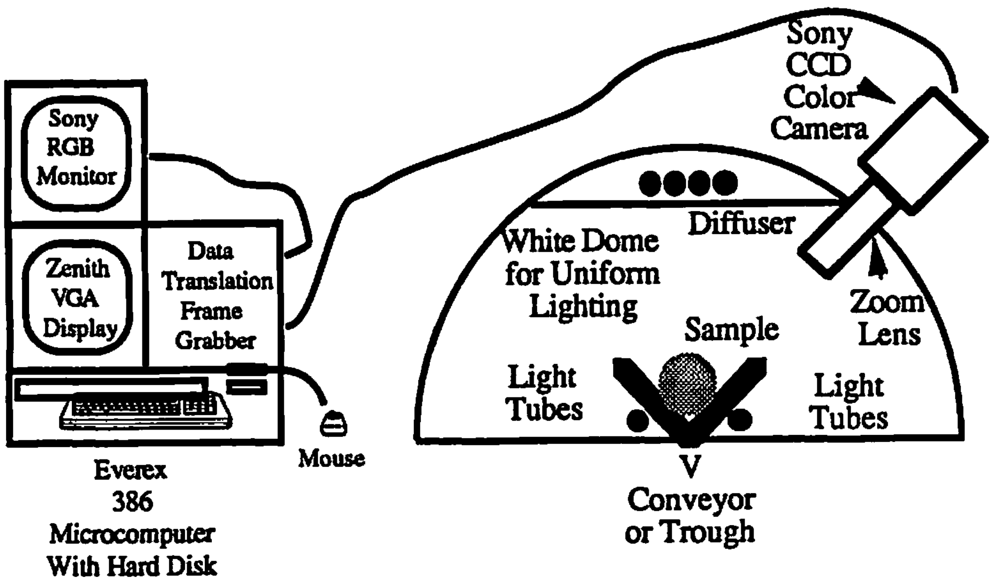

Figure 1. Schematic Layout of Automated Inspection Station

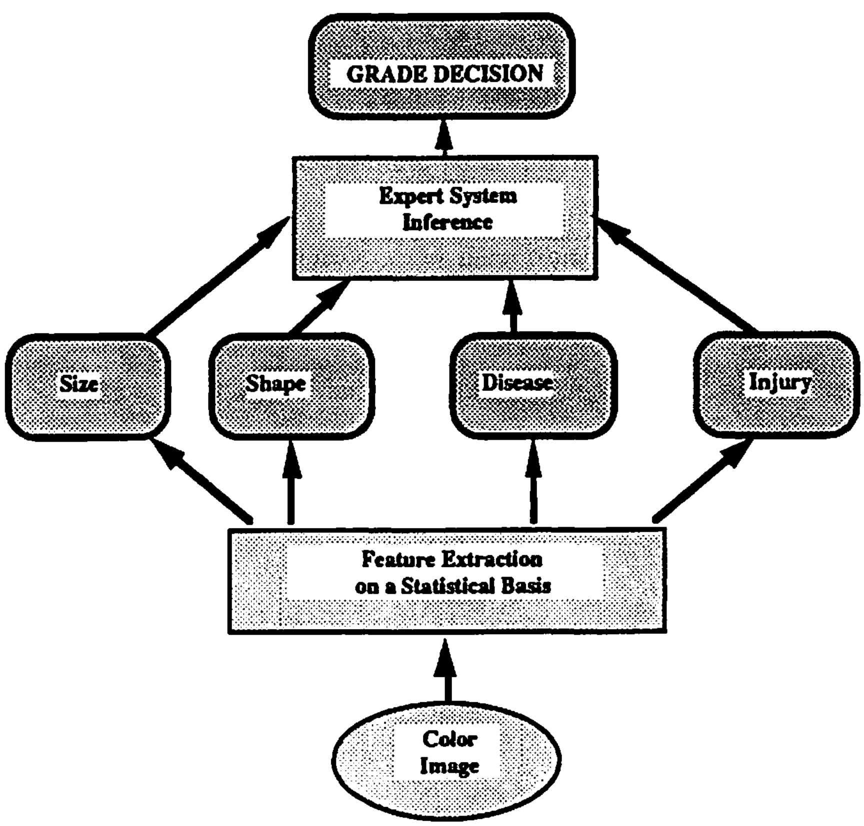

Figure 2. Methodology for Establishing Grades

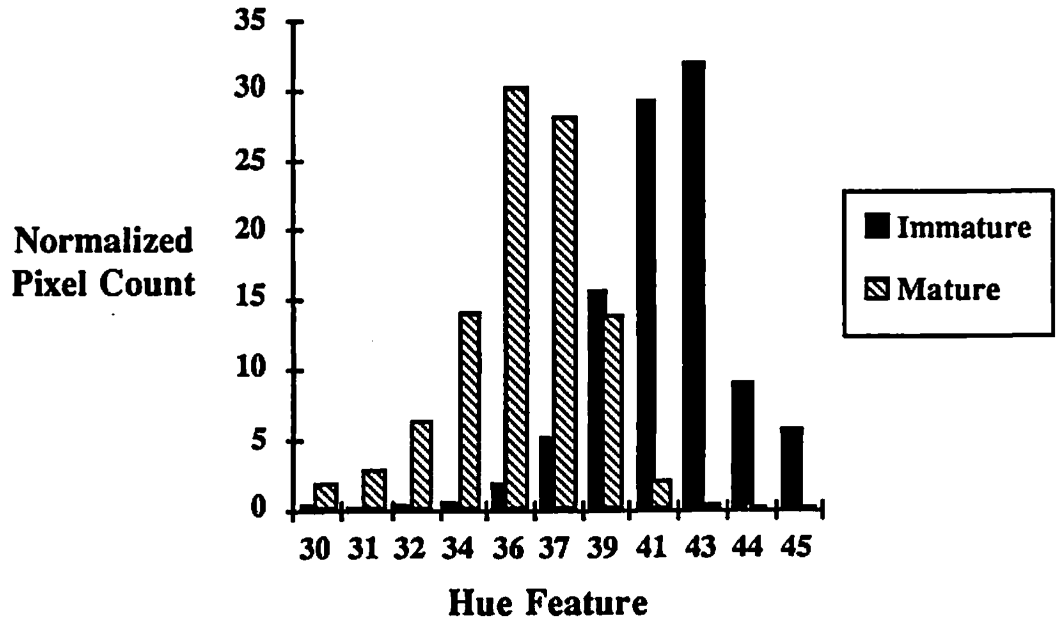

Figure 3. Normalized Hue Histograms for Maturity of Apples

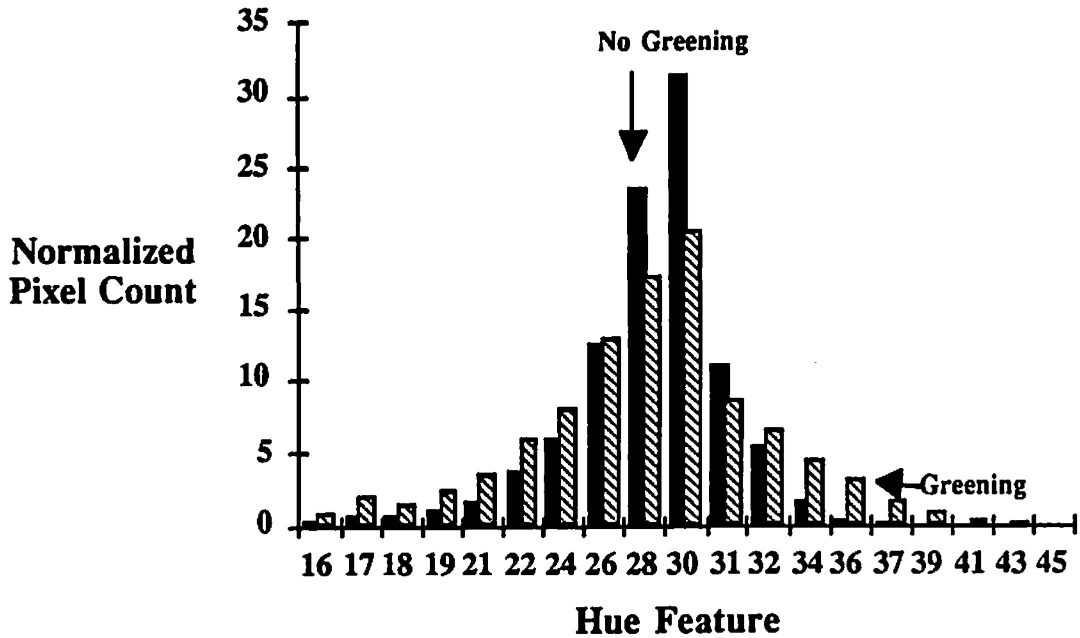

Figure 4. Normalized Hue Histogram for "Greening" of Potatoes

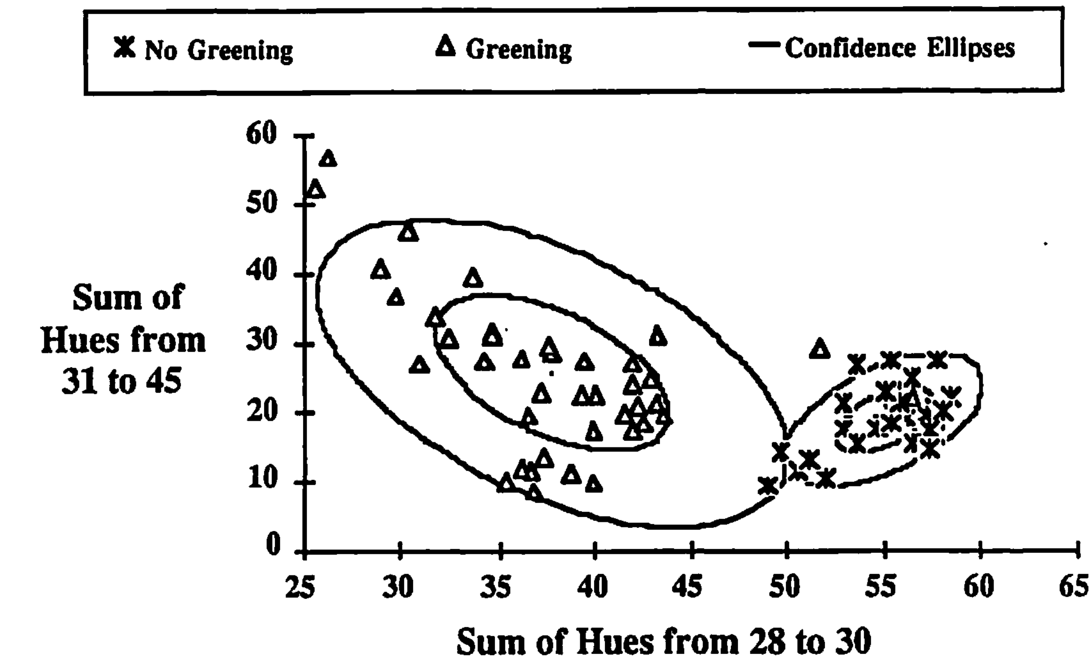

Figure 5. Hue Clusters for Detecting "Greening" in Potatoes

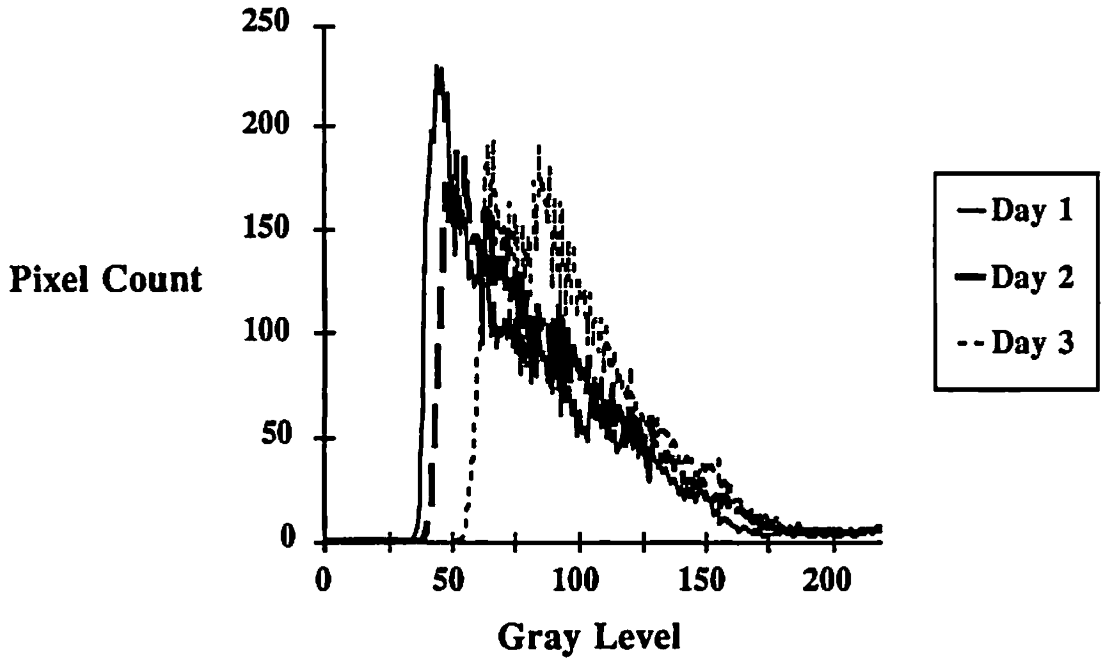

Figure 6. Gray Level Variation in a Mushroom Over Time

1992 Pennsylvania Apple Calcium Spray Recommendations

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The effective use of calcium chloride tree sprays may be the single most cost effective, rapid, cultural practice that will reduce the incidence of low calcium physiological disorders in apples. In the past we have recommended the application of 15 - 50 pounds per acre per season of 77-80 % flake calcium chloride. We have recognized that calcium chloride can increase corrosion so we have recommended that application equipment be throughly washed following use. Recently several new sources of calcium have been made available and are becoming popular. Several of these have been indequately tested and some of them contain very low levels of calcium. On the other hand some of them are comparable to our standard material. In an effort to increase the level of understanding about the various sources of calcium we have reviewed technical information sheets on most of the available calcium spray materials.

Table 1 contains a list of many materials that supply calcium with their analysis and other revevent information.

For 1992 we have changed our recommendations in view of the increased number of materials available. We recommend 4.0 to 14.0 pounds of actual Ca per acre per season applied in the 6 to 8 cover sprays normally used in the eastern US. These rates have proven to be effective in tests around the world depending on the severity of the problem. We recommend applying Ca in the form of $CaCl_2$ due to its proven effectiveness and low cost (Table 2).

Table 2 Recommended calcium sources for apple sprays.

Calcium product	Dilute rate/ 100 gal	Rate/ Sprayed A
CaB'y	21-43 fl oz	2-4 qt
$CaCl_2$ 77-80% flake	0.6-2.1 lb	1.8-6.2 lb
$CaCl_2$ 35% liquid	15-53 fl oz	1.4-5.0 qt
COR-CLEAR DRY FOLIAR CAL.	0.5-1.7 lb	1.5-5.1 lb
MORA-LEAF CALCIUM	0.5-1.7 lb	1.5-5.1 lb
PIT-STOP DRY CONC. FOL. CAL.	0.5-1.8 lb	1.6-5.5 lb
PIT-STOP FOLIAR CALCIUM	16-55 fl oz	1.5-5.2 qt
STCPIT CALCIUM CONCENTRATE	21-43 fl oz	2-4 qt
TRACO PIT-CAL LIQ. CALCIUM	15-53 fl oz	1.4-5.0 qt

Most other materials have undergone only limited or have been shown to be less effective than calcium chloride. There are other products available that supply Ca but many of these formulations are recommended at rates that supply lower amounts of Ca. These products may be beneficial but only when small amounts of calcium are needed to correct the deficiency.

To effectively evaluate the materials you should compare the cost per pound of actual calcium and the amount of the formulation needed to achieve the 4.0 to 14.0 lb of actual calcium per acre per season needed to control problems.

Select the rate of calcium needed to minimize corking, bitter pit, and other calcium deficiency fruit disorders under your specific conditions. Growers experiencing severe bitter pit on summer cultivars, especially "Summer Rambo", may need to apply special calcium sprays in addition to the cover sprays.

Table 1 Calcium materials for use on apples with details on labelled rates per acre per application, per acre per season and calcium rates per acre per year.

Product name	Percent calcium	Pounds/ gallon	Pounds of calcium/ gal or lb	Manufacturer	Product/ acre/spray min.-max.	Number of appli.	Total product acre/season min.-max.	Total calcium/ acre/season lbs min.-max.
CaB	6.0	10.0	.60	Stoller, Inc. 1-800-255-9548	3-6 pints	8	3-6 gal	1.8-3.6
CaB'y	10.0	11.9	1.19	Stoller, Inc. 1-800-255-9548	2-4 qt.	8	4-8 gal	4.8-9.5
calcium chloride (77-80% $CaCl_2$)	27.8	flakes	.28	many	1.8-6.2 lb	8	14.3-50 lb	4.0-14
calcium chloride (35% $CaCl_2$ liquid)	12.6	11.3	1.42	many	.35-1.24 gal	8	2.8-9.9 gal.	4.0-14
COR-CLEAR DRY FOLIAR CALCIUM	34.5	beads	.34	SEGO Intl., Inc. 503-796-0133	4-8 lbs	8	32-64 lbs	10.9-21.8
FOLICAL	10.0	9.6	0.96	Agrimar Corp. 1-800-284-9898	1 gal.	6-8	6-8 gal.	5.8-7.7
FUNG-AID	10.0	11.9	1.19	Stoller, Inc. 1-800-255-9548	2-4 qt.	8-15	5.5-8.2 gal	6.5-9.7
LINK CALCIUM 6%	6.0	10.3	.62	Wilbur-Ellis Co. 509-248-6171	2-4 qts.	4	2-4 gal.	1.2-2.5
MORA-LEAF CALCIUM (94% $CaCl_2$)	34.0	DRY	.34	Wilbur-Ellis Co. 509-248-6171	4-8 lbs	3-6	12-48	4.1-16.3
NUTRI-CAL 8% CALCIUM SOLUTION	8.0	11.1	.89	CSI Chemical Corp 1-800-247-2480	1-2 qts.	3-8	.75-4.0 gal.	.67-3.6
NUTRA-PHOS TEN	10.0	powder	.10	Leffingwell Div. 1-800-262-3861	3-10 lbs	2-6	20-40 lbs	2-4
NUTRA-PHOS 12	11.0	powder	.11	Leffingwell Div. 1-800-262-3861	3-10 lbs	2-6	20-40 lbs	2.2-4.4
NUTRA-PHOS 24	20.0	powder	.20	Leffingwell Div. 1-800-262-3861	3-10 lbs	2-6	20-40 lbs	4-8
NUTRA-PHOS Mg	10.0	powder	.10	Leffingwell Div. 1-800-262-3861	3-10 lbs	2-6	20-40 lbs	2-4

Table 1 continued

Product name	Percent calcium	Pounds/ gallon	Pounds of calcium/ gal or lb	Manufacturer	Product/ acre/spray min.-max.	Number of appli.	Total product acre/season min.-max.	Total calcium/ acre/season lbs min.-max.
NUTRA-PLUS CAL-GARD	6.0	10.0	0.60	Custom Chemicides 209-264-0441	1-3 qts.	8-11	2-8.2 gal.	1.2-4.9
PIT-STOP DRY CON. FOLIAR. CAL 32.5%	32.5	dry	0.32	Ag-Chem, Inc 301-548-2200	4-8 lbs.	4-6	16-48 lbs	5.2-15.6
PIT-STOP FOLIAR CALCIUM 12%	12.0	11.3	1.35	Ag-Chem, Inc 301-548-2200	1.5 gal.	4-6	6-9 gal.	8.1-12.1
SETT	8.0	11.4	.91	Stoller, Inc. 1-800-255-9548	1 gal.	8-11	8-11 gal	7.3-10.0
SORBA-SPRAY Ca	8.0	10.75	0.86	Leffingwell Div. 1-800-262-3861	1-4 qts.	4-5	1-5 gal.	0.9-4.3
SORBA-SPRAY CaB	5.0	10.0	0.50	Leffingwell Div. 1-800-262-3861	1-4 qts.	4-5	1-5 gal.	0.5-2.5
STOPIT CALCIUM CONCENTRATE	12.0	10.7	1.28	Shield-Brite Div 206-827-8717	2-4 qts.	8-11	4-11 gal.	5.1-14.1
TRACITE Calcium 6%	6.0	10.0	0.60	Helena Chem. Co. 901-748-3200	3-6 pts.	8	3-6 gal.	1.8-3.5
TRACO PIT-CAL LIQUID CALCIUM	12.0	11.7	1.40	Traylor Chem. Co. 1-800-348-3361	0.5-2 gal.	7	3.5-14 gal.	4.9-19.6
Wuxal Calcium	10.7	13.3	1.42	AGLUKON Div. 1-800-832-8788	3-4 pts	5	1.9-2.5 gal.	2.7-3.6

Shade and shoot vigor affect bud necrosis in 'Riesling' Grapevines

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Introduction

Bud necrosis has been detected in grapes in Virginia since 1988. The bud necrosis (BN) appears as an abortion of the developing buds of shoots sometime after bloom. The buds become necrotic well before the advent of cold weather in the fall. The necrosis is often limited to the primary bud of the compound dormant bud, but occasionally it affects all primordia. Crops are significantly reduced in affected vineyards. Our surveys of Virginia vineyards have indicated that the winegrape variety Riesling is most severely affected by BN, but that other varieties can show symptoms.

The symptoms of BN observed in Virginia were similar to those described with table grapes in Israel (Lavee et al., 1981); research there suggested that the rate of shoot growth (vigor) was positively correlated with the incidence of BN. The Israeli work also indicated that elevated gibberellin levels in the vine could be responsible for the BN (Lavee, 1987). Recent research in Chile and California has indicated that either natural or artificial shoot shading can also increase the incidence of BN (Perez and Kliewer, 1990).

Materials and methods

1990 survey: We initiated a formal survey of BN in 1990. Our objectives were to determine if there were consistent variables from vineyard to vineyard that the disorder could be related to. Variables examined included time of occurrence (July vs. November), vine size, shoot/cane vigor, rootstock, degree of shoot shading, node position on the shoot/cane, tissue elemental analysis, and topography of the vineyard (high areas vs. low areas). Five vineyards were examined and 25 to 50 shoots were examined in each vineyard. At the time of survey, information was recorded on each shoot examined, per the above criteria. Buds at nodes one through 20 were then sectioned with a razor and examined for BN. Symptoms were readily apparent in the November survey and consisted of a browning of the normally green bud primordia. Drying of the buds had also occurred in severe cases. Buds were rated as either dead or alive.

Effect of artificial shade and shoot thinning: An experiment was conducted during the 1991 growing season to determine the role of natural and artificial canopy shade in affecting BN incidence. The experimental units were mature Riesling vines. Four treatments were compared: (1) vines were shoot-thinned to approximately 10 shoots per meter of row; (2) shoot thinning, as in treatment 1, plus application of shade cloth above the vine canopy; (3) vines left unthinned (approximately 20 shoots per meter of row); and (4) no shoot thinning, plus application of shade cloth. The rationale for treatments was that either the artificial shade cloth or the relatively dense plant canopy produced by no shoot thinning should increase BN if low light levels were involved in the disorder. Shoot thinning was done shortly after fruit set. The artificial shade cloth, which reduced photon flux density about 60%, was installed and retained over the plant canopy in the three-week period just before the time of rapid fruit maturation. The shade cloth was supported above the vine canopy so that foliage was shaded without contact between the shade cloth and foliage. Ten vines or replicates were used for each treatment in a completely randomized design. BN had been assessed in this vineyard in January 1991 and was found to be at a uniform 20% throughout. Buds were examined on five shoots per vine in October 1991. Buds were sectioned with a razor and rated as dead or alive on the basis of browning or drying.

1991 survey: Three Riesling vineyards were reexamined for BN incidence in 1991. Light levels in the canopy as well as shoot vigor were quantified in these surveys. The 1991 surveys were conducted in August and early September. During surveys, shoots were selected on the basis of their relative sky exposure (exposed *vs*. shaded). Photosynthetic photon flux densities (PPFD) were then measured at shoot nodes 5 and 10, as well as above the vine canopy (to maximize reading). Those measures were used to calculate the average percent of available PPFD received by nodes 5 and 10. The shoots were then removed from the vine and the diameter of the stem between nodes one and two was recorded, as was the total length of the first 20 nodes and internodes. Diameter and mean internode length provide measures of shoot vigor. Buds of the first 20 nodes were then sectioned and rated for BN. Twenty to 30 shoots were examined within each exposure category.

Effect of shoot growth rate: An effort was made to quantify the role of shoot vigor on BN incidence in one Riesling vineyard during the 1991 growing season. Shoots of Riesling vines were tagged near bloom-time and the shoot length measured. Total shoot length measurements were repeated twice. Growth rates were expressed as cm of extension per day for the period from 23 May to 10 June. Measurements were made on three shoots per vine and 50 vines for a total of 150 measures. The same shoots (buds one through 20) were evaluated for BN incidence in October 1991 by sectioning buds and examining for browning or drying.

Results and discussion

1990 survey: BN was detected in Riesling vineyards as early as the July survey. Large vines and vigorous shoots (large diameter and internode length) typically had a greater incidence of BN than did weaker vines and shoots (data not shown). We found a consistent pattern, in both the July and November surveys, of decreased BN incidence in the basal one to four nodes. Data from one vineyard, representative of the findings in all five, are shown in Figure 1. The pattern of greater bud survival in the basal nodes argues for spur-pruning of BN-affected vines in order to increase the percentage of viable buds. The pattern of BN incidence is opposite to that reported in Israel, Chile, and California.

The data of Figure 1 also illustrate that rootstock affected BN incidence. 5BB was associated with the greatest BN incidence among the three stocks examined. 5BB rootstocks are described as "vigorous." The rootstock effect observed here is thought to be indirect; the larger vine produced by the 5BB rootstock would likely have more shaded shoots, or shoots that grow more vigorously than the other two rootstocks examined.

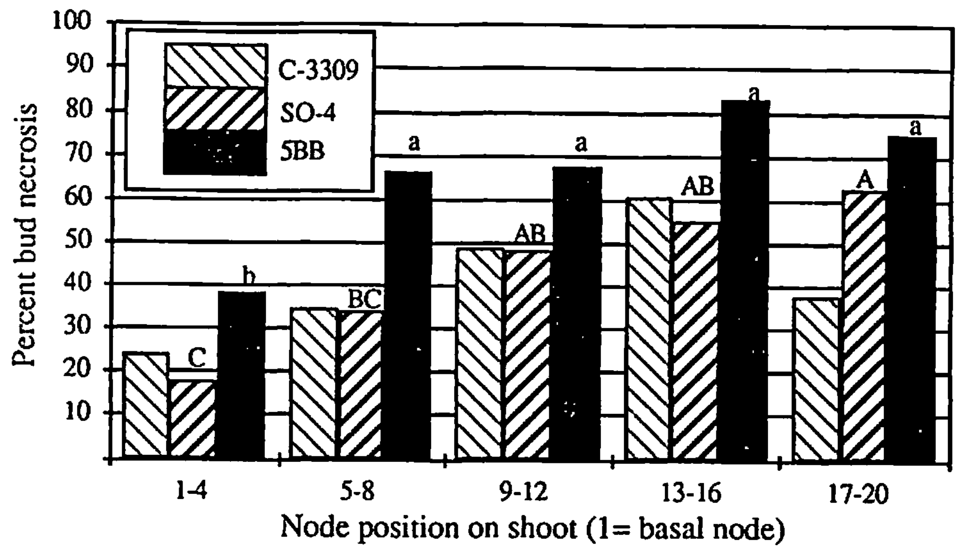

Figure 1. Effect of rootstock (C-3309, SO-4, or 5BB) and node position on shoot on the incidence of bud necrosis in Riesling grapevines. Data were collected 7 November 1990 from a vineyard in which Riesling were planted to several rootstocks in adjacent blocks. Letters above bars indicate the significance of node position ($p \leq 0.05$) effects for rootstock SO-4 (uppercase) and rootstock 5BB (lower case). Bud necrosis incidence did not differ significantly among node positions for rootstock C-3309.

There was no evidence that any of the other variables examined had a bearing on BN incidence. Buds have also been examined for insects and disease, with no signs of either consistently present.

Effect of artificial shade and shoot thinning:

The percentage of BN measured among the first 20 nodes of shoots was unaffected by leaving shoots unthinned or by artificial shade, when either was used separately (Table 1). BN was increased, however, by the combination of no shoot thinning plus application of shade cloth. The combination of no shoot thinning plus artificial shade reduced the percentage of PPFD in the vine canopy to less than one percent. Apparently the combination of artificial shade cloth and thinning of shoots allowed enough PPFD in the vine canopy to avoid an increase in BN. We did not reduce BN by shoot thinning alone, even though PPFD in the vine canopies was increased greatly over no shoot thinning. At least two possible reasons exist for that response. First, it's possible that shade only aggravates a more fundamental problem and that the improvement of light conditions in the vine will reduce BN incidence only so much. Secondly, shoot thinning tends to accelerate shoot growth rates. Rapid shoot growth, as shown below, tends to increase BN incidence. Thus, the potential reduction in BN achieved by shoot thinning might have been offset by an increase due to accelerated shoot growth rate. From a practical standpoint, the shading experiment does suggest that canopy management should aim to minimize canopy shade to reduce the impact of BN.

Table 1. Effects of artificial shade and shoot thinning on four measures of canopy density and percent bud necrosis of Riesling grapevines.

Treatment	Percent PPFD[w]	Leaf layers[x]	Percent gaps[y]	Shoots per m row	Percent bud necrosis[z]
Shoot thinned	11.6 A	1.3 C	20 A	9.5 B	38 B
Shade + shoot thinned	4.7 B	1.7 B	12 B	9.8 B	38 B
No shade, no thinning	1.9 BC	3.3 A	1 C	20.4 A	38 B
Shade + no thinning	0.2 C	3.3 A	0 C	20.8 A	72 A

[w] Percent photosynthetic photon flux density (µmols•m^2•s) measured within vine canopies and relative to PPFD measured above both the vine and artificial shade.

[x] Average number of leaf contacts in a transectional analysis of canopy density.

[y] Average number of canopy gaps (spaces) in a transectional analysis of canopy density.

[z] Bud necrosis assessed on the first 20 nodes of five shoots per vine.

1991 survey: The relationship between shoot exposure and BN incidence is also shown by the data of Table 2. The percentage of BN in at least two of the vineyards was greater when shoots were sampled from shaded (interior) portions of the canopy compared to when shoots were sampled from exterior or exposed locations. The lack of an exposure effect at Naked Mt. vineyard might be due to a delay in shoot positioning at that vineyard. Shoots that appeared well exposed in late-summer might have experienced a transient period of shade earlier in the summer that could have precipitated the events leading to BN. Overall, there was considerable variability from shoot-to-shoot and vine-to-vine with respect to BN incidence: some shoots that were well exposed still had a significant proportion of dead buds. It is, of course, difficult to define the exposure history of a shoot on the basis of a single light measurement. Nevertheless, the trend with these data suggest that shade does at least increase the incidence of BN in BN-sensitive vineyards.

Effect of shoot growth rate: Early season shoot growth rate had a positive and significant effect on the incidence of BN measured on the same shoots near the end of summer (Figure 2).

Conclusion

Both shade and shoot vigor appear to increase the incidence of BN in Riesling grapevines. We do not know how these factors lead to BN. One possibility is that BN results from a senescence process initiated by low light or carbohydrate deprivation. Work in Israel (Lavee, 1987) suggested a possible role of endogenous gibberellin levels in the buds. From a practical perspective, vine canopy management that minimizes canopy shade without increasing shoot vigor would appear to be a prudent course in BN-sensitive varieties and vineyards. Furthermore, spur-pruning, rather than cane-pruning, should increase the proportion of viable buds retained at dormant pruning.

Table 2. Effect of shoot exposure on Riesling bud necrosis incidence.

Vineyard	Shoot exposure	Mean shoot diameter (mm)	Mean internode length (cm)	Percent PPFD[z]	Percent bud necrosis
Meredyth	Exposed	9.0 ± 1.3	4.9 ± 1.2	57 ± 15	2 ± 3
	Shaded	8.1 ± 1.6	6.8 ± 1.3	6 ± 3	22 ± 23
Somerset	Exposed	8.1 ± 1.5	4.8 ± 1.0	14 ± 11	20 ± 15
	Part. exposed	9.5 ± 1.0	6.3 ± 1.1	5 ± 2	41 ± 18
	Shaded	8.9 ± 2.1	6.4 ± 1.1	2 ± 2	63 ± 20
Naked Mt.	Exposed	8.8 ± 1.3	7.9 ± 1.3	17 ± 15	21 ± 16
	Shaded	8.5 ± 1.6	7.2 ± 1.4	5 ± 6	24 ± 19

[z] Photosynthetic photon flux density expressed as a percentage of total available PPFD above the vine canopy. PPFD values are an average of percent available at nodes 5 and 10. Units are μmols•m^2•s.

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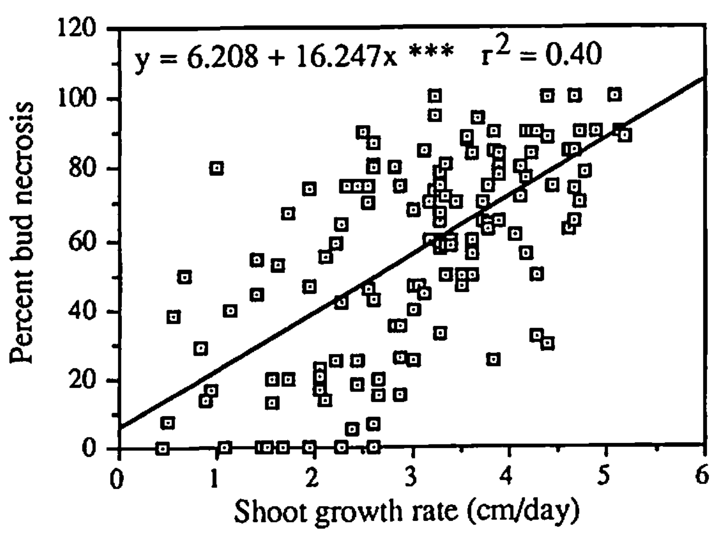

Figure 2. Relationship between shoot growth rate (23 May to 10 June) and BN incidence in early fall of the same shoots.

A Decision Support Program for the Design and Management of Frost Protection Systems

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ABSTRACT

A decision support system exists as a prototype and is being refined to assist managers with the development, implementation, and management of frost protection systems. The program is divided into four main modules: frost protection strategies, operational management, forecasting, and instrumentation. The frost protection strategies module includes summaries of methods, economic comparison of methods, risk partitioning, site selection, and design of heating, sprinkling, wind machine, and cover systems. The operational management assists with the operation of frost protection systems during a frost night. It includes sprinkler rates for undertree and overtree irrigation, heater requirements, and effectiveness of wind machines for a particular frost situation. The forecasting module includes both long term tools to determine "frost windows" or when a particular area is susceptible to frost, and short term tools to show how cold the temperatures will get during a particular night and the duration of those cold temperatures. The instrumentation module shows the user how to instrument a crop for frost detection, including location and types of sensors. The frost program is being designed to be an addition to other commodity management expert systems that have already been or are being developed, including The Penn State Apple Orchard Consultant, PeachES, and VITIS (viticulture management).

INTRODUCTION

Freezing temperatures are responsible for losses of fruit and vegetables each year in many parts of the United States. Frost protection methods exist but seem under-utilized in the face of these disastrous losses. There may be many reasons for the low percentage of growers using frost protection, including cost of implementation vs. payback and the management time involved. Some crops, such as citrus, can be devastated by a single freeze and take years to return to production levels. Other crops, such as deciduous tree fruits, can be completely destroyed although many return to the normal production levels the next year. Growers seem reluctant to implement frost protection measures, even if it can be shown that implementation of a frost protection system would pay for itself in reduced crop loss.

Much information is available on frost protection methodology and management, in the literature (Barfield and Gerber 1979; Martsolf, et al. 1984; Rieger, 1989; Barfield et al. 1991). Transferring and integrating this information into a computer program would assist with the frost protection management decision making process, and therefore reduce the management time and effort by the grower. Improving the efficiency of frost protection management would possibly increase the acceptance of these methods.

The objective of this project is to develop a frost protection decision support program that could be easily implemented and run on a computer by a fruit or vegetable crop manager. The initial effort would include planning, implementation, and management of frost protection systems, and would expand as new information about frost protection is found. The Frost program described in this paper used the artificial intelligence application of expert systems to assist with management support. Expert systems have recently become popular as a means of providing decision support in a form that can easily be used by managers. Some examples of agricultural applications of expert systems can be found in Flinn and Hagstrum, 1990, Davis and Clark, 1989, Crassweller et al., 1989, Travis et al., 1991, and Heinemann et al. 1991.

RELATIONSHIP WITH OTHER EXPERT SYSTEMS

The frost protection program described in this paper, although developed independently, is part of an overall management expert system development effort. Several expert systems for managing fruit crops have been developed, such as PSAOC (Crassweller et al. 1989; Travis et al. 1991) for apple orchards, VITIS for viticulture, and PeachES (Crassweller et al. 1990) for peach orchards. The frost protection expert system can be run in collaboration with these other programs, since it provides frost protection expertise for many fruits. Programs developed at other institutions may also potentially be used with the frost protection program.

Target Audience

The frost program is designed to be used by fruit growers, county agents, and consultants. A computer use survey done in Pennsylvania (Rajotte et al. 1989) indicates that in general, fruit growers are highly educated and computer literate, with well over 50% owning their own computers or using computers within their operation. Therefore, the growers were considered to be the target audience, i.e. those that would actually run the programs and implement the recommendations provided, which is consistent with the development of other fruit management expert systems developed at Penn State. Support and service personnel (extension agents and consultants) were also targeted as users of this system.

OVERALL SYSTEM STRUCTURE

The frost program is composed of four submodules, as shown in Figure 1. These four sections are: 1) strategies module, which includes planning, design, and implementation; 2) operations module, which includes the day-to-day management; 3) forecasting module, which includes both determination of climatological frost dates and short term forecasts; 4) instrumentation module, which includes selecting, calibrating, and locating instruments that detect frost conditions.

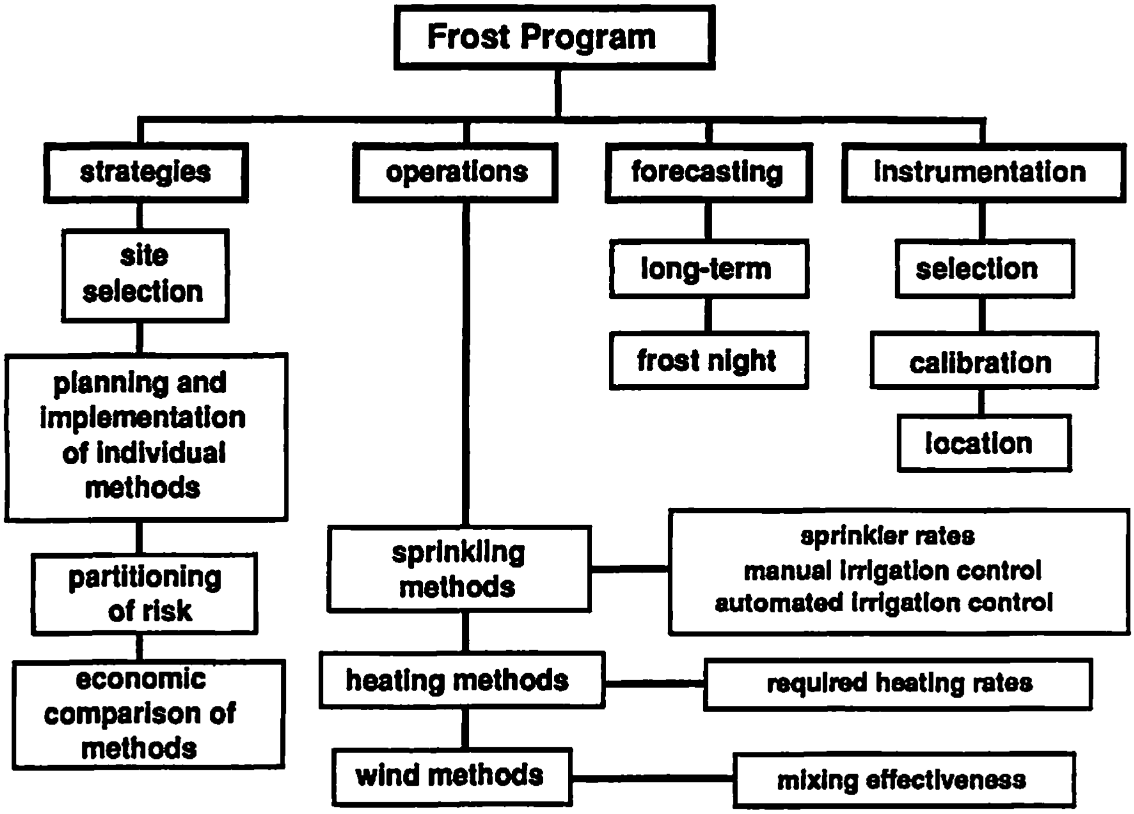

Figure 1. Structure of the frost protection expert system.

STRATEGIES

Frost protection strategies include the planning, design, and implementation of frost protection methods. The "best" system for any particular site is very dependent upon the site characteristics, the crop being grown, the value of the crop, etc. The "best" system may actually be a combination of methods. The user has the option of choosing site selection, risk partitioning, or determining the costs and effectiveness of various individual protection methods including sprinkling, heating, wind machines, and covers.

Site Selection

The most attractive method of frost protection is good site selection because it reduces, if not avoids, the remainder of the effort. If the user has a choice of sites or portions of a site on which to plant a crop, this section assists the user with determining which locations will have lower incidence of frosts and which will be more susceptible to frosts.

Planning and Implementation of Individual Methods

The user can choose assistance with the planning of individual protection systems, including sprinkling, heating, wind machines, and covers. Each module provides information regarding the principals behind the protection system, the advantages and disadvantages of each system, and potential costs for a grower's specific orchard or field.

A module to provide approximate costs of installing a stationary sprinkler system is included in the program. User inputs include sprinkler type, number of acres to be protected, interest charges on capital expenditures, cost of electricity, and percent of time the system is to be used for frost protection. Outputs include number of sprinklers, overall flow rate for system, costs of the system for different pipe sizes, and recommended pipe size based on least cost.

Modules are being developed to assist with design of heater systems, wind machines, and covers. The heater module will help with determining purchase costs, heater spacing, and provide information on types of heaters. The wind machine module will describe various aspects of wind machines for frost protection, including machine types, spacing, and estimated fuel consumption. The covers module will include information on protection methods that interfere with radiative heat loss from the plant canopy.

Risk Partitioning

The concept of risk partitioning is discussed by Martsolf (1990). Risk may be partitioned into several levels of intensity of management, i.e. resources committed. If environmental stress fails to materialize, the blocks in which minimal resources have been committed will reap the greatest profits. However, if a series of frosts or freezes develop there will be varying degrees of damage throughout the blocks depending on their site and the characteristics of the frost protection method employed in that block. The goal of the risk partitioning module is to assist the grower with determining how to partition the field or orchard so as to always have some portion of the crop protected in the event of a severe cold episode, without having to commit protection resources to the entire crop unless this commitment is economically feasible.

Economic Comparison of Frost Protection Systems.

The user can get a rough estimate of the costs involved with designing various frost protection systems. Inputs based on the user's production costs and field characteristics are requested by the program and recommendations are made regarding operational and capital costs of the systems.

A module was developed to compare the cost of frost protection methods based on the system design values. Information requested from the user for the purpose of economic comparisons is shown in Table 1. Based on these inputs, the program compares the potential costs and savings by each method. The irrigation system costs are based on the design determined by the optimization module, previously described. Example values are shown in Table 1, and results based on these example values are shown in Table 2. These compare favorably with economic analysis of actual frost protection systems for a 10 acre orchard documented by Castaldi (1990). Results of Castaldi's work are shown in the table for comparison.

Table 1. Inputs to economic comparison module and values for example farm.

input	units	range of values	example values
value of crop	$/acre	0 - 2000	1200
estimated annual loss from frost	%	0 - 100	50
cost of oil	$/gallon	0.00 - 2.00	1.10
cost of labor	$/hour	0.00-20.00	5.00
cost of stack heaters	$	0.00 - 50.00	28.00
cost of wind machine	$	0-20,000	16,000
sprinkler type (conventional or micro)			micro
acres to be protected	acres	1-100	10
length of irrigation main line	feet	1-1000	100
cost of electricity	$/kw-hr	0-20	0.08
percent of time system is used for frost	%	0-100	25
riser heights (crop dependent)	feet	1-10	9

Table 2. Results of economic comparison module example, compared to values found in literature.

	Frost Program Economic Comparison			Literature Values (Castaldi, 1991)		
method	capital cost (annualized)	annual operational costs	total costs	capital cost (annualized)	annual operational costs	total costs
heaters	$844	$6900	$7744	$2885	$6500	$9385
sprinklers	$1210	$643	$1854*	$790	$388	$1178*
wind machines	$1608	$597	$2205	$1685	$421	$2106

*based on 25% use for frost protection

OPERATIONS

Frost protection operations include the management of resources and decision making that occurs on a particular frost night. The resources include the water and fuels used during protection, and decisions include when to initiate a method operation, how much of a resource is necessary for adequate protection, and when to terminate method operation.

Sprinkling methods

Sprinkler application rates for protecting the crop using irrigation are determined from the application rate model FROSTPRO (Perry, 1986). FROSTPRO is based on the energy balance of a flower bud exposed to cold temperatures, and determines the amount of heat released by the freezing water to keep the flower buds above the critical temperature. The model requires input of air temperature, wind speed, and relative humidity. The original model requested the plant part size and the critical temperatures from the user. The user had to measure the plant part in the field and find the critical temperature from the literature. The critical temperature and bud size are determined by stage of development within the frost management expert system which eliminates time spent finding this information.

The frost protection expert system makes better use of the models than the conventional approach of providing the environmental information from the field at the beginning of the night and then running the system based on those inputs. The program allows either the manager (for manual control) or the computer (for automated control) to respond to changing conditions as they occur. This results in closer control of the situation which lessens water use and lowers the probability of undersprinkling.

Certain information is included in the program that was not found in the original FROSTPRO model. For example, there is a characteristic length used by the model that describes the plant part being protected, such as a closed flower bud or a small berry. This length is very dependent upon the crop type and stage of development. The critical temperature is also dependent upon the phenological stage and crop variety. Originally, the user had to find these values in the literature. In the expert system, these values (which are based upon the literature) are determined by selecting the stage of development and variety.

Undertree sprinkling application rates are in development, based on undertree sprinkling models (Davies et al. 1988). Further refinement of this module to fit within the framework of the frost protection expert system continues.

Sprinkling Operations Decision Support

Protecting a crop from spring frosts using sprinkling requires more than just measurement of environmental parameters. Sprinkling has the potential of doing more damage to a crop than other methods if done incorrectly. Therefore, the decision to turn on a sprinkler irrigation frost protection system is usually based upon a combination of frost protection management experience, some degree of knowledge of the physics of the situation, and knowledge of the particular site in question. All of this information is needed to make a correct decision regarding when to initiate sprinkling, how much water to apply, and when to turn off sprinkling.

Using water more efficiently requires even greater control of the sprinkling system. Water can be saved by delaying sprinkler initiation until just before damaging temperatures are reached. The water can be pulsed (e.g. 2 minutes on, two minutes off) to conserve water. However, in order to prevent accidentally cooling the plants to below damaging temperatures, an understanding of the relationships between the environment, the water, and the plant, must be included in the control system.

The sprinkling can either be controlled manually or automatically. The manual control module includes rules that assist the grower in making control decisions. The grower can either use the conventional approach of just turning the water on at a certain temperature threshold and turning it off after the temperatures have warmed up in the morning, or manage the system more closely in order to save water. If the grower chooses the more controlled approach, the system recommends when to turn the system on, how to implement pulsing cycles and what the cycles should be, and when to turn off, based on environmental conditions entered by the grower.

The automated control section integrates the monitoring, management, and control strategies into a single module that is completely controlled by the computer (Heinemann et al. 1990; Stombaugh et al. 1990). The flow and structure of the automated irrigation control program is shown in Figure 2. The program includes modules that perform essential functions. A knowledge-based system that combined previous management experience and the physics of the environment was written into the irrigation system control program. Although the control section of the program would have to be customized to each particular field or orchard if the user decides to implement it, an example is given here based on work by Stombaugh et al. (1990).

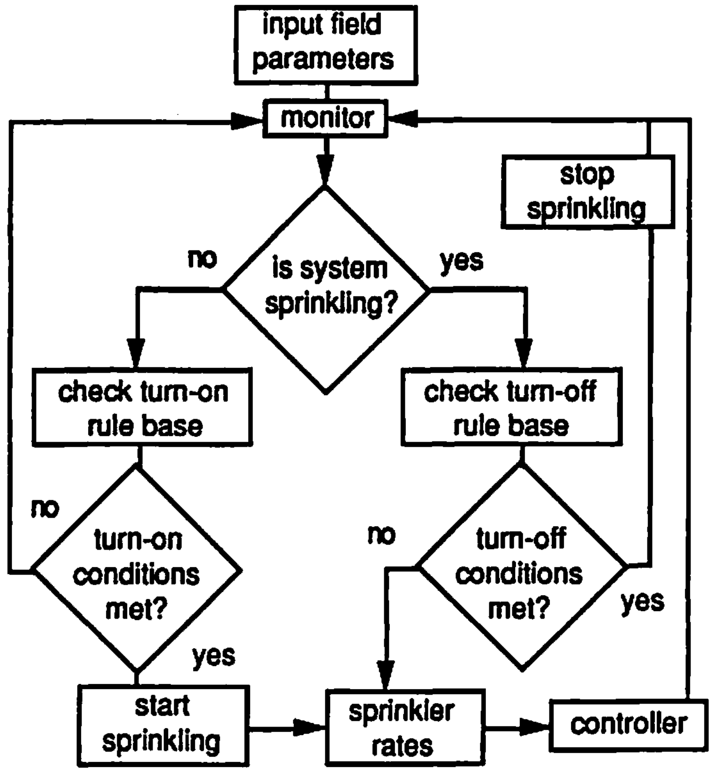

Figure 2. Flow diagram of the frost protection automated irrigation control program.

The program is driven from a menu that is presented when the program is first run. The user must first enter information about the stage of development of the plants, since the critical temperature and plant part size increase as the flower buds develop. The user can then initiate the automated control module. Environmental parameters such as air, plant canopy, and bud temperature, wind speed, and relative humidity, are sampled by the monitoring module. The interval at which these samplings are taken can be set by the user if desired, otherwise the parameters are sampled at a default rate of once every 30 seconds.

After each sampling is made, the measured values are passed to a rule base so that the decision to initiate sprinkling can be made. If the conditions are right, then the program will make the decision that sprinkling should be initiated. For example, if the air temperature has reached 32 F, and the wind speed is less than 5 mph, and the critical temperature is 30 degrees, then the sprinklers should be turned on. If conditions are not met, the program will return to the monitoring module and sampling will continue.

If the decision is made to turn on the sprinklers, then sprinkler rates and pulsing cycles must be established. The application rate is determined by sending the critical temperature and environmental conditions to FROSTPRO. The model is based on the flower bud energy balance, so it ensures that enough water will be applied in order to keep the bud temperatures near the freezing point. The pulsing cycles maintain the proper application rate without having to vary the water flow. The off time of the pulsing cycle is short enough to ensure that there will always be some liquid water on the plants. An example of a pulsing cycle would be 90 seconds on, 120 seconds off.

The application rate information is passed to the control module. This module sends signals from the computer to the valve controls so that the valves will open and close. Monitoring of the environmental conditions continues. As long as potentially damaging conditions remain, the program will continue to protect the plants with irrigation. When the temperatures rise sufficiently so that no damage is likely to occur, the decision is made to turn off the sprinklers.

The automated irrigation control system consists of three main hardware components: the computer, the data acquisition equipment, and the controllers. The computer serves to gather information, process information, make decisions, and control the sprinkler system to assure that frost damage would not occur.

The effectiveness of the automated system in controlling the irrigation and reducing water use can be demonstrated from results of a system test during a frost night in October, 1991. The strawberry plants were sprinkled using three different sprinkler types: "Naan" microsprinklers, which produce an umbrella-shaped pattern by spinning at a high speed; "Dan" microsprinklers, which emit a jet of water at a rotation of about 10-20 rpm; "Rainbird" impact type sprinklers that were used in a plot that was controlled using conventional manual methods. Since buds were not present, thermocouples were inserted into the strawberry plant leaves. The automated system controlled the sprinklers closely in response to the changing environmental conditions, and the sprinkled plot leaf temperatures never dropped below the critical temperature (-1.1 C). The results of water savings are shown in Table 3. The temperatures that occurred during this particular night were considered to be severe (minimum temperature of -5.5 C) for a Pennsylvania frost. The results indicate that even under these conditions a savings of 20-25% in water use can be realized.

Table 3. Water use during October 21, 1991 frost event.

sprinkler type	total time on (min)	water use (gal./acre)	percent water use of conventional approach
rainbird	805.0	35289.1	100
naan	286.5	26455.5	75
Dan	325.0	28828.8	82

Heating and Wind Operations

The heating and wind machine operations modules are in development. Some of the goals of these modules are to assist with management of heater and wind frost protection systems during the actual events, including description of the principles behind these methods, assistance with when to implement protection, heating and air mixing requirements, and projected fuel costs.

FROST PREDICTION

The weather prediction module has two functions. The climate module provides a "frost window" for the user to determine the times when frost is a problem and the likelihood of frost occurring on or after a certain date in the spring or before a certain date in the fall. The probability of temperatures dropping below thresholds of 32, 28, 24, and 20 F are included in a file for any given location within the state of Pennsylvania. These thresholds are available at a 1 km resolution for any location within the United States[1].

The module checks the current date and then determines the probability of frost temperatures occurring on or after that date by comparing the location and date with the frost probability file. The user is presented with a table showing the threshold temperatures and the probability of those thresholds being reached (Table 4). The example shown in the table was from Adams County in southcentral Pennsylvania on April 15, which is about the middle of the spring frost season for that location. The table shows the the probability of

[1]Probability information provided by ZedX, Inc., Box 404, Boalsburg, PA .

each threshold minimum temperature occurring on or later than the current date. For example, temperatures dropping below 24 F after April 15 will occur only once in about 20 years (6% probability).

Table 4. Example of climate module output. Location is Biglerville, Adams County, Pennsylvania; date is April 15.

SPRING FROST PROBABILITY

Frost Probabilities for location
39.82 degrees north, 77.25 degrees west.

The following table indicates the probability of temperatures occuring below the listed thresholds on or after 4/15/91

32	28	24	20	Temperature Threshold (degrees F)
79	33	6	1	Probabilities (percent)

The second part of the prediction module is for short-term, site-specific forecasts. These forecasts are tailored to a particular farm or orchard and show how the frost night will progress over time. The short-term prediction model is based on work done by Heinemann and Martsolf (1988) and Kelley et al. (1988). The goal of this module is to assist with management during the frost night by showing how the temperature progresses with time during the frost event. The user is first provided with a listing of the critical temperature (based on variety and stage of development), minimum predicted temperature, duration of temperatures below the critical value, and whether or not the duration is long enough to warrant frost protection measures. An example of the prediction showing how the temperature changes with time is shown in Figure 3.

The critical temperature and critical time lines are displayed on the graph so that the user can visually get a sense of when the temperatures will approach critical values and how long they will be below that value.

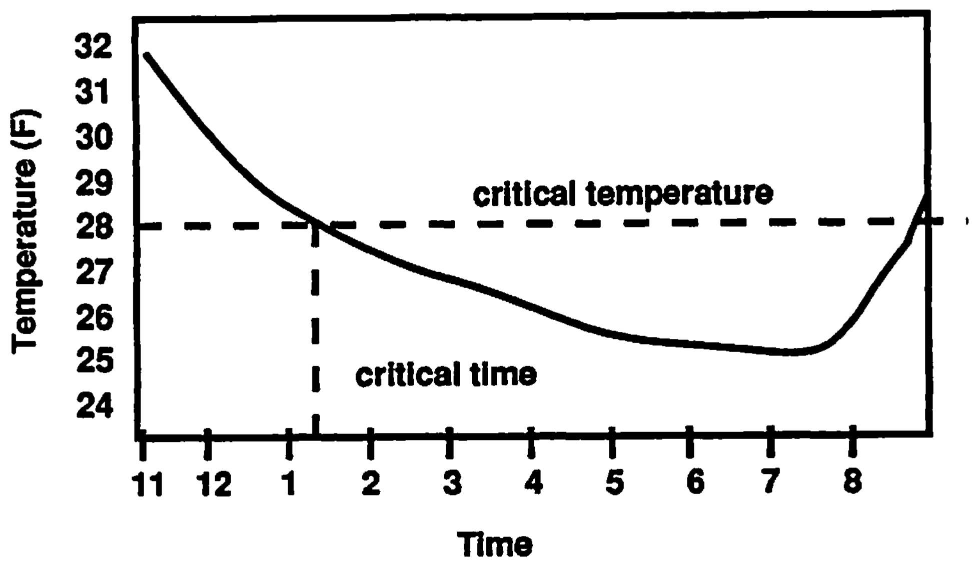

Figure 3. Example of frost night short-term forecast.

INSTRUMENTATION

The instrumentation contains three sections: Instrument selection, calibration, and location. The selection module describes the importance of correct measurements during frost nights and what kind of instrumentation is necessary to monitor frost conditions. This can range from a simple liquid-in-glass thermometer to a sophisticated automated weather station. The calibration section describes the importance of having properly calibrated instruments and gives suggestions for checking the calibration of different instruments. The location section describes where to locate the instruments depending upon the crop and field size.

CONCLUSIONS

The program continues to be refined for eventual use by growers. Although it is currently oriented towards Pennsylvania situations, it can easily be modified to be used in other parts of the United States that experience cold temperatures. The program is being implemented on the Macintosh computer, but it will also be adapted to be run on other platforms.

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Title: Strawberry Plasticulture on Maryland's Eastern Shore (progress report)

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Introduction:

Dr. Chris Walsh of the University of Maryland Horticulture Department was instrumental in introducing strawberry plastic culture in Maryland. Tissue-cultured Chandler plug-grown plants were used in the fall of 1989 and again in 1990 with two Maryland growers. The system of production followed was that outlined by E. B. Poling, Extension Pomologist at N.C. State University, in Extension Leaflet No. 205-E, August 1988. The results of these two grower trials were mixed. The winter of 1989-90 was mild and the plastic mulch and synthetic row covers forced the plants into an early bloom. The March and April freezes then took their toll.

The 1990 planting included the June bearing varieties Cardinal, Allstar, Earliglow, Honeye, Lester, Lateglow, and Jewel along with Chandler. At the major planting location we suffered moderate to heavy deer damage. Once again, the winter was mild; so mild in fact that late August planted, cold storage held, June bearing, bare ground planted plants, especially the variety Earliglow, did exceptionally well in the Salisbury, Maryland area. Once again, results were mixed. The Chandlers out performed all the June bearers; however, because of deer damage, yields were reduced.

The jury is still out on whether this technique will be economically viable in our area. Strawberry plasticulture is a system of production which requires higher management input levels, i.e., fumigated raised beds covered with black plastic, two types of irrigation systems, overhead and trickle are required, along with bed protection and frost protection.

The two unanswered questions which still remain for our area are bed covering timing and the shortening of the frost protection window. If we cannot get and protect an adequate yield, we will not turn a profit. A fall 1991 trial was planted at the University of Maryland Wye Research and Education Center along with three grower demonstrations.

Materials and Methods for Wye Research and Education Planting:

On September 10, 1991 eight rows 100 ft long were bedded, fumigated with Vapam and covered with 4 ft wide black plastic. Drip irrigation was also laid under the black plastic mulch at the time of mulching.

On October 2, 1991 a Chandler plasticulture planting was made utilizing fall dug Chandlers provided by Cottle Strawberry Nursery, Faison, North Carolina. These plants were grown in Prince Edward Island, Canada. Row spacing was approximately 6 ft from mulch center to mulch center on 6" high beds with a double row of plants 12" apart in the row and 14" apart from the other row. The drip tube is between the two rows. Rows are oriented north south.

Plants were overhead irrigated at planting to set plants. The drip system has been used to fertigate and irrigate this fall in accordance with Strawberry Plasticulture Leaflet No. 205-E.

On or near December 19, 1991 the following treatments will be applied.

1. No cover (control)
2. Straw mulch
3. Synthetic (Reemay)
4. Greenhouse white wash

Two different removal dates will be looked at in regards to treatments 2 and 3; one mid-February, the other March 1.

If this system can be made to work in our area, it will have several positive applications in regards to sap beetle control and as a possible organic production technique.

A Decision Support System for Chemical Thinning of Apples

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In apple production one of the most difficult decisions for commercial growers involves chemically thinning fruit. Many factors impinge upon the decision including tree characteristics, climatic conditions before, during and after the applications of thinners, and previous cropping history. Traditional recommendations utilize a range of rates and require the individual grower to consider many factors to determine optimum rates. We have developed a working module of a decision support system that considers a multitude of climatic, cultural and application conditions to make a recommendation for the use of chemical thinners. The expert system was designed to aid commercial growers in arriving at a rate for chemical thinning of apples. The system is designed to take advantage of the grower's experience and to adjust the rate based on the current season's climatic and cultural conditions.

The system operates by asking the grower a series of questions regarding various conditions in the orchard. A +1, -1, or 0 value is assigned to the response depending on whether a factor increases, decreases or has no effect, respectively, on a tree's response to thinners. The basis of the physiological conditions are derived from the list prepared by Williams and Edgerton (1981). Additional factors were also added based upon regional differences pertinent to the Mid-Atlantic region. The list of questions used to determine the potential tree response is presented in Table 1. The range of values runs from +16 to -15. Once the questions have been answered the computer tallies the number of +'s and -'s. A plus would cancel a negative and vice versa. Currently as designed all factors are considered to have equal importance in determining the trees response. In other words a heavy bloom would have the same weight on tree response as would cooler than normal temperatures.

Additional questions are asked to determine how much material needs to be added to the spray tank (Table 2). These questions also serve to determine if the grower has been applying NAA correctly. In previous work, Crassweller & Greene

(1990) had determined that many growers did not understand the concept of parts per million and were mixing solutions in excess of 20 ppm.

If the grower will be using Fruitone-N or Amid-Thin the system will operate in two ways. First it will check the previous rates and based upon the amount of material added to the sprayer into a known gallonage of water it will compare that rate the grower thinks they are applying with what they actually did apply. If the calculation is off by ± 1 ppm the system will show the actual concentration that was applied. At that point the grower has the option of basing the rate for current year upon the amount of material that has in the past worked for them or the system will give a recommendation based on the dilute application of the material. This feature allows growers who have been successful with chemical thinners to maximize their previous experience and successes. If the previous rate and the calculated rate was within ± 1 ppm then the system will continue on as normal and give a new recommendation based upon the responses to the questions.

If the grower has not previously used chemical thinners in the particular block, or does not wish to use the same material and rate as in the past then the system will utilize a standard rate of 12 ppm or 1.25 pounds per 100 gallons of Sevin 50W.

Once the sum of the factors is determined then the rate is adjusted up or down depending upon predominance of +'s increasing the rate; or of -'s decreasing the rate. If the total is positive, that is the trees will be more difficult to thin, then the rate is adjusted as follows:

1 -4 "+'s" = previous rate
5 -7 "+'s" = 1.25 x previous rate
9-12 "+'s" = 1.50 x previous rate
> 12"+'s" = 1.75 x previous rate

If the total is negative then the rate is adjusted as follows:

1 -4 "-'s" = previous rate
5 -8 "-'s" = 0.75 x previous rate
9-12 "-'s" = 0 50 x previous rate
> 12"-'s" = 0.25 x previous rate

The advantage of this method allows the usage of previous grower experience in their particular orchard. The recommendation process will tend toward a conservative or previous rate because rates will only increase or decrease if the sum exceeds +4 or is less than -4.

The standard rate is also increased or decreased based upon the sum of the factors. For example if the grower had previously used 10 ppm NAA and based upon the physiological and climatic factors the sum was +5 then the system would recommend the application of 12.5 ppm NAA (10 ppm x 1.25). If the sum was negative five (easier to thin) then the system would recommend 7.5 ppm (10 ppm x 0.75).

Additional checks in the system also examine fruit size. If the average fruit size exceeds 13.5 mm diameter the final rate is increased by 25% and the user is warned that the fruit size maybe too large and thinning may not be effective. If it is below 9.0 mm and the grower has chosen Fruitone-N then the grower is told that Fruitone-N is not recommended and the user can either wait until fruit size is larger or re-run the system and choose Amid-Thin.

Currently the system is available only for Macintosh computers but should be shortly available for operation on DOS machines and their compatibles. We intend to validate the system in the 1992 growing season by utilizing input from commercial growers that applied thinners.

Literature Cited

Crassweller, R. M. and G. M. Greene II. 1990. Do chemical thinning recommendations reflect the real world? Proceedings 66th Annual Cumberland Shenandoah Fruit Workers Conference.

Williams, M. W. and L. J. Edgerton. 1981. Fruit thinning of apples and pears with chemicals. Washington State Extension Bulletin EB 1126. 21 pp.

Table 1. Questions asked and responses available to determine tree responsiveness to chemical thinners.

1. What is the cultivar to be thinned? a)Delicious, spur, b) Golden Delicious, c) York Imperial, d) Others that are Spur types, e) Others that are Non spur types
2. What is the age of the trees? a) 3- 7 years old, b) > 7 years old
3. What is the tree vigor? a) Low, b) Medium, c) High
4. What is the average tree height? a) < 12 feet , b) ≥12 feet
5. Was bloom heavy? a) Yes, b) No, c) Average
6. Was Promalin applied to the trees at bloom?, a) Yes, b) No
7. What is the average number of seeds per fruit? a)1-3, b) 4-6, c) >6
8. What is the average number of fruits per cluster? a) 1, b) 2, c) ≥3
9. How long was the bloom period? a) 1-4 days, b)4-5 days, c) >5 days
10. Was there any frost damage to the trees within the last two weeks a) Yes, b) No
11. How many days over the past 7 has the weather been cloudy and cool? a) 5-7, b) 3-4, c) 0-2
12. Does the weather forecast for the next 3 days call for cloudy, cool conditions? a) Yes, b) No
13. Have temperatures since bloom been warmer or cooler than normal? a) Warmer, b) Cooler, c) About normal
14. What time of day will you be applying the chemical thinner? a) Early morning 6am - 10 am, b) evening 6 pm or later, c) other
15. Was there a high level of bee activity during bloom? a) Yes, b) No
16. Are the majority of the fruitlets on the: a) Interior of the tree, b) Tops and outer canopy of the tree, c) Evenly spread throughout
17. Is the normal fruiting habit for the cultivar to be biennial bearing? a) Yes,(if yes ask question 17A), b) No

17A If answer was yes then ask the following question:
Is this the "on" or "off" year?, a) "on" year, b) "off" year

Table 2. Questions utilized to determine amount of chemical thinner to add to spray tank in the decision support system for chemical thinning of apples.

18. What material have you used in the past and the rate that was successful? Fruitone-N, _______ppm, , Amid-Thin __ ppm Sevin 50 WP ___ lb/100 gal.__Have not applied thinner to this; or a similar cultivar
19. Do you intend to use the same material as previously? a)Yes, b)No
20. How many gallons of water do you or will you apply per acre?
21. Into how much water will you be mixing the chemical?
22. If you have used a chemical thinner in this block before, how much material in the past have you put in the tank.? a)____ oz [by weight] b) ____ lb, c)_____ fluid oz.
23. What is the current average fruit diameter in millimeters or inches?

PLANT PATHOLOGY

1991 Fungicide Trials in the Hudson Valley

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TRIAL #1: Aliette was evaluated for its effectiveness against common apple fungal diseases, and low rates of Nova and Rubigan were tested to determine what rates of the two compounds would provide comparable effectiveness against apple scab. All treatments were replicated four times in a 6-yr-old orchard on M.9 rootstock. Each plot contained one tree each of Jerseymac, Redcort, and Smoothee. All plots were sprayed 3 Apr with COCS 50WDG (3 lb/100 gal) plus 3% spray oil for control of fire blight and mites. Fungicide treatments were sprayed to runoff using a handgun on 13 Apr (TC), 24 Apr (BL); 8 May (PF), 16, 28 May; 14, 29 Jun; 5 Aug. Moderate levels of apple scab inoculum were introduced into this block by placing approximately one-half bushel of scabby leaves beneath the Jerseymac tree in each plot during late fall of 1990. Cedar trees planted between the three-tree plots contained a few cedar apple rust galls, but additional inoculum was introduced by tying detached cedar galls from other sources into the tops of each Smoothee tree on 2 and 16 May. Powdery mildew was introduced into the block by placing severely infected potted trees from the greenhouse beneath each Redcort tree on 1 and 10 May during periods of warm humid weather. Effectiveness of the fungicide treatments was evaluated by determining the incidence of various diseases on leaves on 25 clusters and 25 terminals, on 50 fruitlets, and on 100 mature fruit per tree on the dates indicated in the data tables. Evaluations for powdery mildew were made using only the eight youngest leaves on each terminal whereas all of the terminal leaves were evaluated to determine the incidence of scab and rust. Incidence of black rot fruit decay was determined by evaluating all fruit both on the tree and on the ground at the time of harvest.

TRIAL #2: Fungicide treatments were replicated four times in a block of 10-yr-old trees on M.7 rootstocks. Each plot contained one McIntosh and one Golden Delicious tree. Fungicide treatments were sprayed to runoff using a handgun. All plots were sprayed with 1.5% Spray Oil 6E on 4 Apr. Syllit 65W 6 oz/100 gal was applied with the oil for all treatments except the control and the treatments where Benlate or Topsin M were used in summer spray programs. Treatments for scab and early-season diseases were applied on 17 Apr (TC), 25 Apr (BL); 4 May (early PF), 14, 23 May. Treatments for summer diseases were applied 3, 17 Jun; 8, and 31 Jul. Apple scab pressure in this block was light because scab was reasonably well controlled the previous year and no additional inoculum was introduced. Phytophagous mite populations were very low because Savey (1 oz/100 gal) had been applied in this block on 18 May and 24 Jul 90. We assumed few predacious mites would be present in the block because a pyrethroid insecticide had been used several times in 1990 and again 17 Apr 91. Because we wished to determine if the benzimidazole fungicides had negative impacts on predator mite survival, approximately 3,000 predatory phytoseid mites, Amblyseius fallacis, were released in the block on 12 Jun 91. Mite populations were evaluated on 9 Jul and 12 Aug 91 by collecting 25 McIntosh leaves per tree. Populations of A. fallacis were evaluated by scanning one half of both the upper and lower surfaces of each leaf under a binocular microscope. Phytophagous mites were then removed from the the leaves using a Henderson-McBurnie mite brushing machine and were counted under a binocular microscope. Effectiveness of the fungicide treatments was evaluated by determining the incidence of various diseases on leaves on 25 clusters and 25 terminals, on 50 fruitlets, and on 100 mature fruit per tree on the dates indicated in the data tables.

TRIAL #3: The experiment was conducted in an old block of Bosc pears planted on 25-ft centers. The trees had been defoliated by Fabraea leaf spot in both 1989 and 1990, and the crop was not marketable in either year. The grower opted to "dehorn" the trees during winter of 1990-91 by reducing the trees from 18-24 ft in height down to 12-14 ft. Because of the severe pruning and the defoliation the previous year, trees had virtually no fruit in 1991. The grower used an airblast sprayer to apply Manzate 200 80W at 1.5 lb/100 gallons to the entire block on 4 and 16 May. The fungicide test treatments were applied with a handgun on 6 and 27 Jun to single-tree plots. Treatments were replicated six times in a randomized block design. Additional treatment applications were planned for 3-wk intervals through Jul and Aug. However, when no disease was evident in control plots by 18 Jul, we decided to terminate the treatment schedule. Sufficient inoculum was still available to initiate disease when rains occurred during the latter two weeks of Jul. Treatments were evaluated on 16 Aug by having five independent observers subjectively rate each tree for incidence and severity of leaf spot. Incidence was rated on a scale of 1-5 where 1= no leaf spot, 2 = leaf spot at one locus within the tree, 3 = leaf spot at more than one locus, but occurring in <50% of the canopy, 4 = 50-80% of the canopy affected, 5 = >80% of the canopy affected. Severity of leaf spot within infection loci was also rated for each tree using a scale of 1-5 where 1 = no leaf spot, 2 = only one or a few spots on a few leaves, 3 = light spotting on numerous leaves, 4 = heavy spotting on some leaves, and 5 = heavy spotting on many leaves. Mean ratings from all five observers were used for statistical analyses. In addition, numerical ratings were made by observing all mature, fully expanded leaves on 25 spurs or short terminal shoots per tree to determine the percent leaves infected and the proportion of leaves with 1-5, 6-20, and >20 lesions per leaf. The trees were evaluated again on 21 Oct by having three independent observers assess percent defoliation. Differences in defoliation were attributable to differences in the severity of Fabraea leaf spot.

Season Weather Conditions: No apple scab infection periods were recorded until tight cluster. Trees progressed very rapidly from silver tip to tight cluster during a period of warm sunny weather between 4 and 11 Apr. There were four primary scab infection periods during Apr and five during May. Jun and the first half of Jul were very dry, but humid weather with light rainfall during the first week of Jun favored establishment of summer diseases. Rainfall for Jun, Jul, Aug and Sep was 1.17, 2.13, 6.01, and 4.90 inches, respectively. Most of the Aug rains (4.17 inches) were hurricane related and occurred 16-22 Aug.

Trial #1 results: Aliette reduced the incidence of apple scab but did not provide adequate control. Aliette had no effect on the incidence of cedar apple rust on leaves or fruit, but was relatively effective against fly speck under light disease pressure. Using low rates of Rubigan and Nova, we found the two compounds provided similar levels of scab control when rate of Rubigan (in fluid ounces) was two times the rate of Nova (in ounces). Mildew data collection was delayed until late in the season because only 5% of the leaves on control trees had mildew in a preliminary evaluation on 21 Jun. There were no significant differences between treatments in the quality of fruit finish. The incidence of black rot fruit decay on Redcort at harvest did not differ significantly between treatments (range = 6-15% fruit affected). Six percent of Smoothee control fruit had sooty blotch, and this was significantly greater than any other treatment (range 0-0.5% for all other treatments).

Trial #2 results: All of the test fungicides provided adequate control of apple scab, but some scab developed during the long preharvest interval on Golden Delicious treated with TD2320. The slightly higher incidence of cluster leaf scab in the Captan treatments as compared to most other treatments was not unexpected because early-season treatments were applied on an 8-10-day spray interval. Mite populations remained low throughout the season. However, predacious mites were just as abundant in plots sprayed with Benlate or Topsin M as in plots sprayed with other compounds. Thus, the benzimidazole fungicides did not adversely impact survival of the predacious mites under conditions of this test. Incidence of fly speck on McIntosh confirmed that summer sprays of Benlate/Captan provide better control of fly speck than do sprays of Captan 50W applied alone. None of the treatments provided adequate control of fly speck on Golden Delicious because >10 inches of rain fell during the 61 days between the last spray and harvest. Under these severe test conditions, Captan 75WDG controlled fly speck on Golden Delicious more effectively than did Captan 50W applied on a season-long program. Plots treated with Benlate/Captan had significantly less fly speck on Golden Delicious than did plots treated with Topsin M/Captan, possibly because of the low rate of

Topsin M we used. However, Topsin M/Captan resulted in a significantly better fruit finish than did Benlate/Captan. The season-long treatment with Captan 50W resulted in exceptionally poor fruit finish, presumably because of some unknown environmental factors at the time sprays were applied early in the season.

Trial #3 results: The sterol-inhibitor fungicides (Bayleton, Nova, and Rubigan) did not provide control of Fabraea leaf spot under the extended spray intervals used in this test. There was no significant benefit from using Rubigan in combinations with Captan or Ziram as compared to using these contact fungicides alone. Most of the contact fungicides provided similar levels of control when evaluated on 16 August, seven weeks after the last treatment. By mid-October, however, it was apparent from defoliation ratings that Manzate 200, Syllit, and Benlate provided the most cost-effective, long-term control of Fabraea. Benlate was effective in this trial but was reported to be ineffective for controlling Fabraea on the ornamental Photinia in trials conducted by other researchers. Thus, it is possible that Fabraea may develop resistance to the benzimidazole fungicides in situations where the benzimidazoles have been heavily used in the past. Neither mancozeb nor dodine are registered for pears east of the Rockies, but dodine is labelled for pear scab on the west coast. If Syllit were labeled in the Northeast, it would be useful for controlling Fabraea leafspot.

Trial #1. Table 1

Material and rate of formulated product per 100 liters (100 gal)	% cluster leaves with scab*		% terminal leaves with scab*		
	Jerseymac 7 Jun	Redcort 11 Jun	Jerseymac 20 Aug	Redcort 21 Aug.	Smoothee 22 Aug
Control	41.8 f	32.0 e	73.8 f	88.6 e	38.3 e
Aliette 80 W 60g (8 oz)	24.3 e	11.0 d	51.1 e	52.0 d	15.5 d
Aliette 80 W 120g (16 oz)	22.2 e	11.5 d	41.8 e	41.3 d	6.9 c
Nova 40W 4.72g (0.63 oz) + Aliette 80 W 60g (8 oz)	2.0 b	1.3 abc	3.4 b	3.4 b	0.4 ab
Nova 40W 9.36g (1.25 oz) + Aliette 80 W 60g (8 oz)	1.3 ab	0.1 a	0.4 ab	0.3 ab	0.9 ab
Nova 40W 9.36g (1.25 oz) + Captan 50W 120g (16 oz)	0.0 a	0.3 a	0.1 a	<0.1 a	<0.1 a
Nova 40W 9.36g (1.25 oz)	0.1 ab	0.2 a	1.2 ab	1.2 ab	0.1 ab
Nova 40W 4.72g (0.63 oz)	2.4 bc	0.7 ab	2.1 ab	2.5 b	0.1 ab
Nova 40W 2.32g (0.31 oz)†	7.9 cd	4.2 bcd	12.7 c	15.4 c	2.4 bc
Rubigan 1EC 9.8 ml (1.25 floz)††	2.2 b	1.9 abc	16.7 c	13.6 c	1.2 ab
Rubigan 1EC 4.9 ml (0.63 floz)††	9.0 d	4.9 cd	28.3 d	23.5 c	1.3 ab

Mean separations were determined using Fisher's Protected LSD (P=0.05). The arcsin transformation was used for statistical analyses.

*Data was collected from all leaves on 25 clusters/tree or 25 terminals/tree on dates indicated.

†Sprayed with Captan 50W 1 lb/100 gal instead of Nova on 5 Aug.
††Sprayed with Benlate 50DF 3 oz/100 gal plus Captan 1 lb/100 gal on 5 Aug.

Trial #1. Table 2

Material and rate of formulated product per 100 liters (100 gal)	% friutlets with scab* Jerseymac 11 Jun	Redcort Jun 11	% fruit with scab at harvest* Jerseymac 29 Jul	Redcort 12 Sep	Smoothee 24 Sep
Control................................	79.6 h	11.3 d	97.8 g	72.5 e	80.8 f
Aliette 80 W 60g (8 oz).............	43.4 g	8.2 cd	85.8 f	30.5 d	48.4 e
Aliette 80 W 120g (16 oz)...........	43.5 g	3.7 bc	75.7 f	15.9 c	25.4 d
Nova 40W 4.72g (0.63 oz) + Aliette 80 W 60g (8 oz)......	7.8 cd	0.0 a	9.5 bc	1.5 ab	3.0 bc
Nova 40W 9.36g (1.25 oz) + Aliette 80 W 60g (8 oz)......	2.5 b	0.0 a	3.2 ab	0.0 a	1.2 ab
Nova 40W 9.36g (1.25 oz) + Captan 50W 120g (16 oz)....	0.0 a	0.0 a	1.0 a	0.0 a	0.2 a
Nova 40W 9.36g (1.25 oz)	2.6 bc	0.3 a	6.3 abc	0.2 a	1.4 ab
Nova 40W 4.72g (0.63 oz)	8.6 d	0.0 a	11.9 bc	1.5 ab	2.6 abc
Nova 40W 2.32g (0.31 oz)†	17.7 ef	1.5 ab	50.8 e	4.1 b	5.6 c
Rubigan 1EC 9.8 ml (1.25 floz)††.	14.0 de	0.0 a	33.3 d	0.8 ab	4.1 bc
Rubigan 1EC 4.9 ml (0.63 floz)††.	24.0 f	0.1 a	54.3 e	4.2 b	7.0 c

Trial #1. Table 3

Material and rate of formulated product per 100 liters (100 gal)	% Redcort lvs. with mildew* 27 Aug	% rust on Smoothee term.lvs** 9 Jul	fruit 24 Sep**	% fruit with fly speck*** Redcort 12 Sep	Smoothee 24 Sep
Control................................	14.2 e	17.0 c	2.4 c	10.0 c	20.0 c
Aliette 80 W 60g (8 oz).............	4.1 d	15.9 c	2.4 c	0.9 a	0.5 a
Aliette 80 W 120g (16 oz)..........	3.1 d	10.8 c	3.4 c	2.3 ab	1.1 a
Nova 40W 4.72g (0.63 oz) + Aliette 80 W 60g (8 oz).......	0.3 ab	0.0 a	0.0 a	0.1a	2.0 ab
Nova 40W 9.36g (1.25 oz) + Aliette 80 W 60g (8 oz).......	0.7 bc	0.0 a	0.0 a	1.4 ab	1.0 a
Nova 40W 9.36g (1.25 oz) + Captan 50W 120g (16 oz)	0.1 ab	0.0 a	0.1 ab	0.1 a	0.4 a
Nova 40W 9.36g (1.25 oz)	0.1 a	0.0 a	0.1 ab	1.8 ab	6.6 b
Nova 40W 4.72g (0.63 oz)	0.4 ab	0.0 a	0.0 a	5.0 bc	2.3 ab
Nova 40W 2.32g (0.31 oz)†	0.6 abc	<0.1 ab	0.0 a	8.2 c	1.5 a
Rubigan 1EC 9.8 ml (1.25 floz)††	0.7 bc	2.0 b	0.4 b	1.2 ab	1.3 a
Rubigan 1EC 4.9 ml (0.63 floz)††	1.3 c	1.9 b	0.2 ab	1.4 ab	0.1 a

Table footnotes: Mean separations were determined using Fisher's Protected LSD (P=0.05). The arcsin transformation was used for statistical analyses.

*Data was collected from 50 fruitlets/tree in June and 100 fruit/tree (if available) at harvest.

**Mildew data were collected from the last eight leaves on each of 25 terminals/tree and rust data was collected from all terminal leaves on 25 terminals/tree on dates indicated.

***Data was collected from 100 fruit/tree (or all fruit available if <100/tree) at harvest.

†Sprayed with Captan 50W 1 lb/100 gal instead of Nova on 5 Aug.

††Sprayed with Benlate 50DF 3 oz/100 gal plus Captan 1 lb/100 gal on 5 Aug.

Trial #2, Tables 1 & 2:

Materials and rate of formulated product per 100 liters (100 gal) [1]	% apple scab on McIntosh: cluster leaves 11 Jun	terminal leaves 21 Jun	terminal leaves 14 Aug	fruitlets 11 Jun	fruit at harvest 29 Aug	% scab on Golden Delicious: terminal leaves scab 14 Aug	terminal leaves rust 18 Jul	fruit scab 30 Sep
Control	40.1 e	19.6 c	47.3 b	30.3 b	79.7 b	2.7 b	36.2 d	42.5 c
Captan 50W 180g (1.5 lb) // 120g (1 lb)[2]	4.9 cd	0.6 b	0.8 a	0.3 a	0.4 a	<0.1 a	7.9 bc	0.0 a
Captan 75WDG 120g (1 lb) // 80g (10.67oz)[2]	5.5 d	0.3 ab	0.8 a	0.0 a	0.2 a	<0.1 a	11.6 c	0.1 a
Rubigan /Captan[2,3] // Captan 50W 120g (1 lb)	<0.1 a	<0.1 a	0.6 a	0.4 a	0.1 a	0.3 a	7.1 bc	0.0 a
Syllit 65W 45g (6 oz) 17, 25 Apr Rubigan /Captan[2,3] // Captan 50W 120g (1 lb)	1.4 abc	0.1 ab	0.6 a	0.0 a	0.0 a	0.0 a	1.9 ab	0.0 a
TD 2320 80DF 395g (3.3 lb)[2]	2.3 bcd	0.8 b	1.3 a	0.0 a	0.4 a	0.2 a	0.2 a	3.0 b
Rubigan /Captan[3,4] // Benlate 50 DF 15g (2 oz) & Captan 50W 120g (1 lb) 17 Jun, 8, 31 Jul	1.1 ab	0.1 ab	0.8 a	0.0 a	0.1 a	0.1 a	3.4 abc	0.0 a
Rubigan /Captan[3,4] // Topsin M 85WDG 15g (2 oz) & Captan 50W 120g (1 lb) 17 Jun, 8, 31 Jul	0.1 a	0.2 ab	1.3 a	0.0 a	0.0 a	0.5 a	1.6 ab	0.0 a

Materials and rate of formulated product per 100 liters (100 gal) [1]	Mean number of mites/leaf[5]: 9 Jul ERM	12 Aug ERM	12 Aug TSM	12 Aug AMB	% fruit infected with: fly speck Mac	fly speck Golden	sooty blotch Mac	sooty blotch Golden	Golden fruit finish[6]: mean russet rating	% fruit rated≥3
Control	0.7	0.4	0.6	0.3	78.2 d	99.9 e	66.6 b	99.5 c	2.5 ab	40.6 ab
Captan 50W 180g (1.5 lb) // 120g (1 lb)[2]	1.3	0.5	0.6	0.6	10.1 c	57.1 cd	0.1 a	9.1 ab	3.1 c	75.5 c
Captan 75WDG 120g (1 lb) // 80g (10.67oz)[2]	1.3	0.7	0.1	0.5	5.7 bc	34.2 b	0.2 a	4.5 ab	2.4 ab	34.5 a
Rubigan /Captan[2,3] // Captan 50W 120g (1 lb)	--	--	--	--	9.7 c	49.5 bcd	0.0 a	4.1 ab	2.3 a	28.1 a
Syllit 65W 45g (6 oz) 17, 25 Apr Rubigan /Captan[2,3] // Captan 50W 120g (1 lb)	--	--	--	--	11.5 c	41.7 bc	0.0 a	4.0 ab	2.5 ab	47.0 ab
TD 2320 80DF 395g (3.3 lb)[2]	0.3	0.6	2.4	0.3	0.0 a	11.4 a	0.1 a	1.4 a	2.2 a	26.7 a
Rubigan /Captan[3,4] // Benlate 50 DF 15g (2 oz) & Captan 50W 120g (1 lb) 17 Jun, 8, 31 Jul	1.3	0.8	0.3	0.4	3.1 b	47.4 bc	0.1 a	6.2 ab	2.8 bc	61.4 bc
Rubigan /Captan[3,4] // Topsin M 85WDG 15g (2 oz) & Captan 50W 120g (1 lb) 17 Jun, 8, 31 Jul	1.1	0.6	0.5	0.9	5.4 bc	70.3 d	0.1 a	11.8 b	2.3 a	28.6 a

Mean separations were determined using Fisher's Protected LSD (P=0.05) The arcsin transformation was used for statistical analyses.
[1]Treatments listed before the double slashes [//] were applied 17, 25 Apr; 4, 14, 23 May. Summer sprays (those listed after the double slashes) were applied 3, 17 Jun; 8,31 Jul. [2]Plots received Syllit 6 oz/100 gal on 4 Apr. [3]Rubigan 1EC 15.6 ml (2 floz) & Captan 50W 120g (1 lb) [4]Followed by Captan 50W 120g (1 lb) 3 Jun. [5]ERM = European red mite; TSM = twospotted spider mite; AMB = Amblyseius fallacis. [6]Fruit russetting was rated on a scale of 1-5 where 1 = very smooth finish and 5 = severe russetting.

Trial #3. Table 1: Evaluation of fungicides for control of Fabraea leafspot on Bosc pears.

Materials and rate of formulated product per 100 gal	Means for subjective whole-tree ratings* incidence	Means for subjective whole-tree ratings* severity	Numerical evaluations** % leaves with leaf spot	% leaves by severity category: Fabraea lesions per leaf 1-5	6-20	>20	Percent defoliation 21 Oct ***
Control	3.2 d	4.2 bc	48.2 d	16.4 d	13.1 c	14.6 c	89.9 d
Manzate 200 80 DF 1.5 lb	1.4 a	1.4 a	1.0 ab	1.0 ab	0.0 a	0.0 a	30.5 a
Captan 50W 1.5 lb	1.6 ab	1.4 a	2.1 ab	2.1 abc	0.0 a	0.0 a	57.6 bc
Syllit 65W 1 lb	1.5 ab	1.5 a	0.3 a	0.3 a	0.0 a	0.0 a	32.2 a
Carbamate 75 WDG 1.5 lb	1.6 ab	1.5 a	2.4 ab	2.2 abc	<0.1 a	0.0 a	66.9 bc
Ziram 76W 1.5 lb	1.7 b	1.6 a	3.1 ab	2.6 bc	0.3 a	0.0 a	66.3 bc
Ziram 76W 1.5 lb & Bond 1 pt	1.8 b	1.9 a	4.8 b	4.5 c	0.1 a	0.0 a	58.0 bc
Benlate 50 DF 4 oz.	1.8 b	1.5 a	1.7 ab	1.7 abc	0.0 a	0.0 a	47.7 ab
Bayleton 50W 1 oz	3.0 d	3.9 bc	30.5 c	16.2 d	6.7 b	3.7 b	86.0 d
Nova 40W 1 oz	2.5 c	3.5 b	28.4 c	15.4 d	6.3 b	4.2 b	86.7 d
Rubigan 1EC 2 fl oz	3.2 d	4.4 c	38.0 cd	13.9 d	9.9 bc	11.9 c	86.0 d
Rubigan 1EC 2 fl oz & Ziram 76W 1 lb	1.7 b	1.7 a	0.5 ab	0.4 ab	<0.1 a	0.0 a	73.0 cd
Rubigan 1EC 2 fl oz & Captan 50W 1 lb	1.7 ab	1.7 a	1.5 ab	0.9 ab	0.1 a	0.0 a	50.9 ab

Mean separations were determined using Fisher's Protected LSD (P=0.05). The arcsin transformation was used for statistical analysis of data expressed as percentages.

*Five independent observers visually evaluated severity and incidence of Fabraea on each tree on 16 Aug using the subjective rating systems in which 1 = no infection and 5 = severe infections.

**Numerical ratings were made by observing all mature, fully expanded leaves on 25 spurs or short terminals collected from each tree on 16 Aug. The means shown in each column are derived by re-converting the transformed means generated in the statistical analysis, and the total percent leaves infected may differ from the totals derived by adding the percentage of leaves in each of the three severity categories.

***Three independent observers estimated percent defoliation for each tree on 21 Oct.

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

EFFICACY OF SEASONAL FUNGICIDE SPRAYS APPLIED AT TRV RATES FOR CONTROL OF APPLE SCAB AND POWDERY MILDEW, 1991: Seasonal fungicide programs in which various fungicides or combinations were applied at specific tree phenophases were evaluated. Fungicides were selected for use during times more favorable for specific disease development and rates were adjusted according to tree row volume of the test orchard. The experimental orchard was a mature block of well-pruned 'Rome Beauty'/seedling trees planted 25 X 30 ft and pruned to a height of 12 ft. Tree row volume was 313,633 ft^3 and rates were adjusted at 55% of recommended rates for each fungicide. Treatment plots consisted of two trees arranged in a randomized complete block design with four replicates bordered by nontreated plots between and adjacent to treated trees. The fungicides were applied as concentrate sprays at 50 gal/A with a commercial orchard airblast sprayer (Metters Model 36) operated at 2.5 mph and a manifold pressure of 200 psi. Applications were applied under still air to low breeze conditions. Ten of the 12 treatments were applied as protective sprays for control of scab and powdery mildew at 6-8 day intervals between tight-cluster (11 Apr) and petal-fall (9 May) and at 11-14 days between petal-fall and second cover (3 Jun). Two post-infection treatments (indicated in the table) were applied at 61-105 hr after each of seven scab infection periods between open-cluster (17 Apr) and fourth cover (8 Jul). The intervals between cover sprays were generally 13-14 da except when specific covers were omitted. The interval between the seventh cover (12 Aug) and harvest (7 Oct) was 56 da. Commercially used insecticides were applied separately as needed to maintain control of insects and mites in the orchard. Conditions were favorable for scab development in the orchard with high inoculum levels and 10 primary scab infection periods which occurred between silver tip (22-24 Mar) and third cover (21 Jun). The inoculum level for powdery mildew was moderate and conditions were only moderately favorable for disease development. Cedar apple rust inoculum was placed in each sprayed tree at the pink and full-bloom stages, but infection did not occur presumably because of low temperatures (44 and 54° F) during rain periods at these times. Scab incidence on cluster leaves was determined on 6-11 Jun by observing all leaves on each of 10 nonbearing spurs/tree (20/replicate). Disease incidence for scab, mildew, and rust on terminal leaves were made on 20-26 Jun by observing all leaves on 10 vegetative terminals/tree (20/replicate). Scab incidence on fruit was determined on 25-26 Jun on 25 fruits/tree and on 7 Oct by observing 100 fruits/tree (200/replicate). Scab severity on fruit was determined by counting all lesions on all of the infected fruit/replicate. Data were analyzed by analysis of variance using appropriate transformations and the Tukey-Kramer HSD ($P \leq 0.05$) for significance among treatments.

Rainfall occurrence from green-tip through the second cover was favorable for scab development, but interfered somewhat with powdery mildew development. Lack of rainfall during the third through seventh cover period was unfavorable for the development of summer diseases. All fungicide spray programs evaluated provided good to excellent control of scab and mildew under moderate disease incidence. All treatments were significantly better than the nontreated and differences among treatments were with few exceptions not significant. The Syllit plus sulfur applied at open-cluster and followed by sulfur alone in sprays from pink through second cover was significantly less effective for scab control than other treatments on cluster or terminal leaves and fruit. Treatments containing Ziram were somewhat less effective for scab control. Powdery mildew incidence on most treatments was relatively low. The wettable sulfur or the Rubigan combination treatments were significantly less effective that the Nova combinations. Programs combining Spray oil with the fungicides Syllit, thiram, ziram, Dithane M-45, Polyram, and Topsin-M plus Penncozeb were equally effective for scab control, chemically compatible in the spray tank and produced no detectable leaf or fruit phytotoxicity. The results in this experiment confirm previous tests results and show that fungicide rates can effectively be reduced to match tree row volume under moderate to high disease severity.

Table 1. Percent Scab and Powdery Mildew Infection on 'Rome Beauty' Apple Treated with Concentrate Fungicide Treatments Applied in Complete Sprays with an Airblast Sprayer in 1991.

Fungicide and rate/A[1]	Spray Timing[1]	Percent Apple Scab				Percent P. mildew Leaves
		Leaves		Fruit Count		
		Spur	Terminal	25 Jun	7 Oct	
1. Spray Oil 6E 3.3 gal + Syllit 65W 9.9 oz	TC					
Nova 40W 2.2 oz	OC,P					
Nova 40W 2.2 oz + Captan 50W 26.0 oz	PF,1C,2C					
Captan 50W 53.0 oz	6C,7C	0.9a[3]	1.5ab	2.0a	1.2a	2.0ab
2. Spray Oil 6E 3.3 gal + Dithane M-45 80DF 26.0 oz	TC					
Dithane M-45 80DF 26.0 oz + Nova 40W 2.2 oz	OC,P,PF					
Captan 50W 26.0 oz + Nova 40W 2.2 oz	1C,2C					
Captan 50W 53.0 oz	5C,6C,7C	0.4a	0.6a	2.0a	1.2a	1.0a
3. Syllit 65W 9.9 oz	TC,OC					
Nova 40W 2.2 oz + Captan 50W 26.0 oz	P,PF,1C,2C					
Captan 50W 26.0 oz + Topsin-M 70W 6.6 oz	5C,6C,7C	0.0a	0.3a	2.0a	1.2a	3.2abc
4. Spray Oil 6E 3.3 gal + Topsin-M 70W 3.3 oz + Penncozeb 80W 26.0 oz	TC					
Topsin-M 70W 3.3 oz + Penncozeb 80W 26.0 oz	OC,P,PF					
Nova 40W 2.2 oz + Captan 50W 26.0 oz	1C,2C					
Captan 50W 26.0 oz + Topsin-M 70W 6.6 oz	6C,7C	0.2a	0.4a	2.5a	3.2ab	9.1b-e

Continuation of Table 1 — next page

Table 1 - continued

Fungicide and rate/A[1]	Spray Timing[1]	Percent Apple Scab: Leaves: Spur	Percent Apple Scab: Leaves: Terminal	Percent Apple Scab: Fruit Count: 25 Jun	Percent Apple Scab: Fruit Count: 7 Oct	Percent P. mildew Leaves
5. Spray Oil 6E 3.3 gal +						
Thiram 76WDG 53.0 oz	TC					
Nova 40W 2.2 oz	OC					
Nova 40W 2.2 oz +						
Thiram 76WDG 26.0 oz	P,PF,1C,2C					
Thiram 76WDG 53.0 oz	5C,6C,7C	0.0a	0.6a	2.0a	0.5a	4.1a
6. Spray Oil 6E 3.3 gal +						
Ziram 76W 53.0 oz	TC					
Ziram 76W 53.0 oz	OC					
Nova 40W 2.2 oz +						
Super Six Sulfur 52L						
8.8 fl oz	P,PF,1C,2C					
Ziram 76W 35.2 oz	4C,5C					
Ziram 76W 53.0 oz	6C,7C	1.4a	0.6a	6.5ab	2.7ab	3.9a-d
7. Spray Oil 6E 3.3 gal +						
Syllit 65W 9.9 oz	TC					
Syllit 65W 9.9 oz +						
Ziram 76W 35.2 oz	OC					
Ziram 76W 35.2 oz +						
Rubigan 1E 3.3 fl oz	P,PF,1C,2C					
Ziram 76W 35.2 oz	4C,5C					
Ziram 76W 53.0 oz	6C,7C	0.0a	0.7a	4.0a	2.0ab	15.4ef
8. Spray Oil 6E 3.3 gal +						
Syllit 65W 9.9 oz	TC					
Syllit 65W 9.9 oz +						
Sulfur 90W 70.4 oz	OC					
Sulfur 90W 70.4 oz	P,PF,1C,2C					
Ziram 76W 26.0 oz +						
Topsin-M 70W 6.6 oz	5C,6C,7C	10.7b	14.9b	20.0b	15.5b	24.4f

Continuation of Table 1 -- next page

Table 1 - continued

Fungicide and rate/A[1]	Spray Timing[1]	Percent Apple Scab				Percent P. mildew Leaves
		Leaves		Fruit Count		
		Spur	Terminal	25 Jun	7 Oct	
9. Spray Oil 6E 3.3 gal +						
Syllit 65W 9.9 oz	TC					
Syllit 65W 9.9 oz +						
Rubigan 1E 3.3 fl oz	OC					
Rubigan 1E 3.3 fl oz +						
Captan 50W 26.0 oz	P,PF,1C,2C					
Captan 50W 26.0 oz	5C					
Captan 50W 26.0 oz +						
Topsin-M 70W 6.6 oz	6C,7C	0.0a	0.8a	4.0a	1.7a	12.7de
10. Spray Oil 6E 3.3 gal +						
Syllit 65W 9.9 oz	1/2" G					
Syllit 65W 9.9 oz +						
Rubigan 1E 5.5 fl oz	OC					
Rubigan 1E 5.5 fl oz +						
Captan 50W 26.0 oz	P,PF,1C,2C					
Captan 50W 26.0 oz	5C					
Captan 50W 26.0 oz +						
Topsin-M 70W 6.6 oz	6C,7C	0.0a	0.2a	3.0a	0.7a	9.7cde
11. Spray Oil 6E 3.3 gal +						
Dithane M-45 80DF 17.6 oz	TC					
Dithane M-45 80W 17.6 oz +						
Nova 40W 2.75 oz	OC-PF (PI)[2]					
Nova 40W 2.75 oz +						
Captec 4F 13.0 fl oz	1C-4C (PI)[2]					
Captec 4F 13.0 fl oz	5C					
Captec 4F 13.0 fl oz +						
Topsin-M 70W 6.6 oz	6C,7C	0.2a	0.6a	6.0a	1.7ab	6.0b-e

Continuation of Table 1 -- next page

Table 1 - continued

Fungicide and rate/A[1]	Spray Timing[1]	Percent Apple Scab: Leaves		Percent Apple Scab: Fruit Count		Percent P. mildew Leaves
		Spur	Terminal	25 Jun	7 Oct	
12. Spray Oil 6E 3.3 gal +						
Polyram 80W 17.6 oz	TC					
Polyram 80W 17.6 oz +						
Rubian 1E 5.5 fl oz	OC-PF (PI)[2]					
Rubigan 1E 5.5 fl oz +						
Captec 4F 13.0 fl oz	1C-4C, (PI)[2]					
Captec 4F 13.0 fl oz	5C					
Captec 4F 13.0 fl oz +						
Topsin-M 70W 6.6 oz	6C,7C	0.6a	1.8ab	3.0a	2.0ab	13.8ef
13. Untreated Check		44.0c	40.3c	58.0c	52.0c	41.1g

1 Rates based on calculated tree-row volume (55% of standard orchard) and adjusted from standard recommended amounts in Pennsylvania. Sprays applied at 50 gpa as protective complete applications at 6-14 da intervals

2 Applications timed at 61-106 hours post-infection for apple scab on 17 Apr (OC), 23 Apr (P), 2 May (PF), 16 May (1C), 30 May (2C), 25 Jun (3C), and 8 Jul (4C). TC = tight cluster, OC = open cluster, P = pink, PF = petal fall, 1C-7C = cover sprays.

3 Means within columns followed by the same letter(s) do not differ signicantly, Tukey-Kramer HSD ($P \leq 0.05$)

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APPLE: Malus domestica 'Rome Beauty', 'Golden Delicious', 'Red Delicious'
Scab; Venturia inaequalis
Powdery mildew; Podosphaera leucotricha
Fruit russet

APPLE SCAB AND POWDERY MILDEW CONTROL WITH SEASONAL FUNGICIDE TREATMENTS APPLIED DILUTE, 1991: Aliette 80W, a new wettable granular formulation of Captan (75WG), pre-packaged mixtures of registered fungicides, and tank mixtures of standard fungicides used at specific times were evaluated for control of apple diseases. Natural inoculum level in the test orchard and existing environmental conditions for nine primary infection periods were favorable for apple scab development. Inoculum levels of powdery mildew and cedar apple rust were adequate but environmental conditions were only moderately favorable for mildew and unfavorable for rust development. Drought conditions from mid-Jun through Aug were highly unfavorable for development of summer diseases such as sooty blotch, flyspeck, and fruit decay. The experimental orchard used was a mature block of semi-dwarf trees planted 30 X 35 ft. and pruned to a height of 10-12 ft. Each plot consisted of three trees, one of each cultivar, planted in a group at each tree site. The treatments were arranged in a randomized complete block design with four replicates for each cultivar. Fungicide treatments were applied as protective dilute sprays timed at 6-8 days from 1/2"-green through petal-fall and at 13-15 days during the post-bloom period. Sprays were applied to the point of "complete wettness" with a high pressure sprayer operated at 400 psi and equipped with a 6-nozzle boom which delivered 2.6 gal/tree (265 gal/A). Dates of applications and phenological tree-growth stages were: 11 Apr (1/2"-green), 19 Apr (open-cluster to pink), 25 Apr (early-bloom), 3 May (late-bloom to petal-fall), 9 May (petal-fall), 20 May, 3, 17 Jun, 2, 15, 30 Jul, and 12 Aug for the 1st through 7th cover sprays, respectively. Fungicide efficacy for apple scab during the pre-petal-fall period was determined on 3 Jun by observing all leaves on 15 nonfruiting spurs/single tree (4 replicates) on 'Delicious'. Seasonal protection of terminal leaves against scab, rust, and powdery mildew was determined for 'Delicious' and 'Rome' on 3 Jul by observing all leaves on 10 vegetative terminals/tree. Observations for fruit infections were made on 25 fruits/tree on 26 Jun ('Delicious') and on 100 fruits/tree on 18 Sep ('Golden Delicious'), 24 Sep ('Delicious'), and 26 Sep ('Rome'). Intervals between the last application and harvest dates were 27, 43, and 45 days, respectively. Fruit finish severity on 'Golden Delicious' was determined by the Horsfall-Barratt rating scale with units transformed to percent surface affected with russet. The data obtained were analyzed by analysis of variance using appropriate transformations and significance between means was determined by the Tukey-Kramer HSD test ($P \leq 0.05$).

On nontreated trees, apple scab incidence was moderate with 64-66% leaf infection on spur and terminal leaves and 68% fruit infection on 'Delicious' and 53% on 'Rome' at harvest time on 24-26 Sep. Powdery mildew incidence was light with only 31% of terminal leaves infected on

'Rome'. Temperatures during the blossoming period was too low for apple rust infection and the summer diseases causing blotches and decay did not develop under the extreme drought conditions that occurred. Aliette 80W provided some protection against scab, but the level was below that acceptable in commercial orchards. It's combination with Nova 40W 1.0 oz/100 gal provided fair control, similar to the level obtained with TD 2320 80DF (combination of sulfur and ziram) and TD 2323 70DF (combination of thiophanate methyl and ziram). Scab and mildew incidence on these combinations were somewhat higher but not always significantly different from the combinations of Nova 40W 1.5 oz plus Captan 50W 16.0 oz/100 gal or the Rubigan-Syllit combination. There was no difference in performance between the two captan formulations. The mean number of scab lesions on infected fruit among the treatments range from 1.0 to 8.5/fruit. The highest mean number of lesions/infected fruit on 'Golden Delicious', 'Rome', and 'Delicious' was 2.4, 6.0, and 8.5, respectively, and occurred on the Syllit-Rubigan treatment. Fruit russet was very low on 'Golden Delicious' and ranged among treatments from 3.5 (Captan 50W) to 5.7% (Aliette) of the fruit surface affected. None of the treatments produced leaf spotting or other phytotoxicities to leaves or fruit.

Table 2. Incidence of Apple Scab and Powdery Mildew Infection on Trees Treated with Protective Fungicides Applied Dilute in 1991. Penn State Fruit Research Laboratory. Old 3-C Block.

		Percent Apple Scab						
		Leaves						
		Spur[1]	Terminal[2]		Fruit[3]			% P. mildew
Fungicide and Rate/100 gal	Spray Timing	'Del'	'Rome'	'Del'	'Del'	'G Del'	'Rome'	Leaves[2]
1. Untreated	____________	66.0d[4]	64.8d	66.0d	61.7e	27.5c	65.7e	30.7d
2. Aliette 80W 10.0 oz	1/2"-G thru 7C	41.3d	40.2cd	41.3c	45.5de	16.0bc	35.2d	23.9cd
3. Aliette 80W 20.0 oz	1/2"-G thru 7C	41.4d	43.3d	41.4c	38.0d	11.5ab	33.7d	24.5cd
4. Aliette 80W 10.0 oz + Nova 40W 1.0 oz Captan 50W 20.0 oz Captan 50W 32.0 oz	1/2"-G thru 2C 3C, 4C, 5C 6C,7C	4.5abc	9.7ab	4.5ab	7.2c	1.5a	9.8c	3.3ab
5. Captan 50W 32.0 oz	1/2"-G thru 7C	0.2a	3.8ab	0.2a	0.0a	0.5a	1.8abc	18.9cd
6. Captan 75WG 21.0 oz	1/2"-G thru 7C	1.2ab	3.8ab	1.2ab	1.0ab	1.7a	2.0abc	22.6cd
7. TD 2320 80DF 40.0 oz	1/2"-G thru 7C	8.4c	17.3bc	8.4b	8.5c	1.2a	8.5bc	13.0bcd
8. TD 2323 70DF 28.0 oz	1/2"-G thru 7C	5.3bc	14.7ab	5.3ab	4.5bc	0.2a	4.7abc	20.1cd
9. Nova 40W 1.5 oz + Captan 50W 16.0 oz Captan 50W 20.0 oz Captan 50W 16.0 oz + Topsin-M 70W 4.0 oz	1/2"-G thru 2C 3C, 4C, 5C 6C, 7C	0.0a	1.5a	0.0a	0.2a	0.5a	1.0a	1.9a

Continuation of Table 2 -- next page

Table 2 - continued

Fungicide and Rate/100 gal	Spray Timing	Percent Apple Scab: Leaves: Spur[1] 'Del'	Leaves: Terminal[2] 'Rome'	Leaves: Terminal[2] 'Del'	Fruit[3] 'Del'	Fruit[3] 'G Del'	Fruit[3] 'Rome'	% P. mildew Leaves[2]
10. Syllit 65W 6.0 oz	1/2"-Green							
Rubigan 1E 3.0 oz + Syllit 65W 4.0 oz	OC thru PF							
Rubigan 1E 2.0 oz + Captan 50W 16.0 oz	1C, 2C							
Captec 4F 12.0 fl oz	3C, 4C, 5C							
Captec 4F 16.0 fl oz + Topsin-M 70W 4.0 oz	6C, 7C	0.5ab	9.5ab	0.5a	0.5a	0.0a	2.0ab	11.4abc

1 Determined by observing all leaves on 15 non-fruiting spurs per single-tree replicate (4) on 3 June 1991.

2 Determined by observing all leaves on 10 terminals per single-tree replicate (4) on 1-3 July 1991

3 Determined by observing 100 fruits per single-tree replicate (4) on 18, 24, 26 Sep for 'G. Del', 'Del', and 'Rome', respectively.

4 Means within columns followed by the same letter(s) do not differ significantly, Tukey-Kramer HSD ($P \leq 0.05$).

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NECTARINE: (Prunus persica var nectarina 'Summer Beaut')
PEACH: (Prunus persica 'Redhaven', 'Sunhigh'
Brown rot; Monilinia fructicola
Rhizopus rot; Rhizopus spp.

BROWN ROT AND RHIZOPUS ROT INCIDENCE ON PEACH AND NECTARINE FRUIT TREATED WITH FUNGICIDES, 1991: Fungicide treatments were applied during the blossom and harvesting periods to evaluate their efficacy against brown rot blossom blight and fruit decay, respectively. Both protective and post-infection applications were made during the blossoming period. Treatments were applied to 5 year-old trees planted 10 ft apart in rows 30 ft wide. Plots consisted of a single-tree of 'Summer Beaut' nectarine planted between 'Redhaven' and 'Sunhigh' peach and were arranged in a randomized complete block design with four replicates. The fungicides were applied as dilute sprays to the point of "complete wettness" using two gallons/tree (200 gal/A) with a high pressure sprayer equipped with a 6-nozzle boom and operated at 400 psi. Treatments applied as protectants (see table) during the blossoming period were sprayed on 8 Apr (early-bloom), 13 Apr (full-bloom), and 27 Apr (petal-fall). Plots receiving the post-infection treatments were inoculated by atomizing conidia of Monilinia fructicola (175 X 10^3 spores/ml) onto open blossoms with an ULV air sprayer on 13 Apr (full-bloom, 63 hr wetting at 43° F) and 20 Apr (late-bloom, 34 hr wetting at 34° F). A single post-infection spray was applied on 23 Apr (71 hr after the second inoculation). All fungicides plots were sprayed with Sulfur 90W 5.0 lb/100 gal during the green-fruit stage on 9 May (shuck-fall), 22 May (first cover) and 6 Jun (second cover). Fungicides as listed were applied in three pre-harvest applications at intervals (PHI) indicated in the table footnote. Incidence of brown rot and Rhizopus rot on fruit was determined by observing 20 uniformly selected fruit/replicate collected 1-2 hrs after final sprays. Fruits used were harvested at a "firm-ripe" stage which showed slight yellowing of the "green ground color". Fruits were placed stem-end down on packing trays and inoculated by uniformly atomizing with a conidial suspension of Monilinia fructicola as indicated in the table footnote. Inoculated fruit were incubated for seven and ten days at 70-92° F and 80-100% RH under polyethylene tarp before disease incidence was determined. Cool temperatures during bloom were not favorable for blossom infection and lack of rainfall from Jun through the harvest period resulted in early and uneven ripening of fruit. The data were subjected to analysis of variance using appropriate transformations and the significance among means was determined by the Tukey-Kramer HSD test ($P \leq 0.05$).

No brown rot blossom blight was observed in any inoculated or noninoculated plot presumably due to the 42-43° F temperatures during bloom which were too low for infection to occur. Observations of green fruit from petal-fall until the day of harvest revealed no brown rot or Rhizopus rot on attached fruit. Inoculated nontreated fruit harvested on or within three days of the last fungicide application developed 23-50% brown rot within seven days. Within 10 days 36-79% of the nontreated fruit showed brown rot. Because of high variability in brown rot incidence among the replicated samples most of the fungicide treatments did not show significant difference in control of brown rot. This wide variability possibly was caused by variation in ripening of the fruit due to the drought conditions occurring in 1991. Although not significantly different, the level of control obtained with RH-7592 was generally higher than with other treatments. The data suggests that 'Redhaven' is somewhat more resistant to brown rot that either 'Sunhigh' or 'Summer Beaut' nectarine. Variability in Rhizopus rot development was also evident with levels much high on several treatments than the nontreated check. Differences among the fungicide treatments were generally not significant.

Table 3. Incidence of Brown Rot and Rhizopus Rot on Peach and Nectarine Fruit Treated with Seasonal Fungicide Dilute Sprays in 1991. Penn State Fruit Research Lab, 3-C Peach/Nectarine Block.

Fungicide and Amt/100 gal Application Timing	Percent Fruit Decay after Incubation (Days)									
	Brown Rot[3]						Rhizopus Rot[3]			
	'Redhaven'		'Summer Beaut'		'Sunhigh'		'Summer Beaut'		'Sunhigh'	
	7-Day	10-Day	7-Day	10-Day	7-Day	10-Day	7-Day	10-Day	7-Day	10-Day
Protective (seasonal)[1]										
1. Untreated	22.5ab[4]	36.3a	25.0a	50.0a	46.3b	78.8b	3.8a	7.5a	7.5a	28.7a
2. Funginex 1.6E 16.0 fl oz	5.0ab	17.5a	20.0a	40.0a	12.5ab	27.5a	1.3a	12.5a	23.8ab	58.7ab
3. Funginex 18.2DC 16.0 fl oz	2.5ab	6.2a	6.2a	21.3a	23.8ab	30.0a	1.3a	13.8a	32.5ab	60.0ab
4. RH 7592 2F 2.4 fl oz + Triton B-1956 4.0 fl oz	1.3a	5.0a	5.0a	20.0a	8.7a	23.7a	5.0a	18.8a	10.0a	58.7ab
5. Ronilan 50DF 12.0 oz	2.5ab	11.3a	6.2a	25.0a	20.0ab	42.5a	0.0a	7.5a	27.5ab	60.0ab
6. Ronilan 50DF 6.0 oz + Captec 4F 16.0 fl oz	35.0b	42.5a	18.8a	50.0a	40.0ab	48.7a	3.8a	18.8a	22.5ab	51.2ab
7. Topsin-M 70W 4.0 oz + Captan 50W 16.0 oz	2.5ab	6.2a	32.5a	43.8a	28.7ab	51.3ab	0.0a	5.0a	17.5a	53.8ab
Post-Infection (blossom only)[2] Protective (near harvest)										
8. Funginex 1.6E 16.0 fl oz	7.5ab	17.5a	11.2a	33.8a	22.5ab	43.8a	0.0a	16.2a	20.0a	46.2ab
9. RH 7592 2F 2.4 fl oz	0.0a	3.8a	21.3a	31.2a	15.0ab	33.7a	1.3a	20.0a	21.3ab	61.3ab
10. Ronilan 50DF 16.0 oz	15.0ab	32.5a	12.5a	32.5a	21.3ab	27.5a	8.8a	23.8a	48.8b	63.7b

Continuation of Table - next page

Table 3 - continued

1 Protective spray schedule- Treatments as listed were applied as follows: all cultivars - 8 Apr (early-bloom), 13 Apr (full-bloom), and 27 Apr (petal-fall; Sulfur 90W 5.0 lb/100 gal applied on 9 May (shuck-fall), 22 May (1st cover), and 6 Jun (2nd cover); 'Redhaven' - 16 Jul (13-day PHI), 22 Jul (7-day PHI), 26 Jul (3-day PHI for all treatments except Funginex, RH-7592, and Ronilan (0-day PHI on 29 Jul); 'Summer Beaut' Nectarine - 16 Jul (20-day PHI), 26 Jul (10-day PHI), 2 Aug (3-day PHI for all treatments except Funginex, RH-7592, and Ronilan (0-day PHI on 5 Aug); 'Sunhigh' - 5 Aug (10 day PHI), 12 Aug (3-day PHI, all treatments except Funginex, RH-7592, and Ronilan (0-day PHI on 15 Aug), NOTE: Ronilan in the post-infection treatment was changed to Rovral 4F 16.0 fl oz/100 gal in the 0-day PHI application on all cultivars.

2 Post-infection blossom schedule - Treatments as listed were applied to all cultivars as follows: 23 Apr (petal-fall), 71 hr following inoculation with *Monilinia fructicola* (175 X 10^3 spores/ml). Post infection treatments were not treated again until the applications near harvest as listed for the protective sprays.

3 Determined by observing 20 fruits/replicate (4 reps) collected 3 days (PHI) after final spray or day of harvest as indicated. Unwounded fruit were inoculated by atomizing with conidia of *Monilinia fructicola*, 171 X 10^3 spores/ml for 'Redhaven' and 'Summer Beaut' and 200 X 10^3/ml for 'Sunhigh', then incubated under polyethylene tarp for 7 and 10 days at mean temperature of 80° F (70-92) and mean relative humidity of 94% (80-100). Fruit were not inoculated with Rhizopus spores.

4 Means within columns followed by the same letter(s) do not differ significantly, Tukey-Kramer HSD ($P \leq 0.05$).

Title: Development of an antibody-based diagnostic kit to detect mature *Venturia inaequalis* ascospores.

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Abstract:

Current management of apple scab is based on effective control of primary infections. This is accomplished with repeated applications of fungicides during the period when ascospores are being released from overwintered leaves on the orchard floor. Successful management of the primary stage of disease development reduces the need for further control measures during the remainder of the growing season. This reduction in fungicide use translates into savings in production costs to the apple grower and mitigates concern about environmental contamination from overuse of fungicides and the development of fungicide resistance.

To efficiently schedule fungicide applications for apple scab, growers need to know when ascospores are mature and when environmental conditions fulfill infection requirements. Presently, apple growers can easily identify infection periods. However, they have no practical way to evaluate the presence of mature ascospores or the potential for ascospore release during a wetting period. The development of a technique that would enable the apple grower to accurately and rapidly determine ascospore maturity in their own orchard would lead to more informed decisions on the necessity of fungicide applications.

We have developed an 'on-farm' antibody-based kit to monitor mature ascospores of *V.inaequalis*. This kit combines 3 features: (1) maturation of ascospores under natural orchard conditions; (2) release of ascospores and capture on an assay medium; and (3) detection of mature ascospores with an immunoassay. By using this technique, individual ascospores become 'visible' and countable with the aid of a hand-held magnifier (30X). The technique was initially field tested Vermont in 1989 and has been subsequently evaluated by researchers/extension personnel from the United States, Canada, Switzerland, and Germany.

Dodder Transmission of Tomato Ringspot Virus

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Introduction

Tomato ringspot virus (TmRSV) is the causal agent of prunus stem pitting (PSP), a severe disease of peach and nectarine in the northeastern United States. Dagger nematodes (Xiphenema americanum Cobb) transmit TmRSV to fruit trees, and weed hosts of TmRSV have been identified as important virus reservoirs in the orchard (3). Cuscuta gronovii Willd. is a common dodder species in Pennsylvania, and has never been reported to transmit TmRSV. Therefore, C.gronovii was tested for its ability to vector TmRSV among weed hosts.

Materials and Methods

Cuscuta gronovii seed was collected from plants established on Chenopodium album L. in a Pennsylvania peach orchard. The TmRSV isolate used was originally obtained from apple in PA (2). ELISA was performed essentially as described (1) using antibody raised against the TmRSV apple isolate (2).

C. gronovii seed was germinated along with Chenopodium quinoa Willd. seed in the greenhouse. Dodder seedlings were tested for TmRSV and tobacco ringspot virus (TRSV) by ELISA. Virus-negative dodder was trained to TmRSV-infected C. quinoa, and upon establishment on the infected plant, to healthy C.quinoa or Cucumis sativus L. Healthy plants were shaded for one week following contact with dodder. TmRSV infection was confirmed by systemic symptom development and by ELISA.

Results

Cuscuta gronovii was easily established on C. quinoa in the greenhouse. C. gronovii appeared to prefer C. quinoa over C. sativus, but did form haustoria on either host. If dodder attachment was made before virus infection was systemic in a mechanically inoculated plant, systemic movement of virus was impaired above the dodder attachment site on that plant.

TmRSV transmission through dodder was obtained in 21/26 plants tested (Table 1). C. gronovii established on TmRSV-infected C. quinoa tested negative for virus in ELISA.

Discussion

Cuscuta gronovii is able to transmit TmRSV between plants of the same or of different species. In the laboratory, dodder may be useful for the transmission of TmRSV from hosts that do not serve as good inoculum sources. In the orchard, dodder could play a role in the local epidemiology of PSP by facilitating TmRSV transmission from weed hosts which are poor acquisition hosts to weeds which are good acquisition hosts for the nematode vector. Dodder might also influence dissemination of virus over longer distances through virus transfer among weed species with varied levels of seed transmission.

References

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2. Powell, C. A. 1987. Detection of three plant viruses by dot-immunobinding assay. Phytopathology 77:306-309.
3. Powell, C. A., et al. 1984. Orchard weeds as hosts of tomato ringspot and tobacco ringspot viruses. Plant Disease 68: 242-244.

Table 1. Number of plants testing positive for TmRSV after inoculation through dodder.

Dodder established on:	Recipient: C. quinoa expt #1	Recipient: C. quinoa expt #2	Recipient: C. sativus expt #1	Recipient: C. sativus expt #2
TmRSV-infected C. quinoa	5/5	6/10	1/1	9/10
Healthy C. quinoa	0/1	0/2	--	0/2

The New *MARYBLYT™* Forecasting Program and Continuing Investigations on Fire Blight Disease of Apples and Pears

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INTRODUCTION

MARYBLYT™, a new computerized program for forecasting fire blight disease of apples and pears, is expected to be ready for commercial release in early 1992. During a recent sabbatical leave, several substantial changes were made in the program. In addition, several new approaches for fire blight disease management were initiated and will be the focus for continuing research at Maryland over the next two years. The purpose of this report is to summarize these developments as an update on the progress being made.

MARYBLYT™ Release in 1992

The new *MARYBLYT™* forecasting program is planned for commercial release by February of 1992. Over the last two years, we've added visual prompt messages coupled with audio alarms to signal high risk periods for blossom blight, infection events and symptom appearance. In addition, there are messages prompting the user to use the simulation program, to consider or make spray treatments, and to remove active cankers. Several other changes allow the program to operate faster and offer ready access to a file library. One drawback during the testing period was the lack of written instructions accompanying the program to explain its operation and the many bases for decision-making. The 1992 program disk will be accompanied by a fully detailed description of the *MARYBLYT™* model including its biological bases, general operation and interpretation of the reports it generates. The copyright for *MARYBLYT™* has been assigned to The University of Maryland who will produce, sell and distribute the program. We anticipate a purchase price of $150 (includes the program disk and hardcopy manual) with a $25 annual renewal fee which will cover any software updates and a semiannual newsletter on program uses and troubleshooting.

One substantial change in the program's operation is the use of a sine wave function to generate cumulative degree day and degree hour indices. This was necessary to meke the program more reliable under the semi-arrid conditions of the Pacific Northwest and parts of the Mediterranean and for other areas and seasons with prolonged cool springs. The original *MARYBLYT™* program determined degree days (DD) using the difference between the daily mean temperature and the base temperatures of 40°F or 55°F. Under prolonged cool periods and in areas like the PNW where there are wide differences between the daily minimum and maximum temperatures, DD indices accrued more slowly than the plant, insect or disease development they were intended to predict, resulting in a delayed forecast error. Using a sine wave function (Baskerville & Emin, 1969) appears to ameliorate such geographical biases. Incorporation of this change also means changing the standard infection-to-early-symptom interval in *MARYBLYT™* from 90 to 103 DD>55°F.

Pear Bud Phenology Models

The progress of apple bud development can be predicted on the basis of cumulative DD>40°F from green tip (Steiner, 1990a). A similar model was developed for Bartlett and D'Anjou pears in 1991 as an aid for blossom blight risk assessment and decision-making in conjunction with the *MARYBLYT™* model. Seven orchards of Bartlett and D'Anjou pears were selected at various elevations from Yakima to Wenatchee in Washington state, all of which varied in the rate and timing of bud development due to location. Weather data was obtained using on-site data loggers and local state weather stations. Observations were made on 20 spurs on each of 5 trees of each variety at frequent intervals from before green tip through primary petal fall. From these data a general bud

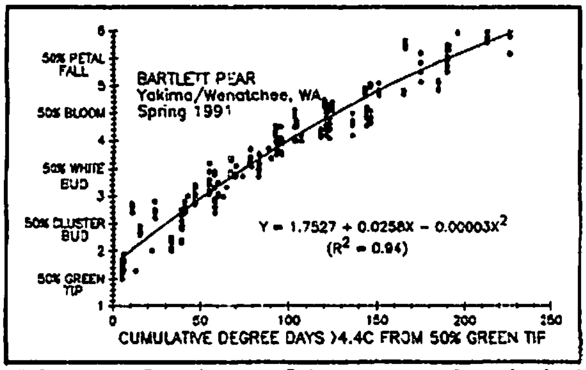

FIGURE 1. Prediction of the average phenological stage of Bartlett pear buds from 50% green tip using cumulative degree days >4.4°F.

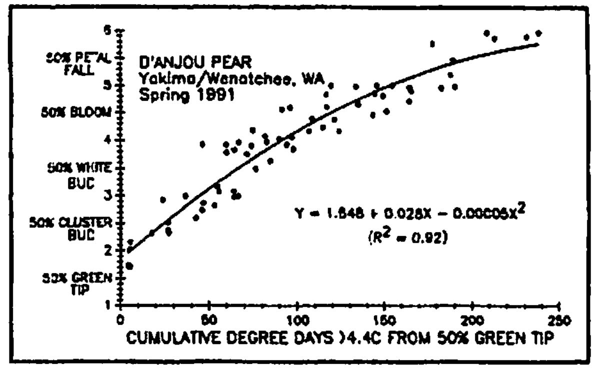

FIGURE 2. Prediction of the average phenological stage of D'Anjou pear buds from 50% green tip using cumulative degree days >4.4°F.

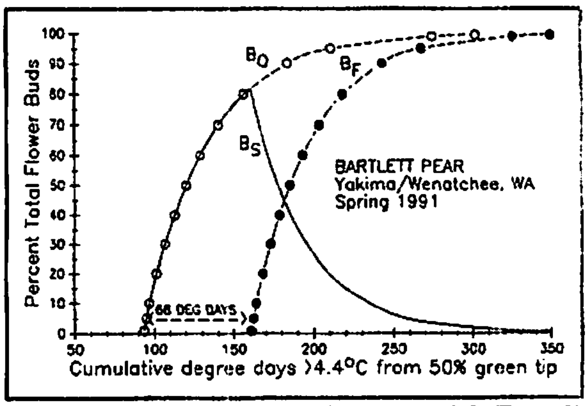

FIGURE 3. Bartlett pear bloom model: B_O= % flower buds opened; B_F= % buds in petal fall; and, B_S= % buds in bloom (susceptible).

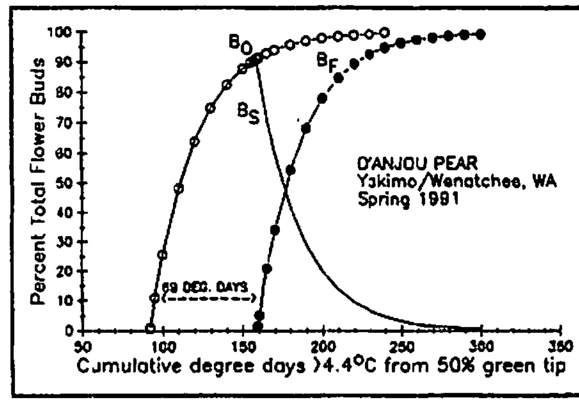

FIGURE 4. D'Anjou pear bloom model: B_O= % flower buds opened; B_F= % buds in petal fall; and B_S= % buds in bloom (susceptible).

stage model (FIGURES 1 and 2) and a specific bloom model (FIGURES 3 and 4) was developed for each cultivar. The latter model defines the rates at which flower buds open and for open flowers entering petal fall, with the difference between the two describing the proportion of total flowers in bloom and, therefore, susceptible to infection. These models also show an average pear blossom life (open to petal fall) of 68-69 DD>4.4°C with 85-95% of the flower buds open at full bloom. By comparison, apples have an average flower life of only 40-45 DD>4.4°C and seldom have more than 65-70% of the flower buds open at full bloom. Thus, *pears may appear more susceptible than apples simply because they have more flowers open longer and, hence, have a greater chance of being infected. In addition, this bloom pattern suggests that, in some years, nearly all flowers may be protected with a single streptomycin treatment, timed with maximum flowering.*

Phytotoxic Potential of Copper Ammonium Carbonate on Pears Using LV Sprays.

Copper sulfate and COCS formulations used for fire blight control can be phytotoxic to D'Anjou pears. A series of treatments using low volume spraying methods and low concentrations of a water soluble formulation of copper ammonium carbonate [Copper Count-N™, Mineral Res. & Dev. Corp., Charlotte, NC] was undertaken to determine if copper phytotoxicity could be avoided. Replicated spray plots were established in a 25-year-old D'Anjou pear orchard at the WSU Columbia View Station. The trees were 15-16 ft high, 16-17 ft wide and planted on a 20 ft X 20 ft spacing, representing a total tree row canopy volume of 557,568 ft^3/acre. LV treatments were made with an FMC airblast sprayer calibrated to deliver 0.10 gal./1,000 ft^3 of tree row volume (ca. 56 gpa) at 2 mph. Uniform target coverage was verified with spray targets. Treatments of 1 to 3 sprays [17 Apr. (full bloom), 26 Apr.(petal fall) and 15 May (20 mm fruit diam.)] at either 25 or 50 ppm copper as CAC and a single treatment (20 mm fruit diam.) at 150 ppm caused no detectable damage to either the fruit or foliage. Replicated treatments of individual fruited branches when the fruit diameter was ca. 35 mm (12 June) with a thorough wetting spray applied by back pack sprayer at 25, 50, 100, 200, 400, 800 and 1,600 ppm showed no damage at 25 or 50 ppm, slight fruit damage at 100 ppm and increasing amounts of fruit and foliar damage at $\geq$200 ppm.

Since the anticipated efficacy range of CAC for fire blight control is ca. 50-75 ppm, these results suggest that LV sprays of CAC may provide a safe, economical alternative to other antibiotics, even on copper sensitive cultivars. We are encouraged also by the fact that a single, thorough wetting application of Copper Count-N™ at 50 ppm Cu^{++} to apples (Gala, Golden Delicious) in early June (approx. 8 leaves/shoot) caused no detectable foliar damage or fruit russetting. If LV/LC sprays of CAC prove non-phytotoxic under east coast conditions, it may provide both a way to manage streptomycin resistance and a more effective approach to shoot blight control where streptomycin is not effective. Specifically, it may be useful where additional treatments are required to protect secondary blossoms and to reduce epiphytic populations fo the pathogen, thereby, delaying shoot blight epidemics.

Modified pruning method for the removal of active fire blight strikes.

Cutting out blighted branches with surface sterilized tools as soon as they appear is is often recommended to limit the amount of damage and to slow the progress of the epidemic. This can be time consuming and may be self-defeating in that such cuts often incite new cankers that provide inoculum for the next season. Tests have shown that fire blight pathogen invades limbs many feet in advance of any visible symptoms and may persist there in a latent state for months due to physiological factors associated with mature tissues. The cutting process breaches this natural defense, allowing the bacteria to multiply and form a small canker around the cut. This was demonstrated on pears in Wenatchee by surface sterilizing cutting shears and the bark to be cut and removing the blighted portion of a branch 6-8 inches below any visible symptoms. Small cankers formed on many of the cut stubs remaining in the tree and the bacteria could be isolated easily from internal bark tissues. Similar wound-induced cankers occurred in a Virginia Gala orchard and in young trees in a western Maryland research orchard in 1991. *Thus, because the pathogen is already present in internal bark tissues, tool sterilization in the field may be moot and unnecessary. By making the cut into at least 2-year-old wood and deliberately leaving a 3-4 inch naked branch stub instead of a conventional heading cut, the induced canker forms in a position isolated from the branch crotch where it can be removed completely during dormancy, reducing the number of carryover cankers in the orchard.* NOTE: Cuts which leave the stub on the current season's wood, may induce secondary shoots which may become infected internally to show canker blight symptoms in late summer, leaving a continuing source of inoculum in the trees.

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

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EVALUATION OF EXPERIMENTAL FUNGICIDES ON THREE APPLE CULTIVARS, 1991: Experimental and standard treatments were compared for disease control and fruit finish effects on a 19-yr-old block of semi-dwarf trees planted in groups with one tree of each cultivar per group. The test was conducted in a randomized block design with four replicate groups per treatment. Treatments were applied as dilute sprays to the runoff point with a single nozzle handgun at 200 psi as follows: 12 Apr (Red Del., 25% bloom; Golden Del., P, pink; Rome, tight cluster); 19 Apr (Red Del., bloom; Golden Del., Bl, 20% bloom; Rome, pink); 30 Apr (Red Del., fruit set, Golden Del., PF, petal fall); 10 May, 23 May, 6 Jun, 21 Jun, 10 Jul, 1 Aug (1C-6C, 1st cover-6th cover). Insecticides applied separately to the entire test block with an airblast sprayer were: Supracide 2E + oil (26 Mar); Dipel 2X (1 May); Guthion 3F + Lannate (8 May, 23 May); Guthion 35W + Swat LC (6 Jun); Guthion 35W + Lannate (20 Jun, 3 Jul, 19 Jul, 2 Aug, and 16 Aug.). Cedar-apple rust galls, bramble canes infected with the sooty blotch and fly speck fungi, and bitter rot mummies were placed in baskets over each test tree. Scab and powdery mildew developed from natural inoculum in the test area. Foliar data represent averages of ten Red Delicious flower cluster leaf sets 4 Jun or ten terminal shoots from Rome (3 Jul) and Golden Delicious (31 Jul). Twenty-five fruit per replicate were harvested 24 Sep (R.Del.), 30 Sep (G.Del.) and 8 Oct (Rome) and rated after 3 wk (Rome), 2 wk (R.Del) and 6 wk (G.Del.) storage at 2C.

Several infection periods between 22 and 30 Mar favored early establishment of scab in the more advanced Red Delicious trees before the first application 12 Apr. Lesions appeared in Red Delicious trees by 17 Apr, giving opportunity for secondary spread to the slower developing cultivars as early as 19 Apr. Under moderate pressure all treatments gave significant control of scab compared to untreated trees. Good control of scab (<6% infection) on leaves and fruit of all cultivars by Ziram-TD 2323, dithianon, captan (1 lb and 2 lb rates) and ziram + sulfur. The lowest rate of EXP 10064B permitted significantly more infection of foliage than the highest rate. Lorsban provided significant control of scab although two sprays were omitted during the bloom period, resulting in a 4-wk spray interval. Rust infection occurred during three wetting periods between 9 and 15 May. Most treatments gave a significant reduction in rust infection with Nova, TD 2320 and EXP 10064B providing the best control. Periods favorable for powdery mildew infection occurred throughout much of the season. Nova provided superior control of mildew and EXP 10064B showed potential for control at the highest rate. Dry weather in mid-summer deterred rot development resulting in variable infection and inconsistent control. Sooty blotch and fly speck incidence was light in the test block. Although there were significant ($p = 0.05$) fruit finish differences among some treatments. The only significant deleterious effect compared to untreated fruit was an apparent increase in opalescence on Red Delicious by all treatments.

Table 1. Early season disease control by experimental fungicides

			Scab incidence (%)						Rust, %		Powdery mildew (%)			
			leaves			fruit			leaves	infec.		Rome Beauty		
Treatment	Rate/ 100 gal	Timing*	R.Del.	G.Del.	Rome	R.Del.	G.Del.	Rome	G.Del.	Rome	G.Del. leaves	leaves	leaf area	fruit
Control	....		39 d	29 c	38 c	50 b	33 b	28 c	32 d	35 f	25 f	37 cd	17 abc	12 b
Exp 10064B 1.67 SC	17.0 ml	P-6C....	11 c	11 b	11 ab	3 a	4 a	6 ab	4 ab	5 a-d	12 b-e	21 abc	7 ab	2 a
Exp 10064B 1.67 SC	28.4 ml	P-6C....	5 ab	6 ab	5 ab	3 a	1 a	5 ab	2 ab	1 a	6 abc	22 abc	8 ab	7 ab
Exp 10064B 1.67 SC	42.6 ml	P-6C....	3 ab	2 a	4 ab	1 a	6 a	3 ab	2 ab	3 abc	5 ab	15 ab	4 ab	1 a
Nova 40W	1.25 oz	P-6C....	3 a	3 a	1 a	1 a	1 a	6 ab	0 a	1 a	2 a	5 a	2 a	1 a
Ziram 76DF TD 2320 80WP	2.0 lb 2.5 lb	pink B1-6C...	6 abc	3 a	5 ab	1 a	6 a	0 a	1 a	2 ab	10 a-d	29 bcd	9 ab	0 a
Ziram 76DF TD 2323 70WDG	2.0 lb 1.25 lb	pink B1-6C...	4 ab	3 a	3 ab	0 a	1 a	0 a	3 ab	7 a-d	17 def	30 bcd	10 ab	4 ab
Dithianon 4.2SC	3.8 fl oz	P-6C....	1 a	3 a	2 a	0 a	0 a	5 ab	4 ab	16 cde	15 b-f	39 cd	27 c	6 ab
Captan 50W	2.0 lb	P-6C....	1 a	3 a	2 a	0 a	2 a	3 ab	8 ab	15 b-e	14 b-e	28 bcd	8 ab	2 a
Captan 50W + Lorsban 50W Captan 50W	1.0 lb + 12.0 oz 2.0 lb	 P,1C-6C. B1-PF	2 a	3 a	2 a	1 a	4 a	2 a	7 ab	13 a-e	17 c-f	37 cd	21 bc	1 a
Lorsban 50W Captan 50W	12.0 oz 2.0 lb	P,1C-6C. B1-PF	6 abc	7 ab	14 ab	3 a	2 a	0 a	9 b	16 cde	13 b-e	31 bcd	11 ab	6 ab
Lorsban 50W	12.0 oz	P,1C-6C.	9 bc	7 ab	15 b	13 a	8 a	12 b	20 c	22 e	16 c-f	32 bcd	10 ab	3 a
Captan 50W	1.0 lb 2.0 lb	P,1C-6C. B1-PF	1 a	2 a	2 a	1 a	2 a	0 a	18 c	25 ef	22 ef	41 d	15 abc	2 a
Ziram 76DF + Sulfur APK 83W	1.0 lb + 1.5 lb	P-6C....	3 ab	3 a	5 ab	0 a	3 a	3 ab	7 ab	13 a-e	13 b-e	27 bcd	8 ab	2 a
Syllit 65W + Sulfur APK 83W	6.0 oz + 1.5 lb	P-6C....	1 a	2 a	6 ab	0 a	2 a	1 a	7 ab	18 de	12 b-e	27 bcd	7 ab	0 a

Mean separation by Duncan's Multiple Range Test (p = 0.05).
*Early season timing reported by bud stage of Golden Delicious which was intermediate in bud development between Red Delicious and Rome Beauty. All cultivars were treated on the same dates.

APPLE (*Malus domestica* 'Starking Delicious')
Scab; *Venturia inaequalis*
Powdery mildew; *Podosphaera leucotricha*
Fruit finish

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COMPARISON OF REGISTERED FUNGICIDES ON STARKING DELICIOUS APPLE, 1991. Fungicide mixtures and possible alternatives to EBDC fungicides were compared for disease control and fruit finish effects on 19-yr-old trees at the VPI and SU Research Farm near Winchester, VA. The test was conducted in a randomized block design with four single-tree replicates separated by border trees in the row and by untreated border rows between treatment rows. 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: 2 Apr (TC, tight cluster); 18 Apr (FB, full bloom); 26 Apr (PF, petal fall); 8 May, 22 May, 5 Jun, 20 Jun, 9 Jul, 31 Jul (1C-6C, 1st-6th covers). Insecticides applied separately with the same equipment included Supracide 4 qt + oil 6 gal/A (26 Mar); Dipel 2X 1 lb/A (1 May); Guthion 3F 1 qt + Lannate 3 pt/A (10 May and 23 May); Guthion 3F 1 qt + Swat LC 12 fl oz/A (6 Jun); and Guthion 35W 2 lb + Lannate 3 pt/A (20 Jun, 3 Jul, 19 Jul, 2 Aug, and 16 Aug). Fruit were harvested 24 Sep and rated after 3 wks storage at 2C.

Scab and powdery mildew developed from natural inoculum in the test area. Three primary scab infection periods occurred between 22 and 30 Mar before the first fungicide application 2 Apr. Sporulating lesions were present 17 Apr. Eleven secondary scab periods occurred in Apr and May. Although scab developed on untreated foliage and fruit, rainfall was relatively light and, except for a significant weakness of the ziram treatment on foliage, other significant treatment differences ($p = 0.05$) were not detected. Mildew infection was light on this cultivar and all treatments involving sterol-inhibiting fungicides gave good mildew control. Summer disease pressure was light and variable. No significant differences were detected in fruit rot incidence with treatment means ranging from 7 to 18% and 16% for untreated fruit. Compared to untreated fruit, several combination treatments resulted in a significant ($p = 0.05$) increase in opalescence and Rubigan 9 fl oz + captan (applied TC-2C) significantly increased fruit russetting. The season-long ziram treatment resulted in good fruit finish with no increase in opalescence or russet compared to untreated fruit.

Table 2. Rot control and fruit finish effects by experimental fungicides

			Rots (%)		Fruit finish ratings*				
					russet			opalescence	
Treatment	Rate/100 gal	Timing	G.Del.	Rome	R.Del.	G.Del.	Rome	R.Del.	Rome
Control	....		13 b	1 a	1.5 a-d	2.3 ab	1.7 ab	1.3 a	1.5 abc
Exp 10064B 1.67 SC	17.0 ml	pink-6C......	1 a	10 ab	1.2 a-d	2.2 a	1.6 ab	2.0 b	1.6 abc
Exp 10064B 1.67 SC	28.4 ml	pink-6C......	10 ab	6 ab	1.0 ab	2.6 ab	1.6 ab	1.9 b	1.1 a
Exp 10064B 1.67 SC	42.6 ml	pink-6C......	4 ab	7 ab	1.4 a-d	2.5 ab	1.2 a	1.9 b	1.8 abc
Nova 40W	1.25 oz	pink-6C......	2 a	8 ab	1.7 cd	2.5 ab	1.7 ab	1.9 b	1.4 abc
Ziram 76DF TD 2320 80WP	2.0 lb 2.5 lb	pink bloom-6C.....	6 ab	6 ab	1.7 d	2.4 ab	1.7 ab	2.4 b	2.0 bc
Ziram 76DF TD 2323 70WDG	2.0 lb 1.25 lb	pink bloom-6C.....	2 a	0 a	1.1 abc	2.4 ab	2.1 ab	1.9 b	1.9 bc
Dithianon 4.2SC	3.8 fl oz	pink-6C......	4 ab	13 b	0.9 a	2.3 ab	1.9 ab	2.3 b	1.2 ab
Captan 50W	2.0 lb	pink-6C......	0 a	6 ab	1.5 bcd	2.5 ab	1.8 ab	1.8 b	1.6 abc
Captan 50W + Lorsban 50W Captan 50W	1.0 lb + 12.0 oz 2.0 lb	pink, 1C-6C.. bloom-PF	2 a	4 ab	1.5 a-d	2.2 a	1.6 ab	2.3 b	1.7 abc
Lorsban 50W Captan 50W	12.0 oz 2.0 lb	pink, 1C-6C.. bloom-PF	5 ab	7 ab	1.1 a-d	2.5 ab	1.9 ab	2.2 b	2.1 c
Lorsban 50W	12.0 oz	pink, 1C-6C..	6 ab	6 ab	1.2 a-d	2.7 b	2.3 b	1.9 b	2.0 c
Captan 50W	1.0 lb 2.0 lb	pink, 1C-6C.. bloom-PF	3 ab	9 ab	1.3 a-d	2.3 ab	1.4 ab	2.3 b	1.5 abc
Ziram 76DF + Sulfur APK 83W	1.0 lb + 1.5 lb	pink-6C......	1 a	5 ab	1.4 a-d	2.3 ab	1.3 a	2.0 b	1.9 bc
Syllit 65W + Sulfur APK 83W	6.0 oz + 1.5 lb	pink-6C......	4 ab	4 ab	1.4 a-d	2.2 a	1.4 ab	1.8 b	1.5 abc

Mean separation by Duncan's Multiple Range Test (p = 0.05).
*Rated on a scale of 0-5 (0 = perfect finish; 5 = severe opalescence or russet, excluding presumed mildew russet).

APPLE (*Malus domestica* 'Rome Beauty')
Scab; *Venturia inaequalis*

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SCAB CONTROL BY SUMMER APPLICATIONS OF PROTECTANT FUNGICIDES AND ADJUVANTS ON ROME BEAUTY APPLE, 1991: Four-yr-old trees which had not been treated with fungicides through mid-season were used to test the protectant residue extending properties of selected adjuvants and to compare fungicide formulations for control of secondary spread of scab to leaves and fruit. The early season was favorable to scab development and lesions were sporulating on the trees before the treatment series was initiated. The test was conducted in a randomized block design with four single-tree replicates. Treatments were applied as dilute sprays to the runoff point with a single nozzle handgun at 200 psi. To test residual properties, rates were reduced and spray intervals extended. Treatments were applied 14 Jun, 16 Jul, and 21 Aug. During the test period the insecticides Guthion + Lannate were applied separately to the entire test block on 20 Jun, 3 Jul, 19 Jul, 2 Aug, and 16 Aug. Foliar data represent averages of 10 terminal shoots 13 Aug and 25-fruit samples from each replicate tree harvested 7 Oct and rated after 3 wk storage at 2C.

After initiation of the test, the weather was relatively dry. The most significant wetting periods were 22 hr 4-5 Jul and 24 hr 10-11 Jul. Rainfall did not exceed one inch in any week during the remainder of the season. Scab infection was more variable on fruit than on leaves. The addition of Bond significantly improved performance by ziram for scab control on foliage. Nu-Film 17 added to ziram significantly reduced the percent fruit infected and lesions per fruit compared to fruit treated with ziram 1 lb. alone. Neither Nu-Film 17 nor Bond significantly improved the effectiveness of Captan 75DF. There was no significant effect ($p = 0.05$) by any treatment on fruit finish.

Table 3. Comparison of registered fungicides on Starking Delicious apple

Treatment, rate/A and timing	Scab (%)		Mildew	Fruit finish*	
	leaves	fruit	% leaves	opalescence	russet
Untreated	45.1 c	54 b	8.3 c	1.0 a	0.9 abc
Nova 40W 5 oz (TC-FB) Nova 40W 5 oz + Captan 50W 3 lb (PF-2C) Captan 50W 6 lb (3C-6C)	0.5 a	0 a	0.9 a	1.9 bc	1.2 bcd
Nova 40W 5 oz + Captan 50W 3 lb (TC-2C) Captan 50W 6 lb (3C-6C)	0.2 a	2 a	0.8 a	1.3 abc	1.0 a-d
Rubigan 1E 9 fl oz (TC-FB) Rubigan 1E 9 fl oz + Captan 50W 3 lb (PF-2C) Captan 50W 6 lb (3C-6C)	0.8 a	5 a	1.1 a	1.7 abc	1.1 a-d
Rubigan 1E 9 fl oz + Captan 50W 3 lb (TC-2C) Captan 50W 6 lb (3C-6C)	0.5 a	5 a	0.9 a	2.0 c	1.4 d
Rubigan 1E 6 fl oz + Captan 50W 3 lb (TC-2C) Captan 50W 6 lb (3C-6C)	0.6 a	4 a	1.7 ab	1.9 bc	1.3 cd
Syllit 65W 1.5 lb (TC) Rubigan 1E 6 fl oz + Syllit 65W 12 oz (FB-1C) Captan 50W 6 lb (2C-6C)	2.2 a	2 a	1.1 a	1.8 bc	1.3 cd
Syllit 65W 1.5 lb (TC) Bayleton 50DF 2.0 oz + Syllit 65W 1.5 lb (FB-1C) Syllit 65W 1.5 lb (2C-6C)	4.0 a	8 a	0.9 a	1.9 bc	0.8 ab
Captan 50W 6 lb (TC-6C)	4.0 a	4 a	2.8 ab	1.3 ab	0.7 a
Ziram 76DF 6 lb (TC-6C)	10.5 b	5 a	3.5 b	1.0 a	0.8 a

Averages of ten terminal shoots (24-25 Jun) or 25 fruit (15 Oct) from each of four single-tree replicates.
Mean separation by Duncan's Multiple Range Test (p = 0.05).
*Rated on a scale of 0-5 (0 = perfect finish; 5 = severe russet or opalescence).

APPLE (*Malus domestica*) 'Stayman Winesap', 'Idared', 'Granny Smith'
Scab; *Venturia inaequalis*
Cedar-apple rust; *Gymnosporangium juniperi-virginianae*
Powdery mildew; *Podosphaera leucotricha*
Fruit finish

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COMPARISON OF FUNGICIDE-ADJUVANT COMBINATIONS FOR DISEASE CONTROL AND PHYSIOLOGICAL EFFECTS ON APPLE, 1991. Combinations of fungicides and pinolene (Nu-Film 17) and synthetic latex (Bond) adjuvants were applied to test their residue extending capabilities. Test trees were 5 yrs-old, 10 ft tall, and planted 15X30 ft. Based on tree-row-volume the usual per acre rates for all materials were reduced 50% for application with a Swanson Model DA-400 airblast sprayer calibrated to deliver 100 gal per acre. The test was conducted in a randomized block design with four three-tree replicates composed of adjacent trees of each cultivar. Treatment rows were separated by untreated border rows. Treatments were applied to both sides of the tree on each application date as follows: 19 Apr (Bl, early bloom); 26 Apr (full bloom); 8 May (fruit set - 1C, 1st cover); 22 May, 5 Jun, 25 Jun, 19 Jul, 6 Aug (3C-6C, 3rd-6th covers). Insecticides were applied separately with the same equipment 27 Mar (Supracide 2E 4 qt + oil 6 gal/A); 1 May (Dipel 2X 1 lb/A); 8 May and 23 May (Guthion 3F 2 pt + Lannate 3 pt/A); 6 Jun (Guthion 3F 2 pt + Swat 12 fl oz/A); 20 Jun, 3 Jul, 19 Jul, 6 Aug, 21 Aug (Guthion 35W 2 lb + Lannate 3 pt/A); 12 Jul (Sevin 50W 6 lb/A). Foliar data represent averages of ten terminal shoots from each replicate tree 17-20 Jun (Granny Smith), 12 Jul (Stayman) and 21 Aug (Idared). Except for "in orchard" counts of cracked Stayman fruit, fruit data are based on 25 fruit per replicate tree harvested 30 Sep (Idared) or 7 Oct (Stayman) and rated after 2 wk storage at 2C.

Several primary scab infection periods occurred 22-30 Mar and 13-15 Apr before the first treatment application. Granny Smith bud development was more advanced than other cultivars during the 22-24 Mar infection period which may have resulted in more secondary infection on this cultivar 19-21 Apr. Under moderate scab pressure, all fungicide treatments gave significant control of scab compared to untreated fruit and foliage. Although the first application had been delayed to assure the presence of scab inoculum in the trees and later spray intervals were extended to provide a stronger test, scab control was not significantly improved ($p = 0.05$) by the addition of Bond or Nu-Film 17 to any of the fungicide combinations. Under relatively dry weather throughout the spring and summer months, no significant benefit by NuFilm or Bond was observed for rust or powdery mildew control. Fruit rot incidence was light and variable. Most fungicide treatments gave significant rot control on Idared. A bitter rot-infected fruit was placed in each Stayman tree 28 Aug, however, most late season wetting periods were relatively cool and little effect of the inoculum was observed. One ziram treatment had significantly greater rot incidence than untreated fruit. Compared to untreated fruit the only significant finish effect was a slight increase in opalescence by captan + sulfur on Stayman. Physiological cracking of Stayman was not unusually severe for the region. Cracks associated with scab lesions were recorded separately in the sample randomly picked from the tree, and incidence of cracking due to scab was generally correlated with overall incidence of fruit scab. Cracking due to scab was not excluded from in orchard counts of total fruit, on and under the tree, and probably increased cracking incidence. In the random sample taken from trees treated with ziram + sulfur + Bond, increased cracking not related to scab was observed.

Table 4. Effects of summer applications of adjuvants with protectant fungicides and adjuvants on Rome Beauty apple

Treatment and rate/100 gal	Scab on underside of 10 most distal leaves		Scab		Fruit finish*	
	% leaves infected	lesions/leaf	% fruit inf	lesions/ fruit	russet	opalescence
No fungicide............	28 c	2.6 b	12 ab	0.18 abc	0.6 a	1.1 a
Ziram 76DF 2.0 lb........	19 bc	1.0 a	15 ab	0.38 a-d	0.7 a	1.4 a
Ziram 76DF 1.0 lb........	10 ab	0.9 a	25 b	0.46 bcd	0.9 a	1.6 a
Ziram 76DF 1.0 lb + Nu-Film 17 4.0 fl oz.....	8 a	0.4 a	2 a	0.03 a	1.2 a	1.4 a
Ziram 76DF 1.0 lb + Bond 1.0 fl oz...........	4 a	0.2 a	17 ab	0.27 a-d	1.2 a	1.4 a
Captan 75DF 21.3 oz......	8 a	0.6 a	16 ab	0.32 a-d	0.9 a	1.1 a
Captan 75DF 10.7 oz......	8 a	0.2 a	15 ab	0.31 a-d	0.7 a	1.2 a
Captan 75DF 10.7 oz + Nu-Film 17 4.0 fl oz.....	6 a	0.3 a	24 b	0.59 d	1.0 a	1.3 a
Captan 75DF 10.7 oz + Bond 1.0 fl oz...........	6 a	0.2 a	8 ab	0.13 abc	1.1 a	1.2 a
Captec 4L 16.0 fl oz.....	7 a	0.2 a	10 ab	0.15 abc	1.1 a	1.5 a
Captan 50W 2.0 lb........	5 a	0.2 a	8 ab	0.08 ab	1.2 a	1.4 a
Captan 50W 1.0 lb........	5 a	0.4 a	8 ab	0.17 abc	1.0 a	1.6 a
Dithane 75DF 2.0 lb......	6 a	0.4 a	18 ab	0.51 cd	1.1 a	1.7 a
Dithane 75DF 1.0 lb......	5 a	0.2 a	17 ab	0.27 a-d	1.2 a	1.4 a

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

Table 5. Effects of fungicide-adjuvant combinations on early season disease control

Treatment and rate/A*	Scab incidence (%) Stayman leaves	Stayman fruit	Idared leaves	Idared fruit	G.Smith leaves	Mildew, % leaves infected Stayman	Idared	G.Smith	Rust, % lvs inf Idared
No treatment......................	52 e	24 cde	11 e	35 b	34 b	30 c	33 d	39 d	8 e
Topsin-M 85WDG 4 oz + Captan 50W 1.5 lb................	6 a	8 ab	2 abc	4 a	8 a	12 a	16 ab	17 ab	1 ab
Topsin-M 85WDG 4 oz + Captan 50W 1.5 lb + Bond 2 fl oz.	6 a	1 a	2 ab	2 a	4 a	11 a	13 a	9 a	1 abc
Topsin-M 85WDG 4 oz + Captan 50W 1.5 lb + Nu-Film 17 8 fl oz...............	10 ab	6 ab	2 a	4 a	4 a	13 a	23 a-d	16 ab	3 a-d
Captan 50W 3 lb (+ Sulfur APK 83% 3 lb, B1-3C)...	6 a	4 ab	2 abc	1 a	3 a	14 a	22 a-d	18 abc	4 a-d
Captan 50W 3 lb + Bond 2 fl oz (+ Sulfur APK 83% 3 lb, B1-3C)...	6 a	5 ab	3 abc	3 a	5 a	17 a	30 cd	21 abc	5 cde
Captan 50W 3 lb + Nu-Film 17 8 fl oz (+ Sulfur APK 83% 3 lb, B1-3C)...	6 a	8 ab	2 ab	3 a	4 a	19 ab	23 a-d	21 abc	2 a-d
Ziram 76DF 3 lb (+ Sulfur APK 83% 3 lb, B1-3C)...	14 ab	19 bcd	4 abc	9 a	11 a	13 a	20 abc	19 abc	2 a-d
Ziram 76DF 3 lb + Bond 2 fl oz (+ Sulfur APK 83% 3 lb, B1-3C)...	20 b	14 abc	6 cd	6 a	7 a	16 a	29 bcd	18 abc	1 a
Ziram 76DF 3 lb + Nu-Film 17 8 fl oz (+ Sulfur APK 83% 3 lb, B1-3C)...	16 ab	13 abc	3 abc	6 a	14 a	17 a	20 abc	15 ab	1 a
Water only........................	37 cd	34 de	5 abc	31 b	30 b	28 c	20 abc	26 bc	5 b-e
Bond 2 fl oz......................	46 de	37 e	5 bcd	35 b	28 b	27 bc	28 bcd	24 abc	4 a-d
Nu-Film 17 8 fl oz................	33 c	30 de	8 de	28 b	27 b	26 bc	31 cd	32 cd	5 de

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

*Formulated material per acre, applied to both sides of the row at 100 gal/A with a Swanson Model DA-400 sprayer. The indicated rates represent a 50% reduction for all treatments based on tree-row volume of the test trees.

Table 6. Effects of fungicide-adjuvant combinations on rot control, fruit finish, and Stayman cracking

Treatment and rate/A*	Rots (% fruit) Idared	Rots (% fruit) Stayman	Fruit finish** Idared russet	Fruit finish** Idared opalescence	Fruit finish** Stayman russet	Fruit finish** Stayman opalescence	Stayman fruit cracked (%) in orchard	Stayman fruit cracked (%) harvest sample due to scab	Stayman fruit cracked (%) harvest sample excluding scab
No treatment	11 b	5 a	1.6 a	1.5 ab	1.3 a	1.3 ab	19 ab	11 b-e	35 a
Topsin-M 85WDG 4 oz + Captan 50W 1.5 lb	3 a	7 ab	1.7 a	1.5 ab	1.5 a	1.6 abc	15 ab	3 a-d	31 a
Topsin-M 85WDG 4 oz + Captan 50W 1.5 lb + Bond 2 fl oz.	2 a	6 ab	1.5 a	1.7 ab	1.2 a	1.0 a	11 a	0 a	26 a
Topsin-M 85WDG 4 oz + Captan 50W 1.5 lb + Nu-Film 17 8 fl oz	3 a	12 ab	1.9 a	2.0 b	1.4 a	1.9 bc	17 ab	1 ab	44 a
Captan 50W 3 lb (+ Sulfur APK 83% 3 lb, B1-3C)	1 a	12 ab	1.6 a	1.3 ab	1.6 a	2.0 c	14 ab	0 a	38 a
Captan 50W 3 lb + Bond 2 fl oz (+ Sulfur APK 83% 3 lb, B1-3C)	4 a	11 ab	1.7 a	1.7 ab	1.5 a	1.6 abc	15 ab	3 abc	37 a
Captan 50W 3 lb + Nu-Film 17 8 fl oz (+ Sulfur APK 83% 3 lb, B1-3C)	2 a	8 ab	1.7 a	1.5 ab	1.7 a	1.5 abc	14 ab	2 abc	34 a
Ziram 76DF 3 lb (+ Sulfur APK 83% 3 lb, B1-3C)	0 a	22 b	1.5 a	1.4 ab	1.6 a	1.8 bc	23 b	7 a-d	35 a
Ziram 76DF 3 lb + Bond 2 fl oz (+ Sulfur APK 83% 3 lb, B1-3C)	5 ab	21 ab	1.4 a	1.2 a	1.4 a	1.6 abc	21 ab	7 a-e	60 b
Ziram 76DF 3 lb + Nu-Film 17 8 fl oz (+ Sulfur APK 83% 3 lb, B1-3C)	1 a	19 ab	1.7 a	1.5 ab	1.2 a	1.3 ab	18 ab	9 a-e	43 a
Water only	2 a	16 ab	1.5 a	1.4 ab	1.4 a	1.4 abc	21 ab	12 cde	29 a
Bond 2 fl oz	6 ab	13 ab	1.7 a	1.4 ab	1.7 a	1.4 abc	24 b	17 e	43 a
Nu-Film 17 8 fl oz	6 ab	13 ab	1.5 a	1.7 ab	1.5 a	1.1 a	19 ab	13 de	32 a

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

*Formulated material per acre, applied to both sides of the row at 100 gal/A with a Swanson Model DA-400 sprayer. The indicated rates represent a 50% reduction for all treatments based on tree-row volume of the test trees.

**Rated on a scale of 0-5 (0 = perfect finish; 5 = severe opalescence or russet, excluding presumed mildew russet).

APPLE (*Malus domestica*
'York Imperial')

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APPARENT PHYTOTOXICITY OF ZIRAM ON YORK IMPERIAL APPLE FOLIAGE, 1991: In 1990 a leaf spot/leaf drop problem caused concern among growers of 'York Imperial' apples, the most important processing cultivar in the Winchester area. Defoliation of older leaves occurred in two major waves in late July and mid-September. The cause of the problem is not known, but there has been some speculation that it might be associated with low Zn levels, possibly as a result of switching to captan from the Zn-containing EBDC fungicides.

The following treatments were applied at the VPI and SU Research Farm during the cover spray period to be demonstration plots if the leaf spot problem appeared again this year:

1. No fungicide
2. Captan 50W 6.0 lb/A
3. Captan 50W 6.0 lb/A +
   9% Zinc EDTA Chelate Solution 3.9 qt/A
4. Ziram 76 6.0 lb/A

The treatments were applied in 100 gal of water per acre with a Swanson Model DA-400 airblast sprayer as 1st-8th cover sprays 10 May, 22 May, 5 Jun, 20 Jun, 3 Jul, 16 Jul, 31 Jul and 28 Aug. The treatments were applied to unreplicated sections of two adjacent rows from both sides of each row on each spray date. Tree-row-volume was determined to require a 400 gal/A dilute base for adequate spray coverage. Insecticides applied separately to the entire test area during the test period with the same equipment were Guthion 3F 1 qt + Lannate 3 pt/A (8 May); Guthion 3F 1 qt + Swat LC 12 fl oz + $CaCl_2$ 6 lb/A (5 Jun); Guthion 35W 2 lb + Lannate 3 pt + CaCl 6 lb/A (20 Jun and 3 Jul); Guthion 35W 2 lb + Lannate 3 pt/A (16 Jul, 31 Jul, 15 Aug, and 28 Aug). The early season schedule was COCS 6 lb/A (21 Mar); Rubigan 1E 9 fl oz + Manzate 200 80W 3.25 lb + Supracide 3 qt + oil 6 gal/A (26 Mar); Nova 40W 5 oz + Ambush 2E 12 fl oz/A (9 Apr); Nova 40W 5 oz + Streptomycin 28 oz/A (16 Apr); Nova 40W 5 oz/A (24 Apr); Dipel 2X 1 lb + Streptomycin 2 lb/A (1 May).

A chlorotic and necrotic mottling was observed on older leaves in the ziram-treated area 8 Aug. This apparent phytotoxic response had not been evident 18 Jul. A block of 'Nittany' trees treated with ziram tank-mixed with insecticides on a similar schedule did not have leaf injury 8 Aug, although some appeared in mid-Sep following additional applications 15 and 28 Aug. No leaf injury appeared on single-tree airblast plots involving ziram full season on Starking Delicious or on dilute application plots on Red Delicious, Golden Delicious and Rome Beauty.

This year there was much less of last year's York leaf spot problem in commercial orchards and none was observed on the treated or untreated demonstration trees on the Research Farm.

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

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FUNGICIDE EVALUATION OF DISEASE CONTROL ON REDHAVEN PEACH AND REDGOLD NECTARINE, 1991. Experimental and registered fungicides were tested for disease control on 12-yr-old trees at the VPI and SU Research Farm. The test was conducted on pairs of adjacent peach and nectarine trees. The peach trees had not been treated with fungicides in 1990 to encourage carry-over inoculum for scab and other diseases. Dilute treatments were applied to the point of run-off (approximately 200 gal/A) with a single nozzle handgun at 200 psi in a randomized block design with four replicate pairs of trees. The treatment schedule for both fruits was identical through the 6th cover spray: 12 Mar (D, dormant); 2 Apr (Bl, bloom); 16 Apr (PF, petal fall); 30 Apr (SS, shuck split); 14 May, 28 May, 12 Jun, 25 Jun, 10 Jul, 19 Jul (1C-6C, 1st-6th covers). Peaches received preharvest treatments 26 Jul (4 PH, 4 days preharvest) and 30 Jul (0 PH, day of harvest). Nectarines received a 7th cover spray 5 Aug and preharvest sprays 13 Aug (3 PH, 3 days preharvest) and 16 Aug (0 PH, day of harvest). Insecticides applied at 2 wk intervals to the entire test block with a commercial airblast sprayer included Lannate + Guthion or Sevin. After harvest 25 apparently rot-free fruit per replicate tree were selected for uniform ripeness, placed on fiber trays, and misted with water (indicated as non-inoculated) or inoculated with a suspension containing $3X10^4$ *M. fructicola* conidia/ml. All were incubated in polyethylene bags at 24C for the indicated interval before assessing rot development.

Several wetting periods suitable for leaf curl infection occurred between 22 and 30 Mar. Dormant applications of copper or ziram gave adequate leaf curl control on peach and nectarine although not significantly different from untreated trees. Leaf curl pressure was less variable on the peach trees than the nectarines which had received experimental treatments in 1990, consequently some treatments which appeared to have been effective when applied to nectarines at bloom may have been escapes. Mid-season weather was characterized by light rains suitable for scab infection on untreated trees, but not heavy enough to compare residual scab control by treatments. All treatments gave complete scab control on both peach and nectarine. Light showers during the preharvest period favored natural development of brown rot on peaches and nectarines and misting uninjured fruit with a spore suspension did not add much to the severity of the test on either fruit. On peaches the Rovral + Triton CS-7 treatment applied the day of harvest had the least fruit infected for the longest period after harvest, significantly ($p = 0.05$) better than captan applied 4 days before harvest. On nectarines Rovral + Triton CS-7 and RH-7592 + Triton B-1956 had the least infection and all treatments applied the day of harvest gave better control than Topsin-M + captan applied 3 days before harvest. Ziram F-4 prevented Rhizopus infection on stored nectarine fruit.

Table 7. Disease control on Redhaven peach

Treatment and rate/100 gal	Timing	Leaf curl % terminal shoots inf. 7 May	Scab (%) 30 Jul	Brown rot incidence (%), days after harvest: inoculated 3 days	inoculated 6 days	inoculated 8 days	non-inoculated 3 days	non-inoculated 6 days	non-inoculated 8 days
No fungicide	---	35 ab	22 b	38 b	88 c	98 d	22 b	92 c	100 c
RH-7592 2F 2.6 fl oz + Triton B-1956 4.0 fl oz	Bl-OPH	23 ab	0 a	1 a	12 a	31 ab	4 a	13 ab	31 ab
Rovral 4SC 1 pt + Triton CS-7, 1 pt Captan 50W 2.0 lb	Bl,PF,5C-OPH SS-4C	40 b	0 a	1 a	8 a	20 a	0 a	2 a	12 a
Rovral 4SC 8 fl oz + Topsin-M 85WDG 4.7 oz Captan 50W 2.0 lb	Bl,PF,5C-OPH SS-4C	43 b	0 a	7 a	25 ab	43 abc	3 a	19 ab	36 ab
Ziram F-4 2.0 pt	D-OPH	5 a	0 a	2 a	22 ab	45 abc	4 a	19 ab	38 ab
COCS WDG 2.0 lb Captan 50W 2.0 lb	Dormant Bl-4PH	5 a	0 a	6 a	46 b	67 c	2 a	33 b	55 b
Kocide DF 2.0 lb Captan 50W 2.0 lb	Dormant Bl-4PH	3 a	0 a	6 a	38 ab	63 bc	0 a	22 ab	48 b

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

Table 8. Disease control on Redgold nectarine

Treatment and rate/100 gal	Timing	Leaf curl % terminal shoots inf. 7 May	Scab (%) 16 Aug	Brown rot incidence (%), days after harvest						Rhizopus inf. (%) 7 days
				inoculated			non-inoculated			
				3 days	5 days	7 days	3 days	5 days	7 days	
No fungicide	---	24 ab	40 b	28 b	80 c	94 c	14 b	48 c	83 c	16 c
RH-7592 2F 2.6 fl oz + Triton B-1956 4.0 fl oz	Bl-OPH	2 a	0 a	0 a	5 a	9 a	0 a	3 a	4 a	14 bc
Rovral 4SC 1 pt + Triton CS-7, 1 pt Captan 50W 2.0 lb	Bl,PF,6C-OPH SS-5C	42 b	0 a	0 a	5 a	15 a	0 a	2 a	11 a	2 abc
Rovral 4SC 8 fl oz + Topsin-M 85WDG 4.7 oz Captan 50W 2.0 lb	Bl,PF,6C-OPH SS-5C	9 a	0 a	0 a	12 a	28 a	3 a	10 a	20 a	1 ab
Ziram F-4 2.0 pt	D-OPH	5 a	0 a	0 a	3 a	22 a	0 a	3 a	12 a	0 a
COCS WDG 2.0 lb Captan 50W 2.0 lb Topsin-M 85WDG 4.7 oz + Captan 50W 1.0 lb	Dormant Bl-7C 3PH	4 a	0 a	0 a	48 b	72 b	4 ab	21 ab	59 b	15 c
Kocide DF 2.0 lb Captan 50W 1.0 lb Topsin-M 85WDG 4.7 oz + Captan 50W 1.0 lb	Dormant Bl-7C 3PH	6 a	0 a	0 a	43 b	77 bc	6 ab	31 b	68 bc	8 abc

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

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

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DISEASE CONTROL BY PREHARVEST AND POSTHARVEST ROVRAL TREATMENTS ON LORING PEACH, 1991: For these studies uniformly ripe fruit were selected from a pooled sample taken from trees which had not received any fungicide, or from trees which had been treated with a single dilute application of Rovral 50W 2 lb + Triton CS-7 1 pt/100 gal 5 days before harvest (non-inoculated fruit, table 9) or 7 days before harvest (inoculated fruit, table 10). Postharvest treatments were applied as dilute sprays to fruit rolling under spray nozzle, or as 20-second dip treatments. The severity of the test was varied by not inoculating (fruit stored at 2C one day before postharvest treatments) or by mist-inoculating with a suspension of 60,000 M. fructicola conidia/ml after treatment (following 3 days storage at 2C). After treatment, uninoculated fruit were allowed to dry on fiber trays and were stored in polyethylene bags at 21-27C for the indicated incubation period. Inoculated fruit were handled as non-inoculated fruit, but were placed moist into the polyethylene bags. Differences in the time of application and handling preclude direct statistical comparison of postharvest spray treatments versus dip treatments and inoculated versus non-inoculated fruit.

In general, inoculation increased the severity of the test, with fruit receiving no postharvest, or weaker postharvest treatments, reaching higher levels of infection sooner in the incubation period. The preharvest Rovral treatment significantly reduced postharvest brown rot and Rhizopus rot incidence on fruit treated with postharvest Botran or "water only." Under heavy disease pressure at longer incubation intervals several treatments involving Rovral gave significantly better brown rot control than the Botran standard. On inoculated fruit which received a preharvest treatment of Rovral, spray treatments including the adjuvants Triton B-1956 and CS-7 significantly improved brown rot control compared to Rovral 2 lb without the adjuvant. The addition of Triton B-1956 to Rovral spray treatments also improved control of brown rot on non-inoculated fruit which had not been treated pre-harvest.

Table 9. Disease control by preharvest and postharvest treatments on non-inoculated Loring peach fruit

Postharvest treatment and rate/100 gal	Preharvest Rovral treatment	Brown rot, % fruit infected, days after postharvest treatment: 6 days	8 days	12 days	Rhizopus rot, % fruit infected 12 days post-treatment
Spray treatments					
Water only	yes	1 a	16 d	58 c	20 c
Rovral 50W 1 lb + Triton B-1956 0.5 pt	yes	0 a	2 ab	24 ab	3 ab
Rovral 50W 2 lb + Triton CS-7 1 pt	yes	0 a	0 a	9 a	2 ab
Rovral 50W 2 lb + Triton B-1956 0.5 pt	yes	0 a	2 ab	12 a	2 ab
Rovral 50W 2 lb	yes	1 a	1 ab	11 a	2 ab
Botran 75W 1 lb	yes	0 a	7 bc	36 b	8 abc
Water only	none	14 b	30 e	78 d	41 d
Rovral 50W 1 lb + Triton B-1956 0.5 pt	none	0 a	2 ab	16 a	2 ab
Rovral 50W 2 lb + Triton CS-7 1 pt	none	1 a	3 ab	37 b	8 abc
Rovral 50W 2 lb + Triton B-1956 0.5 pt	none	0 a	2 ab	15 a	1 a
Rovral 50W 2 lb	none	2 a	11 cd	38 b	9 bc
Botran 75W 1 lb	none	0 a	14 d	54 c	15 cd
Dip treatments					
Water only	yes	9 C	12 B	47 C	11 B
Rovral 50W 1 lb + Triton B-1956 0.5 pt	yes	0 A	0 A	2 A	0 A
Rovral 50W 2 lb + Triton CS-7 1 pt	yes	0 A	0 A	9 A	0 A
Rovral 50W 2 lb + Triton B-1956 0.5 pt	yes	0 A	0 A	3 A	0 A
Rovral 50W 2 lb	yes	0 A	0 A	7 A	0 A
Botran 75W 1 lb	yes	0 A	0 A	5 A	0 A
Water only	none	5 B	18 C	67 D	25 C
Rovral 50W 1 lb + Triton B-1956 0.5 pt	none	0 A	0 A	7 A	2 A
Rovral 50W 2 lb + Triton CS-7 1 pt	none	0 A	0 A	4 A	0 A
Rovral 50W 2 lb + Triton B-1956 0.5 pt	none	0 A	0 A	0 A	0 A
Rovral 50W 2 lb	none	0 A	0 A	8 A	0 A
Botran 75W 1 lb	none	0 A	1 A	32 B	1 A

Averages of four 25-fruit replications. Mean separation of spray or dip treatments by Duncan's Multiple Range Test (p = 0.05). Direct comparison of spray treatments with dip treatments not statistically valid.

Table 10. Disease control by preharvest and postharvest treatments on Loring peach fruit inoculated with *Monilinia fructicola*

Postharvest treatment and rate/100 gal	Preharvest Rovral treatment	% fruit infected with brown rot - days after postharvest trt and inoculation: 3 days	5 days	8 days	Rhizopus rot, % fruit infected 8 days post-treatment
Spray treatments					
Water only	yes	7 b	21 b	73 ef	21 b
Rovral 50W 1 lb + Triton B-1956 0.5 pt	yes	0 a	0 a	15 ab	3 a
Rovral 50W 2 lb + Triton CS-7 1 pt	yes	0 a	1 a	3 a	2 a
Rovral 50W 2 lb + Triton B-1956 0.5 pt	yes	0 a	1 a	17 ab	0 a
Rovral 50W 2 lb	yes	0 a	5 a	46 cd	2 a
Botran 75W 1 lb	yes	2 ab	8 a	60 de	0 a
Water only	none	29 c	64 d	97 g	58 c
Rovral 50W 1 lb + Triton B-1956 0.5 pt	none	2 ab	10 ab	62 de	3 a
Rovral 50W 2 lb + Triton CS-7 1 pt	none	1 ab	6 a	46 cd	4 a
Rovral 50W 2 lb + Triton B-1956 0.5 pt	none	0 a	4 a	41 bcd	2 a
Rovral 50W 2 lb	none	0 a	2 a	32 bc	5 a
Botran 75W 1 lb	none	6 ab	34 c	88 f	21 b
Dip treatments					
Water only	yes	5 B	30 B	88 C	31 B
Rovral 50W 1 lb + Triton B-1956 0.5 pt	yes	0 A	1 A	11 A	0 A
Rovral 50W 2 lb + Triton CS-7 1 pt	yes	0 A	2 A	13 A	0 A
Rovral 50W 2 lb + Triton B-1956 0.5 pt	yes	0 A	0 A	3 A	0 A
Rovral 50W 2 lb	yes	0 A	0 A	6 A	0 A
Botran 75W 1 lb	yes	0 A	1 A	11 A	0 A
Water only	none	20 C	66 C	95 C	63 C
Rovral 50W 1 lb + Triton B-1956 0.5 pt	none	0 A	3 A	18 A	0 A
Rovral 50W 2 lb + Triton CS-7 1 pt	none	0 A	0 A	13 A	0 A
Rovral 50W 2 lb + Triton B-1956 0.5 pt	none	0 A	0 A	4 A	0 A
Rovral 50W 2 lb	none	0 A	2 A	15 A	1 A
Botran 75W 1 lb	none	1 A	5 A	77 B	6 A

Averages of four 25-fruit replications. Mean separation of spray or dip treatments by Duncan's Multiple Range Test (p = 0.05). Direct comparison of spray treatments with dip treatments not statistically valid.

Evaluation of fungicides in preharvest sprays for brown rot control, 1991.

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Preharvest fungicides for control of brown rot were applied on 7-yr-old 'Redskin' peach trees by handgun at approximately 250 psi and 2 gallons of spray per tree. Trees were arranged in a randomized complete block design on a 22 x 24 ft. spacing, with single-trees replicated four times. Fungal inoculum came from nearby peach trees that were infected earlier. Fungicides were applied on 16 July and 25 July, and peaches were harvested 29 July. The number of rotted fruit on the tree and on the ground at harvest were counted and the total number of fruit on the tree was estimated to determine the percentage brown rot at harvest. One hundred firm-ripe, apparently healthy peaches per tree were harvested and stored in deep-pocket fiber trays in cardboard boxes, which were kept in an air-conditioned room at 70-75 F. Peaches infected with *M. fructicola* were counted 4 and 7 days postharvest.

Although rainfall was light during the first 2 weeks of July, rain was recorded on 6 days (3.25 inches) during the preharvest period. Brown rot was common in all treatments at harvest time, and infection might have begun before the first spray was applied. Postharvest brown rot was extremely variable among replicates in the control and low rate of ASC 66825 treatments. Means were not significantly different ($\underline{P}$ = 0.05) at harvest or 4 days postharvest. The low rate of ASC 66825 with or without Rovral was not very effective on any sampling date, but the higher rate was similar to the Funginex and Rovral standards. The 12- and 16-oz rates of Funginex were of almost identical performance.

Treatment and rate per 100 gallons	Mean number of infected fruit: At Harvest	4 days Postharvest	7 days Postharvest
Control	11.7a	24.5a	50.0a
ASC 66825 50W 4.0 oz + Rovral 4F 4.0 oz	6.7a	10.5a	27.5ab
ASC 66825 50W 4.0 oz	8.5a	14.2a	26.0ab
ASC 66825 50W 8.0 oz	5.7a	4.5a	11.5 b
Orbit 2E 2.0 oz	7.4a	4.5a	13.2 b
Funginex 1.6EC 16 oz	4.7a	1.2a	7.2 b
Funginex 1.6EC 12 oz	8.5a	1.8a	7.8 b
Rovral 4F 16 oz	5.1a	2.2a	11.0 b

Treatment means followed by the same letter are not significantly different at 0.05 level by Duncan's Multiple Range Test.

Control of peach fruit diseases with certain experimental fungicides in 1991

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Seven-year-old 'Redglobe' peach trees were sprayed with several experimental fungicides for control of bacterial spot, scab, and brown rot at the Clemson University Experiment Station. Spraying began at shuck split (11 Apr) and additional sprays were applied 18 Apr; 2, 15, and 29 May; 12 and 27 June, and 9 July. Treatments were replicated four times in a randomized complete block design (single-tree replicates). Sprays were applied with a single-nozzle handgun at 250 psi to runoff (ca. 2 gallons per tree). Insecticides, applied separately by airblast sprayer, were (per 100 gallons) Penncap-M, 2.0 pt, on 3 Apr, 16 May, and 13 June; Imidan 50W, 1.0 lb on 16 Apr, 1 and 28 May; Guthion 0.5 lb on 25 Apr; and Sevin 50W on 28 June. At maturity (11 July), 100 mature fruit per tree were harvested at random, examined for scab and bacterial spot, packed in deep pocket fiber trays, placed in cardboard boxes, and stored at 22-24C for 8 days.

Rainfall was unusually high for the season (5.82, 5.35, and 5.50 inches for Apr, May, and June, respectively), except during the 2-week preharvest period when less than 0.1 inch was recorded. Scab was severe, bacterial spot moderate, and brown rot relatively light. The standard captan program did not control scab satisfactorily; LS86263 at the higher rate, TD2323, Microzir, and Dyrene all were superior to captan for scab control. Treatments that contained Ziram (Ziram, TD2323, and Microzir) appeared to be somewhat suppressive of bacterial spot on fruit but not on leaves (data not shown for leaves). All treatments except Ziram controlled brown rot in this experiment. Treatments containing LS86263 seemed to enhance red color and attractiveness of the fruit.

Treatment and rate per 100 gallons	% fruit infected			
	scab	bacterial spot	postharvest brown rot 4 days	postharvest brown rot 8 days
LS86-263 1.67SC 3.8oz[a]	13.2	16.5	0.2	0.8
LS86-263 1.67SC 1.9oz[a]	44.0	9.5	0.5	4.5
LS86-263 1.67SC 1.9oz+ Rovral 4F 0.5 pt[a]	33.0	15.0	0.0	0.5
TD2323 70WDG 2.5 lb	7.5	5.8	0.5	1.0
Microzir 80DF 5.0 lb	8.8	5.5	0.8	4.2
Ziram 4F 2.0 qt	56.2	4.0	1.5	12.8
Dyrene 50W 1.0 lb	5.0	21.0	0.2	1.5
Captan 50W 2.0 lb (cover sprays); Rovral 4F 1:0 pt preharvest	30.8	10.0	0.0	2.2
Control (no fungicide)	100.0	[b]	2.8	15.5
L.S.D. .05	13.3	7.7	1.4	7.3

[a]Applied the first three and last two sprays only. Captan 50W, 2.0 lb, was applied in mid-season (three sprays).

[b]Lesions of bacterial spot were obscured by scab.

Application schedules for Bravo and RH 7592 on peaches in 1991

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Two formulations of chlorothalonil (Bravo), a high rate of Bravo 720 for scab control, and RH7592 either mixed with sulfur as a full season spray or applied alone with a wetting agent in preharvest sprays were compared on 3-yr-old 'Summer Pearl' peach trees. Bravo 720 and Bravo 825 were applied at equivalent rates a.i. at shuck split and shuck fall, except that an additional treatment at 4.0 pt per 100 gallons was applied at shuck fall and the next three sprays were omitted to test residual efficacy at this high rate. Sprays were applied to runoff (ca. 1 gal per tree) using a handgun and 250 psi pressure. Treatments were replicated four times (single trees) in a randomized complete block design. Application dates were 10 (shuck split) and 17 April (shuck fall), 1, 14, and 28 May; 11 and 25 June; and 9 and 22 July. At maturity (25 July), 100 fruits per tree were harvested at random, examined for scab and bacterial spot, and stored in fiber trays packed in cardboard boxes at 22-24C in an air-conditioned room.

Except for the first 2 weeks in July when very little rain fell, the entire growing season was unusually wet--5.82, 5.35, 5.50, and 3.33 inches of rain in April, May, June, and July, respectively. The peach trees had not been sprayed in 1990, and scab was extremely severe--many fruit on unsprayed trees abscised before harvest as a result. Scab control was unsatisfactory with even standard fungicides such as Bravo and wettable sulfur programs. Using a large amount of Bravo at shuck fall and omitting the next three sprays was not effective in this experiment. However, RH7592 mixed with sulfur was effective for scab and brown rot control. RH7592 was impressive for brown rot control when used for the entire season, but when used in the two preharvest sprays only it did not provide long residual activity in the postharvest period. No treatment suppressed bacterial spot.

Treatment and rate per 100 gallons	% fruit infected			
	scab	bacterial spot	postharvest brown rot 4 days	postharvest brown rot 7 days
Bravo 720 F 1.5 pt shuck split and shuck fall; wettable sulfur 6.0 lb thereafter	49.0	46.5	0.0	10.2
Bravo 825 F 1.39 pt shuck split and shuck fall; wettable sulfur 6.0 lb thereafter	55.8	50.5	1.2	11.2
Bravo 720 F 1.5 pt shuck split and 4.0 pt shuck fall; next 3 sprays omitted; wettable sulfur 6.0 lb thereafter	92.8	44.2	2.5	13.8
RH7592 2F 3.0 oz + Triton B-1956 4.0 oz + wettable sulfur 1.5 lb	14.8	42.2	0.0	3.2
Wettable sulfur 1.5 lb cover sprays; RH7592 2F 3.0 oz + Triton B-1956 4.0 oz preharvest	100.0	[a]	0.8	20.0
Wettable sulfur 6.0 lb cover sprays; Rovral 4F 1.0 pt preharvest	83.5	40.5	0.0	7.5
Control (no fungicide)	100.0	[a]	18.8	37.8
L. S. D. .05	11.9	N.S.	3.7	9.0

a Severe scab development prevented accurate assessment of bacterial spot.

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

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Efficacy of Several Commercial Fungicides for Summer Disease Control on Apples in 1991. The commercial standard fungicide mixture of captan plus a benzimidazole fungicide for control of summer diseases is sometimes less than satisfactory for control of fruit decay. Ziram plus thiophanate methyl (TD 2323) or sulfur (Microzir) were compared with the standard on Golden Delicious trees in a randomized complete block of single trees replicated four times. Fungicide sprays were applied with a handgun to runoff (ca. 8 liters per tree). All trees were sprayed three times during April with captan or dodine for suppression of scab. Sprays for summer disease control began at second cover (8 May), with additional sprays on 22 May, 4 and 17 June, 2, 17, and 31 July, and 14 August. Insecticides, applied separately by airblast sprayer, were (per 100 gallons) Sevin 50W, 2 lb on 29 April, 17 June, 9 and 23 July, and 7 and 20 August; Guthion 50W, 1.9 lb on 7 and 28 May; Penncap M, 2.0 pt on 16 May; and Imidan 50W, 1.0 lb on 28 May. Agrimycin 17 was applied for fire blight control on 6,8, 11, 16 and 28 April. At maturity (30 Aug), 100 fruits per tree were harvested and examined for bitter rot, flyspeck, and sooty blotch. Number of fruits on the ground affected by white rot and bitter rot was estimated by counting the number under one quadrant of each tree, and the percent infection calculated according to the estimated number of fruits remaining on the trees and the number harvested.

Rainfall was above average during the entire growing season -- monthly totals March through August were 6.17, 4.81, 6.96, 4.28, 3.20, and 8.97 inches, respectively. Fruits on unsprayed trees were a total loss -- almost 90% decayed and the remainder were covered with sooty blotch and flyspeck. The standard captan-Topsin M schedule was best overall for summer disease control, but losses to decay were high.

Treatment and rate per 100 gallons	% fruit infected			
	bitter rot	white rot	flyspeck	sooty blotch
Captan 50W 2.0 lb + Topsin M 70W 4.0 oz	7.0	36.5	0.5	2.5
Microzir 80 DF 4.0 lb	23.0	66.8	1.0	46.7
TD 2323 70WDG 2.5 lb	10.5	41.5	0.0	0.5
Ziram 4F 2.6 pt	25.5	53.5	2.5	26.0
Control (no fungicide)	28.2	59.5	85.8	100.0
L. S. D. .05	15.9	23.7	4.6	16.6

Title: Economic Feasibility of the Maryland Tree Fruit Integrated Pest Management Program

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Abstract:

To recruit and maintain grower support, Integrated Pest Management Programs must be economically feasible as well as environmentally sound. The purpose of IPM should be to reduce pesticide use by employing all available methods of pest control which are realistic. At the same time the total cost to the grower must not exceed what the program can save him in time, energy, money, and pesticide.

Introduction

In 1990, a Tree Fruit Integrated Pest Management Program was started in Maryland. Trapping and visual monitoring have been used to detect the presence of fruit damaging pests in the orchard. Through applied entomological research, economic thresholds have been set for nearly all of the major apple pests. These thresholds are set by allowing the presence of various pests, but maintaining them below damaging levels through the use of sanitation, predation, biological control, and the use of pesticides.

A bonafide IPM Program requires that insect populations be monitored on a regular basis throughout the growing season. This necessitates the hiring of a trained scout as well as purchasing pheromone traps for the major pests. Most IPM Programs have been administered through Land-Grant Universities giving them a strong agricultural support base. In a few instances, an individual may hire on as an independent consultant to accomplish the same task. In Maryland, the need for licensing and insurance has made this difficult without University affiliation.

Materials and Methods

During the 1990 and 1991 growing season, fruit growers in central and western Maryland were recruited into the Tree Fruit IPM Program. A fee of $20 per acre was set with a minimum of 20 acres needed for any one particular location. Several scouts were hired and trained to do the weekly monitoring and reporting. Pesticide recommendations were left to the county agent or specialist who receives weekly reports along with the grower.

Table 1 shows the average time of appearance for the major fruit pests which are monitored with pheromone traps. Table 2 shows the insects which must be visually observed and counted. Any given year these insect populations may shift one way or another due to changes in weather, but this approximate timing will do for the sake of discussion. Tables 3 and 4 show the normal routine application of cover sprays which is suggested at two week intervals throughout the season. From petal fall until harvest most apple growers apply nine sprays on the average. During the past two years (90 and 91) growers have been able to stretch spray intervals or skip one to two sprays over the course of the season. Reduction has come during the following two periods: May 15 to June 1, and July 15 to August 1 (see Tables 5 and 6). These reductions have been possible because most orchards do not have insects such as Codling Moth reaching economic thresholds during these periods.

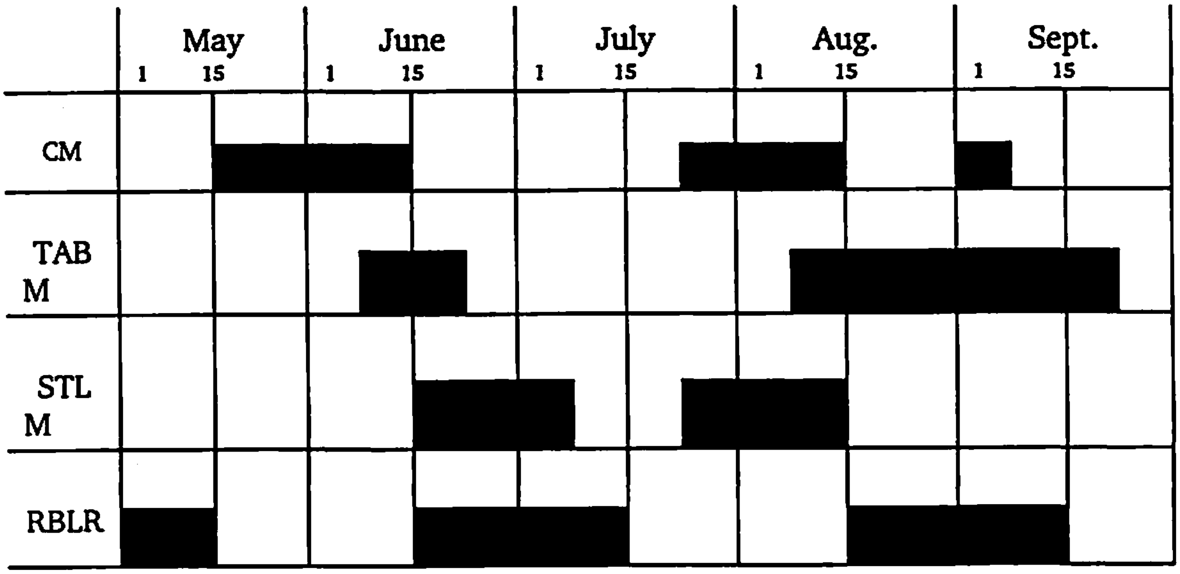
Results and Conclusions

The average cost for insecticide application is approximately $250 per acre per season (Management Guide for Low-Input Sustainable Apple Production). When growers apply insecticide on a calendar basis generally 12 applications are made a season. Three applications are made during the pre-bloom period, one is made at petal fall, and eight cover sprays follow-up until harvest.

Using the $250 per acre figure, it costs a grower $5,000 a year for pest control for 20 acres. If a grower applies an insecticide twelve times during the season, then each application costs $417. The cost to put the same 20 acres into the IPM Program is $400. If by following the IPM recommendations a grower saves one spray he has paid for the cost of the service. Any additional savings will result in money in his pocket.

It takes an IPM scout two hours per week to properly monitor a 20 acre block. There are eighteen weeks during the season that orchards must be regularly monitored. This means a scout would spend 36 hours a season monitoring a 20 acre block. If a scout is paid an average of $7 an hour, he would then receive $252 for scouting 20 acres all season. The cost for the pheromone trap supplies to service 20 acres is approximately $100 (University of Maryland, Department of Entomology). After totalling these costs, it is evident that the $20 per acre fee being charged to growers should cover the expenses of the program.

Table 1. Insects Monitored By Trapping



CM Codling Moth
TABM Tufted Apple Bud Moth
STLM Spotted Tentiform Leafminer
RBLR Red Banded Leaf Roller

Table 2. Insect Monitored By Visual Observation

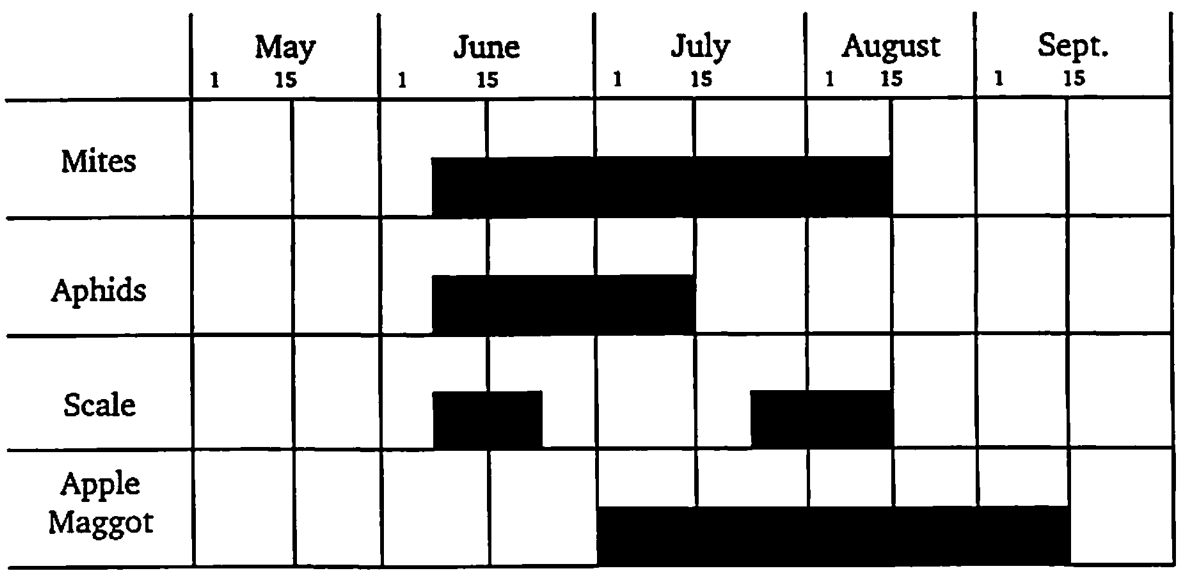
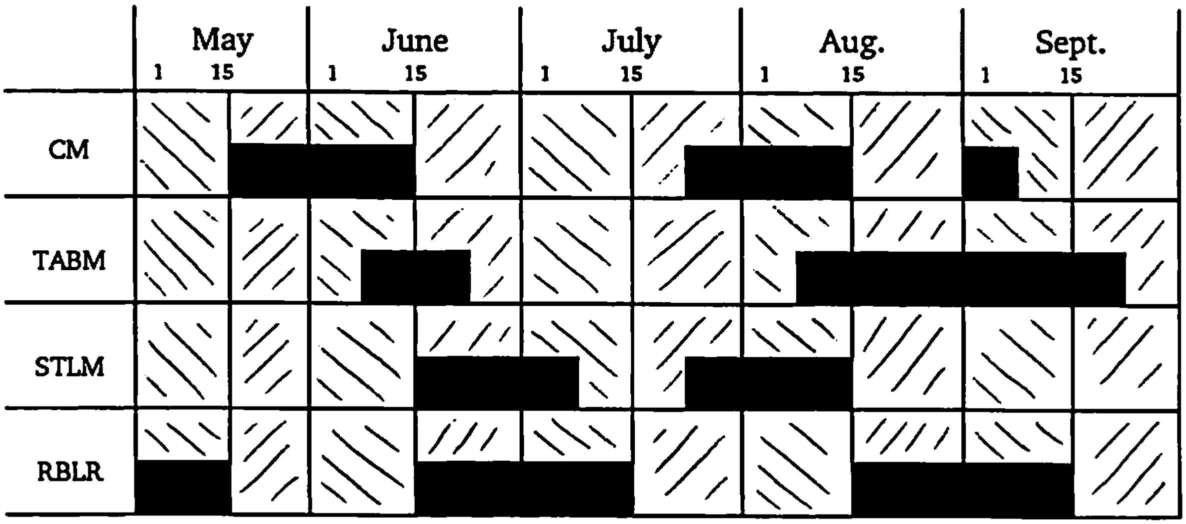


Table 3. Insects Monitored By Trapping



CM Codling Moth
TABM Tufted Apple Bud Moth
STLM Spotted Tentiform Leafminer
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Table 4. Insect Monitored By Visual Observation

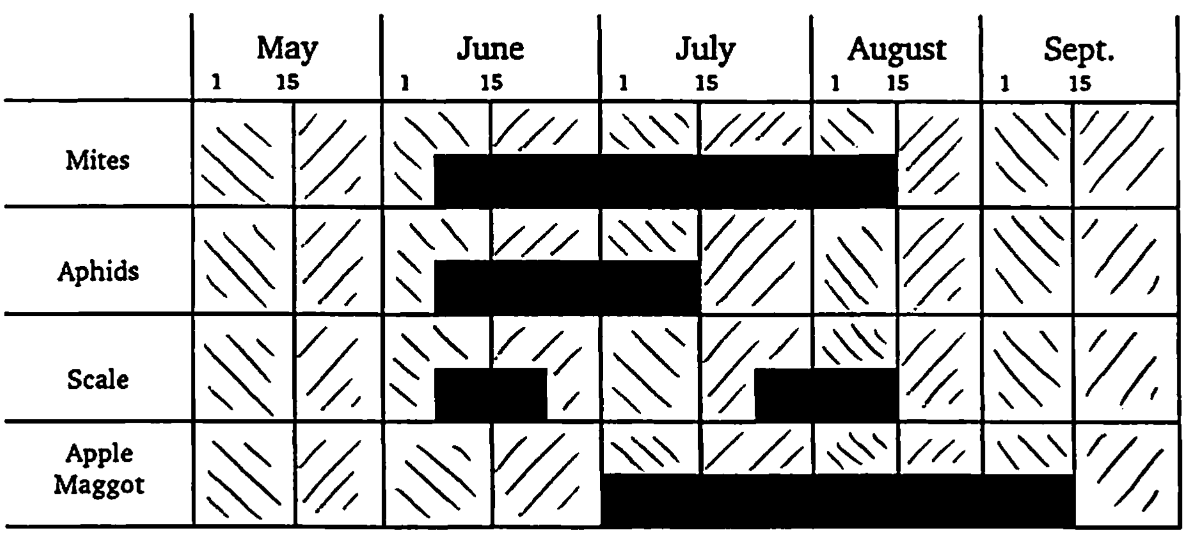
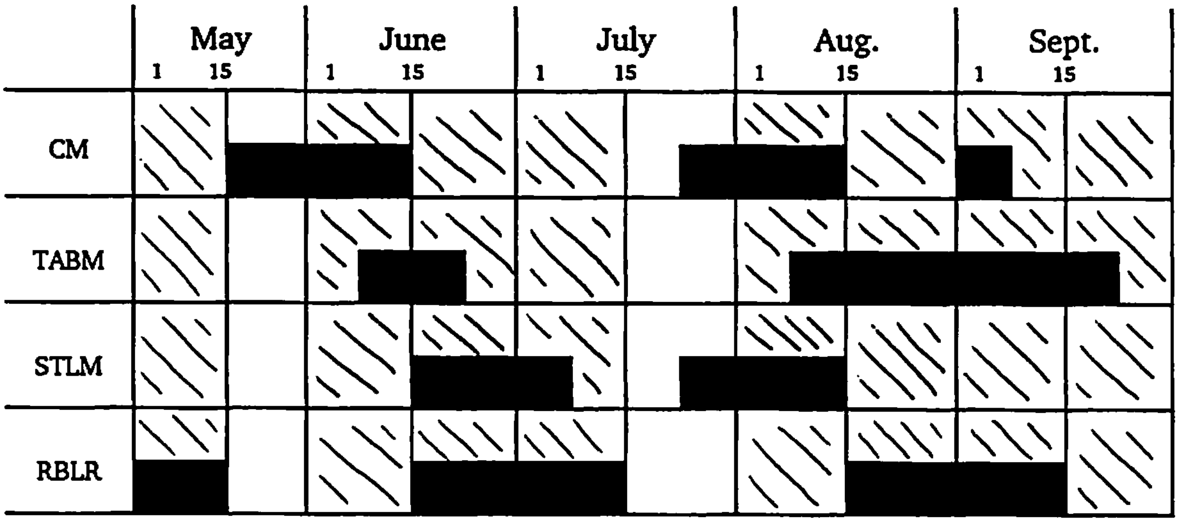
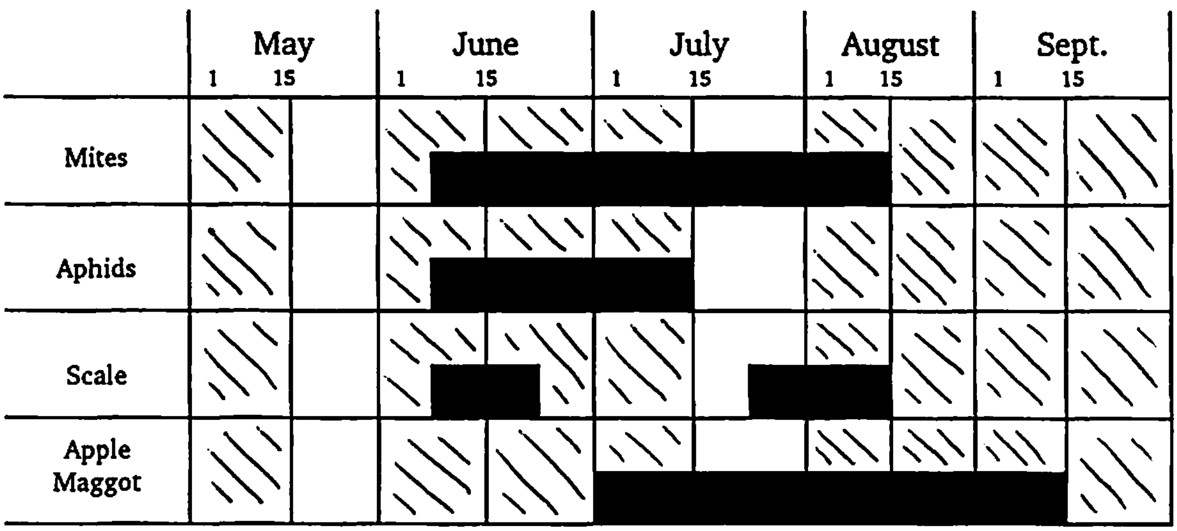


Table 5. Insects Monitored By Trapping



CM Codling Moth
TABM Tufted Apple Bud Moth
STLM Spotted Tentiform Leafminer
RBLR Red Banded Leaf Roller

Table 6. Insect Monitored By Visual Observation



DAGGER NEMATODE POPULATION DYNAMICS AND SUSTAINABLE NEMATODE MANAGEMENT STRATEGIES

by

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Reduced control of dagger nematodes, *Xiphinema americanum* and *X. rivesi*, after repeated annual applications of fenamiphos has been observed in some peach orchards in West Virginia. The development of 'aggressive soils' has been reported in other states. Since more than one application of this nematicide is needed to achieve acceptable control, alternative control measures are needed. Preplant soil fumigants may provide some control during orchard establishment, but these materials are costly and difficult to use safely. This report describes dagger nematode population dynamics in orchard soils managed using alternative strategies.

Trials were initiated to evaluate novel rotation crops for nematode suppressiveness in orchard replant sites. Replicated microplots of corn, Canola cv Westar, Marigold cv Sparky, Fescue cvs Kentucky-31 and Fawn, and fallow controls were established in the greenhouse using soil infested with *Xiphinema americanum*. Dagger nematode population densities and nematode biomass are being determined at regular intervals to evaluate host suitability of these crops. Randomly selected specimens of each stage at each sample date are measured for length and body diameter and total nematode biomass is calculated. Significant increases in nematode numbers for all stages and for total biomass were observed in most plots 68 days after planting (Table 1). This is much shorter than the estimated life cycle of *X. americanum*, thus results are not readily interpretable. Nevertheless, the increase was least in plots planted to canola and Kentucky-31 fescue and greatest on corn.

Another field trial was established at the WVU Experiment Farm, Kearneysville, WV, to further evaluate rotation crops. Five replicate plots of canola, marigold, K-31 and Fawn fescues, perennial ryegrass cv Repell, wheat cv Stacy, oats cv Saia, and ten plots of corn were planted in May, 1990. Wheat and canola plots were replanted in September 1990 to winter varieties, and five replicate corn plots were fumigated with Vapam. The corn, marigolds, and oats were replanted in May 1991 and the canola and wheat were replanted again in June 1991. Emergence and plant growth were limited by drought stress in both years, so yield data were not collected. Soil samples were collected in Sept. 1991 and nematode population densities were determined.

Population densities of dagger nematodes, *Xiphinema* spp., were significantly lower in fumigated plots than in the unfumigated rotation crops (Table 2). Lesion nematodes, *Pratylenchus* spp., were highest in corn and canola and were lowest in fumigated plots. Spiral nematodes, *Helicotylenchus* spp., were highest in Fawn fescue, ryegrass and wheat, and were lowest in fumigated corn plots. Populations of lesion and spiral nematode, but not dagger nematode, were significantly lower in K-31 fescue than in Fawn fescue. Populations of predatory nematodes, *Clarkus* spp., did not differ under these crops.

In another field trial, nematode trapping fungi were isolated from silt loam orchard soil rotated for one year to Kentucky-31 tall fescue or to corn treated with ethoprop nematicide. One gram of soil was sprinkled over four petri dishes containing water agar. Plates were inoculated with 500 *P. penetrans*, incubated at 25 C, and observed regularly for six weeks. Higher numbers of nematode trapping fungal colonies and increased numbers of species were recovered from soil planted to Kentucky-31 tall fescue than to corn (Figure 2). Numbers of *Xiphinema* spp. and *Pratylenchus* spp. declined in plots rotated to Kentucky-31 tall fescue (Figure 1), but increased in plots treated with ethoprop and rotated to corn. Numbers of predatory nematodes were unchanged in the corn plus ethoprop plots, but increased five-fold in fescue plots.

Nematode population dynamics are also being evaluated under three soil management regimes in peach orchards. Plots were established in the spring of 1990 with the area under the trees maintained in a killed sod system, mechanically cultivated, or treated with herbicides without cultivation. Plots were treated with carbofuran, fenamiphos, or were untreated in all combinations with the soil management regimes. Population densities of *Xiphinema* spp. and *Pratylenchus* spp. were reduced in soil under killed sod as compared to the conventional herbicide soil management system (Figure 3). Numbers of predatory nematodes were slightly higher under killed sod than under the other treatments, but differences were not statistically significant.

Together, these experiments suggest an alternative management system for orchard replant sites. Under the current conventional system, growers rotate to corn for two years prior to replanting the orchard, which is then maintained with a weed-free strip under the trees by the use of herbicides. Nematode control is achieved through the use of chemical nematicides. The alternative management system being evaluated involves rotating to fescue for two years, with the orchard floor being managed using a killed sod under the trees. The alternative system results in the ready establishment of the orchard floor management regime and appears to be at least partially suppressive of plant-parasitic nematodes without the use of chemical nematicides.

These studies provide information needed to intelligently manage nematode populations. Improved understanding of the effects of nematicides on nematode population dynamics, nontarget microorganisms, and biocontrol agents allows better recommendations for use of nematicides. Assessment of rotation crops and alternative orchard floor soil management systems may reduce the need for nematicides and thereby lessen the economic and environmental impacts of these materials.

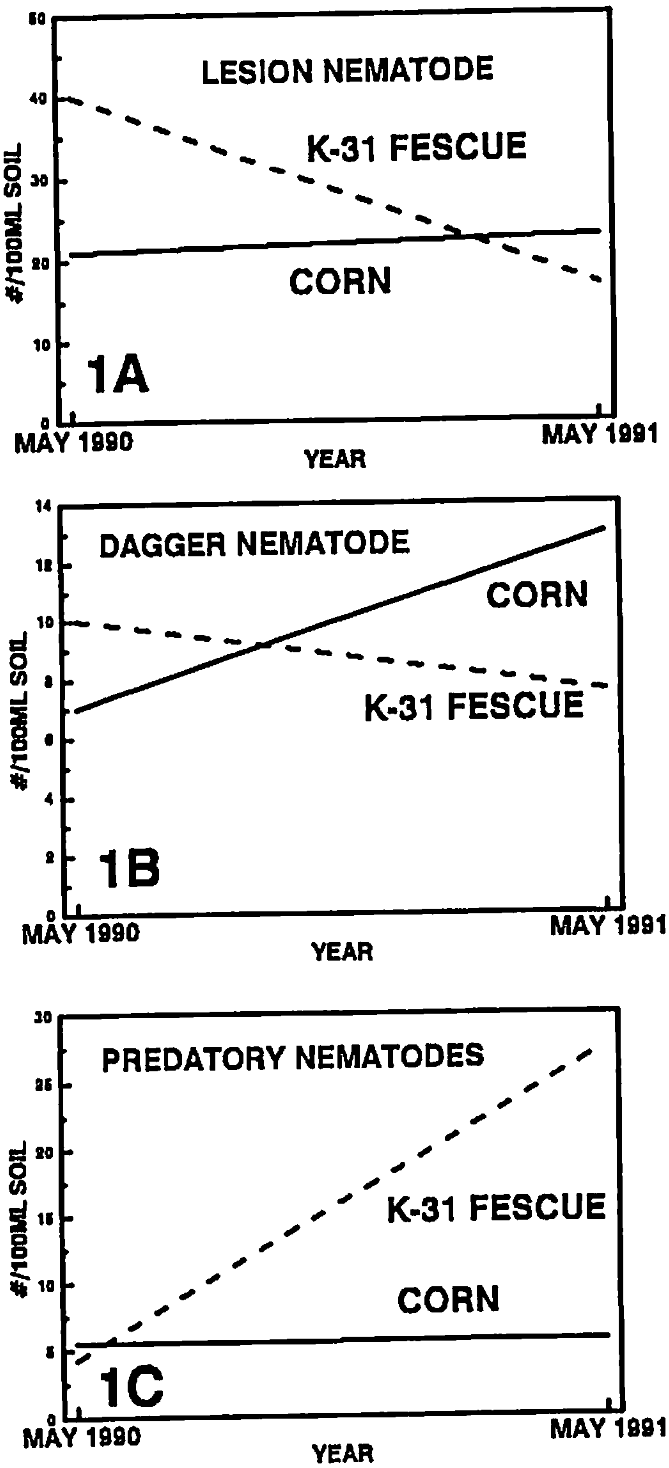

Figure 1. Population densities of nematodes in rotation crops.

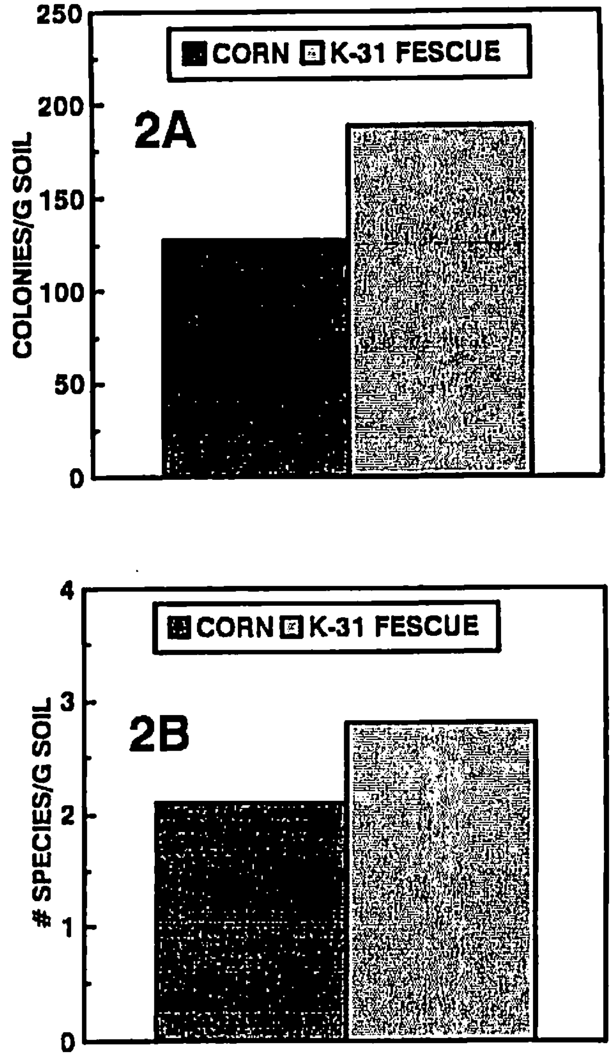

Figure 2. Nematode-destroying fungi in soil from two rotation crops.

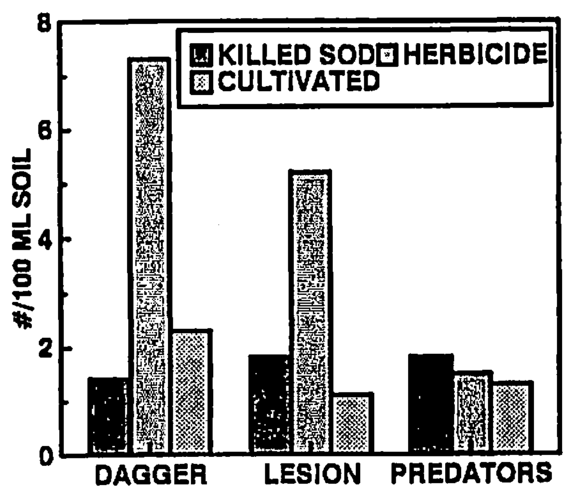

Figure 3. Nematode population densities associated with three soil management systems.

Table 1. Population density and biomass of Xiphinema americanum in greenhouse microplots planted with five rotation crops.

Crop	Nematodes/100cc soil Days after planting 1	68	Biomass (ug/100 cc soil) Days after planting 1	68
Corn	8	36*	10	39*
Canola	17	24	20	27
Marigold	7	26*	8	30*
Fawn fescue	7	27*	10	32*
K-31 fescue	7	15	9	20
Fallow	9	25	10	32*
LSD	-----16-----		-----19-----	

Means of six replicate microplots.
* Significant increase in dagger nematode numbers or biomass.

Table 2. Nematode population densities after two years in rotation crops.

Crop	Pratylenchus	Helicotylenchus	Xiphinema	Clarkus
Corn	221 ab	98 d	11 ab	1.8 a
Canola	274 a	200 bcd	21 a	0.4 a
Fawn Fescue	100 bc	799 a	15 a	2.9 a
K-31 Fescue	28 d	257 bc	15 a	0.6 a
Marigolds	42 cd	135 cd	16 a	2.7 a
Wheat	70 cd	398 ab	7 ab	0.8 a
Ryegrass	98 bc	732 a	13 a	0.6 a
Oats	37 cd	134 cd	28 a	6.4 a
Corn+Vapam	7 e	14 e	2 b	0.9 a

Means of five replicates. Means followed by the same letter(s) do not differ significantly ($P = 0.05$) according to Duncan's Multiple Range Test.

ENTOMOLOGY

Mating Disruption of Codling Moth - 1991

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I. Introduction:

Codling moth (CM), *Cydia pomonella* (L.), has been the subject of mating disruption in Virginia since 1987; this work has become more intensive since 1989 (Pfeiffer et al. 1990). 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:

Daleville Orchard - Mating disruption of CM was performed in a 1.9-ha (4.7-acre) block at Daleville (Botetourt Co.), primarily composed of 'Red Delicious', also including 'Golden Delicious'. The block treated with pheromone was isolated, but with a small abandoned block about 50 m away. Shin-Etsu CM pheromone dispensers (Shin-Etsu Chemical Co., Tokyo, Japan) were used in this block. The pheromone blend contained in the dispensers was 192 mg of (*E,E*)-8,10-dodecadien-1-ol (also known as codlemone; 63%)/ dodecenol (31%)/ tetradecenol (6%). Dispensers were placed on 24 April at the rate of 1000/ha (400/acre). Tree density was 300 trees/ha (120/acre). After the first cover spray the grower agreed to withhold all insecticide sprays until pest conditions required action. Leafrollers were controlled using mating disruption. The control block, treated with a conventional spray program, was about 1.6 km (1 mi) away, and was surrounded by additional commercial apple orchard.

Three CM pheromone traps (Trece Inc., P.O. Box 6278, Salinas, Ca.) were placed in the blocks treated with pheromone and with conventional sprays and were monitored weekly. Damage was assessed weekly by examining at least 200 fruit in the pheromone-treated, control, and abandoned blocks. At the harvest count (6 September), 200 fruit of both 'Red Delicious' and 'Golden Delicious' were sampled from the edge and center of both the disruption and control blocks (800 fruit per block). Fruit were examined *in situ* until the final count, when fruit were removed from the trees for closer examination.

Fincastle Orchard - A block near Fincastle (Botetourt Co.) was treated with dispensers on 24 April. 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). Dispensers were placed at 1000/ha. A standard insecticide program was followed through first cover, after which no further insecticides were applied unless conditions warranted them. Leafrollers were controlled using mating disruption (unpubl. data). 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. Injury was assessed weekly as in the Daleville block. Harvest injury was assessed on 27 August. The grower harvested fruit earlier than planned; fruit were retrieved from bins in the orchard with no separation into block edge and middle.

Batesville Orchard - CM was the target of mating disruption in a 4-ha (10-acre) block, primarily 'Winesap', at Batesville (Albemarle Co.). The control block, also primarily 'Winesap'. was about 0.4 km (0.25 mi) away from the pheromone-treated block. A different type of dispenser was employed in this study, containing codlemone alone (Consep Membranes). This dispenser is intended to be applied three times per season, at 60-day intervals. Dispensers were placed at 300/ha (120/acre) on 17 April and 17 July (the second shipment was received late). The third placement was not received from the company. Leafrollers were controlled using mating disruption. Four CM pheromone traps were placed in both pheromone-treated and control blocks and checked weekly. The grower agreed to refrain from all insecticide sprays after first cover until recommended otherwise.

Damage was assessed on 18 June; 100 fruit were sampled in each corner of each block and 200 from the block centers. Harvest injury was assessed on 10 September. At that time, 200 fruit were harvested from each block.

Spring Valley - A 4-ha (10-acre) block was treated with Shin-Etsu pheromone dispensers at Spring Valley (Albemarle Co.). Dispensers were applied at 1000/ha on 12 April. A conventional insecticide program was followed through first cover. Leafrollers were controlled using mating disruption. A control block of similar varietal representation was located about 50 m away. Injury was evaluated on 18 June by collecting 400 fruit from the edge and 400 from the center of each block. Harvest damage was assessed on 10 September, when 400 fruit were collected from the center of the pheromone block and 200 from the center of the control.

Criglersville Orchard - A 2-ha (5-acre) CM disruption block was located in an organic orchard at Criglersville (Madison Co.). Shin-Etsu dispensers were placed on 18 April at the rate of 1000/ha. The control block was treated with botanical insecticides (ryania, rotenone, and a rotenone-pyrethrum blend) and *Bacillus thuringiensis* Berliner. A nearby abandoned block was included in the damage assessment. The block treated with pheromone was also treated with *B. thuringiensis* , for control of leafrollers. This would not have affected CM populations (Andermatt et al. 1988). This orchard has had high levels of CM damage historically. Damage was assessed on 12 July, after the first generation of CM, and on 10 September (harvest), after the second generation.

III. Results and discussion:

Flight data: Orientation of CM males to pheromone traps was totally suppressed in Daleville, Fincastle, BAtesville (Crown) and Spring Valley Orchards (Figs. 1-4).

Damage data: Almost no CM injury was detected during weekly fruit inspections at Daleville and Fincastle; damage in the abandoned block had reached 29.5% by 27 August (Fig. 5). In the more intensive harvest sample, CM injury at Daleville was estimated in the mating disruption block edge and center as 0% and 0.2%, respectively. In the control block, injury in the block edge and center was 0% and 0.3%, respectively.

Almost no CM injury was detected during weekly fruit inspections at Fincastle. In the harvest sample, damage in both the mating disruption and control blocks was 0.2%.

On the 18 June injury assessment at Batesville, no CM injury was detected in either block. However, in the harvest sample, important injury occurred in the disruption block, estimated as 9%. This injury appeared somewhat unusual; exit holes were small and occasionally very inconspicuous. They were not associated with protruding frass. Typical injury from lesser appleworm (LAW), *Grapholita prunivora* (Walsh), was also high, 6%. LAW normally tunnels just below the surface of apple, however Chapman & Lienk (1971) depicted a larva tunneling in the flesh of hawthorn.

At Spring Valley, no leafroller injury was detected on 18 June in the mating disruption block. In the control, 0.5% injury was estimated in both the edge and center. At harvest, CM injury was estimated as 0% in the mating disruption block and 0.5% in the control.

Control given by Shin-Etsu dispensers in 1991 was generally better than in 1990. One factor may have been the loading rate. Dispensers contained 192 mg in 1991, compared with 172 in earlier trials. Continuing sprays through first cover rather than petal fall probably brought populations to a more manageable level. The high levels of injury resulting in the block where Consep dispensers were deployed must be viewed in light of the missing third placement of dispensers and the high levels of LAW injury as confounding factors.

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Fig. 1
Codling Moth Flight Activity
Daleville - 1991

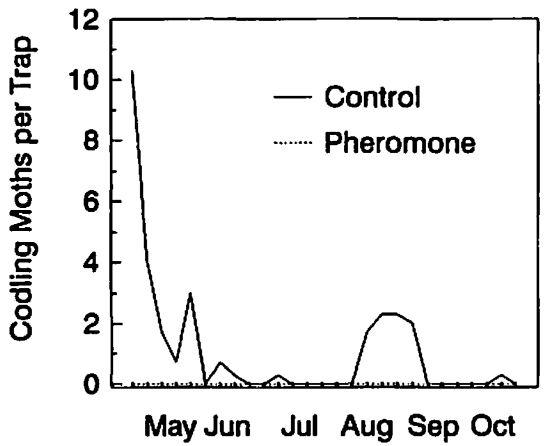


Fig. 2
Codling Moth Flight Activity
Fincastle - 1991

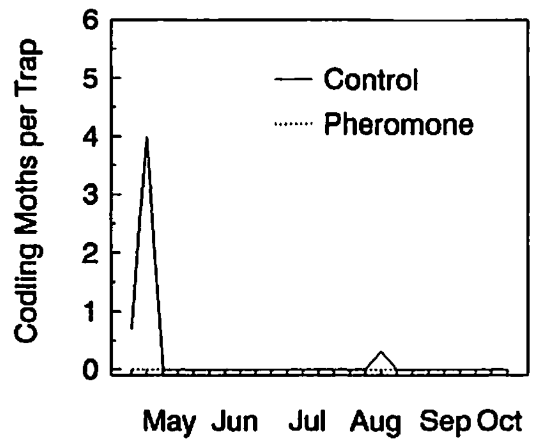


Fig. 3
Codling Moth Flight Activity
Crown Orchard - 1991

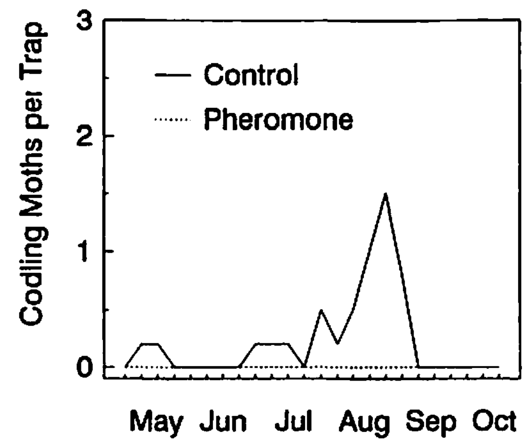


Fig. 4
Codling Moth Flight Activity
Spring Valley - 1991

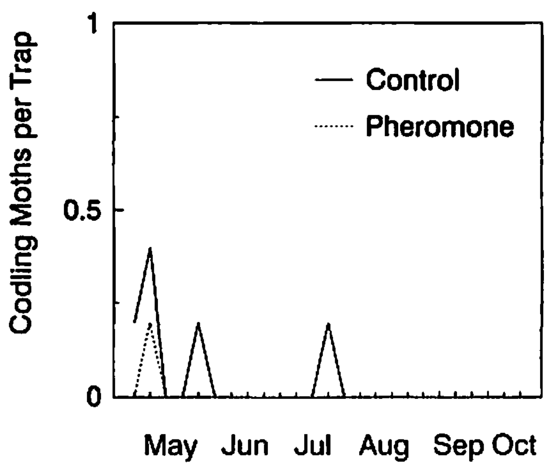
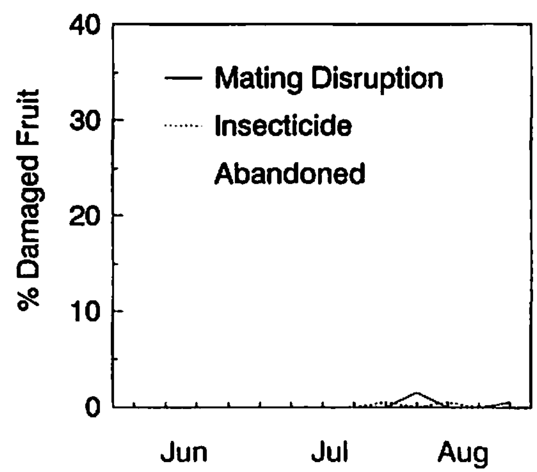


Fig. 5
Codling Moth Damage at Daleville
Orchard - 1991



Mating Disruption of the Leafroller Complex on Apple - 1991

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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. ideausalis* Walker, and redbanded leafroller (RBL), *Argyrotaenia velutinana* (Walker). Research has been performed on mating disruption for this complex in recent years (Pfeiffer & Kaakeh 1989, Pfeiffer et al. 1990); further results are reported here.

II. Materials and Methods:

Daleville Orchard - Mating disruption of the leafroller complex was performed in a 1.9-ha (4.7-acre) block at Daleville (Botetourt Co.), primarily comprised of 'Red Delicious', also including 'Golden Delicious'. The block treated with pheromone was isolated, but with a small abandoned block about 50 m away. Shin-Etsu redbanded leafroller and variegated leafroller pheromone dispensers (Shin-Etsu Chemical Co., Tokyo, Japan) were used in this block.

The pheromone blend contained in the VLR dispensers was 141 mg of *E*-11-tetradecenol (70%)/ *Z*-11-tetradecenol (30%); this is an approximation for the 90:10 blend of these components found in VLR sex pheromone (Hill et al. 1977). The blend used for RBL was 163 mg of *Z*-11-tetradecenyl acetate (90%)/ *E*-11-tetradecenyl acetate (10%). The natural blend for RBL is reported to be *Z*-11-tetradecenyl acetate (37%)/ *E*-11-tetradecenyl acetate (3%)/ dodecenyl acetate (60%) (Roelofs & Brown 1982).

RBL dispensers were placed on 24 April and VLR dispensers on 2 May, both at the rate of 1000/ha (400/acre). Tree density was 300 trees/ha (120/acre). After the first cover spray the grower agreed to withhold all insecticide sprays until pest conditions required action. The control block, treated with a conventional spray program, was about 1.6 km (1 mi) away, and was surrounded by additional commercial apple orchard.

Three pheromone traps each for VLR, TBM and RBL (Trece Inc., P.O. Box 6278, Salinas, Ca.) were placed in the blocks treated with pheromone and with conventional sprays and were monitored weekly. Damage was assessed weekly by examining at least 200 fruit in the pheromone-treated, control, and abandoned blocks. At the harvest count (6 September), 200 fruit of both 'Red Delicious' and 'Golden Delicious' were sampled in the disruption and control blocks. Fruit were examined *in situ* until the final count, when fruit were removed from the trees for closer examination.

Fincastle Orchard. A block near Fincastle (Botetourt Co.) was treated with tea tortrix (TT), *Adoxophyes* sp., dispensers on 24 April and VLR dispensers on 2 May. The TT dispensers contained 170 mg of *Z*-11-tetradecenyl acetate. TT pheromone is similar to that of redbanded leafroller (Roelofs & Brown 1982); mating disruption is used commercially in Japan for that species (P. Kirsch, pers. comm.). This block was 1.8 ha (4.5 acres), comprised of 'Red Delicious' (67%) and

'Golden Delicious' (33%). Tree density was 325 trees/ha (130/acre). Dispensers were placed at 1000/ha. A standard insecticide program was followed through first cover, after which no further insecticides were applied unless conditions warranted them. Injury was assessed as in the Daleville block. Harvest samples were collected on 27 August. Codling moth was controlled using mating disruption (unpubl. data). 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.

Spring Valley - A 4-ha (10-A) block was treated with Shin-Etsu VLR pheromone dispensers at Spring Valley (Albemarle Co.); in addition, half of the block was treated with RBL dispensers. Dispensers were applied at 1000/A on 17 April (RBL) and 8 May (VLR). A conventional insecticide program was followed through first cover. A control block of similar varietal representation was located about 50 m away. Injury was evaluated on 18 June by examining 200 fruit from the edge and center of both halves of the disruption block (VLR plus RBL permeation versus VLR permeation alone), and 400 fruit from both the edge and center of the control block. Harvest injury was assessed on 10 September, when 200 fruit were collected from the middle of each half of the disruption block, and from the control.

Batesville Orchard - VLR was the target of mating disruption in a 4-ha (10-acre) block, primarily 'Winesap', at Batesville (Albemarle Co.). Dispensers were placed on 7 May at 1000/ha. The control block, also primarily 'Winesap', was about 0.4 km (0.25 mi) away from the pheromone-treated blocks. Four pheromone traps for each leafroller species were placed in both pheromone-treated and control blocks and checked weekly. The grower agreed to refrain from all insecticide sprays after first cover until recommended otherwise.

Damage was assessed on 18 June; 100 fruit were sampled in each corner of the block and 200 from the block centers. Harvest damage was assessed on 10 September. At that time, 200 fruit were harvested from each block.

III. Results and Discussion:

Flight data: Orientation of male VLR to traps was almost totally suppressed (Figs. 1-4). There was also substantial reduction in trap captures of TBM (Figs. 5-8). There was no suppression of RBL orientation by VLR pheromone alone (Fig. 12) because there is overlap in the pheromone composition of VLR and RBL.

RBL dispensers were deployed at Daleville (Fig. 9) and half of the Spring Valley pheromone block (Fig. 11). RBL captures were totally eliminated in these blocks. In the half of the Spring Valley block without RBL dispensers (VLR alone), captures were still lower than in the control block. This is probably because of the proximity of RBL pheromone permeation. Trap captures were also almost totally reduced in the Fincastle block (Fig. 10), where TT dispensers were employed. No dispensers targeted at RBL were used at Batesville (Fig. 12). Trap captures were not reduced by VLR pheromone dispensers.

Damage data: During weekly fruit inspections at Daleville, leafroller injury was seen in neither the mating disruption nor control blocks. Combined leafroller injury in the abandoned block reached 37% at its maximum. In the more intensive harvest sample, *Platynota* injury in the mating disruption block edge and center was estimated as 0% and 0.2%, respectively. Injury in the control block edge and center was 0.8% and 0.5%, respectively. RBL injury in the mating disruption block was 0% in both edge and center. In the control edge and center, injury was 1.1% and 0%, respectively.

At Fincastle, no leafroller injury of either type was detected in the weekly inspections. Injury was estimated as 0% in the intensive harvest sample in both blocks.

At Spring Valley, no leafroller injury of either type was detected in the disruption blocks or the control. At harvest, leafroller injury was still evaluated as 0% in all blocks.

In the 18 June injury assessment at Batesville, no leafroller injury of either type was detected. At harvest, *Platynota* and RBL injury in the mating disruption block was estimated as 0.5% and 0%, respectively. No injury of either type was found in the control.

In 1991, successful control of the leafroller complex was achieved using separate sets of dispensers for VLR and RBL. TT dispensers gave control of RBL comparable to RBL dispensers. The pheromone composition of RBL is *Z*-11-tetradecenyl acetate (37%/ *E*-11-tetradecenyl acetate (3%)/ dodecenyl acetate (60%), and of TT is *Z*-9-tetradecenyl acetate (63%)/ *Z*-11-tetradecenyl acetate (31%/ *E*-11-tetradecenyl acetate (4%)/ 10-methyl-dodecenyl acetate (2%) (Roelofs & Brown 1982). Control by mating disruption was probably enhanced by continuing insecticide sprays through first cover rather than stopping after petal fall, as in earlier years (Pfeiffer et al. 1990).

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Roelofs, W. L. & R. L. Brown. 1982. Pheromones and evolutionary relationships of Tortricidae. Annu. Rev. Ecol. Syst. 13: 395-422.

Fig. 1

Variegated Leafroller Flight Activity
Daleville - 1991

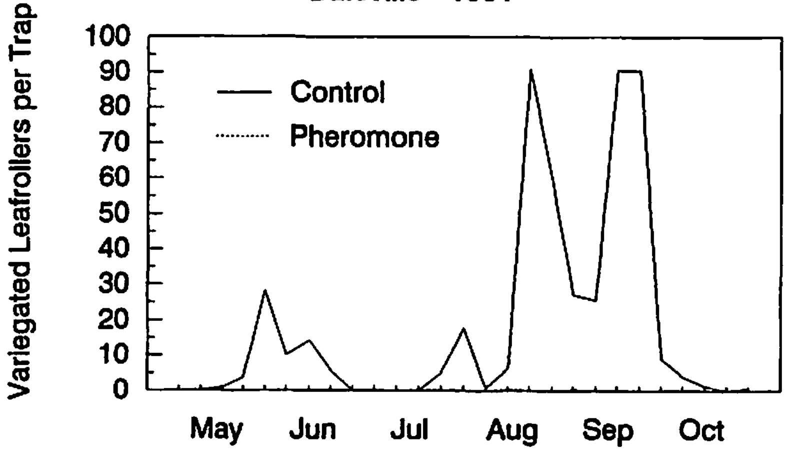


Fig. 2

Variegated Leafroller Flight Activity
Fincastle - 1991

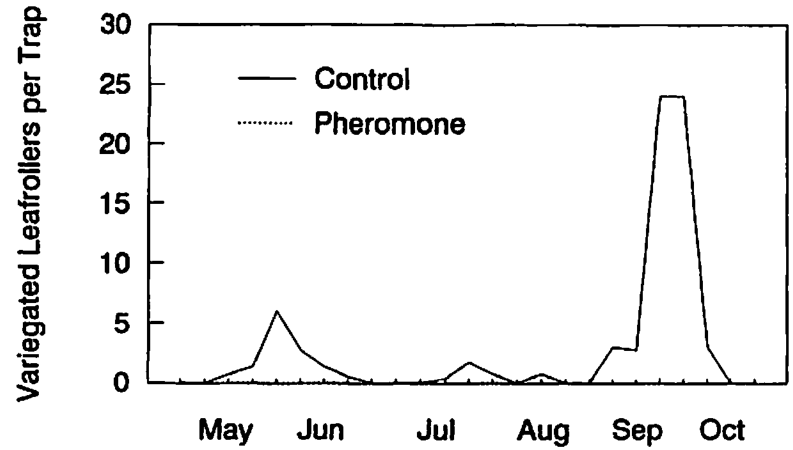


Fig. 3

Variegated Leafroller Flight Activity
Spring Valley - 1991

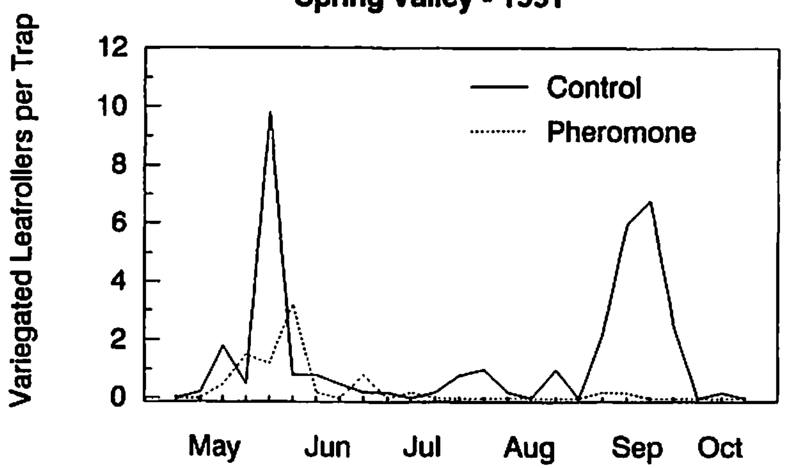
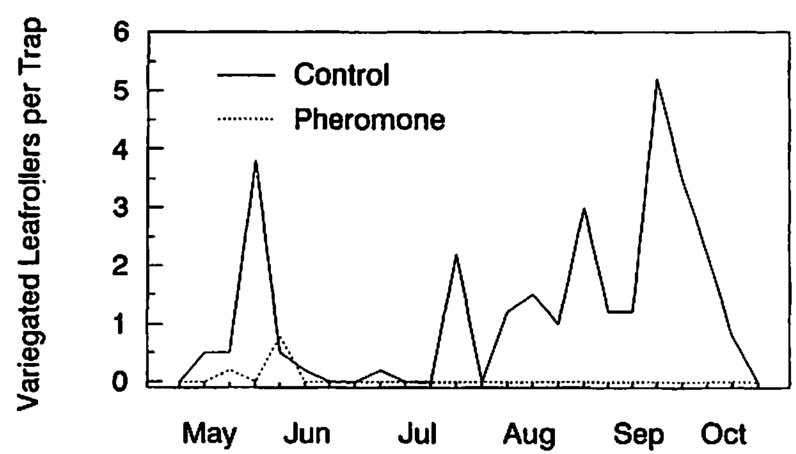


Fig. 4

Variegated Leafroller Flight Activity
Crown Orchard - 1991



Secondary Pest and Predatory Populations in Apple Orchards using Mating Disruption - 1991

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I. Introduction:

One advantage of mating disruption is ostensibly the reduction of secondary pest outbreaks through enhanced survival of predatory populations (Kirsch 1988). Biological control of pear psylla, *Cacopsylla pyricola* (Foerster), was enhanced in codling moth, *Cydia pomonella* (L.), mating disruption blocks (Westigard & Moffitt 1984). Pfeiffer et al. (1990) presented data consistent with this hypothesis from apple pest disruption blocks in Virginia. Other studies have shown mating disruption not to interfere with natural enemies (Sower et al. 1990). Because of the high cost of mating disruption and the complex arthropod community structure in orchards, it is necessary to examine this hypothesis more critically.

II. Materials and Methods:

Research was conducted in several low spray blocks that were part of mating disruption trials for codling moth and leafrollers. Blocks were located at Daleville (1.9 ha), Fincastle (1.8 ha), Batesville (4 ha) and Spring Valley (4 ha). Conventional sprays were applied through first cover, after which few if any insecticide sprays were applied.

European red mite (ERM), *Panonychus ulmi* (Koch), was evaluated by counting mites on 10 leaves per tree on four trees per block weekly. Numbers of the predatory mite, *Amblyseius fallacis* (Garman), were also recorded. Aphids, *Aphis* spp., were assessed by counting the number of infested terminals in 10 shoots per tree on these four trees. The number of shoots containing predators of aphids (larvae of Syrphidae, Cecidomyiidae, Chrysopidae, adults and immature stages of Coccinellidae and Anthocoridae, spiders) were also noted at Daleville and Fincastle.

III. Results and Discussion:

European red mite - At Daleville, ERM densities were higher in the mating disruption block than in the control (Fig. 1). This is the same block which experienced an outbreak in 1990, apparently in response to border sprays to prevent immigration of codling moth and leafrollers (Pfeiffer et al. 1990). The predator *A. fallacis* was at low densities at Daleville, being detected on two dates in the disruption block and never in the control. There was no clear trend in ERM densities at Fincastle (Fig. 2). *A. fallacis* were recorded on only one date in the control, never in the pheromone-treated block. ERM densities at Batesville (Crown) were higher in pheromone block (Fig. 3); *A. fallacis* was detected on only one date in both blocks. There was no clear difference in ERM densities at Spring Valley. *A. fallacis* was detected in both blocks on one date during the early peak of ERM activity. The predator was detected in the control on three additional dates in September in response to the peak of ERM in that block (Fig. 4).

Aphids - In the first comparison (Figs. 5-8), *Aphis* populations are compared in disruption versus control blocks. At Daleville (Fig. 5), aphids were somewhat more numerous in the control block; however, populations in both blocks exceeded the current action threshold of 50% of terminals infested. At Fincastle (Fig. 6), aphid populations were the same in the early part of season, the main period of aphid activity. During a later resurgence associated with a new flush of twig growth, aphids were more numerous in the control block. At Crown (Fig. 7), aphid populations were higher in the pheromone block. At Spring Valley (Fig. 8), there was no clear trend.

In the second comparison (Figs. 9-12), aphids and their predators are compared in the Daleville and Fincastle disruption and control blocks. At Daleville (Figs. 9-10), predators were more common in the disruption block; these were primarily the predatory cecidomyiid, *Aphidoletes aphidimyza* (Rondani). Larvae were found on four dates in the disruption block, never in the control. The main peak of predators in the control block resulted from the presence of *Orius* on one date.

At Fincastle, aphids reached high levels in both disruption and control blocks (Fig. 11-12). However, predatory populations were clearly higher in the disruption block. These were mainly *A. aphidimyza*, with a few *Orius* adults and syrphid larvae. On 14 June, an average of 90% of shoots were infested in the disruption block, with 62% of shoots containing predators. In the control, 80% of the shoots were aphid-infested, with no predators. Unfortunately, the clear impact of predators in the two blocks cannot be seen because by 20 June the grower had sprayed for aphids in the control. However, since counts were made on the basis of % infested shoots, populations were still recorded as high in the following weeks (20 June: 95% of shoots with aphids, 77% with predators in the disruption block, 100% of shoots with aphids and 0% with predators in the control block; 27 June: 70% of shoots with aphids and 18% with predators in the disruption block, 86% with aphids in the control). Although the % infested shoots was slow in dropping in both blocks, the number of aphids within colonies in both blocks was noticeably lower. Additional methods of assessing aphid populations should be used in such studies.

In summary, ERM populations were not consistently lower in disruption blocks. Additional research is needed to explain this. Pesticides in addition to insecticides may induce ERM outbreaks. Replacing insecticides alone through mating disruption may not be sufficient to prevent induction of mite outbreaks. Aphid predators were more common in disruption blocks than in controls.

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Fig. 5
Tufted Apple Bud Moth Flight Activity
Daleville - 1991

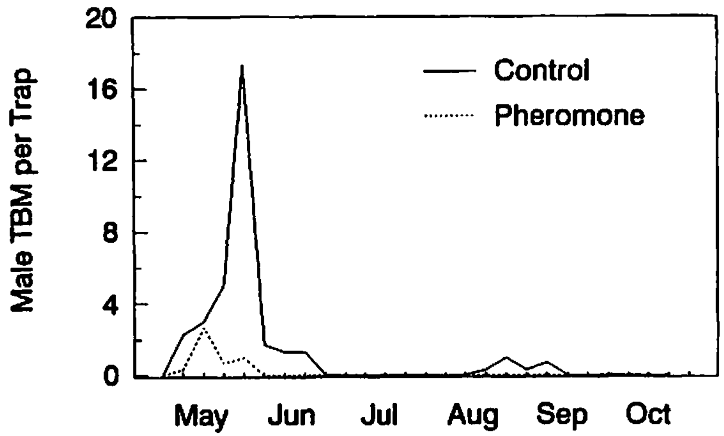


Fig. 6
Tufted Apple Bud Moth Flight Activity
Fincastle - 1991

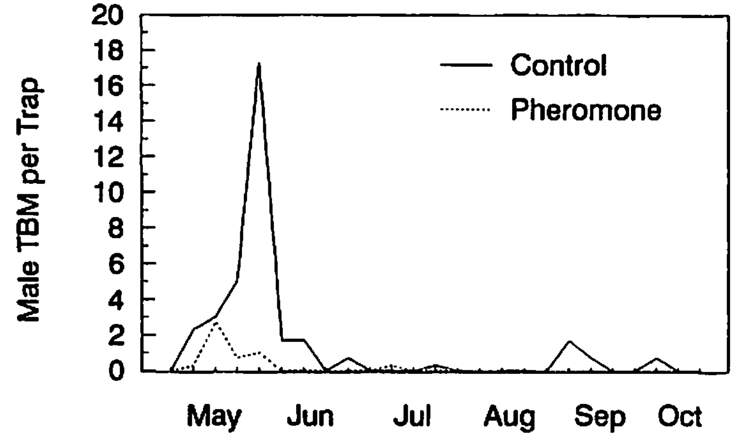


Fig. 7
Tufted Apple Bud Moth Flight Activity
Spring Valley - 1991

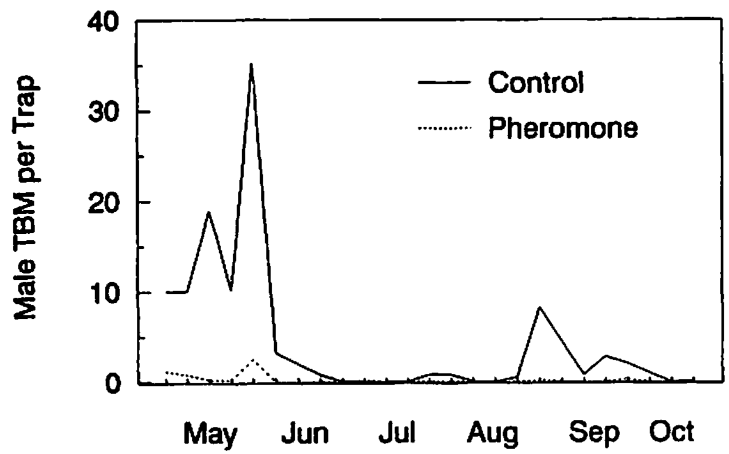


Fig. 8
Tufted Apple Bud Moth Flight Activity
Crown Orchard - 1991

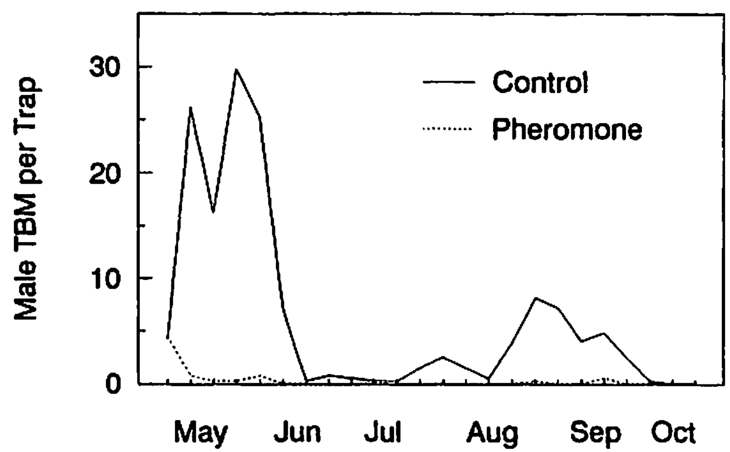


Fig. 9

Redbanded Leafroller Flight Activity
Daleville - 1991

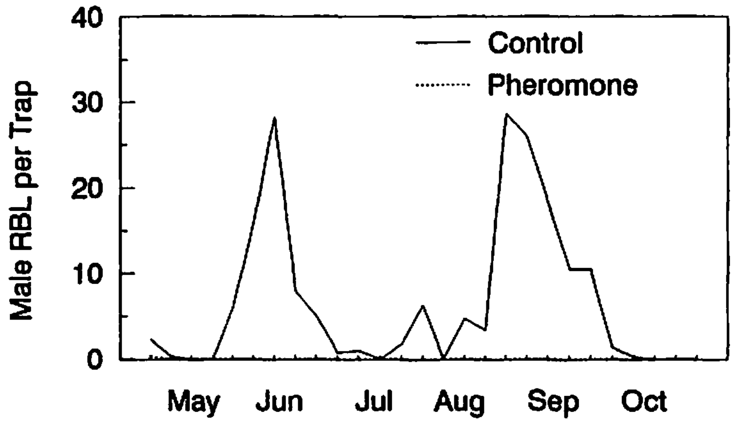


Fig. 10

Redbanded Leafroller Flight Activity
Fincastle - 1991

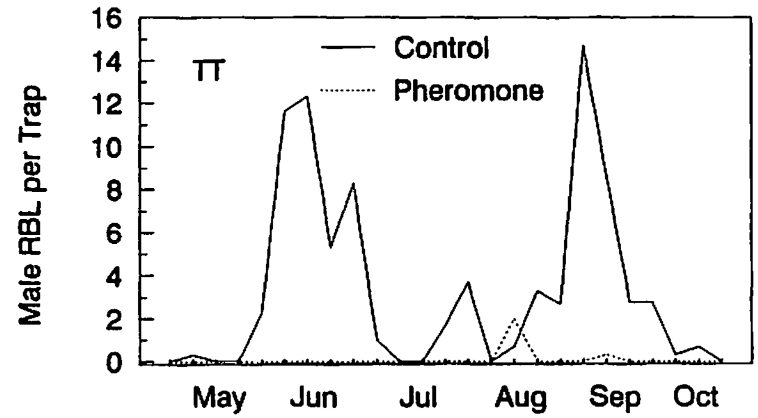


Fig. 11

Redbanded Leafroller Flight Activity
Spring Valley - 1991

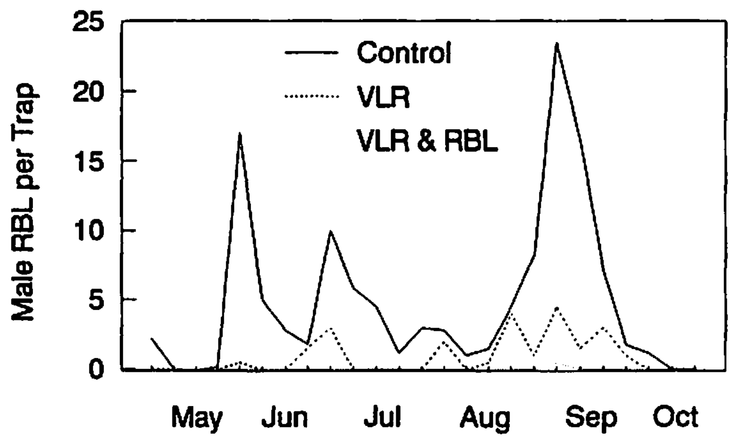
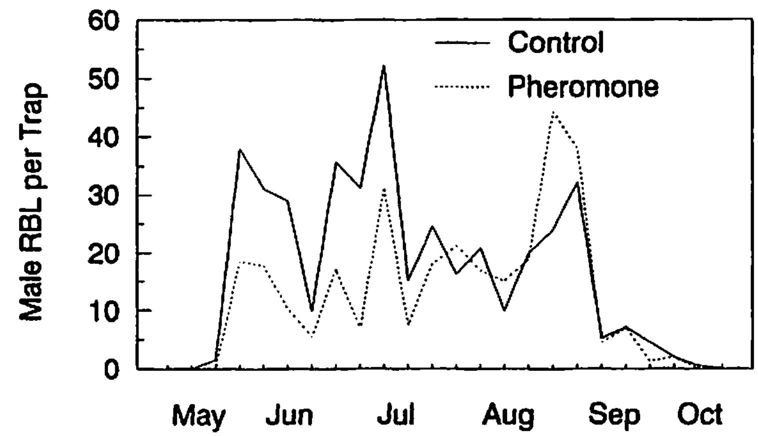


Fig. 12

Redbanded Leafroller Flight Activity
Crown Orchard - 1991



Phenology of Grape Berry Moth in Virginia - 1991

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Virginia Polytechnic Institute & State University

I. Introduction:

Grape berry moth (GBM), *Endopiza viteana* Clemens, is a potentially serious pest of Virginia vineyards. Two to three generations per year have been described for the mid-Atlantic states (Dozier et al. 1932, Gleissner 1943). Earlier descriptions of a bivoltine life history in Virginia were based on samples so low as to make conclusions tenuous (Pfeiffer et al. 1990). Pfeiffer & Wolf (1990) reported clear evidence in Virginia for three and four generations, and apparently five in one vineyard. Similar patterns were reported from other states (Dennehy et al. 1990).

II. Materials and Methods:

In the spring of 1991, GBM pheromone traps were distributed to 15 growers in various parts of the state. In addition, the authors monitored eight vineyards, so that study sites included the Delmarva Peninsula, Piedmont, Blue Ridge, Shenandoah Valley and Roanoke Valley. When feasible, growers were instructed in person on identification of GBM and a sumac moth (SM), *Episimus argutanus* (Clemens), also attracted to GBM pheromone traps (Jubb 1973). Otherwise, photographs were provided. Stamped postcards were provided to growers for submitting weekly trap counts. Four grower-submitted data sets were complete.

III. Results and Discussion:

Where patterns could be discerned, there usually appeared to be three generations (Figs. 1-6). There were no clearly bivoltine populations, with the possible exception of Flint Hill (Fig. 7). There was no clear evidence for four generations as in 1990 (Pfeiffer & Wolf 1990), but GBM populations were active earlier than anticipated in 1991; adults were active before trapping started (Figs. 1,2,6,7,8). Furthermore, at Prince Michel, mature GBM larvae were found at full bloom. In published accounts of GBM life history, adults emerge from overwintered pupae at bloom. The first flight of adults was therefore not detected in our 1991 trapping.

Vineyards differed in the relative magnitude of early versus later generations. While more males were captured in early generations in some vineyards (Figs. 1,2,7,8), GBM was more numerous in later generations (near harvest) in other vineyards (Figs. 3-6). Vineyards also differed with respect to captures of *E. argutanus*. In some vineyards, population peaks coincided closely with those of GBM (Fig. 1). In some vineyards, *E. argutanus* greatly outnumbered GBM, emphasizing the need for proper grower education before pheromone traps are used in monitoring programs.

In addition to the population activity patterns discerned in the trap captures, data was collected on the relation between trap captures and damage at harvest. Ladd vineyard is surrounded on three sides by mixed deciduous woodland, including several species of wild grapevines. Banjo Shack is composed of the same varieties and is managed by the same grower, but is surrounded by open agricultural land. Although trap captures were lower at Ladd than at Banjo Shack, damage at harvest (28 August) was more prominent at Ladd. Berry infestation at Ladd was 10.4% and 1.7% for the edge and middle, respectively. Berry injury at Banjo Shack was 0.0%

Colonized shoots per 10 shoots

Fig. 9

Aphids and Predators in Disruption Block
Daleville - 1991

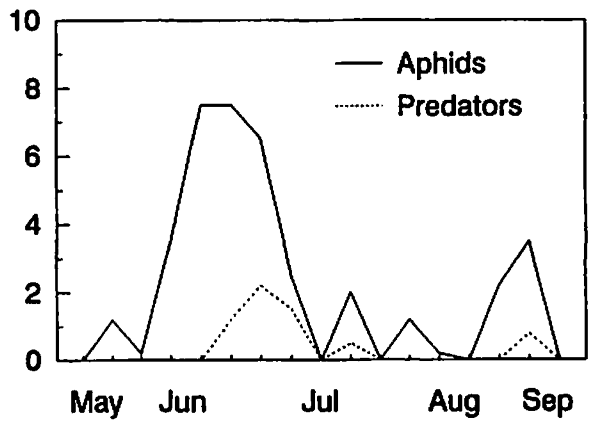


Fig. 10

Aphids and Predators in Control Block
Daleville - 1991

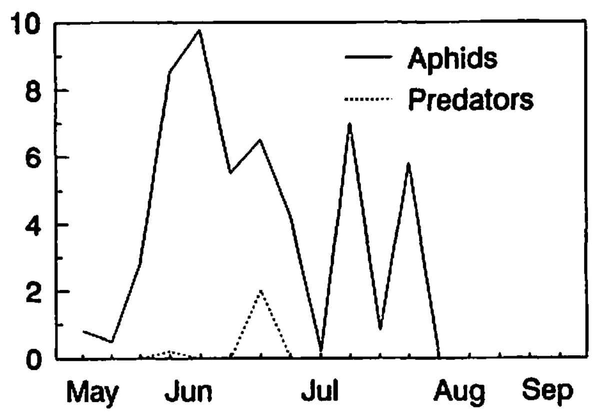


Fig. 11

Aphids and Predators in Disruption Block
Fincastle - 1991

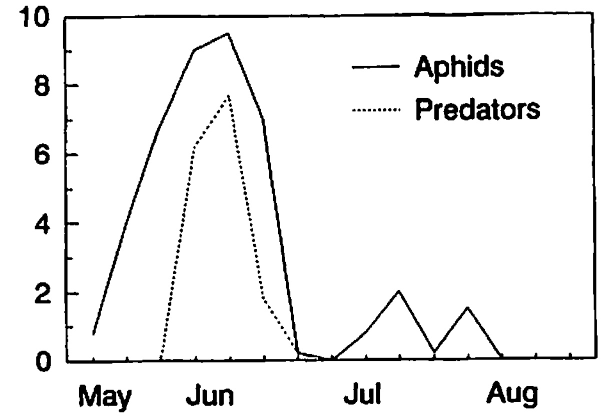
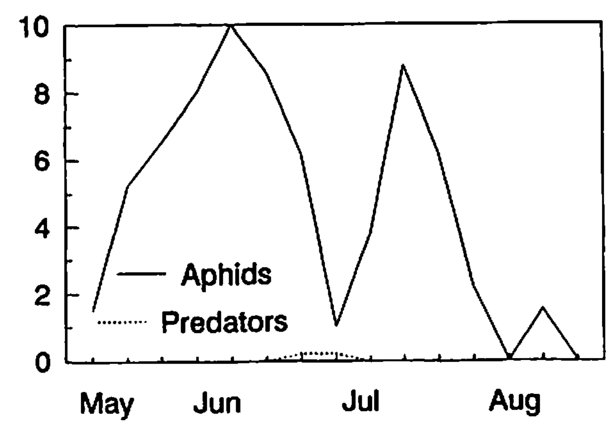


Fig. 12

Aphids and Predators in Control Block
Fincastle - 1991



and 0.1% for edge and middle, respectively. Therefore trap captures must be interpreted differently for vineyards in wooded versus open settings.

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Fig. 1
Grape Berry Moth Flight Activity
Piedmont Vineyard - 1991

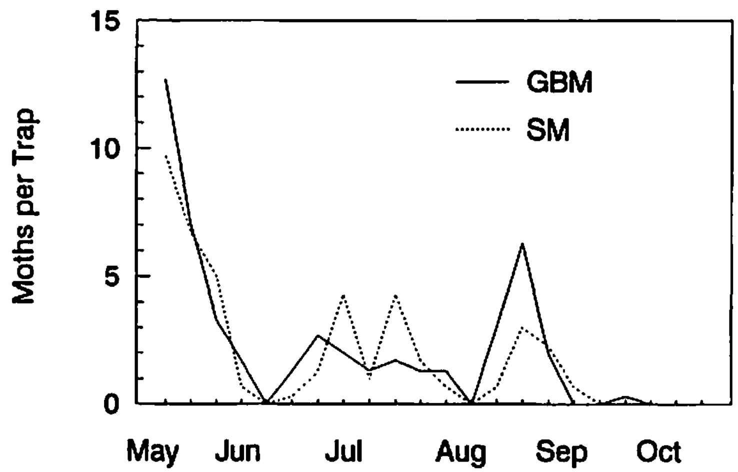


Fig. 2
Grape Berry Moth Flight Activity
Oak Spring Vineyard - 1991

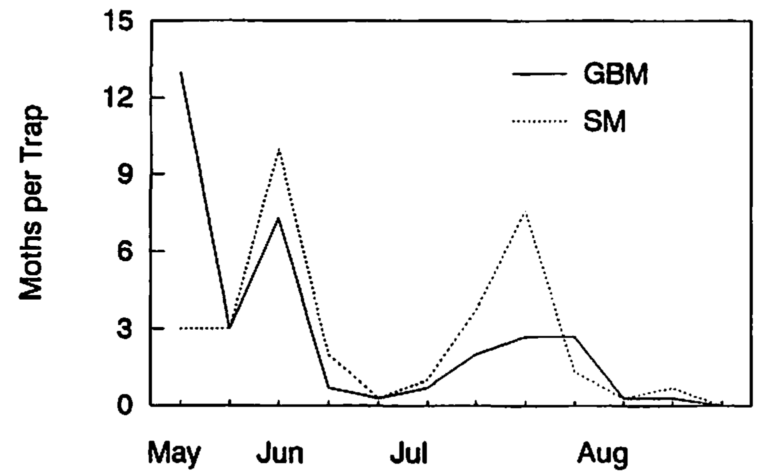


Fig. 3
Grape Berry Moth Flight Activity
Prince Michel Vineyard - 1991

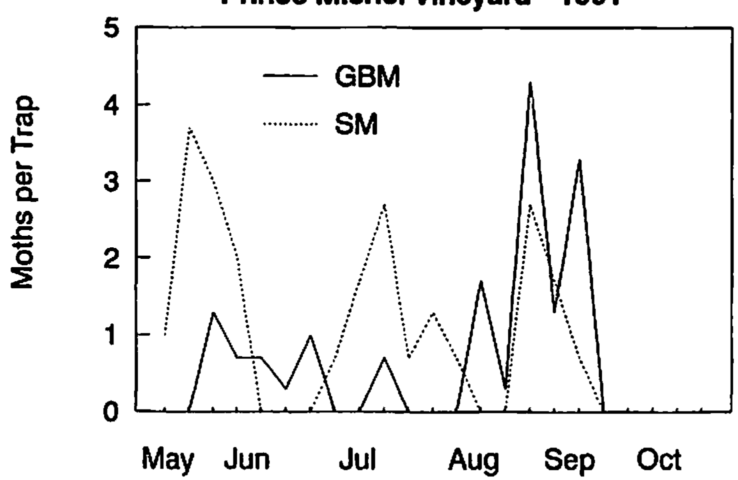


Fig. 4
Grape Berry Moth Flight Activity
Meredyth Vineyard - 1991

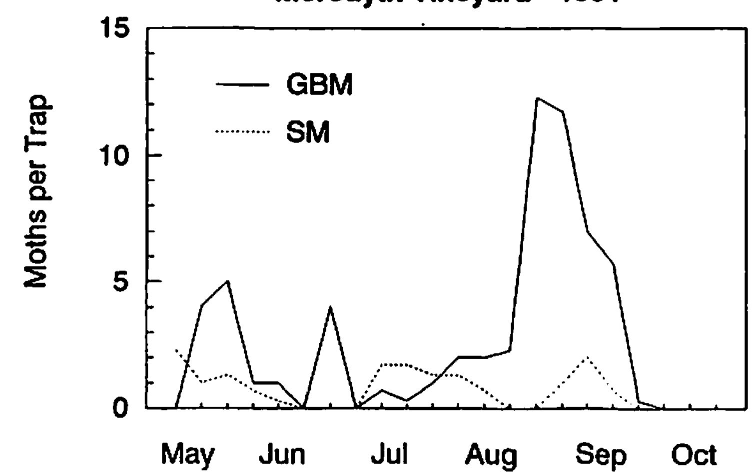


Fig. 1
European Red Mites
Daleville - 1991

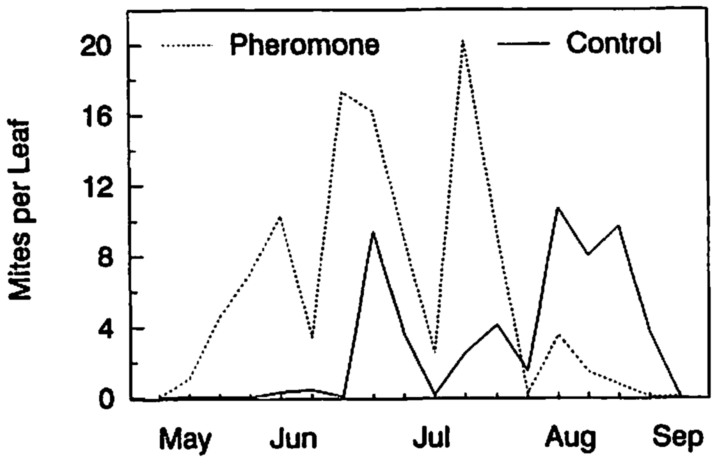


Fig. 2
European Red Mites
Fincastle - 1991

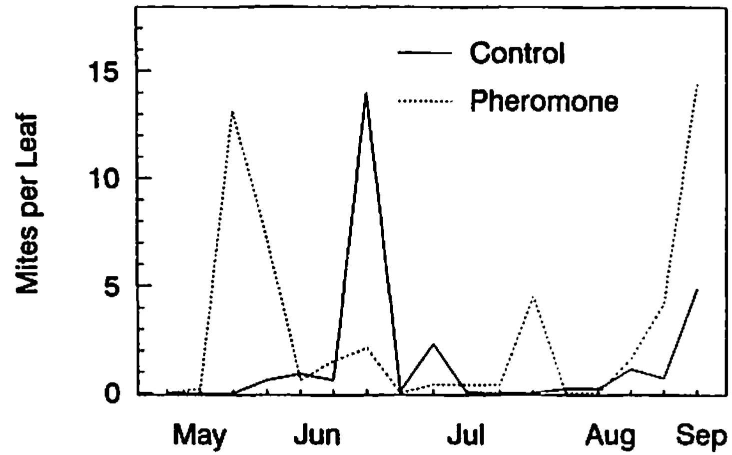


Fig. 3
European Red Mites
Crown Orchard - 1991

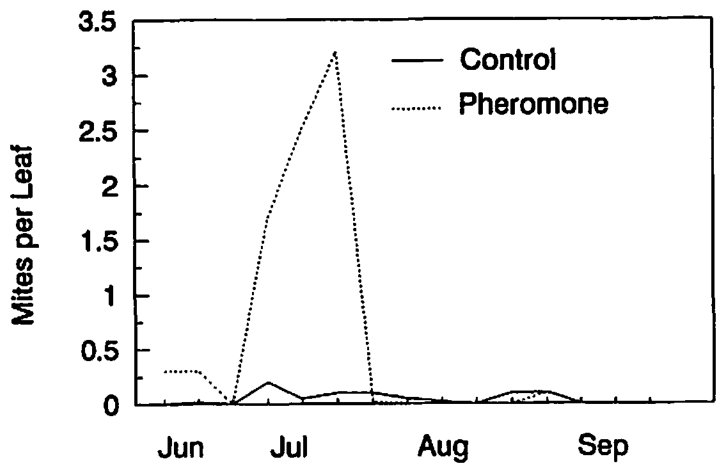


Fig. 4
European Red Mites
Spring Valley - 1991

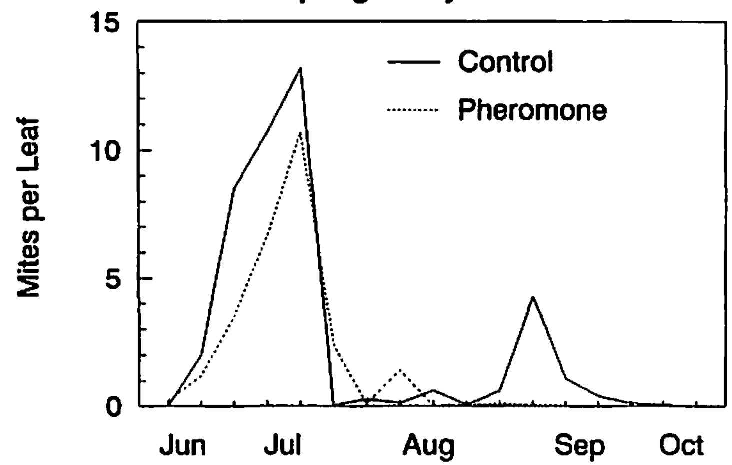


Fig. 5

Aphis spp.
Daleville - 1991

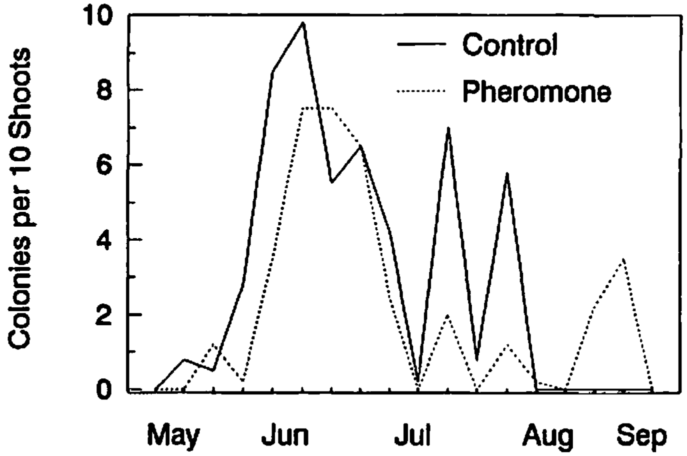


Fig. 6

Aphis spp.
Fincastle - 1991

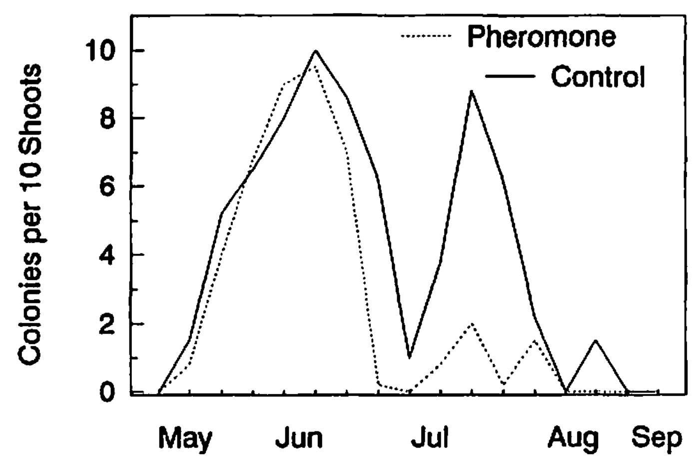


Fig. 7

Aphis spp
Crown Orchard - 1991

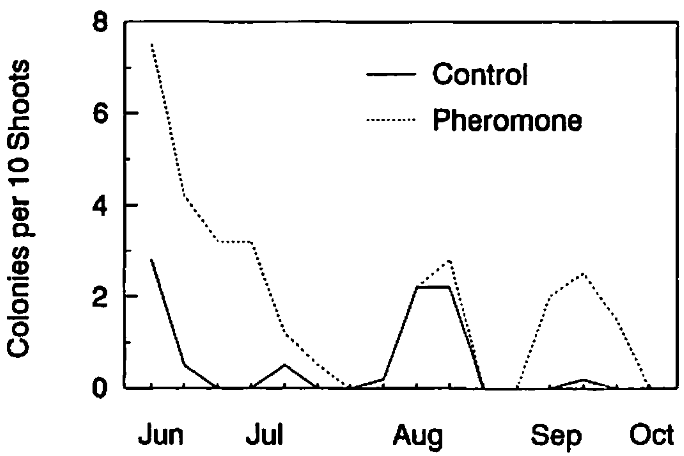
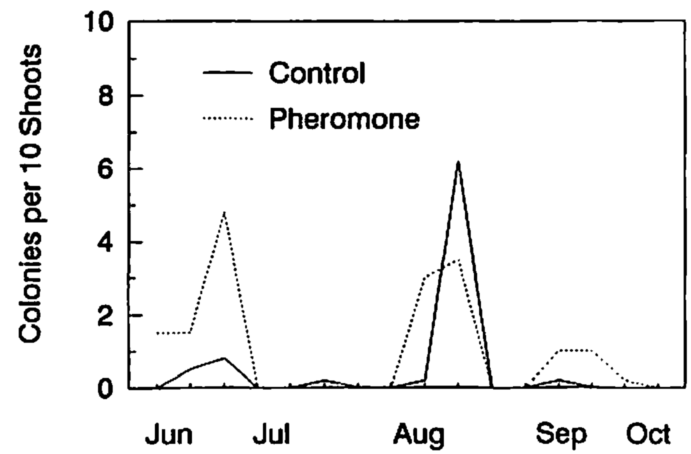


Fig. 8

Aphis spp.
Spring Valley Orchard - 1991



Grape Berry Moth Mating Disruption - 1991

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Virginia Polytechnic Institute & State University

I. Introduction:

Mating disruption for grape berry moth (GBM), *Endopiza viteana* Clemens, received EPA registration in 1990. The research supporting this tactic for GBM has been performed mainly in New York, on processing grapes (Dennehy et al. 1990). Research must be carried out in Virginia, where most vineyards include *vinifera* varieties, more susceptible to *Botrytis* and other rots, and having a warmer climate. Such factors were found to impede the success of mating disruption at times in Virginia (Pfeiffer & Wolf 1990).

II. Materials and Methods:

In 1991, four 5-acre blocks were treated with the full label rate of 400 dispensers per acre (1000/ha). Each dispenser contained 69 mg of *Z*-9-dodecen-1-yl acetate (90%)/ *Z*-11-tetradecen-1-yl acetate (10%). A block at Prince Michel Vineyard (Madison Co.) consisted of 'Chardonnay' vines, a block at Meredyth Vineyard (Fauquier Co.) of 'Seyval'; a block at Redlands Vineyard (Albemarle Co.) of 'Cabernet Franc' and 'Chardonnay', and a block at Ladd Vineyard (Augusta Co.) of 'Concord' vines. Dispensers were placed on 14 May at Prince Michel and Meredyth (before bloom), 16 May at Redlands (a little early bloom) and at the Ladd vineyard. 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. Assessments were made on 28 May (full bloom) at Prince Michel, on 5 June and 27 July at Meredyth, 25 June at Redlands and Ladd. Percent infested berries were also determined at Ladd. No further assessments were made at Redlands. The grower decided to terminate the experiment on 21 June, removing dispensers.

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 23 August at Meredyth and 28 August at Ladd. The block at Prince Michel was sprayed with Penncap during the summer and harvest damage is not discussed here.

III. Results and Discussion:

<u>Prince Michel Vineyard</u>

Trapping Data: Suppression of male captures in traps was almost completely eliminated in the mating disruption block relative to the control. One male was captured in the disruption block on each of two dates (Fig. 1).

Fig. 5
Grape Berry Moth Flight Activity
Banjo Shack and Ladd Vineyards - 1991

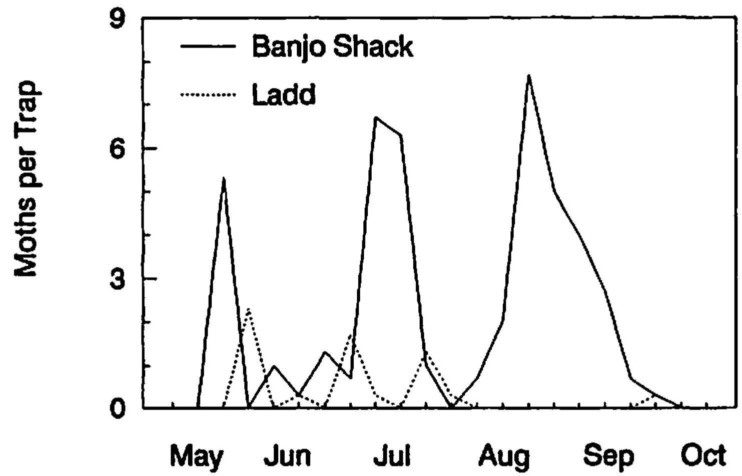


Fig. 6
Grape Berry Moth Flight Activity
Ingleside Vineyard - 1991

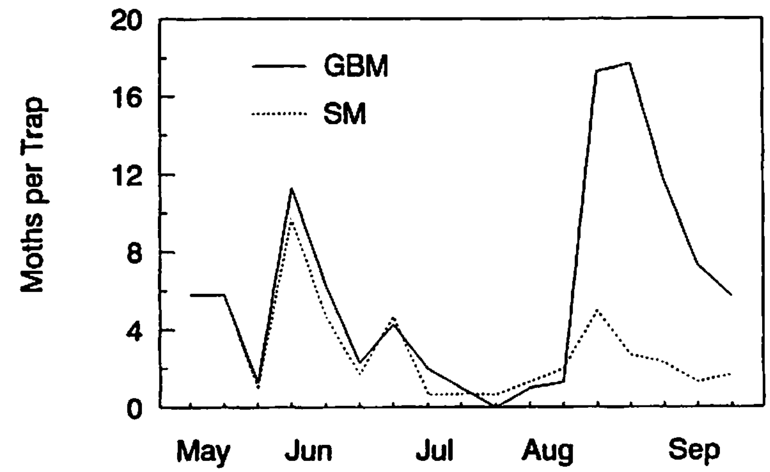


Fig. 7
Grape Berry Moth Flight Activity
Flint Hill Vineyard - 1991

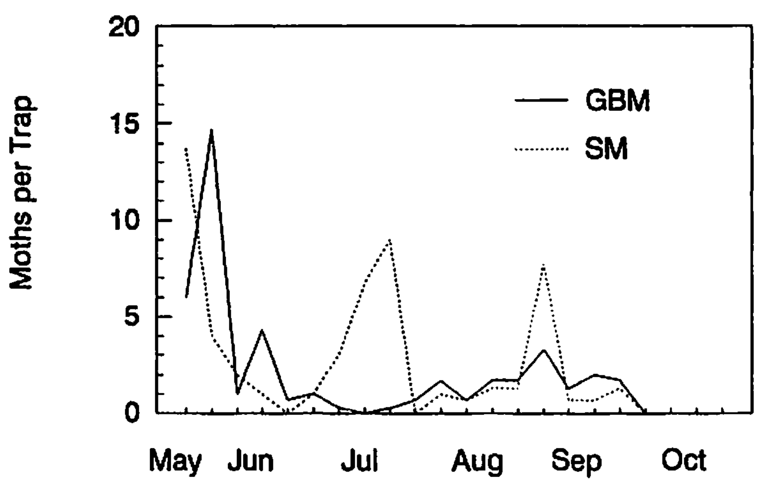
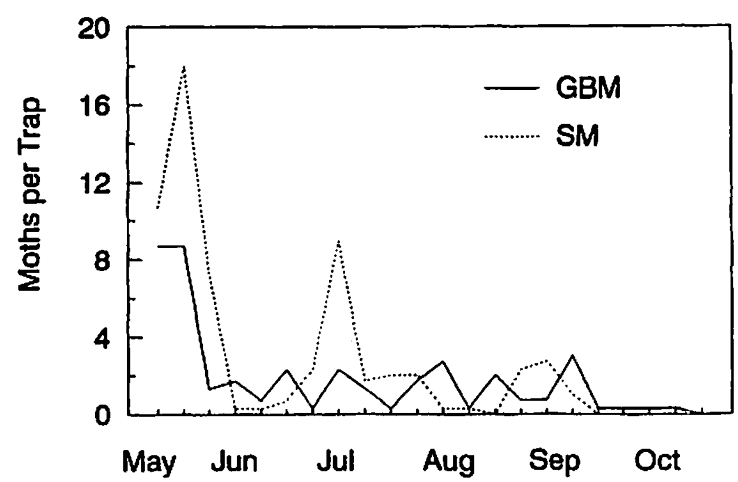


Fig. 8
Grape Berry Moth Flight Activity
Schloss-Tucker Vineyard - 1991



First Generation Damage:

Row	Pheromone	Control
	% Infested Clusters 28 May (Full Bloom)	
3	17.2	16.8
15	11.2	16.8
20	6.6	7.3

The GBM population was active earlier in the 1991 season than anticipated. A damage assessment at full bloom revealed the presence of both large and small GBM larvae in clusters. Adults have been reported to emerge from overwintered pupae around bloom. The damage shown above at bloom did not differ between blocks, and reflects reproduction occurring before the deployment of pheromone dispensers.

Meredyth Vineyard

Trapping Data: Almost total trap shutdown was achieved until late in the season. A substantial number of males (about 5/trap) were captured during the peak of activity in the last generation (Fig. 2).

Successful control was achieved at Meredyth Vineyard. Injury to clusters and berries is shown below:

First Generation Damage: % Infested Clusters

	5 June	27 July
Pheromone	2.7	1.5
Control	7.7	0.0

Harvest Damage: % Infested Berries (23 Aug)

	Pheromone	Control
Edge	1.4	0.2
Middle	0.2	0.3

Damage in secondary clusters was higher than in primary clusters:

	Primary	Secondary
Pheromone		
Edge	1.4	11.8
Middle	0.2	5.1
Control		
Edge	0.2	2.1
Middle	0.3	20.4

Redlands Vineyard

Trapping Data: Male captures in traps was substantially reduced through 21 June; data was not collected after the experiment was terminated by the grower. An average of 1.0 males per trap were caught in the second week of trapping. In the control, mean moths per trap for the five weeks of the experiment were 0.0, 1.7, 0.7, 0.0, 0.3. Population pressure was light in this vineyard.

First Generation Damage: % infested clusters were determined on 25 June. In the edge row, an average of 10% of the clusters were infested. In row 8, 7% of the clusters were infested. In Row 17, 3% (if only the interior portion of this row was considered, only 1% of the clusters were infested). Damage in the control was 4.5% of the clusters infested.

Ladd Vineyard

Trapping Data - Orientation of males to pheromone traps was totally eliminated in this vineyard. Population pressure in this vineyard surrounded by woodland as reflected by pheromone traps was light (Fig. 3) However damage is typically higher than in a similar vineyard with higher trap catches but surrounded by open land (unpubl.).

First Generation Damage: % Infested Clusters (25 June)

	Pheromone	Control
Edge	2.0	1.0
Middle	1.5	3.0

Harvest Damage: % Infested Berries (28 Aug)

	Pheromone	Control
Edge	2.9	10.4
Middle	1.9	1.7

Results from 1991 were more promising than those from 1990 regarding the prospects of mating disruption in Virginia. Nevertheless, caution will be needed, especially in areas of high risk from GBM. Trimble et al. (1991) reported success using this technique in an area of high GBM pressure as well.

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

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APPLE: Malus domestica
Codling moth (CM): Cydia pomonella L.
Variegated Leafroller (VLR): Platynota flavedana
Tufted apple bud moth (TBM): Platynota ideausalis
Redbanded leafroller (RBL): Argyrotaenia velutinana
Aphids: Aphis spp.

APPLE, PYROLLE INSECT CONTROL STUDY, 1991: Three rates of AC 303,630 24EC (2 lb AI/gal) (13.3, 26.6, and 53.2 g AI/100 liters) were applied to an orchard at Steeles Tavern, comprised of 'Golden Delicious', 'Delicious', Stayman' and 'York', and were compared with Penncap (29.4 g AI/100 liters) and an untreated control. Applications were made on 6 May, 22 May, 17 Jun, 1 Jul, 15 Jul and 29 Aug; these dates correspond with the petal fall sprays, and first and subsequent cover sprays. A truck-mounted Swanson airblast sprayer with a handgun attachment was used. Trees were sprayed to drip (ca. 180 gal/A). Four single-tree replications were used, using variety as a blocking factor. Fruit damage was assessed on 13 Jun (20 fruit per tree) and at harvest (50 fruit per tree). Aphids were assessed by examining 10 terminal shoots per tree and recording the number infested by Aphis spp.

On the first sampling date, fruit damage by CM, VLR/TBM and RBL were not significantly different. The middle rate of AC 303,630 and Penncap reduced damage by PC. Aphis spp. were not affected; population pressure was very light. In the harvest assessment, Penncap and the higher two rates of AC 303,630 gave equivalent control of CM, VLR/TBM, RBL and PC. The lowest rate of AC 303,630 was generally intermediate in performance against CM and leafrollers; no control of PC was provided by that treatment.

Fig. 1
Grape Berry Moth Flight Activity
Prince Michel Vineyard - 1991

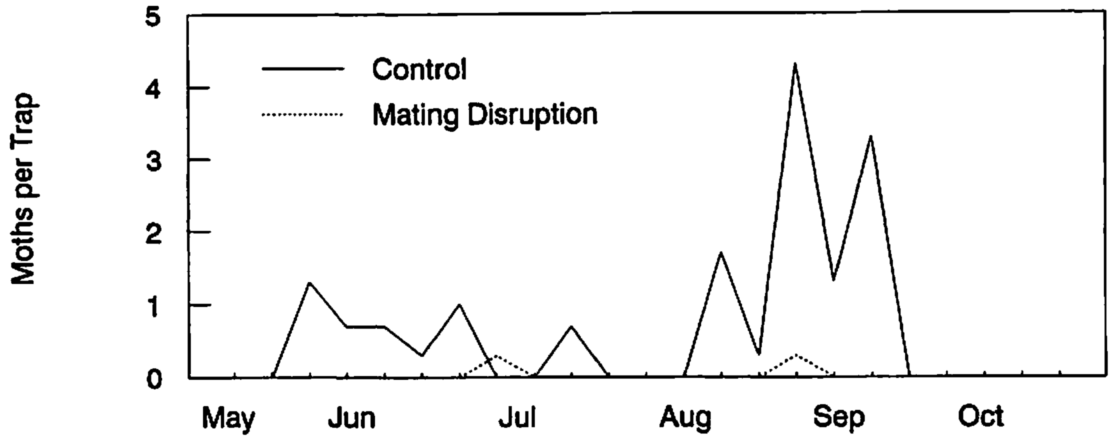


Fig. 2
Grape Berry Moth Flight Activity
Meredyth Vineyard - 1991

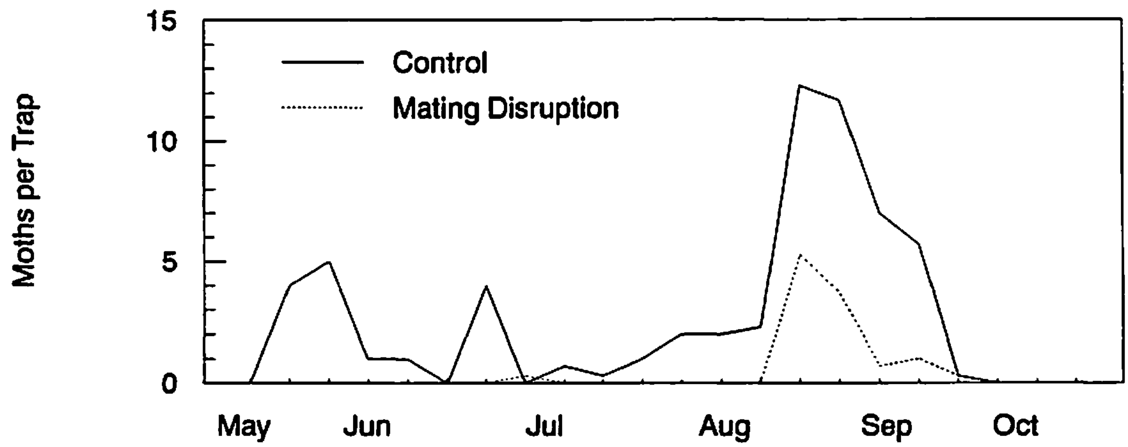
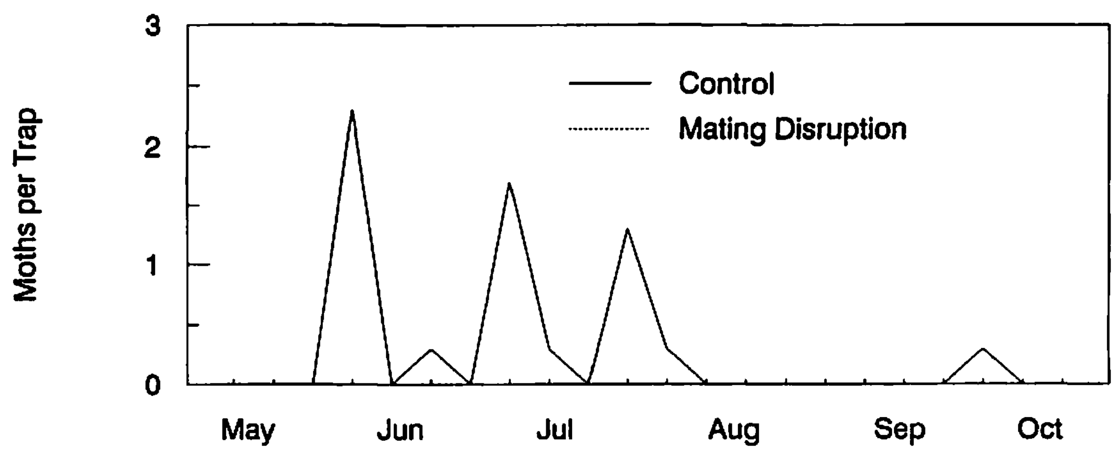


Fig. 3
Grape Berry Moth Flight Activity
Ladd Vineyard - 1991



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APPLE: Malus domestica
European red mite (ERM): Panonychus ulmi (Koch)

APPLE, MITE STUDY, 1991: Several acaricides were applied to an orchard at Steeles Tavern, comprised of 'Golden Delicious', 'Delicious', Stayman' and 'York'. Three rates of AC 801,757 20EC (1.7 lb/gal) (4.9, 7.4, and 9.9 g AI/100 liters) and a single rate of fenpropathrin (Danitol 2.4EC; 19.2 g AI/100 liters) were compared with dicofol (Kelthane 4F; 58.9 g AI/100 liters) and an untreated control. Because of low population densities of ERM, Asana was applied on 9 Jul. Two applications were made for each treatment, on 16 and 30 Jul. Applications were made using a truck-mounted Swanson airblast sprayer with a handgun attachment. Trees were sprayed to drip (ca. 200 gal/A). Four single-tree replications were used, using variety as a blocking factor.

A single sample of 20 leaves per tree was collected on each sampling date. Mites were evaluated using a leaf-brushing machine. Subsamples of the glass disc were examined for ERM. Densities of apple rust mite, Aculus schlechtendali (Nalepa), and the predatory mite, Neoseiulus fallacis (Garman) were too low to merit further analysis.

In the pretreatment count, there were no significant differences in either ERM motile forms or eggs among treatments. Danitol lowered ERM densities after the first application. Mites in AC 801,757 treatments were slower in dropping to levels significantly lower than in the control, the two higher rates reaching such levels after two applications. The lowest rate of AC 801,757 never reduced densities of ERM. ERM densities on the dicofol-treated trees were never significantly different than the control.

Table 1. Infested fruit per 20 fruit, 13 Jun 1991.

Treatment	g AI/ 100L	CM	LR	PC	Aphis
AC303,630 24EC	13.3	0.2a	0.0a	4.2bc	0.8a
AC303,630 24EC	26.6	0.2a	0.0a	0.7ab	1.2a
AC303,630 24EC	53.2	0.0a	0.0a	2.5bc	0.5a
Penncap M 2F	29.4	0.0a	0.0a	0.2a	1.8a
Control		1.2a	0.5a	6.5c	0.8a

[1]Means followed by the same letter are not significantly different at alpha=0.05. Data transformed for analysis [arcsin $(x+0.5)^{0.5}$].

Table 2. Infested fruit per 20 fruit, 2 October 1991.

Treatment	g AI/ 100L	CM	VLR/TBM	RBL	PC
AC303,630 24EC	13.3	2.8ab	1.0ab	1.5ab	10.8b
AC303,630 24EC	26.6	0.5a	0.6a	0.0a	3.8b
AC303,630 24EC	53.2	0.2a	0.0a	0.8ab	4.0a
Penncap M 2F	29.4	0.2a	0.2a	0.2a	4.8a
Control		8.2b	3.0b	3.0b	9.2b

[1]Means followed by the same letter are not significantly different at alpha=0.05. Data transformed for analysis [arcsin $(x+0.5)^{0.5}$].

		ERM/20 leaves[1]							
		15 Jul		25 Jul		8 Aug		28 Aug	
Treatment[2]	g AI/ 100 L	motile	eggs	motile	eggs	motile	eggs	motile	eggs
AC 801,757 20 EC	4.9	47.5 a	92.0 a	2.0 a	84.0 ab	4.0 ab	36 b	6 a	10 a
AC 801, 757 10 EC	7.4	46.0 a	86.0 a	2.0 a	78.0 ab	4.0 a	6 a	4 a	8 a
AC 801, 757 20 EC	9.9	86.0 a	134.0 a	2.0 a	46.0 ab	4.0 a	16 ab	6 a	12 a
Danitol 2.4 EC	19.2	60.0 a	144.0 a	0.0 a	16.0 a	0.0 a	12 ab	20 a	20 a
Kelthane 4F	58.9	66.0 a	143.0 a	34.0 b	60.0 ab	20.0 c	34 b	4 a	14 a
Control		36.0 a	74.0 a	34.0 b	140.5 b	14.0 bc	20 ab	2a	2a

[1] Means within a column followed by the same letter are not significantly different (alpha = 0.05; DMRT). Data transformed for analysis [$(x + 0.5)^{0.5}$].

[2] 20EC for AC 801,757 denotes 200 g AI/liter, or 1.7 lbs/gal. 2.4 EC for Danitol demotes 2.4lb/gal.

Title: Implications of Groundcover Management on Tufted Apple Bud Moth and *Stethorus punctum*

Authors: Carl M. Felland, Larry A. Hull, and D. J. Biddinger
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Abstract:

Two efficacy trials for Asana XL against tufted apple bud moth (TABM), *Platynota idaeusalis* (Walker) larvae in the groundcover were conducted in Adams County, Pennsylvania in 1991. The first used field collected larvae caged on dandelions. In this study Asana XL applied at pink, but not at petal fall, produced significant mortality. In the second study Asana XL was applied to the groundcover of 12 acre grower blocks at petal fall. In this case significant TABM mortality in the ground cover occurred in one orchard and in both orchards fruit injury by TABM at harvest was reduced by 50%. A third study examined spring emergence of the coccinellid predator, *Stethorus punctum* (LeConte) from the groundcover. Emergence was associated with maximum daily temperature over 72°F after the first week of April and was over 90% complete by petal fall.

Introduction:

Obligate feeding of overwintering larvae of tufted apple bud moth (TABM), *Platynota idaeusalis* (Walker), in the groundcover of apple orchards may allow alternate control stategies for this pest. One approach is to apply insecticide with herbicide treatments in the spring. Groundcover applications may allow a wider option of insecticide chemistry and a reduction of insecticide applied during the season. We have shown high mortality of larvae from groundcover applications, but no reducton in fruit injury was observed in 1990 grower trials. It was discovered that significant numbers of larvae fed just outside of the herbicide strip and were not exposed to the insecticide. In 1991 we repeated grower trials, adding an additional spray swath out to the dripline on the trees.

Groundcover insecticide applications must not be detrimental to the coccinellid predator *Stethorus punctum* (LeConte), which overwinters in the same areas as TABM. We did not see a negative effect on *S. punctum* in 1990, but continued our research into this aspect by monitoring this predator the 1991 grower trial and by obtaining a spring emergence curve for overwintering adults.

Materials and Methods:

Asana XL Timing Bioassay: Experimental sprays were applied to 2.5 ft^2 plots containing dandelion plants in an untreated orchard herbicide strip. Each plot was infested on 16 Apr 1991 with 25 TABM larvae in dead leaf shelters which were collected from the ground cover of a nearby apple orchard. Each plot was covered with a pyramid-shaped screen emergence cage with a reservoir of ethylene glycol to trap adult moths. The experiment was arranged as a completely random design with five cages for both treatments and two cages for a water-treated control for each application date. The results from the four control plots were pooled for analysis. Four additional plots were destructively sampled on the treatment dates for a pre-treatment estimate of TABM density and condition.

Plots received applications with a Bean herbicide sprayer calibrated to deliver 100 GPA using T-Jet nozzles. The first treatment was made on 23 Apr (pink stage of apple development) and the second treatment was applied on 8 May (petal-fall). A pre-treatment count was made from two cages on each treatment date to estimate initial density and host association. The effect of the materials on TABM was made by calculating total adults trapped in the glycol from 25 May to 25 Jun. Percent mortality was calculated as follows: (total moth emergence per cage/number of larvae infested per cage) x 100%.

Asana XL Groundcover Trials: Asana XL was applied to the groundcover of two commercial apple orchards during the petal-fall stage of apple development as a control measure for overwintering TABM larvae. At both orchards Asana XL at 0.075 lb AI/A was applied by the growers to the herbicide strip (two 5 ft. swaths) in a tank-mix with the standard herbicide sprays and applied by lab personnel to an additional 5 ft. swath on each side of the herbicide strip out to the tree dripline. The untreated blocks received only the standard herbicide treatment. Both orchards received a normal insecticide schedule throughout the season. In Quaker Valley a 22 acre orchard was divided into a 12 acre Asana-treated and a 10 acre untreated block. The orchard was 26-yrs-old and planted on a 15 x 35 ft. spacing. Applications were made on 15 May 1991 at 50-55 gal/treated acre. Herbicides applied were Dacamine 4D (2,4-D), Princep 4L (Simazine) and Gramoxone Extra (Paraquat dichloride) at 1.1 qt, 2.2 qt, and 0.8 qt formulated material/treated acre, respectively, along with LI-700, at 60 psi using two TeeJet OC-06 nozzles. The swaths outside the herbicide strips were applied at 120 psi using one OC-02 and three 8002 TeeJet nozzles.

In Arendtsville adjoining 12 acres orchard blocks were used. The blocks were 25 and 28-yrs-old and planted on 20 x 27 ft. spacings. Applications including Asana XL were made between 15 and 17 May 1991 and the standard herbicide application was made on 21 May at 70-72 gal/treated acre. The herbicide Dacamine 4D (2.0 qt/treated acre) was applied along with LI-700 and a drift retardant at 30 psi using one OC-08 and three 8004 TeeJet nozzles. The swaths outside the herbicide strips were applied at 85 psi using one OC-03 and three 8003 TeeJet nozzles.

On 13 May at Quaker Valley and on 8-9 May at Arendtsville TABM leaf shelters were located in both the herbicide strip and the border regions. Then a circular metal band was placed over the plant with the leaf shelter to prevent larval escape. On 25 May (4-10 days post-treatment) the arenas were checked and larvae recorded as alive, dead, or missing. Total mortality was estimated by combining dead and missing larvae. Treatment effect was evaluated for ERM and *Z. mali* by brushing 25 leaves/tree and for *S. punctum* by three min. counts around the periphery of trees at 8 sites in each block on 5-6 Aug. Fruit injury by leafrollers and first and second brood TABM was evaluated at harvest using 200 picked samples and 50 dropped samples at each of 8 'Yorking' trees at the Quaker Valley site and 12 'Yorking' trees at the Arendtsville site. Pick and drop samples were combined for total fruit injury.

Stethorus punctum Emergence: Spring emergence of *S. punctum* was monitored in a block of 'York' and 'Golden Delicious' planted on a 20 x 35 ft spacing that were 35 years old. Six 0.25 sq-m cages were placed within the herbicide strip in areas with concentrated leaf cover under four trees selected based on presence of *Stethorus punctum* adults in Sep 1990. One cage was placed in the herbicide strip on 22 Feb and the other five were placed out 9 Apr. An additional three cages were placed in a drive row of an adjacent newly established apple block on 9 Apr. Adult *S. punctum* were counted and removed daily from ethylene glycol traps in the tops of each cage.

Results:

Asana XL Timing Bioassay:: Only the application at pink resulted in significant reduction in numbers of TABM adults from the control (Table 1). Moth emergence occurred from 25 May to 17 Jun. The average emergence date of the moths was not affected by treatment. Pre-treatment density of 14 larvae per cage on 23 Apr and 7 larvae per cage on 8 May indicated a high level of natural mortality. On both dates 50% of the recovered larvae had sheltered on host plants. The larvae collected in the pre-treatment counts were reared on diet and 63% from the 23 Apr sample and 67% from the 8 May sample eventually died from virus infection.

Asana XL Groundcover Trials: Significant mortality of TABM larvae occurred in the Asana treatment at the Arendtsville site where mortality in the standard treatment was moderate (Table 2). The same trend occurred at the the Quaker Valley site although high mortality of TABM larvae in the standard treatment may have masked a treatment effect. Density of ERM had declined by the sample date (Table. 3). However, no consistent treatment effects were observed for ERM or mite predators. Fruit injury by TABM was about 50% lower in the Asana than in the standard treatment at both sites, with the most treatment effect observed for brood 1 injury (Table 4).

Stethorus punctum Emergence: A total of 133 adults were recovered from the 1.5 m^2 covered by the emergence cages in the selected habitat in the herbicide strip and none from the 0.75 m^2 sampled in the drive row. *S. punctum* emergence peaked on 27 Apr and was highly correlated with the maximum daily temperature of greater than 72°F after the first week of Apr (Fig.1). By the first of May *S. punctum* adult density in the trees peaked, but than quickly declined (Fig. 2). Emergence was over 90% complete by petal fall (Fig. 3).

Discussion:

Higher mortality may be expected from applications during the pink stage of apple development rather than petal fall, as the TABM larvae are smaller and none have begun to pupate. However, the success in the grower trials and the timing of the *S. punctum* emergence may make a petal fall application the best choice.

Apparently the extended application width of the insecticide aided in control of TABM larvae in the groundcover in 1991. While only 29% of the larvae were located outside the herbicide strip, survival and fitness of these larvae may have been higher than that of those located inside the herbicide strip.

Conclusion:

These studies suggest that groundcover treatments for TABM may be beneficial for reducing in-season pressure. Further studies are planned to determine whether *S. punctum* adults feed in the groundcover and their susceptiblity of to insecticides applied to the groundcover in the spring.

Table 1. Effect of timing of insecticide on mortality of tufted apple bud moth (TABM) larvae in the groundcover, 1991

Treatment	Rate (lb AI/A)	Applic. date	Mean TABM percent mortality: Actual	Corrected
Asana XL (0.66EC)	0.075	23 Apr	100.0a	(100.0)
Asana XL (0.66EC)	0.075	8 May	97.6ab	(60.7)
Water-treated control	---	23 Apr,8 May	93.9b	(0.0)

Means followed by the same letter(s) are not significantly different (Tukey-Kramer P > 0.05)

Table 2. Effect of petal fall applications of insecticide to orchard groundcover on mortality of tufted apple bud moth (TABM) larvae in the groundcover at two orchards in Adams County, Pennsylvania, 1991

	Post-treatment TABM mortality (Corrected[1])	
Treatment	Quaker Valley (25 May)	Arendstville (25 May)
Asana XL	95.8a (66.4)	83.5a (67.3)
Standard	87.5a	49.6b

Means followed by the same letter are not different, P > 0.05, t-test.

1 Abbot's Formula

Table 3. Effect of petal fall applications of insecticide to orchard groundcover on mites and predators in two orchards in Adams County, Pennsylvania, 1991

	Quaker Valley (6 Aug)			Arendstville (5 Aug)		
	Mites/leaf		*S. punctum*	Mites/leaf		*S. punctum*
Treatment	ERM	Z.mali	/3 min	ERM	Z. mali	/3 min
Asana	0.02a	0.1b	0.25a	0.03a	0.01a	3.0a
Standard	0.00a	0.7a	0.50a	0.03a	0.01a	0.9b

Means followed by the same letter are not different, P > 0.05, t-test.

Table 4. Effect of petal fall applications of insecticide to orchard groundcover on fruit injury at harvest in two orchards in Adams County, Pennsylvania, 1991

	Quaker Valley (3 Oct)				Arendtsville (27 Sep)			
	Injury/100 apples				Injury/100 apples			
Treatment	LR	1st Br. TABM	2nd Br. TABM	% Clean	LR	1st Br. TABM	2nd Br. TABM	% Clean
Asana	0.0a	1.9a	11.2a	87.1a	0.0a	1.8a	8.6a	89.7a
Standard	0.1a	4.3b	22.6b	73.4b	0.0b	5.3b	13.5a	82.2b

Means followed by the same letter are not different, P > 0.05, t-test.

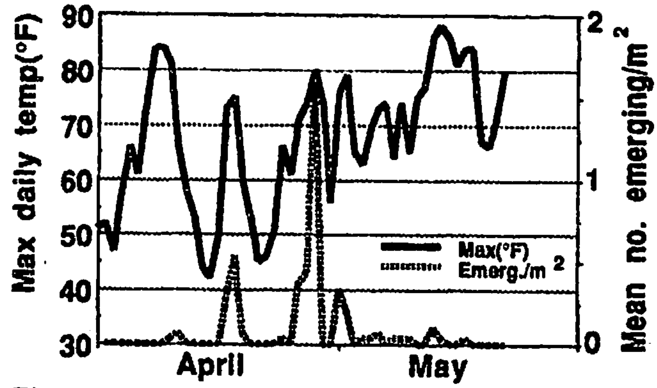

Figure 1. Effect of date and temperature on Stethorus punctum emergence. Biglerville, PA Spring 1991.

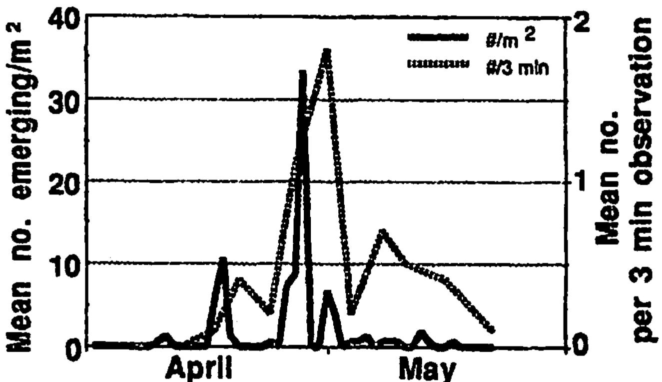

Figure 2. Relationship of spring emergence and density in trees of Stethorus punctum. Biglerville, PA Spring 1991.

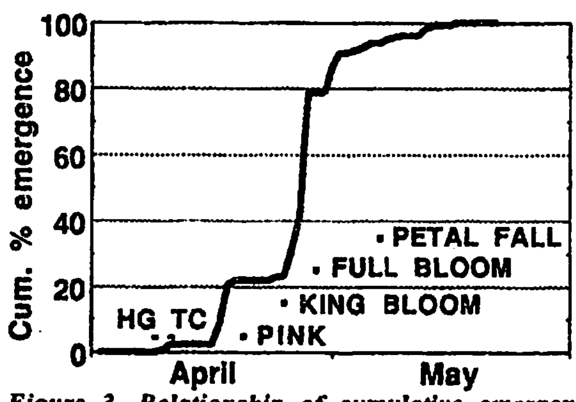

Figure 3. Relationship of cumulative emergence of Stethorus punctum and apple phenology ('Yorking'). Biglerville, PA Spring 1991.

Title: Pheromone Disruption of the Tufted Apple Bud Moth

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Abstract:

Mating disruption of tufted apple bud moth (TABM), *Platynota idaeusalis* (Walker), was tested in orchards with low and moderate TABM density in Adams County, Pennsylvania in 1991. At each site TABM pheromone from Shin-Etsu in tubes (172 mg load) and from Scentry in spirals (46 mg load) was tested in contiguous five acre blocks, and compared with an insecticide treated standard. Trap shutdown of males was more complete at the moderate density orchard for the pheromone from Shin-Etsu. Fruit injury in the pheromone treatments exceeded that in the standard, but was low in all treatments. Relative injury in the pheromone treatment compared with the standard was similar for first and second brood TABM with the Shin-Etsu pheromone, but higher for second brood than the first for the Scentry pheromone. Density of spotted tentiform leaf miners and fruit injury by leafrollers tended to be higher in the pheromone treatments than in the standard.

Introduction:

Tufted apple bud moth (TABM), *Platynota idaeusalis* (Walker) is the most serious direct pest of apples in Pennsylvania. The larvae damage fruit, causing loss of yield and reduced quality at harvest and in storage. This pest has developed resistance to the OP insecticide azinphosmethyl. The switch to alternate insecticides threatens the successful IPM program of control of European red mite by the coccinellid predator *Stethorus punctum*. And in spite of routine insecticide usage against this pest, incidence of fruit injury by TABM has been increasing steadily over the past 18 years.

Mating disruption of TABM has the potential to reduce insecticide usage and to be a tool in resistance management. Research on mating disruption of TABM has been in progress since 1989 at the Fruit Research Laboratory. While results of disruption trials have tended to be less than satisfactory in orchards with high density of TABM, promising results have been observed in several trials. In 1991 we applied the two of the best pheromone treatments from this research to large, well managed grower blocks.

Materials and Methods:

Grower trials of pheromone disruption of tufted apple bud moth were conducted at two sites in Adams County in 1991. At each site pheromone from two sources was applied to contiguous five acre sections of an orchard block. The block in Buchanan Valley was isolated with the insecticide standard 0.5 km away. The block in Wenksville was part of a 22 acre orchard. The remaining 12 acres served as a standard. The pheromone was a 1:1 ratio of E-11 C14 acetate and E-11 C14 alcohol. Pheromone from Scentry was dispensed from solid plastic spirals loaded with 46 mg active ingredient. Pheromone from Shin-Etsu was dispensed from hollow plastic tubes with a 172 mg load rate. Dispensers were placed in the top third of the canopies on 17 May at Wenksville and between 22 and 28 May at Buchanan Valley.

Evaluation of treatment effect was based on pheromone trap shutdown, fruit injury at harvest, and density of spotted tentiform leafminer (STLM). Trap shutdown was based on weekly capture of males in each of four traps loaded with pheromone lures (Scentry) in each block except the standard at Wenksville which had two traps. Lures were replaced every 4-5 weeks. Number of STLM mines per five minutes was determined at eight trees in each treatment on 24-25 July, the end of the second summer generation. Harvest fruit evaluation was determined based on samples of 200 picked apples and 50 dropped apples from 16 trees per treatment at Buchanan Valley and on samples of 100 picked apples and all the drops (average of 17) from 24 trees per treatment at Wenksville.

Results:

Trap shutdown of male TABM was high in both pheromone treatments at Buchanan Valley (Fig. 1a). At Wenksville TABM density was greater and shutdown was less complete for the Shin-Etsu treatment both generations and for the Scentry treatment during the second generation (Fig. 1b).

Fruit injury was low in all treatments in both orchards (Fig. 2). Relative injury in the pheromone treatment compared with the standard was similar for first and second brood TABM for the Shin-Etsu pheromone (high load rate), but higher for second brood than the first for the Scentry pheromone (low load rate). Leafroller injury to fruit was significantly higher in the pheromone treatments at Wenksville. Spotted tentiform leafminer density in mines per leaf was numerically higher in the pheromone treatments in both orchards (Fig. 3).

Discussion:

Mating disruption of TABM probably is most likely to succeed in orchards with relatively low TABM density. For example, a 3-fold higher injury in pheromone treatments than in the standard may be acceptable where the injury in the standard is 1%, but not 10%. Low initial density is a prerequisite for successful codling moth disruption programs.

The Scentry pheromone probably did not release as consistently as needed to maintain season-long mating shutdown of TABM. In 1990 another Scentry pheromone was applied twice with fruit injury only 1.5x that of the standard in that trial. In the western US pheromone dispensers were applied twice to maintain mating disruption of codling moth in commercial orchards. Analysis of pheromone residuals is planned for dispensers from both treatments removed at periodic intervals from the Wenksville site.

Mating disruption of TABM in the complete absence of insecticides over several years is probably impractical because of secondary pests. Although obliquebanded leafroller has been very uncommon in Adams County, injury by this species was greater than 4% in one disruption orchard in 1990. Further research is needed for pheromone disruption in conjunction with limited insecticide use.

Conclusion:

Mating disruption of tufted apple bud moth appears feasible in sites of low to moderate TABM density. Improved pheromone release may be needed for season-long control. Also, the issue of secondary pests must be further addressed.

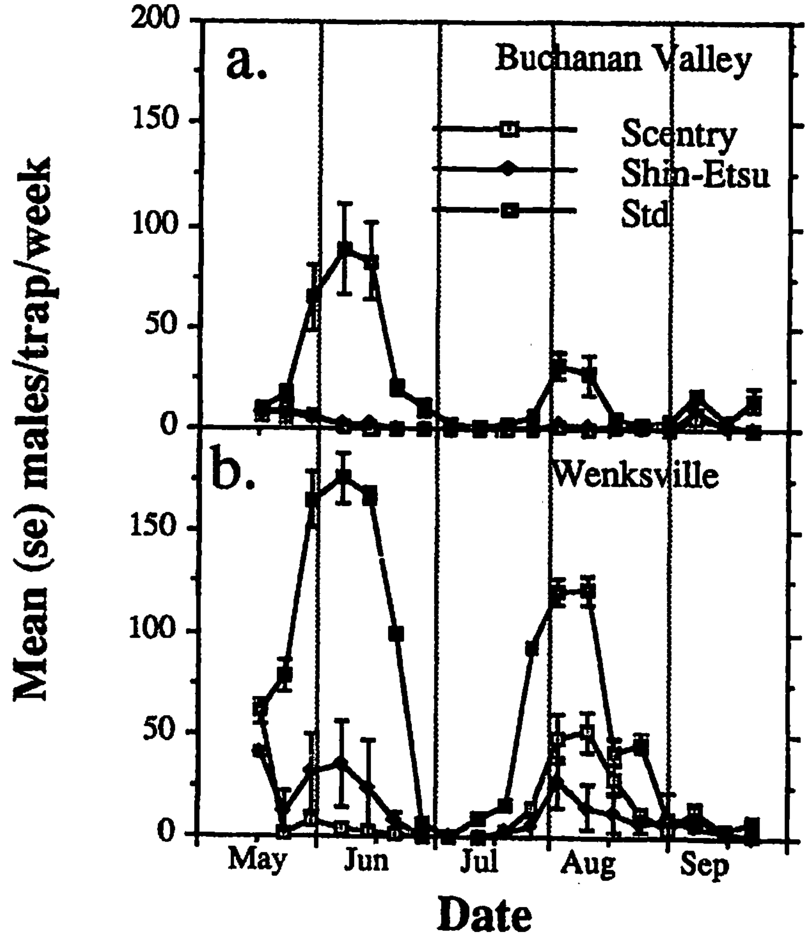

Fig. 1. Effect on TABM Mating Disruption on Pheromone Trap Shutdown at Buchanan Valley (a) and Wenksville (b), Adams Co., PA, 1991.

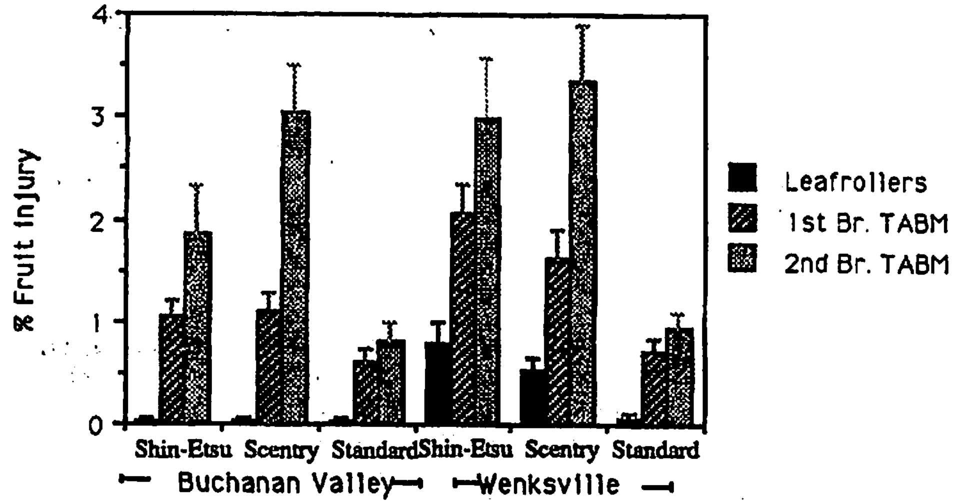

Fig. 2. Effect of pheromone treatment on fruit injury at harvest, Adams County, PA, 1991

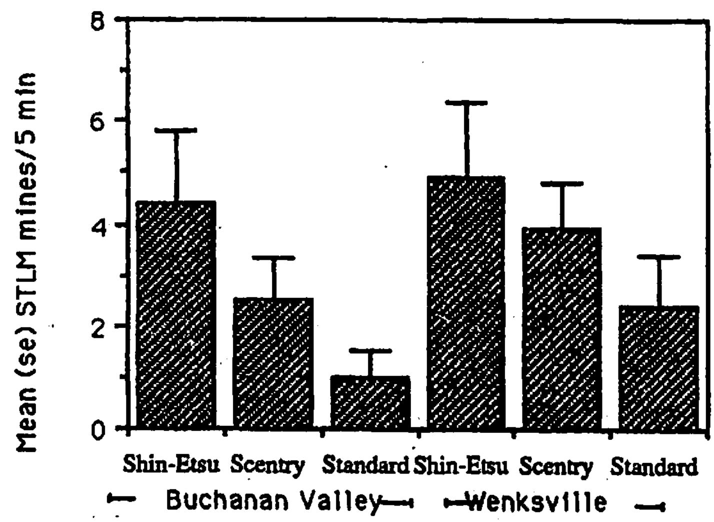

Fig. 3. Effect of pheromone treatments on density of spotted tentiform leafminer (STLM), Adams County, PA, 1991

Title: Silvering Injury by Western Flower Thrips to Peaches and Nectarines in Adams County, Pennsylvania

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Abstract:

An infestation of western flower thrips, *Frankliniella occidentalis* (Pegande) caused widespread injury to mature peach and nectarine fruit during the final fruit swell stage of fruit development in Adams Co., Pennsylvania in 1991. Thrips feeding caused silvering on the skin of the fruit, primarily at points of contact with twigs or leaves. In general, injury was more apparent on nectarine than on peach. 'Sunhigh' and 'Red Haven' had higher injury than later peach varieties. About 50% of fruit from midseason nectarine varieties showed some silvering injury. Economic losses in the county were nominal for peaches but at least $100,000 for nectarines. This was the first confirmed incidence of this species not associated with greenhouses or with greenhouse transplants in the Commonwealth.

Introduction:

Injury by thrips to stone fruits has been reported in several European countries, in New Zealand, and in California and Georgia. Most injury is attributed to feeding injury during the bloom period that results in russet on the fruit surface. However, ocassional infestations of thrips occur on fruit several weeks before and during harvest. The thrips feed at points of contact with leaves and twigs. In these protected sites the thrips empty cell contents leaving silvery blotches on the skin of the fruit. It is thought that the smooth skin of nectarines makes then more susceptible than peaches to thrips injury. In New Zealand the association of thrips eggs with the silvering injury has necessitated up to seven applications of Sevin before and during harvest to control thrips infestation in nectarines grown for export.

Western flower thrips, *Frankliniella occidentalis* (Pegande) (Thysanoptera: Thripidae) was uncommon in samples taken in 1983-1986 in Georgia peach orchards. In 1988 this species became abundant and peaked in population during the final swell stage of fruit development of the early peach varieties. Incidence of silvering injury was >90% in early varieties, 45% in midseason varieties and 1% in late season varieties. Higher levels of injury than in the previous years were also observed on nectarines in Georgia in 1988. The thrips injury was associated with drought and has not been widely observed since then.

In Pennsylvania western flower thrips were first reported in 1976 on African Violets in greenhouses in York County. Infestations in greenhouses have become widespread in the Commonwealth and western flower thrips have recently been collected in fields of greenhouse-transplanted tomatoes. However, no overwintering population was thought to have established in the Commonwealth. In early August 1991 we found thrips associated with silvering on stone fruits in Adams County and began investigating the extent of the problem.

Materials and Methods:

Samples of thrips were collected in early August from nectarine and peach fruit at the Fruit Research Laboratory in Biglerville and sent the D. Tuelon at Penn State University for identification. In early September personnel from the Bureau of Plant Industry collected and identified thrips from orchards and surrounding groundcover in several sites in the fruit belt in Adams County.

The number of thrips per peach and percent of fruit with silvering injury was monitored on four peach varieties during August in a block at the Fruit Research Laboratory. This block consisted of consectutive pairs of rows of the following peach varieties: 'Sunhigh', 'Loring', 'Redskin', and 'Autumnglo' with maturity dates of 9, 15 23 August and 1 September, respectively. Five trees per variety were sampled. Each sample consisted of counting adult and larval thrips and percent silvering on ten fruit. The latest insecticide application was Imidan and Penncap M on 17 July and latest fungicide application was Benlate and Ronilan on 1 August.

Fruit evaluations were conducted during August in bins of nectarines from orchards throughout the fruit belt in Adams County. Fifty fruit were rated 0=clean, 1=light, 2=moderate, 3=heavy for russet and silvering. Samples were taken of 'Flavortop' (15 Aug maturity date) from Fox Hill (FH), of 'Redgold' (23 Aug maturity) from York Springs (YS), Piney Mountain (PM), and Bear Mountain (BM), and of 'Fantasia' (25 Aug maturity) from York Springs (YS), Arendtsville (AV), and Piney Mountain (PM). An evaluation was also made for the peach variety 'Jerseyqueen ' (25 Aug maturity) at Fox Hill.

Results:

All the thrips (n>60) collected on stone fruits at the Fruit Research Laboratory in August 1991 were western flower thrips. Western flower thrips were present and generally the most abundant species in all the samples taken in September in the Adams County fruit belt.

Thrips density and silvering injury was highest on early peach varieties (Fig. 1). Injury occurred within the final two weeks before harvest for 'Redskin'. Injury on peach was generally concentrated in the suture or stem end and was not noticable. However obvious injury was reported in a grower block of 'Red Haven' (25 July maturity) in near Fairfield.

Silvering injury averaged about 50% over all the nectarines sampled (Fig. 2). Most injury was light, but it did result in grade reductions and loss of markets for the largest packer in the county. The moderate injury recorded corresponded with the 10% of nectarines culled on account of silvering injury by this same packer, who estimated losses attributed to thrips were $100,000. 'Fantasia' tended to have more silvering than 'Redgold'. Incidence of russeting was more variable and was not correlated with silvering. Russeting tended to be higher in 'Fantasia' than in 'Redgold'. It is not known how much of the russeting was caused by thrips.

The peach variety 'Jerseyqueen', also sampled at the Fox Hill site, had only 5% light silvering and 2% light russeting. This was considerably less injury than for the nectarines sampled at the same site.

Discussion:

Although one Adams County grower has observed silvering injury as early as 1989 and packers had noticed the damage in 1990, damage in 1991 was apparently much more extensive than before. This could be due to, as was the infestation in Georgia, severe drought conditions in the region. It is thought that lack of alternate hosts plants may have caused the thrips to move to the stone fruits.

No thrips infestions were reported in other nectarine growing regions in the Commonwealth or adjoining states, regardless of drought status. It is probable that this species has established outside greenhouses in Adams County and will have to be considered in the future. While damage may not be as high in years with normal precipitation, monitoring techniques should be developed for this species.

General observations suggested that the highest thrips populations occurred where insecticide applications had been skipped. But high injury in sprayed orchards in Georgia and in this study suggests that thrips are not well controlled by the current insecticide programs. In New Zealand repeated applications are needed in control thrips. The proximity to harvest in which control is needed and the limited number of insecticides registered for the preharvest period for nectarine (Sevin and Malathion) make control of this pest difficult. In California and Arizona Lannate is labelled for use on thrips in nectarines up to one day before harvest. Lannate is labelled for use up to 4 days before harvest for peaches.

Conclusion:

The prevalence of western flower thrips injury in 1991 suggests that incidence of this species in stone fruits should be monitored, particularly in Adams County. Future work should include efficacy and timing trials for the available insecticides.

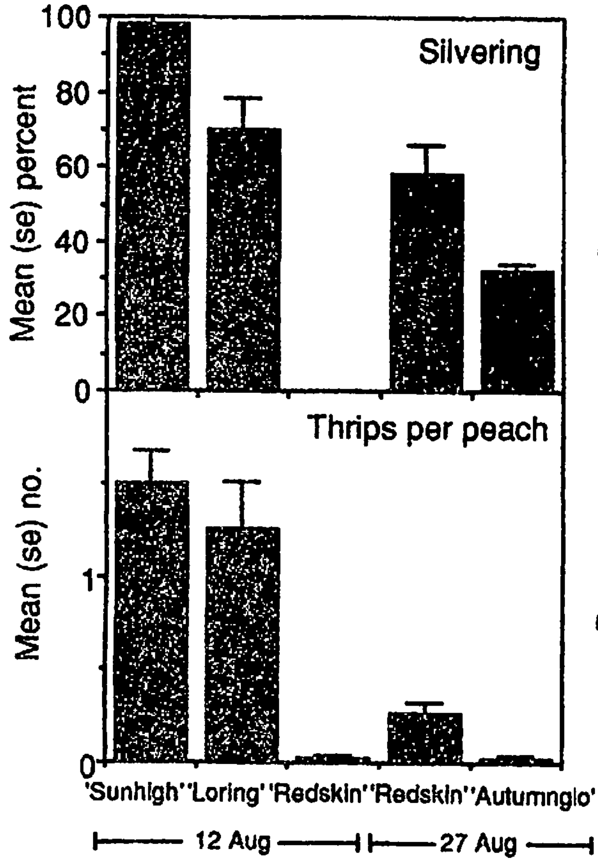

Figure 1. Effect of peach cultivars on western flower thrips density and damage on unsprayed trees. Fruit Research Lab, Biglerville PA 1991

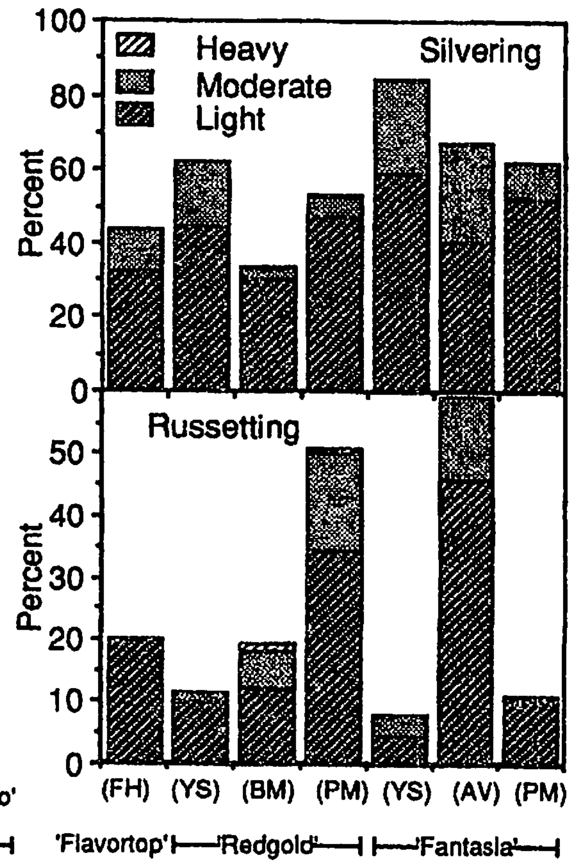

Figure 2. Incidence of silvering and russeting caused by western flower thrips in grower orchard blocks. Adams County PA 1991

Pest Incidence in Disease Resistant Cultivars Grown Under Organic Methods Compared to Standard Cultivars Grown Under A Traditional IPM Program

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Introduction

During the past 3-4 years there has been a renewed grower interest in the production of disease resistant apple cultivars (DRC's). Although DRC plantings represent only a small amount of acreage at the present time, improved selections, decreased pesticide availability, public awareness of pesticide issues, as well as pesticide costs are likely to contribute to an increased interest in these cultivars over the foreseeable future.

Many DRC's have cross resistance to apple scab, powdery mildew, cedar apple rust and fire blight. Of course, they are still susceptible to summer diseases as well as insects and mites. Since DRC pest management practices will require decreased fungicide use, other pest and beneficial populations may be affected. For example, Benlate is toxic to the predacious mite, *Amblysius fallacis*. Decreased use of this fungicide may lead to increased mite predator populations, and therefore decreased mite populations and miticide use. Eastern growers who produce certified organic fruit have focused on DRC's as cultivars of choice for their operations.

Materials and Methods

This project is part of an ongoing study examining pest pressure and pesticide use associated with producing "organic" fruit compared to conventional cultivars grown under an IPM program with standard pesticides. The orchard site is on a commercial farm with 23 acres of trellised apples on M9 rootstock. Trees were planted in 1980 in 13 foot rows with 6.5 feet between the trees (except 'Prima') within each row. The cultivar 'Prima' was planted on a 7.5 foot spacing. The planting consists of 'Empire', 'Red Delicious', 'Stayman', 'Jonamac', 'Jonathan', 'McCoun', 'McIntosh', 'Golden Delicious', and 'Granny Smith'. One corner (1.5 acres) consists of the DRC's 'Prima', 'Priscilla', 'Freedom' and 'Liberty'.

Weekly pest monitoring was done in the Liberty, Prima, Red Delicious and Stayman. Sampling was replicated 4 times within each block. Each sample location was marked at the beginning of the season, so that repeated samples were taken in the same locations. Weekly counts were done for European red mites, mite days, mite eggs, predacious mites, apple aphids, white apple leafhopper, spotted tentiform leafminer, and leafroller & budmoth feeding. Cedar apple rust and sooty blotch/fly speck were rated on a 1 to 9 scale, with 1 = none, 3 = slight (up to 5% infected), 5 = moderate (up to 10% infected), 7 = severe (up to 20% infected) and 9 = extreme (> 20% infected). A post-harvest analysis was done on Priscilla, Liberty, Prima, Freedom, Stayman, Red Delicious and Empire. Three replicated samples of 100 fruit each were randomly picked from the bins.

Pesticides

The standard cultivars were treated with a total of 10 full spray (both sides) equivalents, in mixed alternate middle and full spray applications. Chemicals consisted of: Insecticides--Carzol, Diazinon, Imidan, Lannate, Lorsban, Oil, Penncap, Vydate; Fungicides--Captan, Dikar, Nova, Penncozeb, Rubigan, Topsin and Ziram. The organic block was treated with 3 full sprays consisting of delayed dormant oil, and 2 sprays of Ryania. Apple maggot fly adults were trapped out by using a total of 45 red sticky balls baited with synthetic apple volatile, placed around the outside rows of the block.

Results

Weekly sampling data is shown in Table 1, and post-harvest injury is shown in Table 2. Mite activity was more intense on delicious than in the other 3 monitored cultivars. Mite day accumulations were also significantly greater on delicious, reaching 975 mite days by mid-August. Mite day accumulations never reached economic levels on the other 3 cultivars. Apple aphid populations were significantly greater on delicious and stayman throughout much of June. Leafminer activity showed no significant differences by the end of the season, nor did budmoth or leafroller feeding. Also through much of June and early July, leafhopper populations were heavier on stayman and continued this trend for the second generation in August. As expected, rust was present at greater levels on Prima which is not resistant to this disease. Sooty blotch & fly speck were present on all cultivars at varying levels, and increased significantly during September, as seen in the post-harvest samples.

Post-harvest counts showed that Priscilla had the greatest level of apple maggot injury, and that other organic fruit had higher levels of plum curculio scars. Sooty blotch and fly speck were the principle problems on the organic fruit, reaching above 80% of the fruit infected in the Liberty and Freedom.

Table 1 - Seasonal Pest Pressure, Organic DRC's and Standard Cultivars 1991

05/17/91

CULTIVAR	M/L[1]	MD	ME/L	PRM/L	AA	WALH	STLM/L	STLM-S/L	%LR	RR	SB/FSR
LIBERTY	0.03	--	0.03b[2]	0.0	19.00a	0.0b	0.0	--	--	1.0	--
PRIMA	0.0	--	0.0b	0.0	11.50b	0.01a	0.01	--	--	1.0	--
RED DEL	0.0	--	0.60a	0.0	6.00cb	0.0b	0.02	--	--	1.0	--
STAYMAN	0.08ns	--	0.03b	0.0	1.75c	0.0b	0.01ns	--	--	1.0ns	--

05/27/91

CULTIVAR	M/L	MD	ME/L	PRM/L	AA	WALH	STLM/L	STLM-S/L	%LR	RR	SB/FSR
LIBERTY	0.0b	0.15b	0.04	0.0	57.0a	0.07a	0.01b	--	0.0	1.00b	--
PRIMA	0.0b	0.0b	0.0	0.0	9.00b	0.06ba	0.09a	--	0.0	3.00a	--
RED DEL	0.31a	1.58a	1.25	0.0	55.00a	0.01b	0.03b	--	0.0	1.00b	--
STAYMAN	0.03b	0.58ba	0.50ns	0.0ns	49.75a	0.05ba	0.03b	--	0.0ns	1.00b	--

05/31/91

CULTIVAR	M/L	MD	ME/L	PRM/L	AA	WALH	STLM/L	STLM-S/L	%LR	RR	SB/FSR
LIBERTY	0.11b	0.38b	0.13b	0.09	47.0b	0.06a	0.04ba	--	--	1.00b	--
PRIMA	0.0b	0.0b	0.0b	0.03	36.50b	0.02b	0.09a	--	--	3.00a	--
RED DEL	0.61a	3.43a	0.78a	0.0	89.75a	0.01b	0.02b	--	--	1.00b	--
STAYMAN	0.13b	0.88b	0.28b	0.06ns	86.75a	0.03ba	0.05ba	--	--	1.00b	--

06/07/91

CULTIVAR	M/L	MD	ME/L	PRM/L	AA	WALH	STLM/L	STLM-S/L	%LR	RR	SB/FSR
LIBERTY	0.05	0.95ba	0.06b	0.05ba	41.00b	0.01ba	0.09ba	--	--	1.00b	--
PRIMA	0.0	0.0b	0.0b	0.0b	48.50b	0.01ba	0.16a	--	--	4.00a	--
RED DEL	0.95	8.93a	1.75a	0.0b	89.50a	0.0b	0.04b	--	--	1.00b	--
STAYMAN	1.23ns	5.60ba	0.93ba	0.11a	91.50a	0.05a	0.04b	--	--	1.00b	--

06/14/91

CULTIVAR	M/L	MD	ME/L	PRM/L	AA	WALH	STLM/L	STLM-S/L	%LR	RR	SB/FSR
LIBERTY	0.03b	1.23b	0.26b	0.25a	19.00b	0.02b	0.06b	--	--	1.00b	--
PRIMA	0.05b	0.20b	0.15b	0.10ba	29.0b	0.04b	0.16a	--	--	4.00a	--
RED DEL	1.50a	17.48a	8.75a	0.0b	74.50a	0.01b	0.02b	--	--	1.00b	--
STAYMAN	0.25b	10.78ba	2.55b	0.10ba	74.50a	0.24a	0.03b	--	--	1.00b	--

06/21/91

CULTIVAR	M/L	MD	ME/L	PRM/L	AA	WALH	STLM/L	STLM-S/L	%LR	RR	SB/FSR
LIBERTY	0.0b	1.33b	0.11b	0.10	0.0b	0.02b	0.09	--	--	1.00b	--
PRIMA	0.03b	0.45b	0.03b	0.0	10.0a	0.01b	0.15	--	--	4.00a	--
RED DEL	7.15a	47.75a	17.50a	0.0	2.50b	0.06b	0.13	--	--	1.00b	--
STAYMAN	1.00b	15.15b	2.38b	0.18ns	8.75a	0.45a	0.11ns	--	--	1.00b	--

06/28/91

CULTIVAR	M/L	MD	ME/L	PRM/L	AA	WALH	STLM/L	STLM-S/L	%LR	RR	SB/FSR
LIBERTY	0.03b	1.40b	0.23b	0.05ba	0.0b	0.02b	0.23a	0.15	--	1.00b	--
PRIMA	0.0b	0.52b	0.03b	0.14a	2.00a	0.03b	0.26a	0.19	--	4.00a	--
RED DEL	14.75a	124.43a	52.50a	0.0b	0.0b	0.08b	0.38a	0.30	--	1.00b	--
STAYMAN	2.16b	26.23b	5.63b	0.1ba	0.0b	0.60a	0.36a	0.28ns	--	1.00b	--

07/06/91

CULTIVAR	M/L	MD	ME/L	PRM/L	AA	WALH	STLM/L	STLM-S/L	%LR	RR	SB/FSR
LIBERTY	0.48b	3.40b	0.40b	0.28b	0.0	0.07b	0.50ba	0.31	--	1.00b	--
PRIMA	0.28b	1.62b	0.05b	0.23b	0.0	0.02b	0.26b	0.21	--	4.00a	--
RED DEL	35.50a	325.43a	81.25a	0.0b	0.0	0.03b	1.13ba	0.80	--	1.00b	--
STAYMAN	1.68b	41.57b	5.25b	1.43a	0.0ns	0.56a	1.35a	0.79ns	--	1.00b	--

07/12/91

CULTIVAR	M/L	MD	ME/L	PRM/L	AA	WALH	STLM/L	STLM-S/L	%LR	RR	SB/FSR
LIBERTY	0.08b	5.05b	0.0b	0.0b	0.0	0.05b	0.38b	0.20b	0.0	1.00b	--
PRIMA	0.08b	2.67b	0.0b	0.20b	0.0	0.02b	0.56b	0.28b	0.0	5.00a	--
RED DEL	25.25a	507.67a	62.50a	0.0b	0.0	0.03b	1.48a	0.73a	0.0	1.00b	--
STAYMAN	0.35b	47.65b	1.25b	0.63a	0.0ns	0.55a	1.26a	0.38b	0.0ns	1.00b	--

07/19/91

CULTIVAR	M/L	MD	ME/L	PRM/L	AA	WALH	STLM/L	STLM-S/L	%LR	RR	SB/FSR
LIBERTY	0.0b	5.30b	0.13b	0.0	--	0.02b	0.85bc	0.31b	0.0	1.00b	1.00
PRIMA	0.0b	2.95b	0.0b	0.23	--	0.05b	0.75c	0.33b	0.0	5.00a	1.25
RED DEL	26.00a	687.05a	102.5a	0.19	--	0.03b	1.55ba	0.39ba	0.0	1.00b	1.00
STAYMAN	0.03b	48.95b	4.63b	0.20a	--	0.17a	1.93a	0.78a	0.0ns	1.00b	1.25ns

07/29/91

CULTIVAR	M/L	MD	ME/L	PRM/L	AA	WALH	STLM/L	STLM-S/L	%LR	RR	SB/FSR
LIBERTY	0.0b	5.30b	0.0b	0.0b	--	0.05b	1.33	0.65	0.0	1.00b	2.75ba
PRIMA	0.0b	2.95b	0.0b	0.30ba	--	0.04b	1.45	0.70	0.0	5.00a	3.25a
RED DEL	9.88a	866.42a	79.75a	0.50a	--	0.04b	2.33	0.80	0.0	1.00b	1.00c
STAYMAN	0.05b	49.33b	4.00b	0.18ba	--	0.11a	2.08ns	0.40ns	0.0ns	1.00b	2.50b

08/02/91

CULTIVAR	M/L	MD	ME/L	PRM/L	AA	WALH	STLM/L	STLM-S/L	%LR	RR	SB/FSR
LIBERTY	0.05b	5.40b	0.03b	0.10	--	0.30	1.33	0.55	0.0b	1.00b	2.50a
PRIMA	0.0b	2.95b	0.05b	0.25	--	0.02	1.55	0.69	0.0b	5.00a	2.00ba
RED DEL	13.80a	913.77a	68.75a	0.20	--	0.0	2.35	1.10	1.00a	1.00b	1.00b
STAYMAN	0.03b	49.48b	0.50b	0.25ns	--	0.09ns	2.01ns	0.63ns	0.0b	1.00b	2.50a

08/09/91

CULTIVAR	M/L	MD	ME/L	PRM/L	AA	WALH	STLM/L	STLM-S/L	%LR	RR	SB/FSR
LIBERTY	0.0	5.57b	0.0b	0.0b	--	0.03b	2.98	2.08	0.50	1.00b	4.00a
PRIMA	0.03	3.05b	0.0b	0.20a	--	0.02b	2.00	1.01	0.50	5.00a	3.00b
RED DEL	1.65	967.85a	30.0a	0.03ba	--	0.01b	3.50	1.88	0.0	1.00b	1.00c
STAYMAN	0.0ns	49.58b	0.0b	0.0b	--	0.11a	2.58ns	1.1ns	0.0ns	1.00b	4.00a

08/16/91

CULTIVAR	M/L	MD	ME/L	PRM/L	AA	WALH	STLM/L	STLM-S/L	%LR	RR	SB/FSR
LIBERTY	0.0b	5.57b	0.0b	0.35	--	0.08ba	--	--	0.50	1.00b	3.50a
PRIMA	0.0b	3.12b	0.0b	0.35	--	0.03b	--	--	1.00	5.00a	2.25b
RED DEL	0.33a	974.75a	35.00a	0.43	--	0.03b	--	--	0.0	1.00b	1.25b
STAYMAN	0.0b	49.58b	0.08b	0.73ns	--	0.23a	--	--	0.0ns	1.00b	3.75a

08/26/91

CULTIVAR	M/L	MD	ME/L	PRM/L	AA	WALH	STLM/L	STLM-S/L	%LR	RR	SB/FSR
LIBERTY	--	--	--	--	--	0.20ba	5.38	2.83a	--	1.00b	3.50a
PRIMA	--	--	--	--	--	0.14ba	3.08	1.53ba	--	5.00a	1.50b
RED DEL	--	--	--	--	--	0.04b	5.35	2.03ba	--	1.00b	2.25ba
STAYMAN	--	--	--	--	--	0.32a	3.05ns	0.96b	--	1.00b	3.50a

[1] = CODE:

M/L	Mites per leaf
MD	Mite days
ME/L	Mite eggs per leaf
PRM/L	Predatory mites per leaf
AA	Apple aphid % terminals infested
WALF	White apple leafhopper per leaf
STLM/L	Spotted tentiform leafminer mines per leaf
STLM-S/L	Spotted tentiform leafminer sap feeding mines per leaf
%LR	% Leafroller/Budmoth damage
RR	Cedar Apple Rust rating
SB/FSR	Sooty Blotch/Fly Speck rating

[2] Means within a column followed by the same letter are not significantly different at p = .05 ANOVA/LSD test.

Table 2 - Post Harvest Analysis - Percent Pest Damage Between DRC's & Standard Cultivars 1991

Cultivar	AM[1] EST	AM ABORT	CM	EAS	PC	LR/ TABM	TPB	BRK SPOT	CORK	FLY SPECK	SOOTY BLOTCH	ROTS	SCAB	CLEAN
Priscilla	2.33a[2]	1.0ab	0.3	0.0b	1.3c	1.0ab	0.3	11.7b	1.7ab	52.0b	38.7b	2.7	0.0b	37.7b
Liberty	0.7b	0.3ab	0.0	0.0b	8.3a	0.0b	0.0	7.0bc	0.0b	88.3a	84.7a	0.0	0.0b	11.3c
Prima	0.0	1.7a	0.0	0.7a	3.3bc	0.0b	1.3	32.3a	0.7ab	41.3b	29.7b	0.3	0.0b	37.7b
Freedom	0.5b	1.5ab	0.5	0.0b	6.0ab	4.0a	1.0	11.0b	2.5a	91.0a	92.0a	1.0	0.0b	3.0c
Stayman	0.0b	0.0a	0.0	0.0b	1.0c	0.3b	1.0	0.3d	0.3b	8.0c	13.7c	0.7	0.0b	80.0a
Red Del	0.0b	0.0a	0.0	0.0b	0.0c	0.7b	2.0	1.0d	0.0b	13.0c	9.0cd	1.0	0.0b	81.3a
Empire	0.0b	0.0a	0.0ns	0.0b	1.0c	0.0b	0.7ns	2.3cd	0.0b	4.3c	1.7d	0.7ns	2.0a	90.0a

[1] = CODE:

AM EST	Fruit with established apple maggot tunnels
AM ABORT	Fruit with aborted apple maggot tunnels
CM	Codling moth
EAS	European apple sawfly
PC	Plum curculio
TPB	Tarnished plant bug
BRK SPOT	Brooks spot
CORK	Corking
FLY SPECK	Fly speck
SOOTY BLOTCH	Sooty blotch
ROTS	White, black and bitter rots
SCAB	Apple scab
CLEAN	Clean fruit

[2] Means within a column followed by the same letter are not significantly different; P = .05 GLM,LSD test.

NOT FOR PUBLICATION

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APPLE: *Malus domestica* Borkh. 'Red Delicious'
European red mite; *Panonychus ulmi* (Koch)

ACARICIDE EVALUATION, 1991: This experiment was conducted in a one third acre block of 6-yr-old 'Redchief' trees on M26, which measured 10.5 ft. in height and 9 ft. in width and were planted at a spacing of 10 x 15 ft. The experimental design consisted of 4 single-tree plots in a randomized block design, with each replicate surrounded by at least one unsprayed tree on each side. Acaricides were applied to runoff on 14 Jun with a WW Grinder, Inc. handgun sprayer (model no. PS325-3) operated at 100 psi. Each tree received approximately two-third gallon of spray (ca. 192 GPA). Other materials applied separately to all treatments were Agristrep, Ambush, Asana, Bordeaux mixture, Captan, Dodine, Guthion, Lannate, Nova, Oil, Penncap-M, Rubigan, Sevin, Solubor, and Topsin-M. European red mite control was evaluated by sampling 25 leaves from the periphery of each tree, removing mites with a mite-brushing machine, and counting active stages with a binocular microscope.

Omite provided a greater reduction of mites than a combination of Kelthane and Triton AG-44M four days after application. The mite population in the Kelthane + Triton AG-44M treatment was reduced to a lower level than that in the Omite treatment on 9 Jul due to an observed increased response of *Stethorus punctum* to the higher mite population in the Kelthane + Triton AG-44M treatment following 1 Jul. Following an application of Sevin on 12 Jul to reduce *S. punctum,* the mite population remained lower in the Kelthane + Triton AG-44M treatment than in the Omite treatment for the remainder of the season, resulting in a significantly lower accumulation of mite-days. Omite provided a significantly greater reduction of mites than a half rate of Omite in combination with Pyrellin through 10 days after application. AC801,757 was the most effective treatment. The low rate of this compound resulted in a significantly higher accumulation of mite-days than the middle and high rates, which were not significantly different.

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No.	Treatment	Rate/acre	lb AI	European red mites/leaf 11 Jun	18 Jun	24 Jun	1 Jul	9 Jul
1.	Kelthane 50 W Triton AG-44M	1362 g 902 ml	1.50+	6.1 a	1.3 b	1.2 c	4.1 b	0.9 b
2.	Omite 6 EC	710 ml	1.13	5.3 a	0.5 c	0.8 c	2.9 bc	2.5 a
3.	Pyrellin 0.1 EC Omite 6 EC	947 ml 355 ml	0.025+ 0.565	5.5 a	1.8 b	3.7 b	3.9 b	2.6 a
4.	AC 801,757 20 EC	282 ml	0.127	9.1 a	2.0 b	0.5 c	1.2 cd	0.5 b
5.	AC 801,757 20 EC	426 ml	0.191	6.0 a	0.4 c	0.3 c	0.6 d	0.4 b
6.	AC 801,757 20 EC	564 ml	0.254	7.6 a	1.8 b	0.5 c	0.5 d	0.3 b
7.	Untreated	------	-----	5.3 a	9.6 a	19.0 a	22.2 a	1.8 a

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

NOT FOR PUBLICATION

No.	Treatment	Rate/acre	lb AI	European red mites/leaf 16 Jul	24 Jul	29 Jul	5 Aug	12 Aug	Accumulated mite-days 11 Jun to 12 Aug
1.	Kelthane 50 W Triton AG-44M	1362 g 902 ml	1.50+	1.1 b	2.3 b	6.5 ab	9.3 ab	12.5 ab	163.9 b
2.	Omite 6 EC	710 ml	1.13	3.9 a	5.4 a	10.1 a	15.3 a	29.1 a	287.0 a
3.	Pyrellin 0.1 EC Omite 6 EC	947 ml 355 ml	0.025+ 0.565	3.2 a	6.5 a	11.9 a	12.0 a	51.3 a	381.2 a
4.	AC 801,757 20 EC	282 ml	0.127	0.3 b	1.0 bc	4.5 ab	3.6 bc	8.0 abc	93.5 b
5.	AC 801,757 20 EC	426 ml	0.191	0.1 b	0.4 c	1.8 b	2.5 c	3.6 bc	45.8 c
6.	AC 801,757 20 EC	564 ml	0.254	0.5 b	0.4 c	2.3 ab	1.4 c	1.3 c	44.9 c
7.	Untreated	------	-----	4.8 a	4.8 a	6.3 ab	8.3 ab	12.0 ab	380.6 a

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

NOT FOR PUBLICATION

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APPLE: *Malus domestica* Borkh. 'Rome Beauty', 'Golden Delicious'
Rosy apple aphid (RAA); *Dysaphis plantaginea* (Passerini)
Spirea aphid (SA); *Aphis spiraecola* Patch
White apple leafhopper (WALH); *Typhlocyba pomaria* McAtee
Rose leafhopper (RLH); *Edwardsiana rosae* (L.)
Spotted tentiform leafminer (STLM); *Phyllonorycter blancardella* (F.)
Codling moth (CM); *Cydia pomonella* (L.)
Tufted apple bud moth (TABM); *Platynota idaeusalis* (Walker)
Redbanded leafroller (RBLR); *Argyrotaenia velutinana* (Walker)
San Jose scale (SJS); *Quadraspidiotus pernicosus* (Comstock)

INSECTICIDE EVALUATION, 1991: This experiment was conducted in a 5.4 acre block of 37-yr-old trees, which measured 16.5 ft. in height and 23 ft. in width and were planted at a spacing of 20 x 40 ft. The experimental design consisted of 6 single-tree plots (3 'Rome Beauty', 3 'Golden Delicious') in a randomized block design. Insecticides were applied with a Swanson DA500A airblast sprayer, which traveled at 2.4 mph and delivered a spray volume of 100 gal/acre. Dates of application were 2 Apr (delayed dormant [DD]), 9 Apr (prepink [PP]), 8 May (petal fall [PF]), 21 May (first cover [1C]), 31 May (second cover [2C]), 13 Jun (third cover [3C]), 27 Jun (fourth cover [4C]), 16 Jul (fifth cover [5C]), 30 Jul (sixth cover [6C]), 12 Aug (seventh cover [7C]), and 29 Aug (eighth cover [8C]). Other materials applied separately to all treatments were Agristrep, Bordeaux mixture, Captan, Dodine, NAA, Nova, Rubigan, Solubor, and Topsin-M. Control of RAA was evaluated by counting colonies/tree. Effect of treatments against SA was determined by counting aphids on the most infested leaf on each of five terminals/tree around the periphery of 'Rome Beauty'. Control of WALH and RLH was evaluated by counting nymphs on 25 leaves selected from the periphery of trees. Treatment effect against STLM was determined by counting mines observed in 5 minutes around the periphery of trees. Control of fruit-feeding insects was determined by scoring for injury 600 picked apples/treatment (100/replication) plus up to 600 drop apples/treatment (up to 100/replication) sampled on 17 Sep. Fruit picked from 'Golden Delicious' trees were rated for finish as 0 (no russet), 1 (enlarged and raised lenticels), 2 (1-10% russeted surface), 3 (11-25% russeted surface), 4 (26-50% russeted surface), or 5 (> 50% russeted surface).

Lorsban and RH-7988 provided excellent control of RAA, and along with Danitol were very effective against SA. Excellent control of RLH and WALH were provided by AC 303,630, Danitol, and RH-7988. Lorsban was more effective than Guthion against RLH. Effective treatments against STLM included Danitol, RH-5992, and the highest rate of AC 303,630. Danitol/Guthion/Penncap-M and Guthion treatments provided the best control of TABM & RBLR and the highest % of clean fruit, and along with a Lorsban/Guthion treatment were the most effective against CM. A rate response in the control of CM was observed with AC 303,630. A Javelin + half rate Guthion treatment was more effective than Javelin alone in the control of CM, but not as effective as Guthion alone at full rate. The low incidence of TABM & RBLR injury in the untreated drop sample is believed to be due to the very high incidence of CM which caused excessive drop before apples could be attacked by late season populations of TABM & RBLR. The Danitol/Guthion/Penncap-M treatment resulted in less russeting of 'Golden Delicious' fruit than Guthion, Guthion/Lorsban, Javelin, or MVP.

NOT FOR PUBLICATION

No.	Treatment	Rate/acre	lb AI	Time of application	RAA colonies/tree	SA/most inf leaf/term	
					29 May	11 Jun	18 Jun
1.	Lorsban 4 EC	1184 ml	1.25	DD	0 d	117.6 a	6.7 abc
	Guthion 3 F	888 ml	0.70	PF-8C			
2.	Lorsban 4 EC	1184 ml	1.25	DD	0.2 cd	197.4 a	0.5 c
	Guthion 3 F	888 ml	0.70	PF-2C,5C,6C			
	Lorsban 50 W	908 g	1.00	3C,4C,7C,8C			
3.	AC 303,630 24 SC	284 ml	0.15	PP,3C,4C,7C,8C	1.5 cd	168.9 a	14.9 a
	Guthion 3 F	888 ml	0.70	PF-2C,5C,6C			
4.	AC 303,630 24 SC	568 ml	0.30	PP,3C,4C,7C,8C	1.5 bcd	148.3 a	6.5 ab
	Guthion 3 F	888 ml	0.70	PF-2C,5C,6C			
5.	AC 303,630 24 SC	1136 ml	0.60	PP,3C,4C,7C,8C	1.6 bcd	169.9 a	5.0 abc
	Guthion 3 F	888 ml	0.70	PF-2C,5C,6C			
6.	Danitol 2.4 EC	474 ml	0.30	PP,3C,8C	1.8 bcd	150.1 a	1.1 bc
	Guthion 3 F	888 ml	0.70	PF			
	Penncap-M 2 F	1420 ml	0.74	1C,2C,4C-7C			

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

NOT FOR PUBLICATION

No.	Treatment	Rate/acre	lb AI	Time of application	RAA colonies/tree 29 May	SA/most inf leaf/term 11 Jun	SA/most inf leaf/term 18 Jun
7.	RH-7988 25 WP	454 g	0.25 +		0.5 cd	204.9 a	0.3 c
	Sun 6 E Oil	947 ml	----	PF,3C			
	RH-5992 2 F	474 ml	0.25 +				
	Triton B-1956	228 ml	----	PF-8C			
8.	Javelin WG	454 g	0.06	PF,3C,4C,7C,8C	1.3 bcd	104.0 a	6.6 ab
	Javelin WG	1362 g	0.19	1C,2C,5C,6C			
9.	Javelin WG	454 g	0.06 +		6.0 ab	210.3 a	10.7 a
	Guthion 3 F	444 ml	0.35	PF,3C,4C,7C,8C			
	Javelin WG	1362 g	0.19 +				
	Guthion 3 F	444 ml	0.35	1C,2C,5C,6C			
10.	MVP 0.9 F	2842 ml	0.67	PF-8C	4.5 abc	144.8 a	11.7 a
11.	Untreated	--------	----		12.2 a	127.5 a	17.5 a

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

NOT FOR PUBLICATION

No.	Treatment	Rate/acre	lb AI	Time of application	WALH/25 leaves 29 May	RLH/25 leaves 24 Jul	WALH & RLH /25 leaves 19 Aug	STLM/ 5 min 15 Aug
1.	Lorsban 4 EC	1184 ml	1.25	DD	0.3 d	5.0 b	22.5 a	48.0 a
	Guthion 3 F	888 ml	0.70	PF-8C				
2.	Lorsban 4 EC	1184 ml	1.25	DD	1.3 cd	2.0 d	10.8 bc	32.0 ab
	Guthion 3 F	888 ml	0.70	PF-2C,5C,6C				
	Lorsban 50 W	908 g	1.00	3C,4C,7C,8C				
3.	AC 303,630 24 SC	284 ml	0.15	PP,3C,4C,7C,8C	1.7 cd	1.5 d	1.3 d	10.8 cd
	Guthion 3 F	888 ml	0.70	PF-2C,5C,6C				
4.	AC 303,630 24 SC	568 ml	0.30	PP,3C,4C,7C,8C	1.0 d	0.8 d	1.2 d	7.3 de
	Guthion 3 F	888 ml	0.70	PF-2C,5C,6C				
5.	AC 303,630 24 SC	1136 ml	0.60	PP,3C,4C,7C,8C	1.2 d	0.5 d	0.2 d	3.5 ef
	Guthion 3 F	888 ml	0.70	PF-2C,5C,6C				
6.	Danitol 2.4 EC	474 ml	0.30	PP,3C,8C	0.8 d	0.8 d	1.6 d	1.4 g
	Guthion 3 F	888 ml	0.70	PF				
	Penncap-M 2 F	1420 ml	0.74	1C,2C,4C-7C				

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

NOT FOR PUBLICATION

No.	Treatment	Rate/acre	lb AI	Time of application	WALH/25 leaves 29 May	RLH/25 leaves 24 Jul	WALH & RLH /25 leaves 19 Aug	STLM/ 5 min 15 Aug
7.	RH-7988 25 WP	454 g	0.25 +		2.0 cd	1.8 cd	9.7 c	2.8 fg
	Sun 6 E Oil	947 ml	----	PF,3C				
	RH-5992 2 F	474 ml	0.25 +					
	Triton B-1956	228 ml	----	PF-8C				
8.	Javelin WG	454 g	0.06	PF,3C,4C,7C,8C	4.2 bc	12.7 a	41.0 a	11.5 cd
	Javelin WG	1362 g	0.19	1C,2C,5C,6C				
9.	Javelin WG	454 g	0.06 +		2.2 cd	4.3 bc	29.3 a	25.2 bc
	Guthion 3 F	444 ml	0.35	PF,3C,4C,7C,8C				
	Javelin WG	1362 g	0.19 +					
	Guthion 3 F	444 ml	0.35	1C,2C,5C,6C				
10.	MVP 0.9 F	2842 ml	0.67	PF-8C	6.5 ab	7.0 ab	19.2 ab	16.0 cd
11.	Untreated	--------	----		7.8 a	5.3 b	11.7 bc	9.3 cd

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

NOT FOR PUBLICATION

No.	Treatment	Rate/acre	lb AI	Time of application	% CM Injury			% TABM & RBLR Injury		
					Pick sample	Drop sample	Total sample	Pick sample	Drop sample	Total sample
1.	Lorsban 4 EC	1184 ml	1.25	DD	1.8 de	29.0 de	13.3 g	4.5 c	11.9 bc	7.7 bc
	Guthion 3 F	888 ml	0.70	PF-8C						
2.	Lorsban 4 EC	1184 ml	1.25	DD	3.5 de	38.6 cde	12.4 g	15.3 abc	22.9 ab	15.7 ab
	Guthion 3 F	888 ml	0.70	PF-2C,5C,6C						
	Lorsban 50 W	908 g	1.00	3C,4C,7C,8C						
3.	AC 303,630 24 SC	284 ml	0.15	PP,3C,4C,7C,8C	10.5 bc	58.0 b	33.6 bcd	19.5 ab	25.3 a	22.0 a
	Guthion 3 F	888 ml	0.70	PF-2C,5C,6C						
4.	AC 303,630 24 SC	568 ml	0.30	PP,3C,4C,7C,8C	2.2 de	50.8 bc	25.9 cde	14.7 abc	11.5 abc	13.3 ab
	Guthion 3 F	888 ml	0.70	PF-2C,5C,6C						
5.	AC 303,630 24 SC	1136 ml	0.60	PP,3C,4C,7C,8C	6.5 cd	42.3 b-e	21.8 ef	19.2 ab	18.1 ab	18.8 a
	Guthion 3 F	888 ml	0.70	PF-2C,5C,6C						
6.	Danitol 2.4 EC	474 ml	0.30	PP,3C,8C	0.4 e	31.3 de	11.4 g	8.8 bc	3.7 d	6.9 c
	Guthion 3 F	888 ml	0.70	PF						
	Penncap-M 2 F	1420 ml	0.74	1C,2C,4C-7C						

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

NOT FOR PUBLICATION

No.	Treatment	Rate/acre	lb AI	Time of application	% CM Injury Pick sample	% CM Injury Drop sample	% CM Injury Total sample	% TABM & RBLR Injury Pick sample	% TABM & RBLR Injury Drop sample	% TABM & RBLR Injury Total sample
7.	RH-7988 25 WP	454 g	0.25 +		8.0 cd	26.1 e	15.6 fg	19.2 ab	16.3 ab	18.3 ab
	Sun 6 E Oil	947 ml	----	PF,3C						
	RH-5992 2 F	474 ml	0.25 +							
	Triton B-1956	228 ml	----	PF-8C						
8.	Javelin WG	454 g	0.06	PF,3C,4C,7C,8C	34.5 a	57.6 b	45.3 bc	23.3 a	15.7 ab	19.4 a
	Javelin WG	1362 g	0.19	1C,2C,5C,6C						
9.	Javelin WG	454 g	0.06 +							
	Guthion 3 F	444 ml	0.35	PF,3C,4C,7C,8C	5.5 cd	46.4 bcd	25.9 de	16.2 abc	20.8 ab	18.5 a
	Javelin WG	1362 g	0.19 +							
	Guthion 3 F	444 ml	0.35	1C,2C,5C,6C						
10.	MVP 0.9 F	2842 ml	0.67	PF-8C	32.3 ab	76.6 a	54.0 ab	25.2 a	15.3 ab	20.2 a
11.	Untreated	--------	----		60.7 a	91.0 a	75.8 a	20.8 ab	7.5 cd	14.2 ab

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

NOT FOR PUBLICATION

No.	Treatment	Rate/acre	lb AI	Time of application	% SJS Injury: Pick sample	% SJS Injury: Drop sample	% SJS Injury: Total sample	% Clean fruit: Pick sample	% Clean fruit: Drop sample	% Clean fruit: Total sample
1.	Lorsban 4 EC	1184 ml	1.25	DD	0.8 ab	0.7 a	0.7 ab	93.2 a	59.4 ab	79.0 ab
	Guthion 3 F	888 ml	0.70	PF-8C						
2.	Lorsban 4 EC	1184 ml	1.25	DD	0 b	0.6 a	0.1 b	81.2 abc	46.5 a-d	69.8 abc
	Guthion 3 F	888 ml	0.70	PF-2C,5C,6C						
	Lorsban 50 W	908 g	1.00	3C,4C,7C,8C						
3.	AC 303,630 24 SC	284 ml	0.15	PP,3C,4C,7C,8C	0.3 ab	2.3 a	1.2 ab	74.7 bc	25.2 efg	51.0 de
	Guthion 3 F	888 ml	0.70	PF-2C,5C,6C						
4.	AC 303,630 24 SC	568 ml	0.30	PP,3C,4C,7C,8C	2.7 ab	5.8 a	4.3 ab	82.0 abc	39.9 b-e	61.1 cd
	Guthion 3 F	888 ml	0.70	PF-2C,5C,6C						
5.	AC 303,630 24 SC	1136 ml	0.60	PP,3C,4C,7C,8C	2.3 ab	1.8 a	2.1 ab	75.2 bc	45.4 a-e	62.7 cd
	Guthion 3 F	888 ml	0.70	PF-2C,5C,6C						
6.	Danitol 2.4 EC	474 ml	0.30	PP,3C,8C	1.6 ab	5.0 a	2.8 ab	90.0 ab	64.2 a	80.8 a
	Guthion 3 F	888 ml	0.70	PF						
	Penncap-M 2 F	1420 ml	0.74	1C,2C,4C-7C						

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

NOT FOR PUBLICATION

No.	Treatment	Rate/acre	lb AI	Time of application	% SJS Injury: Pick sample	% SJS Injury: Drop sample	% SJS Injury: Total sample	% Clean fruit: Pick sample	% Clean fruit: Drop sample	% Clean fruit: Total sample
7.	RH-7988 25 WP	454 g	0.25 +		6.7 ab	4.3 a	5.5 ab	69.0 c	56.3 abc	63.6 bcd
	Sun 6 E Oil	947 ml	----	PF,3C						
	RH-5992 2 F	474 ml	0.25 +							
	Triton B-1956	228 ml	----	PF-8C						
8.	Javelin WG	454 g	0.06	PF,3C,4C,7C,8C	9.0 ab	2.8 a	5.9 a	48.7 d	34.3 def	42.2 ef
	Javelin WG	1362 g	0.19	1C,2C,5C,6C						
9.	Javelin WG	454 g	0.06 +							
	Guthion 3 F	444 ml	0.35	PF,3C,4C,7C,8C	3.8 ab	1.9 a	2.8 ab	77.0 abc	37.5 cde	57.4 cde
	Javelin WG	1362 g	0.19 +							
	Guthion 3 F	444 ml	0.35	1C,2C,5C,6C						
10.	MVP 0.9 F	2842 ml	0.67	PF-8C	7.8 a	2.0 a	5.0 ab	43.8 de	15.9 fg	30.2 fg
11.	Untreated	--------	----		2.5 ab	0.3 a	1.4 ab	29.2 e	8.8 g	19.0 g

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

NOT FOR PUBLICATION

No.	Treatment	Rate/acre	lb AI	Time of application	Fruit finish rating
1.	Lorsban 4 EC	1184 ml	1.25	DD	2.04 ab
	Guthion 3 F	888 ml	0.70	PF-8C	
2.	Lorsban 4 EC	1184 ml	1.25	DD	2.10 a
	Guthion 3 F	888 ml	0.70	PF-2C,5C,6C	
	Lorsban 50 W	908 g	1.00	3C,4C,7C,8C	
3.	AC 303,630 24 SC	284 ml	0.15	PP,3C,4C,7C,8C	1.83 a-d
	Guthion 3 F	888 ml	0.70	PF-2C,5C,6C	
4.	AC 303,630 24 SC	568 ml	0.30	PP,3C,4C,7C,8C	1.70 cd
	Guthion 3 F	888 ml	0.70	PF-2C,5C,6C	
5.	AC 303,630 24 SC	1136 ml	0.60	PP,3C,4C,7C,8C	1.70 cd
	Guthion 3 F	888 ml	0.70	PF-2C,5C,6C	
6.	Danitol 2.4 EC	474 ml	0.30	PP,3C,8C	1.63 d
	Guthion 3 F	888 ml	0.70	PF	
	Penncap-M 2 F	1420 ml	0.74	1C,2C,4C-7C	

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

NOT FOR PUBLICATION

No.	Treatment	Rate/acre	lb AI	Time of application	Fruit finish rating
7.	RH-7988 25 WP	454 g	0.25 +		1.70 cd
	Sun 6 E Oil	947 ml	----	PF,3C	
	RH-5992 2 F	474 ml	0.25 +		
	Triton B-1956	228 ml	----	PF-8C	
8.	Javelin WG	454 g	0.06	PF,3C,4C,7C,8C	1.99 abc
	Javelin WG	1362 g	0.19	1C,2C,5C,6C	
9.	Javelin WG	454 g	0.06 +		1.76 bcd
	Guthion 3 F	444 ml	0.35	PF,3C,4C,7C,8C	
	Javelin WG	1362 g	0.19 +		
	Guthion 3 F	444 ml	0.35	1C,2C,5C,6C	
10.	MVP 0.9 F	2842 ml	0.67	PF-8C	2.08 a
11.	Untreated	-------	----		1.71 cd

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

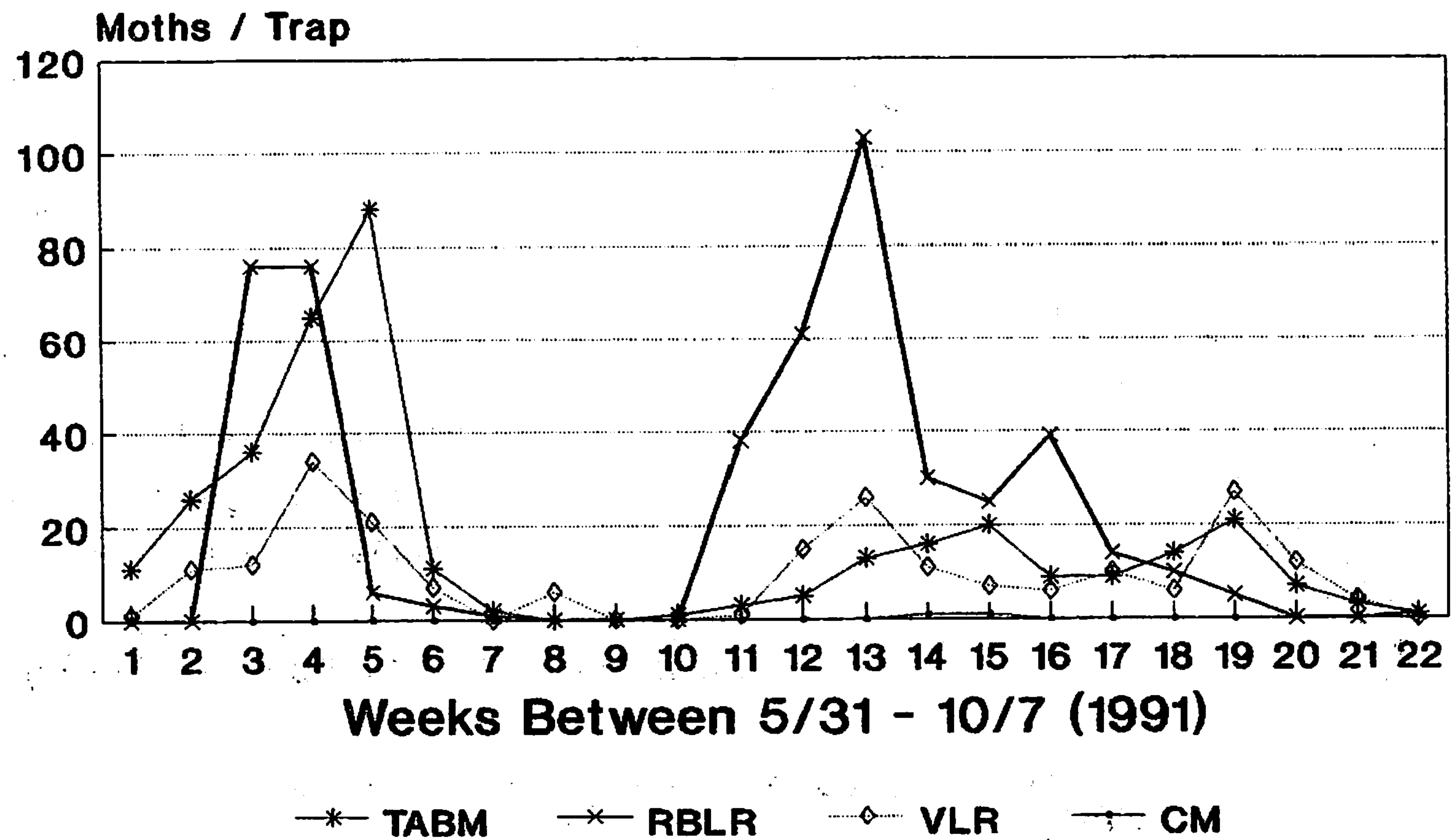
1991 RESEARCH REPORT

VAES - WINCHESTER

"A V.P.I. Fruit Research Station"

DR. R. L. HORSBURGH
Professor of Entomology

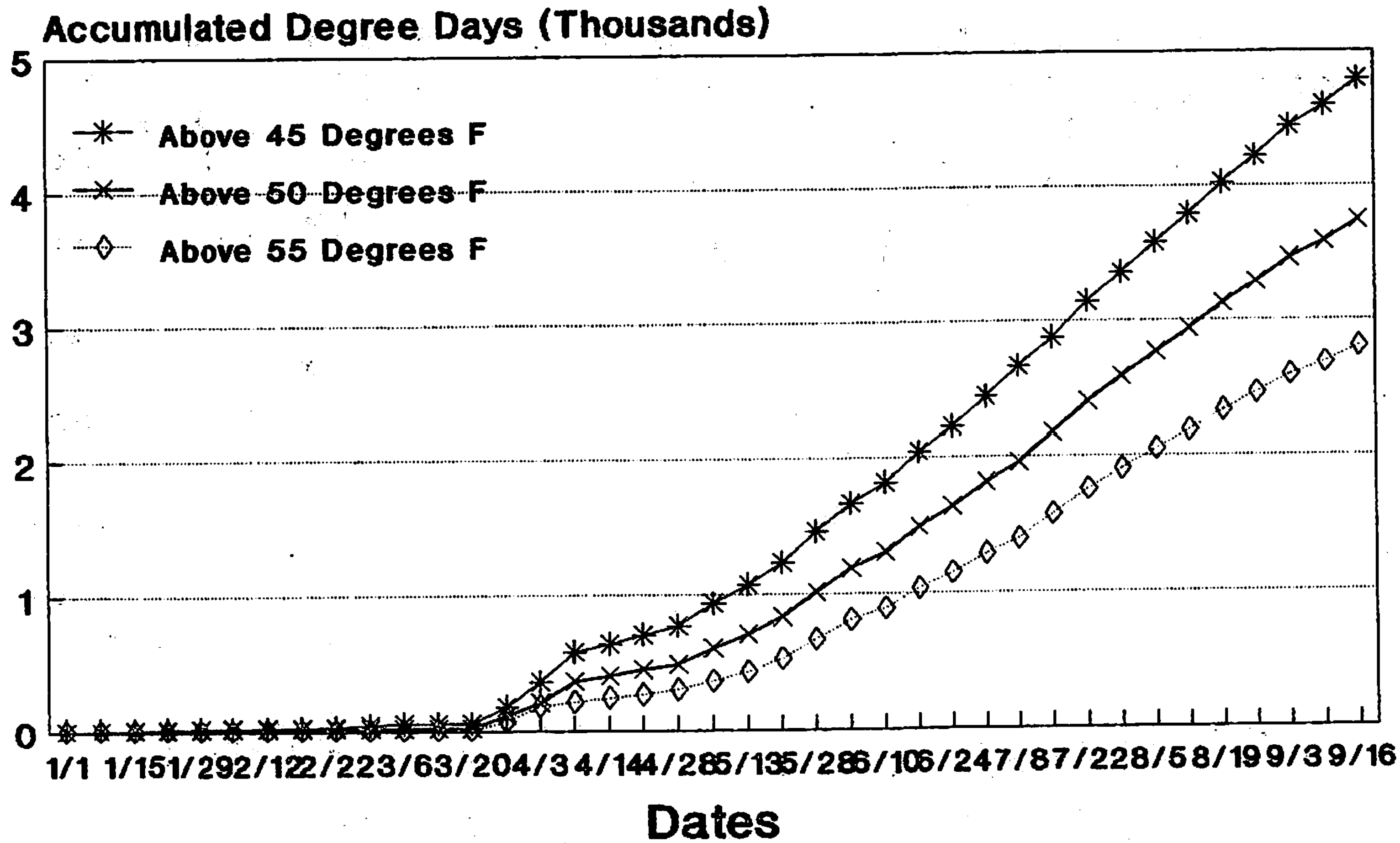
MOTH CAPTURES
Redspur Block - VAES Winchester



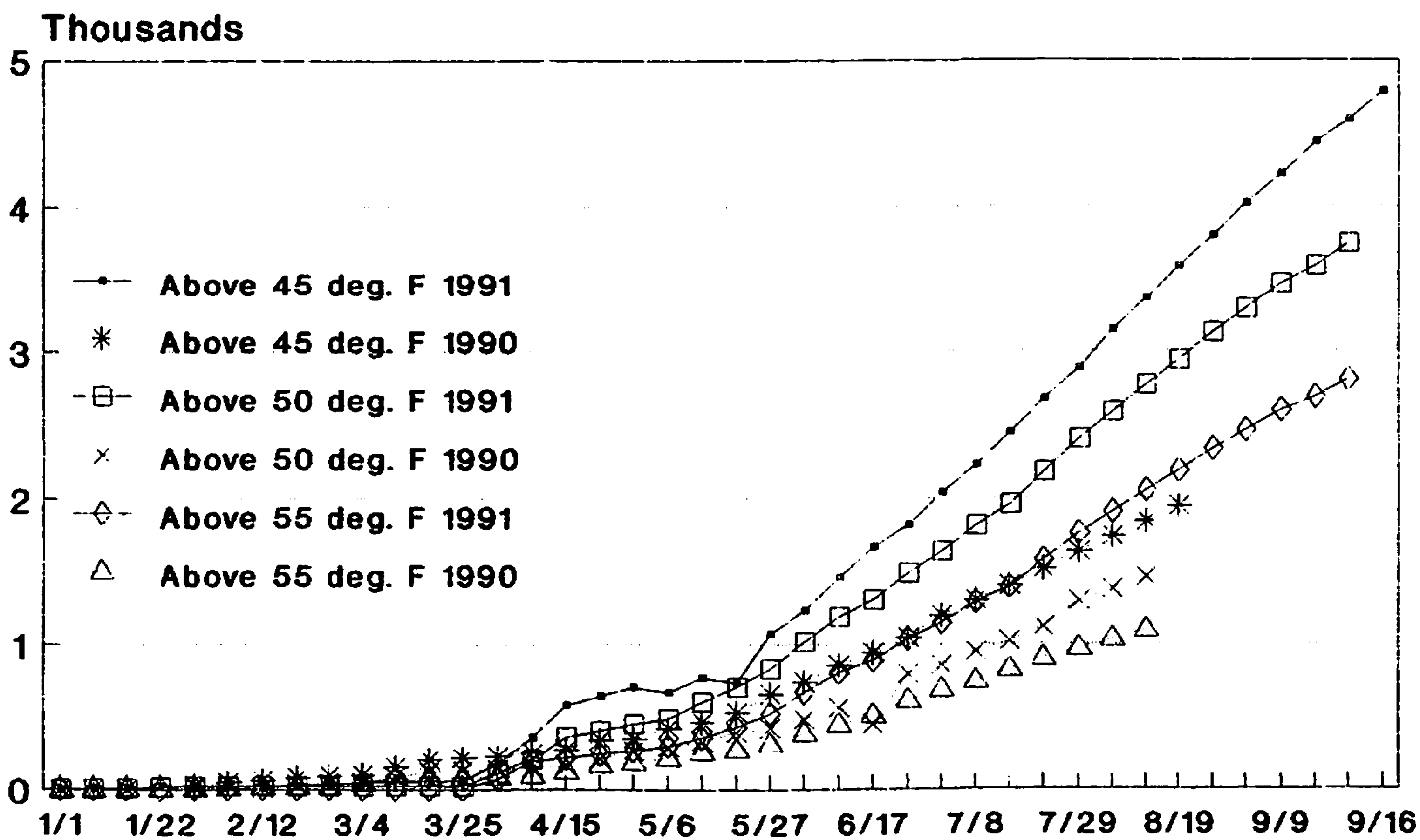
Data = Moths removed after each counting

ACCUMULATED DEGREE DAYS

VAES - Winchester -1991



ACCUMULATED DEGREE DAYS
VAES - Winchester - (1990-91)



APPLE:
Malus domestica Borkh
European red mite (ERM);
Panonychus ulmi (Koch)
Cecciodomyiidae spp. (CECC)
Twospotted spider mite (TSM);
Tetranychus urticae Koch
Predatory beetle (sp);
Stethorus punctum (LeConte)
Predatory bug (OI);
Orius insidiosus (Say)
Coccinellidae spp. (COCC)
Leptothrips mali (Ewing)
Predatory mite (ZM); *Zetzellia mali* (Ewing)
Apple aphid (AA); *Aphis pomi* DeGeer
Spirea aphid (SA); *Aphis citricola* Van der Goot
Redbanded leafroller (RBLR); *Argyrotaenia velutinana* (Walker)
Chrysopidae; egg (CRE); larva (CRL)
Variegated leafroller (VLR); *Platynota flavedana* (Clemens)
White apple leafhopper (WALH); *Typhlocyba pomaria* McAtee
Tufted apple budmoth (TABM); *Platynota idaeusalis* (Walker)
Rosy apple aphid (RAA); *Dysaphis plantaginea* (Passerini)
Gypsy moth; *Lymantria dispar* (Linnaeus)
Spotted tentiform leafminer (STL); *Phyllonorycter blancardella* (F.)
Apple leafminer (ALM); *Lyonetia speculella* Clemens
Wooly apple aphid (WAA); *Eriosoma lanigerum* (Hausmann)
Codling moth (CM); *Cydia pomonella* (Linnaeus)

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APPLE, SEASONAL INSECTICIDE EVALUATIONS, 1991: Experimental insecticide treatments were applied in a comparative test to 8 year old Ida Red apple trees. A randomized block design was used and each treatment consisted of 4 single tree replicates. Trees were sprayed to runoff using a Bean hydraulic sprayer operating at 400 psi. Dates of application of treatments and maintenance sprays are given in the tables. Mite populations were evaluated on each sample date by randomly selecting 25 leaves per replicate, brushing them onto a sticky glass plate and counting all motile mites and viable eggs with a binocular microscope. Specific counts of predators of mites were made during timed counting periods of three minutes per replicate. RAA and the GAA-SA complex populations were quantified by four different methods: 1) each replicate tree was ranked from 0-5 (5 = heavily infested) 2) 25 terminal shoots per replicate were examined and the number of active colonies recorded; 3) the number of active colonies observed during a timed 3 minute examination of each replicate tree was recorded; and 4) average ranks (0 = none, 5 = heavily infested) of aphid populations on 5 succulent terminal shoots were calculated for each replicate. WALH populations were quantified by method 1 above and also by counting the number of leafhoppers per 20 leaves per replicate (80 per treatment). The latter count was made 48 hrs after treatments were applied. Populations of spotted tentiform leafminer (STL), apple leafminer (ALM), and wooly apple aphid (WAA), were evaluated on 28 Aug by counting all vacated (old) and occupied (new) STL mines, the number of WAA colonies, and the number of ALM infested leaves observed per replicate during a 3 minute counting period. One hundred apples per replicate tree were picked at harvest. Fifty apples were graded for stem end and side russetting on a scale from 0-5 for each category where 0 = no russetting and 5 = completely russetted. These data were used to assign each fruit to the appropriate USDA grade (extra fancy, fancy, No. 1, or utility). Percentages of fruit in each category are presented in the tables. All injuries caused by RBLR, TABM, CM, and other Lepidoptera were recorded and averaged. These data are also presented in the tables. The orchard was inoculated with CM infested fruit in the fall of 1990 and twice during the 1991 season. A complete record of all agricultural chemicals applied to the trees in this experiment is provided. Chemicals and amount used in the tables are for 50 gallons of spray mixture.

AC303630 24SC at 106.17 ml and 213 ml; Danitol 2.4EC, 140.48 ml (4.75 oz); Guthion 35W, 170.10 g (6 oz); Imidan 50W, 340.20 g (12 oz) and Guthion 3F, 177.44 ml (5 oz) all reduced WALH populations when compared to the control. However, the Guthion 35W and 3F plots had been sprayed with dimethoate two days before the data was collected. Since dimethoate is recognized as a control agent for leafhoppers, the data was analyzed without these treatments being included. This procedure did not change the significant differences obtained. Imidan 50W, 340.20 g (12 oz); Danitol 2.4EC, 140.48 ml (4.75 oz); and AC303630 24SC, 213 ml were the most effective treatments followed by AC303630 24SC, 106.17 ml. There was no significant difference between the Guthion 35W, 85.05 g (3 oz); Imidan 50W, 226.80 g (8 oz); and the control. Analysis of ranked WALH data revealed significant differences between treatments with Danitol and AC303630 being better than Guthion 35W, 85.05 g (3 oz); Imidan 50W, 226.80 g (8 oz); AC303630 24SC, 53.75 ml; or the control. RAA and GAA + SA populations reached serious infestation levels. Analysis of 3 minute count data for RAA revealed significant differences between treatments. All materials tested were better than the control (fungicides only). The alternating Guthion, Lorsban program was the most efficacious. There were no significant differences between treatments revealed in the analysis of the GAA + SA data. Data based on counts of live aphid colonies on 25 succulent terminal shoots also did not show significant differences when analyzed. Ranking of RAA based on visual examination of 5 terminals per replicate and also ranking a single whole tree replicate gave results that were quite similar. In both data sets, the least infested treatment was the one where two different insecticides were applied on alternating spray dates. Lorsban 50W, 170.10 g (6 oz) + Lannate 157.63 ml (5.33 oz) had been applied on 3 Jun. The material alternated with the preceding treatment was Guthion 35W, 170.10 g (6 oz). The second and third most effective materials were Guthion 35W, 340.20 g (12 oz) and Guthion 3F, 177.44 ml (6 oz). The highest rank was given to the control in both ranking systems. Slight differences occurred between the rankings given GAA and RAA, but in both cases the least infested treatments were the same. WALH ranking of the treatments varied greatly from aphid rankings as expected. The control was the most heavily infested plot and it was followed closely by the alternating Guthion 35W and Lorsban 50W + Lannate plot. The Danitol plot had the lowest rating indicating the best control of WALH. Predators associated with the various aphid species and/or phytophagous mites were also counted. The first count, 6 Jun presents the analysis of the numbers of predators observed during a 5 minute period for each replicate tree. Significant differences between the means for all treatments and the control were found for the Cecciodomyiidae (CECC) and <u>Orius insidiosus</u> (OI). No significant differences were found for the other species counted. Data was also recorded on 6 Jun for the same predators but the number of active colonies found on 6 terminal leaves on each of 5 succulent shoots per replicate was the sample unit used. Significant differences between means were found for the Cecciodomyiidae, but not the other predators. All the treatments had fewer CECC larvae than the highest rate of AC303630 or the control in this test.

Predators were also counted on 22 Jul and 15 Aug when phytophagous mite data was taken. On 22 Jul the higher numbers of TSSM and TSSME were probably reflective of the hot dry summer experienced in the Frederick County area of Virginia in 1991. At the same time, ERM and ERME were fewer than normally experienced at the test location. Significant differences between means were evident for all the mite and insect species tabulated on 22 Jul. The greatest suppression of ERM occurred with the Danitol treatment and the least with Imidan at the 340.2 g (12 oz) rate. The most ERM eggs were also found on the Imidan 340.2 g (12 oz) treatment. Experiments conducted at this laboratory in 1990 showed that significantly more ERM and ERM eggs were found where Guthion 3F was used than where the toxicant was Guthion 35W. A similar trend is evident in the data presented here. All treatments reduced TSSM and TSSME over the control levels. The analysis also indicates that ZM are more abundant where Imidan 50W was used. However, very few ZM were included in the analysis. The count of mites and predators on 15 Aug provided significantly different means for ERME, TSSM and TSSME when the analysis was performed. ERME were the most numerous on the Guthion 50W 170.10 g (6 oz) plot. However, only Danitol and the control had fewer ERM eggs than the other treatments. The increase in ERM with the 3F formulation over the levels obtained with Guthion 35W 170.10 g (6 oz) was again apparent. Danitol produced the best control of TSSM and TSSME. Differences in numbers of SPA and PHYTO between treatments were not apparent in this analysis. After a season of spraying, all treatments provided significant suppression of both vacant and occupied STL mines when compared to the control. The means of ALM mines were also significantly different ($p = 0.05$) with all treatments and the control being better than the median and low rates of AC303630 24SC and Guthion 35WP. No significant differences in average numbers of WAA colonies were detected. The control and the alternating Lorsban + Guthion treatments had the greatest percentage of fruit that were not in the extra fancy or fancy grades. No significant differences in TABM or CM injuries were found between treatments. More RBLR injuries were found in the Imidan 340.2 g treatment than the others or the control. Also, there were differences between treatments in the miscellaneous Lepidoptera (primarily gypsy moth) injury category.

The 30 Aug count revealed the presence of more ERM on the treatment where Guthion 35W was applied than any other treatment or the control. Also, there were more ERME on this treatment than any other, but the difference was not significant when compared to the high rate of AC303630. Danitol provided the best control of both ERM and ERME. Differences in TSM and TSME were not as pronounced as ERM and ERME, but significant differences between means were found.

INSECTICIDE EVALUATION SPRAY SCHEDULE - 1991
(All treatments sprayed unless specific treatments are identified.)

Date	Material and rate/A or /50 gal (maintenance sprays)
3/21	COCS 6 lb/A
3/26	Rubigan 6 lb + Manzate 200, 9 oz/A
4/9 (pink)	Rubigan 6 lb + Manzate 200, 9 oz/A
4/11	AC303630 24SC, 53.75 ml/50 gal (1.82 oz) AC303630 24SC, 106.17 ml/50 gal (3.59 oz) AC303630 24SC, 213.0 ml/50 gal (7.20 oz) Danitol 2.4EC, 140.48 ml/50 gal (4.75 oz) Guthion 35WP, 170.10 g/50 gal (6 oz) Fungicides only Imidan 50WP, 340.20 g/50 gal (12 oz) Guthion 3F, 177.44 ml/50 gal (5 oz) Guthion 35WP, 85.05 g (3 oz) alt. with Lorsban 50W 226.80 g (8 oz) Imidan 50W, 8 oz/50 gal/A
4/17	Rubigan 6 lb + Manzate 200 9 oz/A
4/18	Paraquat 4.5 lb + Karmey 3 lb + Sinbar 8 oz + X-77/100 gal/A
4/26	Nova 5 oz + Ziram 3.25 lb + Streptomycin 32 oz/A
5/8	All treatments but No. 3 sprayed.
5/10	Only treatments 5 and 8 sprayed.
5/13	Only treatment 3 sprayed.
5/20	All treatments (Note: Trt 9 = Lorsban 50W, 1.25 lb/50 gal)
5/22	Nova, 5 lb + Captan, 3.25 lb + CaCl, 6 lb/A
6/3	Treatments sprayed, nos. 6 and 7 were sprayed with fungicides only.
6/5	Fungicides applied to all but 6 and 7. Nova + Captan + CaCl
6/7	All treatments SWAT (Phosphamidon) 12 oz/A
6/17	All treatments applied; trt 9 = Guthion 50W 6 oz/50 gal
6/24	Ziram 6.5 lb + Topsin 8 oz + CaCl 6 lb/A
7/1	Ziram 6.5 lb + Topsin 8 oz + CaCl 6 lb/A
7/9	All treatments. (Note: No. 9 = Lorsban 50W 1.25 lb/50 gal)
7/10	All treatments Ziram 6.5 lb + Topsin 8 oz + CaCl 6 lb/A
7/19	All treatments. (Note: No. 9 = Lorsban 6 oz + Lannate 5.2 oz/50 gal)
7/25	All treatments. Benlate 8 oz + Thiram 3 lb + CaCl 6 lb/A
7/30	All treatments. (Note: No. 9 Guthion 35W 6 oz/50 gal)
8/16	Thiram 3 lb + Benlate 3 oz + CaCL 6 lb/A
8/21	All treatments. (Note: No. 9 Guthion 35W 6 oz/50 gal)

Treatment/189.25 l (50 gal)	Live WALH 48 hrs post-trt[1]		Visual ranking[1,2]
	All trts	Trt 5,8 removed	WALH (average)
AC303630 24SC, 53.75 ml	28.00 ab	28.00 ab	2.75 b
AC303630 24SC, 106.17 ml	13.00 bc	13.00 bc	1.25 c
AC303630 24SC, 213.0 ml	3.75 c	3.75 c	1.50 bc
Danitol 2.4EC, 140.48 ml	0.50 c	0.50 c	0.25 c
Guthion 35WP, 170.10 g	0.00 c	--	1.50 bc
Fungicides only	32.75 a	32.75 a	4.75 a
Imidan 50WP, 340.20 g	0.00 c	0.00 c	Not counted
Guthion 3F, 177.44 ml	5.00 c	--	1.50 bc
Guthion 35WP, 85.05 g alternates with Lorsban 50W 170.10 g	38.00 a	38.00 a	2.75 b
Imidan 50W, 226.80 g	35.00 a	35.00 a	2.75 b

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

[2]Rank (0-5) with 0 = none and 5 = heavily infested.

Treatment/189.25 l (50 gal)	Aphid counts - 15 May RAA-3[1]	GAA-3[1] (ns)	RAA-25[2] (ns)	GAA-25[2] (ns)	(Aphid counts (ranked data) RAA[4]	GAA[4]	RAA[5]
AC303630 24SC, 53.75 ml	5.00 bc	0.75	2.25	0.50	2.05 ab	2.75 bcd	3.75 a
AC303630 24SC, 106.17 ml	15.00 a	0.50	4.50	0.75	2.18 ab	4.23 a	3.00 ab
AC303630 24SC, 213.0 ml	4.25 bc	0.50	2.00	0.75	1.20 bcd	3.10 abc	3.75 a
Danitol 2.4EC, 140.48 ml	3.50 bc	0.00	1.50	0.25	2.05 ab	0.23 e	3.00 ab
Guthion 35WP, 170.10 g	--[3]	--[3]	--[3]	--[3]	0.40 cd	1.70 d	1.00 bc
Fungicides only	7.00 b	1.25	5.00	2.50	3.20 a	3.55 ab	5.00 a
Imidan 50WP, 340.20 g	2.50 bc	0.00	2.25	0.25	--	--	--
Guthion 3F, 177.44 ml	--[3]	--[3]	--[3]	--[3]	0.60 cd	2.25 cd	2.75 ab
Guthion 35WP, 85.05 g alternates with Lorsban 50W 170.10 g	0.25 c	0.00	0.50	0.00	0.10 d	0.08 e	0.50 c
Imidan 50W, 226.80 g	7.50 b	0.25	4.25	1.25	1.75 bc	2.18 cd	3.50 a

[1]Live aphid colonies per 3 minute observation.
[2]Live aphid colonies per 25 terminal shoots.
[3]Data deleted as treatments oversprayed with dimethoate 2 days before count.
[4]Rank 0-5 with 5 being heavily infested. Visual ranking of infestation of 10 terminals/replicate on 6 Jun.
[5]Rank 0-5 with 5 being heavily infested. Visual ranking of each replicate after viewing whole tree on 6 Jun.
Numbers in the same column followed by the same letter are not significantly different (P = .05, DMRT).

Legend: RAA = rosy apple aphid; GAA = green apple aphid

Insecticide evaluations, 1991: Ranks of RAA, GAA, and WALH populations by treatment using two rating methods

	RAA		GAA	WALH
Treatment/189.25 l	10 term/rep	tree	10 term/rep	tree
AC303630 24SC, 53.75 ml	6	8	6	7
AC303630 24SC 106.17 ml	8	4	9	2
AC303630 24SC, 213.0 ml	4	7	7	4
Danitol 2.4EC, 140.48 ml	7	5	2	1
Guthion 35WP, 170.10 g	2	2	3	5
Fungicides only	9	9	8	9
Imidan 50WP, 340.20 g	-	-	-	-
Guthion 3F, 177.44 ml	3	3	5	3
Guthion 35WP, 85.05 g alternates with Lorsban 50W 170.10 g	1	1	1	8
Imidan 50W, 226.80 g	5	6	4	6

Ranks (0-9) = least to most infested.

Legend: RAA = rosy apple aphid; GAA = green apple aphid;

WALH = white apple leafhopper

Insecticide evaluations, 1991 (predators/5 minute visual observation)

Treatment/189.25 l (50 gal)	CECC	OI	CHE (ns)	COCC (ns)	SL (ns)
AC303630 24SC, 53.75 ml	0.05 b	0.00 b	0.75	0.00	0.00
AC303630 24SC 106.17 ml	0.00 b	0.00 b	2.00	0.25	0.50
AC303630 24SC, 213.0 ml	3.25 b	0.05 b	1.00	0.00	0.00
Danitol 2.4EC, 140.48 ml	0.00 b	0.00 b	0.00	0.00	0.00
Guthion 35WP, 170.10 g	0.00 b	0.00 b	1.00	0.00	0.00
Fungicides only	8.25 a	0.75 a	2.50	0.00	0.00
Imidan 50WP, 340.20 g	0.00 b	0.25 b	0.00	0.00	0.00
Guthion 3F, 177.44 ml	0.00 b	0.00 b	3.00	0.00	0.00
Guthion 35WP, 85.05 g alternates with Lorsban 50W 170.10 g	0.00 b	0.00 b	0.50	0.00	0.00
Imidan 50W, 226.80 g	0.75 b	0.00 b	1.00	0.00	0.25

Insecticide evaluations, 1991 (predators/6 terminal leaves/5 shoots/rep)

Treatment/189.25 l (50 gal)	CECC	OI (ns)	CHE (ns)	COCC (ns)	SL (ns)
AC303630 24SC, 53.75 ml	1.00 b	0.00	0.25	0.00	0.25
AC303630 24SC, 106.17 ml	0.50 b	0.00	0.00	0.00	0.75
AC303630 24SC, 213.0 ml	5.50 a	0.25	0.00	0.00	0.50
Danitol 2.4EC, 140.48 ml	0.00 b	0.00	0.00	0.00	0.25
Guthion 35WP, 170.10 g	0.00 b	0.00	0.00	0.00	0.00
Fungicides only	6.25 a	0.00	0.25	0.00	0.25
Imidan 50WP, 340.20 g	0.00 b	0.25	0.00	0.00	0.00
Guthion 3F, 177.44 ml	0.25 b	0.00	0.00	0.00	0.00
Guthion 35WP, 85.05 g alternates with Lorsban 50W 170.10 g	0.00 b	0.00	0.00	0.00	0.00
Imidan 50W, 226.80 g	2.00 b	0.00	0.00	0.00	0.00

Data was transformed to $\sqrt{X + .5}$ for analysis.
Arithmetic means presented in table.
CECC = Cecciodomyiidae; OI = Orius insidiosus; CHE = Chrysopidae spp. eggs; COCC = Coccinellidae spp.; SL = Syrphidae spp. larvae; NS = not significant. Numbers in the same column followed by the same letter are not significantly different (P = 0.05, DMRT).

Average spotted tentiform leafminer mines (vacant and inhabited), wooly apple aphid colonies, and apple leafminer/leaf/3 minute observation; per replicate, 28 Aug 1991

Treatment/189.25 l (50 gal)	Vacant STL mines/rep	Occupied STL mines/rep	WAA colonies/ rep (ns)	Leaves infested ALM/rep
AC303630 24SC, 53.75 ml	0.75 b	0.00 b	0.00	52.00 ab
AC303630 24SC, 106.17 ml	0.25 b	0.00 b	1.25	75.00 a
AC303630 24SC, 213.0 ml	1.00 b	0.00 b	0.75	34.75 b
Danitol 2.4EC, 140.48 ml	0.00 b	0.00 b	1.25	29.50 b
Guthion 35WP, 170.10 g	0.25 b	0.00 b	0.50	47.25 ab
Fungicides only	18.25 a	1.75 a	1.00	20.50 b
Imidan 50WP, 340.20 g	1.25 b	0.25 c	0.25	21.50 b
Guthion 3F, 177.44 ml	2.75 b	0.75 b	0.50	31.00 b
Guthion 35WP, 85.05 g alternates with Lorsban 50W 170.10 g	0.25 b	0.25 b	0.50	30.50 b
Imidan 50W, 226.80 g	2.75 b	0.00 b	0.50	16.00 b

Numbers in the same column followed by the same letter are not significantly different (p = 0.05).

Legend: STL = spotted tentiform leafminer; WAA = wooly apple aphid; ALM = apple leafminer

Insecticide evaluations, 1991

Injuries per 100 harvested apples/replicate

Treatment/189.25 l (50 gal)	RBLR	TABM (ns)	CM (ns)	LEP
AC303630 24SC, 53.75 ml	0.00 b	1.00	1.25	2.25 ab
AC303630 24SC, 106.17 ml	0.75 b	0.75	0.75	3.00 a
AC303630 24SC, 213.0 ml	0.50 b	0.25	0.00	0.00 c
Danitol 2.4EC, 140.48 ml	0.00 b	0.25	0.00	0.50 bc
Guthion 35WP, 170.10 g	0.25 b	0.00	0.25	0.25 bc
Fungicides only	3.00 a	1.25	7.25	0.25 bc
Imidan 50WP, 340.20 g	1.25 b	1.25	0.50	1.50 abc
Guthion 3F, 177.44 ml	0.00 b	0.50	0.00	0.00 c
Guthion 35WP, 85.05 g alternates with Lorsban 50W 170.10 g	0.50 b	0.00	0.75	0.50 bc
Imidan 50W, 226.80 g	0.00 b	0.00	0.00	1.50 abc

Numbers in the same column followed by the same letter are not significantly different (p = 0.05).

Legend: RBLR = redbanded leafroller; TABM = tufted apple budmoth; CM = codling moth; LEP = Lepidoptera

Phytophagous mites or mite eggs/leaf (22 Jul and 15 Aug)

Treatment/189.25 l (50 gal)	ERM	ERME	TSSM	TSSME	ZM
AC303630 24SC, 53.75 ml	1.04 ab	5.37 a	0.00 b	0.69 bc	0.15 b
AC303630 24SC, 106.17 ml	1.06 ab	5.31 a	0.50 b	0.50 bc	0.00 b
AC303630 24SC, 213.0 ml	0.57 abc	2.63 ab	0.00 b	0.22 bc	0.00 b
Danitol 2.4EC, 140.48 ml	0.00 c	0.00 c	0.00 b	0.00 c	0.00 b
Guthion 35WP, 170.10 g	0.55 abc	2.37 ab	0.09 b	0.37 bc	0.00 b
Fungicides only	1.12 ab	5.00 a	1.83 a	3.26 a	0.00 b
Imidan 50WP, 340.20 g	1.51 a	6.45 a	0.27 b	1.00 b	0.00 b
Guthion 3F, 177.44 ml	0.78 ab	4.81 a	0.09 b	0.76 bc	0.00 b
Guthion 35WP, 85.05 g alternates with Lorsban 50W 170.10 g	0.23 bc	0.67 bc	0.15 b	0.18 bc	0.19 a
Imidan 50W, 226.80 g	1.42 a	2.86 ab	0.76 ab	0.84 bc	0.00 b

Insecticide evaluations, 15 Aug 91 (25 leaves/replicate)

Treatment/189.25 l (50 gal)	ERM (ns)	ERME	TSSM	TSSME	SPA (ns)	PHYTO (ns)
AC303630 24SC, 53.75 ml	4.85	16.82 a	2.00 abc	0.30 cd	0.09	0.00
AC303630 24SC, 106.17 ml	1.54	10.22 ab	3.06 ab	0.30 cd	0.13	0.00
AC303630 24SC, 213.0 ml	0.95	2.51 abc	0.70 bc	1.84 bcd	0.00	0.00
Danitol 2.4EC, 140.48 ml	0.18	0.37 c	0.00 c	0.19 d	0.00	0.00
Guthion 35WP, 170.10 g	4.96	18.91 a	1.01 bc	0.96 bcd	0.26	0.09
Fungicides only	0.96	0.96 bc	1.16 abc	16.78 a	0.00	0.05
Imidan 50WP, 340.20 g	0.65	1.39 bc	0.30 bc	5.79 ab	0.22	0.00
Guthion 3F, 177.44 ml	3.43	7.04 abc	1.83 abc	3.90 ab	0.22	0.09
Guthion 35WP, 85.05 g alternates with Lorsban 50W 170.10 g	1.20	3.69 abc	2.39 ab	2.06 bcd	0.13	0.13
Imidan 50W, 226.80 g	1.17	4.26 abc	6.35 a	3.55 abc	0.00	0.00

Data was transformed to $\sqrt{X + .5}$ for analysis.
Arithmetic means presented in table.
ERM = European red mite; ERME = European red mite eggs; TSSM = two spotted spider mite; TSSME = two spotted spider mite eggs; SPA = *Stethorus punctum* adults; PHYTO = *Phytoseiidae* spp.; ZM = *Zetzellia mali*.
Numbers in the same column followed by the same letter are not significantly different (P = 0.05, DMRT).

Insecticide evaluations, 1991

Phytophagous mites or mite eggs/leaf (30 Aug)

Treatment/189.25 l (50 gal)	TSM[1,2]	TSME[1,2]	ERM[1,2]	ERME[1,2]
AC303630 24SC, 53.75 ml	0.68 bc	0.00 d	0.13 de	0.38 d
AC303630 24SC, 106.17 ml	0.22 c	0.02 cd	1.24 bc	1.20 cd
AC303630 24SC 213.0 ml	0.13 c	0.05 cd	1.96 b	6.83 ab
Danitol 2.4EC, 140.48 ml	0.00 c	0.09 cd	0.00 c	0.52 d
Guthion 35WP, 170.10 g	0.32 bc	0.29 abcd	4.62 a	33.67 a
Fungicides only	1.86 a	0.70 abc	0.45 cde	0.99 cd
Imidan 50WP, 340.20 g	1.07 abc	0.62 abcd	0.24 cde	1.70 cd
Guthion 3F, 177.44 ml	0.77 abc	0.46 abcd	0.89 bcd	2.16 cd
Guthion 35WP, 85.05 g alternates with Lorsban 50W 170.10 g	1.66 ab	0.77 ab	0.60 bcde	2.95 bc
Imidan 50W, 226.80 g	1.75 a	0.93 a	0.85 bcde	3.07 bc

[1]Numbers in the same column followed by the same letter are not significantly different ($p = 0.05$).
Data transformed to log X + 1 for analysis.
Arithmetic means presented in table.
[2]Sample size = 25 leaves/replicate.
Legend: TSM = two spotted spider mite; TSME = two spotted spider mite eggs; ERM = European red mite; ERME = European red mite eggs

Insecticide evaluations, 1991

Fruit grades (50 apples per replicate)

Treatment/189.25 l (50 gal)	% Extra Fancy (ns)	% Fancy (ns)	% No. 1	% Utility (ns)	% Extra fancy + Fancy (ns)
AC303630 24SC, 53.75 ml	0.66	0.29	0.040 bc	0.015	95
AC303630 24SC, 106.17 ml	0.47	0.49	0.035 c	0.005	96
AC303630 24SC, 213.0 ml	0.75	0.19	0.055 bc	0.100	94
Danitol 2.4EC, 140.48 ml	0.58	0.36	0.055 bc	0.100	94
Guthion 35WP, 170.10 g	0.56	0.40	0.045 bc	0.000	96
Fungicides only	0.71	0.26	0.040 bc	0.000	97
Imidan 50WP, 340.20 g	0.42	0.46	0.115 ab	0.010	88
Guthion 3F, 177.44 ml	0.63	0.31	0.065 bc	0.005	94
Guthion 35WP, 85.05 g alternates with Lorsban 50W 170.10 g	0.53	0.29	0.160 a	0.025	82
Imidan 50W, 226.80 g	0.53	0.42	0.055 bc	0.000	95

Numbers in the same column followed by the same letter are not significantly different (p = 0.05, DMRT).

NS = no significant differences (p = .05, DMRT).

APPLE; Malus domestica Borkh
'Triple Red Delicious'
European red mite (ERM);
Panonychus ulmi (Koch)
Twospotted spider mite eggs (TSME);
Tetranychus ulmi Koch
Zetzellia mali (ZM) (Ewing)
Zetzellia mali eggs (ZME) (Ewing)
Phytoseiidae spp. (Phyto)
Phytoseiidae spp. eggs (PhytoE)
Stethorus punctum larvae (SPL) (LeConte)
Stethorus punctum eggs (SPE) (LeConte)
Chrysopidae spp. eggs (CHE)
Chrysopidae spp. larvae (CHL)
Codling moth; Cydia pomonella (Linnaeus)
Redbanded leafroller (RBLR); Argyrotaenia velutinana (Walker)
Gypsy moth; Lymantria dispar (Linnaeus)
Tufted apple budmoth (TABM); Platynota idaeusalis (Walker)

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APPLE, MITICIDE EVALUATIONS, 1991: Treatments were applied to 16 year old Triple Red Delicious trees using single tree plots arranged in a randomized block design and replicated 4 times. Trees were sprayed to runoff using a Bean hydraulic sprayer operating at 400 psi. All plots were inoculated twice (29 May and 12 Jun) with mite infested water sprouts (10 per replicate) which were taped to existing foliage. Insecticides used during the season follow; fungicides, nutrient sprays, herbicides, etc. used are listed separately. All plots were oversprayed with Pounce 3.2EC, 814 kg/ha (7.5 lb/A) on 9 Apr and 10 May; Dipel 3.36 kg/ha (3 lb/A) 1 May; and Sevin 50W 3.36 kg/ha (3 lb/A) 25 Jul to reduce predator numbers in the mite plots. Morestan 25W, 28.38 g/189.25 l (1 oz/50 gal), was applied only once during the season [(2 Apr (pink spray)]. All other miticide plots were sprayed on 2 Jul. Populations of mites did not reach levels requiring treatment after 2 Jul. One hundred apples per replicate were picked at random at harvest time and graded on a scale from 0-5 for both stem end and side russetting where 0 = no russetting and 5 = completely russetted. These data were used to place each fruit in the appropriate USDA grade (extra fancy, fancy, No. 1, utility). Each fruit was also examined for injury by RBLR, TABM, CM and miscellaneous Lepidoptera (primarily gypsy moth). No significant differences between treatments or between treatments and the control were found.

Difficulty in attaining populations of ERM was experienced although Pounce and Sevin were applied to remove predators. Two inoculations of ERM were required to attain satisfactory mite levels. The Morestan 25W, 28.38 g/189.25 l (1 oz/50 gal) plot, (sprayed on low mite levels in the pink) had the highest TSM and ERME counts of any plot when the 10 Jul treatment count was recorded. These differences were not significant when statistically analyzed. By 10 Jul, three days after the treatments were applied, differences of means for TSM were significant, but those for ERM, ERME, ZM, and ZME were not. In the 10 Jul TSM data, all treatments were statistically superior to the control. The high rate (91 ml) of AC801757-20 and Exp. Cpd. 1 (90.72 g) + .95 l 60 sec. oil were the more efficacious. One week after treatment, 16 Jul, similar results were obtained for TSM, but differences for ERM and ERME were now significant. All treatments except Kelthane 50W (453.6 g) + Triton QS-44M (88.72 ml) and Omite 30W (453.6 g) gave better control of ERM than the control. The high rate of AC801757-20 and Exp. Cpd. 1 (90.72 g + oil) were the more effective on ERM. However, ERME numbers had begun to increase by 16 Jul, the fewest being found where Exp. Cpd. 1 (90.72 g) and Kelthane 50W + Triton QS-44M had been applied. Statistical differences between treatment means are shown for TSM, TSME, ERE and ZM on 23 Jul; TSM, TSME and ERM on 31 Jul; TSM, TSME and ERM on 6 Aug; and TSM on 13 Aug. Predator numbers were kept low by the two Pounce applications and a Sevin spray applied for this purpose. Even so, statistical differences were found between the control and Morestan plots and all the rest of the treatments on both sampling dates 9 Jul and 17 Jul.

MITICIDE EVALUATION NOTES - 1991

Date	Treatment	Materials	Rate	Water pH
3/26	Sprayed miticide block	Manzate 200 + Rubigan	3 qt + 9 oz/A	
4/2	Sprayed plot #10	Morestan 25W	1 oz/50 gal water	6.6
4/3	Sprayed whole block	Swat	4 oz/100 gal	6.6
4/9	Sprayed RD (10% bloom)	Pounce 3.2EC + Rubigan + Manzate DF	7.5 oz + 9 oz + 3.25 lb/A	6.6
4/16	Sprayed RD	Rubigan + Manzate + Streptomycin	9 oz + 3.25 lb + 28 oz/A	6.8
4/17	Applied herbicide under trees	Paraquat + Karmex + Sinbar	4.5 pt + 3 lb + 8 oz + X-77/100 gal	7.5
4/24	Sprayed RD	Nova 40W + Captan	5 oz + 3.2 oz/A	
5/1	Sprayed RD	Dipel + Streptomycin	3 lb + 32 oz/A	7.3
5/10	Sprayed RD (thinning)	NAA 800 + Regulaid + Pounce + Nova + Captan	28.37 ml + 1 pt + 7.5 oz + 5 oz + 3.25 lb/A	
5/15	Sprayed RD	Boron	4 lb/A	
5/20	Some leaf burning - possibly the captan or thinner (no mites found).			
5/22	Sprayed RD	Nova + Captan + CaCl	5 oz + 3.25 lb + 6 lb/A	
5/29	Miticide plot trees inoculated with 10 mite infested shoots per tree. Collected from Moore and Dorsey Orchard, Berryville, VA and taped onto trees.			
6/5	Sprayed RD	Captan 50W + Nova + CaCl + Guthion 50W	3.25 lb + 5 oz + 6 lb + 1.5 lb/A	
6/12	Inoculated mite plots with 10 infested shoots per tree. Shoots from Point of View Orchard, Marshall, VA.			
6/24	Sprayed RD	Guthion 50W + Topsin + Ziram + CaCl	1.5 lb + 8 oz + 6.5 lb + 6 lb/A	
7/2	Mite plots sprayed as scheduled (Morestan not applied).			
7/26	Sprayed RD	CaCl + Thiram + Benlate + Sevin	6 lb + 3 lb + 8 oz + 3 lb/A	
7/31	Made mite count to determine levels, treatments not required.			
8/14	Sprayed RD (one side)	CaCl + Thiram + Benlate + Sevin	6 lb + 3 lb + 8 oz + 3 lb/A	

MITICIDE EVALUATIONS - 1991[1]
Mites and predators/leaf

Trt and materials per 189.25 l	1 July (pre-trt)[2,3] TSM (ns)	ERM (ns)	ERME (ns)	10 July (3 days post-trt)[2,3] TSM	ERM (ns)	ERME (ns)	ZM (ns)	ZME (ns)	16 July (7 days post-trt)[2,3] TSM	ERM	ERME	ZM (ns)	ZME (ns)
1 AC801757 20EC 44 ml	4.66	13.09	45.88	0.47 bc	1.89	63.57	0.06	2.09	0.63 b	0.56 c	23.26 abc	0.09	0.35
2 AC801757 20EC 71 ml	2.48	15.03	52.21	0.39 bc	2.83	30.84	0.00	0.46	0.14 b	0.30 c	34.00 ab	0.00	0.24
3 AC801757 20EC 91 ml	1.24	18.68	57.48	0.13 c	0.34	52.21	0.05	0.10	0.65 b	0.42 c	48.10 a	0.00	0.41
4 Omite 30WP 453.6 g	1.91	9.84	34.16	0.80 bc	4.62	40.50	0.08	0.13	1.13 b	1.35 bc	13.79 abc	0.27	0.59
5 Exp Cpd 1 56.79 g	1.90	9.86	31.81	0.32 bc	2.43	22.17	0.00	0.00	0.85 b	0.66 c	9.91 bc	0.05	0.24
6 Exp Cpd 1 90.72 g	2.47	9.62	25.24	0.76 bc	0.87	26.35	0.16	0.57	0.65 b	0.15 c	5.40 c	0.00	0.05
7 Exp Cpd 1 137.08 g	6.69	15.87	49.35	0.41 bc	2.30	42.75	0.00	0.04	0.82 b	1.56 bc	23.77 abc	0.05	0.28
8 Exp Cpd 1 56.79 g + .95 l oil	1.62	11.71	36.76	1.03 bc	1.67	33.28	0.21	0.99	0.65 b	1.06 bc	20.87 abc	0.10	0.36
9 Exp Cpd 1 90.72 g + .95 l oil	1.99	7.57	28.31	0.18 c	7.20	9.40	0.48	0.81	0.10 b	0.30 c	8.44 bc	0.00	0.09
10 Morestan 25W 28.35 g (pink only)	1.79	12.40	37.64	1.55 ab	6.84	42.85	0.07	0.38	11.27 a	4.60 a	11.64 bc	0.00	0.00
11 Kelthane 50W 453.6 g + Triton AS-44M 255.15 g	1.45	10.51	56.94	0.61 bc	2.42	32.96	0.00	0.16	0.55 b	1.11 bc	7.32 c	0.12	0.00
12 Control	5.18	17.45	76.63	3.23 a	6.24	34.81	0.44	0.27	8.77 a	3.33 ab	8.79 bc	0.00	0.00

[1]All values are per leaf.

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

[3]Data transformed to log (X + 1) for analysis. Data back transformed to arithmetic means for tables.

Legend: TSM = two spotted spider mite; TSME = two spotted spider mite eggs; ERM = European red mite; ZM = *Zetzellia mali*; Phyto = *Phytoseiidae* spp. mites; PhytoE = *Phytoseiidae* spp. eggs; SPE = *Stethorus punctum* eggs

MITICIDE EVALUATIONS - 1991[1]
Mites and predators/leaf

Trt and materials per 189.25 l	23 July (14 days post-treatment)[2,3] TSM	TSME	ERM	ERME (ns)	SPE (ns)	ZM (ns)	ZME	31 July (22 days post treatment)[2,3] TSM	TSME	ERM	ERME (ns)	ZM (ns)	ZME (ns)	Phyto (ns)
1 AC801757 20EC 44 ml	0.96 bc	1.76 a-d	0.27 c	7.30	0.05	0.22	0.22 b	0.76 bcd	1.13 cd	0.05 c	2.22	0.00	0.00	0.00
2 AC801757 20EC 71 ml	0.21 c	0.44 cd	0.00 c	9.33	0.00	0.05	0.00 b	0.10 d	0.36 cd	0.05 c	1.04	0.05	0.12	0.00
3 AC801757 20EC 91 ml	0.00 c	0.14 d	0.05 c	8.38	0.00	0.00	0.00 b	0.30 cd	0.30 cd	0.14 c	3.22	0.00	0.00	0.00
4 Omite 30WP 453.6 g	0.48 c	0.42 cd	0.58 bc	4.40	0.00	0.10	0.18 b	1.04 bcd	0.90 cd	0.50 bc	1.67	0.14	0.12	0.21
5 Exp Cpd 1 56.79 g	0.09 c	0.67 cd	0.38 c	1.75	0.00	0.00	0.05 b	0.73 bcd	1.08 cd	0.05 c	1.66	0.00	0.00	0.09
6 Exp Cpd 1 90.72 g	0.66 c	0.59 cd	0.09 c	2.85	0.00	0.00	0.09 b	2.57 b	2.21 cd	0.09 c	0.61	0.00	0.09	0.22
7 Exp Cpd 1 137.08 g	1.11 bc	1.06 bcd	0.22 c	3.52	0.00	0.00	0.00 b	1.09 bcd	0.82 cd	0.19 bc	2.21	0.00	0.00	0.05
8 Exp Cpd 1 56.79 g + .95 l oil	0.87 bc	2.27 abc	0.62 bc	5.50	0.00	0.09	0.05 b	1.76 bc	2.38 bc	0.43 bc	1.31	0.18	0.00	0.05
9 Exp Cpd 1 90.72 g + .95 l oil	0.28 c	0.77 bcd	0.10 c	2.83	0.00	0.00	0.00 b	0.93 bcd	0.67 cd	0.24 bc	0.78	0.00	0.09	0.00
10 Morestan 25W 28.35 g (pink only)	3.36 ab	5.30 a	2.80 a	8.62	0.05	0.52	0.71 a	6.91 a	5.78 ab	2.02 a	2.61	0.12	0.33	0.24
11 Kelthane 50W 453.6 g + Triton AS-44M 255.15 g	0.00 c	0.18 cd	0.51 c	4.61	0.00	0.00	0.00 b	0.24 d	0.21 d	0.36 bc	1.76	0.05	0.00	0.00
12 Control	3.94 a	3.68 ab	1.54 ab	5.00	0.09	0.00	0.73 a	9.00 a	12.87 a	1.07 ab	1.07	0.00	0.14	0.00

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[3]Data transformed to log (X + 1) for analysis. Data back transformed to arithmetic means for tables.

Legend: TSM = two spotted spider mite; TSME = two spotted spider mite eggs; ERM = European red mite; ZM = *Zetzellia mali*; Phyto = *Phytoseiidae* spp. mites; PhytoE = *Phytoseiidae* spp. eggs; SPE = *Stethorus punctum* eggs.

MITICIDE EVALUATIONS - 1991[1]
Mites and predators/leaf

Trt and materials per 189.25 l	6 August (28 days post-treatment)[2,3] TSM	TSME	ERM	ERME (ns)	SPE (ns)	ZM (ns)	13 August (35 days post-treatment)[2,3] TSM	TSME (ns)	ERM (ns)	ERME (ns)	ZM (ns)	Phyto (ns)	PhytoE (ns)
1 AC801757 20EC 44 ml	0.40 cd	0.99 cd	0.09 c	0.79	0.00	0.00	1.32 ab	1.03	0.23	1.20	0.10	0.05	0.30
2 AC801757 20EC 71 ml	0.05 d	0.32 d	0.09 c	1.96	0.00	0.05	0.16 bc	1.36	0.10	0.92	0.00	0.00	0.05
3 AC801757 20EC 91 ml	0.09 d	0.05 d	0.10 c	1.96	0.00	0.00	0.10 c	0.95	0.21	1.55	0.00	0.00	0.00
4 Omite 30WP 453.6 g	0.55 cd	1.12 cd	0.83 a	2.50	0.05	0.05	0.40 abc	0.85	0.13	0.48	0.00	0.00	0.00
5 Exp Cpd 1 56.79 g	0.71 cd	0.71 cd	0.19 c	0.57	0.00	0.00	0.62 abc	2.18	0.25	1.40	0.00	0.00	0.17
6 Exp Cpd 1 90.72 g	0.47 cd	0.72 cd	0.05 c	0.18	0.00	0.00	0.44 abc	1.49	0.16	1.03	0.10	0.00	0.00
7 Exp Cpd 1 137.08 g	0.57 cd	1.19 cd	0.27 bc	1.31	0.00	0.00	0.14 bc	1.12	0.63	0.76	0.00	0.05	0.09
8 Exp Cpd 1 56.79 g + .95 l oil	1.36 bc	2.07 bc	0.97 a	3.80	0.09	0.00	1.76 a	0.85	0.40	1.52	0.00	0.00	0.25
9 Exp Cpd 1 90.72 g + .95 l oil	0.62 cd	0.97 cd	0.24 c	1.32	0.00	0.00	0.93 abc	0.84	0.40	1.16	0.00	0.00	0.00
10 Morestan 25W 28.35 g (pink only)	3.18 ab	5.12 ab	1.03 a	1.67	0.00	0.00	1.34 ab	3.15	0.82	1.38	0.10	0.22	0.46
11 Kelthane 50W 453.6 g + Triton AS-44M 255.15 g	0.09 d	0.41 cd	0.50 ab	1.77	0.00	0.00	0.10 c	1.25	0.16	0.77	0.00	0.00	0.05
12 Control	4.69 a	5.61 a	0.79 ab	1.96	0.00	0.09	1.64 a	1.56	0.42	0.88	0.13	0.05	0.09

[1]All values are per leaf.

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

[3]Data transformed to log (X + 1) for analysis. Data back transformed to arithmetic means for tables.

Legend: TSM = two spotted spider mite; TSME = two spotted spider mite eggs; ERM = European red mite; ZM = *Zetzellia mali*; Phyto = *Phytoseiidae* spp. mites; PhytoE = *Phytoseiidae* spp. eggs; SPE = *Stethorus punctum* eggs.

MITICIDE EVALUATIONS - 1991[1]
Predators per leaf

Trt and materials per 189.25 l	9 Jul[2] SPA	SPL (ns)	SPP (ns)	CHA (ns)	CHE (ns)	CHL (ns)	17 Jul[2] SPA	SPL (ns)	CHL (ns)	CHE (ns)
1 AC801757 20EC 44 ml	0.25 c	1.25	1.50	0.00	1.25	0.00	0.00 b	0.00	0.00	1.75
2 AC801757 20EC 71 ml	0.00 c	0.00	3.25	0.00	0.00	0.00	1.25 ab	0.00	0.75	4.00
3 AC801757 20EC 91 ml	0.50 c	0.25	1.75	0.25	1.75	0.00	0.00 b	0.00	0.25	2.75
4 Omite 30WP 453.6 g	1.75 c	2.00	0.75	0.00	0.75	0.00	0.25 b	0.00	0.25	2.50
5 Exp Cpd 1 56.79 g	0.25 c	0.00	0.00	0.00	0.50	0.00	0.05 b	0.00	0.50	2.50
6 Exp Cpd 1 90.72 g	0.00 c	0.75	2.75	0.00	0.25	0.00	0.25 b	0.00	0.75	4.00
7 Exp Cpd 1 137.08 g	0.00 c	0.25	0.75	0.00	0.00	0.00	0.75 b	0.00	0.00	1.25
8 Exp Cpd 1 56.7 g + .95 l oil	1.25 c	1.75	2.25	0.00	0.00	0.00	0.75 b	0.00	0.00	4.00
9 Exp Cpd 1 90.72 g + .95 l oil	1.00 c	0.50	2.00	0.00	0.00	0.00	0.50 b	0.00	0.25	7.25
10 Morestan 25W 28.35 g (pink only)	3.75 ab	8.00	1.50	0.00	1.00	0.00	5.75 a	4.50	0.75	3.50
11 Kelthane 50W 453.6 g + Triton AS-44M 255.15 g	0.75 c	4.00	0.50	0.00	0.00	0.00	0.50 b	0.00	0.50	2.00
12 Control	6.75 a	2.00	1.75	0.00	0.00	0.00	4.50 a	2.75	0.50	3.00

[1]Data transformed to X + .5 for analysis. Data back transformed to arithmetic means for tables.

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

Legend: SPA = Stethorus punctum adults; SPL = Stethorus punctum larvae;
SPP = Stethorus punctum pupae; CHA = Chrysopidae spp. adults;
CHE = Chrysopidae spp.; CHL = Chrysopidae spp. larvae

MITICIDE EVALUATIONS - 1991

Fruit finish and % fruit in USDA grades

(100 fruit/replicate)

Trt and materials per 189.25 l (50 gal)	% Extra Fancy (ns)	% Fancy (ns)	% No. 1 (ns)	% Utility (ns)
AC801757 20EC 44 ml	0.62	0.35	0.03	0.00
AC801757 20EC 71 ml	0.30	0.59	0.11	0.00
AC801757 20EC 91 ml	0.47	0.47	0.07	0.00
Omite 30WP 453.6 g	0.60	0.26	0.10	0.04
Exp Cpd 1 56.79 g	0.49	0.41	0.10	0.00
Exp Cpd 1 90.72 g	0.59	0.38	0.03	0.00
Exp Cpd 1 137.08 g	0.76	0.22	0.02	0.00
Exp Cpd 1 56.7 g + .95 l oil	0.51	0.47	0.02	0.00
Exp Cpd 1 90.72 g + .95 l oil	0.72	0.27	0.02	0.00
Morestan 25W 28.35 g (pink only)	0.76	0.20	0.02	0.01
Kelthane 50W 453.6 g + Triton AS-44M 255.15 g	0.48	0.37	0.08	0.07
Control	0.51	0.42	0.06	0.01

N.S. = no significant differences (P = .05, DMRT).

MITICIDE EVALUATIONS - 1991

Insect injuries per 100 apples/replicate

Trt and materials per 189.25 l (50 gal)	RBLR (ns)	TABM (ns)	CM (ns)	LEP (ns)
AC801757 20EC 44 ml	1.00	1.00	0.25	0.75
AC801757 20EC 71 ml	1.00	2.00	0.00	0.50
AC801757 20EC 91 ml	1.50	1.50	0.50	0.75
Omite 30WP 453.6 g	1.50	1.50	0.00	0.00
Exp Cpd 1 56.79 g	1.50	1.50	0.00	0.25
Exp Cpd 1 90.72 g	1.00	0.75	0.50	2.75
Exp Cpd 1 137.08 g	1.00	0.50	0.00	0.25
Exp Cpd 1 56.7 g + .95 l oil	0.50	0.00	0.00	1.50
Exp Cpd 1 90.72 g + .95 l oil	0.75	1.25	0.00	1.75
Morestan 25W 28.35 g (pink only)	2.25	0.75	0.00	0.00
Kelthane 50W 453.6 g + Triton AS-44M 255.15 g	0.75	1.00	0.25	1.75
Control	0.75	0.25	0.00	0.75

N.S. = no significant differences (P = .05, DMRT).

APPLE: *Malus domestica* Borkh
Redbanded leafroller (RBLR);
Argyrotaenia velutinana (Walker)

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APPLE; LABORATORY EVALUATION OF PENNCAP M FOR CONTROL OF LARVAE OF RBLR, 1991: Redbanded leafroller (RBLR) larvae caused serious damage to fruit in Frederick County, Virginia, in 1990. In one orchard where Penncap M had been used for several years (including 1990) the problem was particularly severe and larvae from eggs laid by the overwintering generation was very abundant in the spring of 1991. The efficacy of the insecticide against RBLR larvae in this orchard was questioned. Consequently, two laboratory toxicity studies were conducted. Exp. 1 was designed to evaluate the relative toxicities of several pesticides currently recommended including Penncap M for control of RBLR. Exp. 2 was performed to determine an effective dosage of pesticide for grower use.

In both experiments, terminal apple shoots bearing 5 live RBLR larvae were dipped in the appropriate toxicant solutions which had been mixed in 1 gal battery jars. There were 4 replicates of each treatment and a control. After dipping, the basal portion of the shoot was passed through a fine meshed nylon screen into water in the bottom of a styrofoam cup. The screen was taped so as to seal it to the top of the cup and served to prevent larvae from entering the water. Each cup and the shoot bearing all 5 larvae from each replicate was then placed in a clean glass battery jar. The top of the jar was covered with fine nylon netting, held in place with a rubber band and held at 80 F in a lighted room. Larvae were examined after 24 and 48 hours had elapsed and categorized as live or dead. Death was determined by the lack of any movement when the larva was probed gently with a blunt steel probe. Analysis of the data in Exp. 1 indicated that Penncap M at either rate was not statistically better than the check. Guthion 35W, 294.84 g/378.5 l (10.4 oz/100 gal) + methomyl (Lannate), .47 l/378.5 l (1 pt/100 gal) was excellent but was not statistically better than Lorsban 50W, .68 kg (1.5 lb) or methomyl .47 l (1 pt/100 gal). Exp. 2 revealed that after 24 hours Lorsban 50W at any of the 3 rates tested and Guthion 50W + methomyl at both rates tested were better than Penncap 170 g (16 oz), Imidan 170 g (16 oz), or methomyl 85 g (8 oz) per 378.5 l (100 gal). After 48 hours, all the materials and rates were statistically superior to the control except Penncap 170 g/378.5 l (16 oz/100 gal) which was equal. Imidan 50W, 170 g (16 oz) was more effective than Penncap, but less efficacious than the other materials in the experiment.

REDBANDED LEAFROLLER-LARVAL TOXICITY STUDY
1991

EXPERIMENT 1 (21 May 1991)

Treatments and rates per 378.5 l (100 gal)	Average no. live/rep[1,2] 24 hrs post-treatment	Average no. live/rep[1,2] 48 hrs post-treatment
Penncap M .47 l (1.0 pt)	3.75 ab	3.75 ab
Penncap M .94 l (2.0 pt)	4.75 ab	4.75 ab
Guthion 35W 294.84 g (10.4 oz)	3.50 b	3.25 b
Guthion 35W 589.68 g (20.8 oz)	1.75 c	1.25 c
Guthion 35W 294.84 g (10.4 oz) + methomyl (Lannate) .47 l (1.0 pt)	0.00 d	0.00 c
Penncap M .47 l (1.0 pt) + methomyl (Lannate) .47 l (1.0 pt)	1.50 c	0.75 c
Lorsban WP 680.40 g (1.5 lb)	0.75 cd	0.00 c
Methomyl .47 l (1.0 pt)	0.75 cd	0.75 c
Control (water)	5.00 a	5.00 a

EXPERIMENT 2 (28 May 1991)

Treatments and rates per 378.5 l (100 gal)	Average no. live/rep[1,2] 24 hrs post-treatment	Average no live/rep[1,2] 48 hrs post-treatment
Lorsban 50W .68 kg (1.5 lb)	0.00 c	0.00 c
Lorsban 50W .45 kg (1.0 lb)	0.50 c	0.00 c
Lorsban 50W .28 kg (0.5 lb)	0.50 c	0.00 c
Guthion 35W 152.79 ml (5.2 oz) + methomyl 236.59 ml (8.0 oz)	0.75 c	0.25 c
Guthion 35W 305.58 ml (10.4 oz) + methomyl 473.18 ml (16.0 oz)	0.00 c	0.00 c
Penncap M 473.18 ml (16.0 oz)	5.00 a	5.00 a
Methomyl 236.59 ml (8.0 oz)	2.25 b	0.25 c
Imidan 50W 453.6 g (16.0 oz)	4.75 a	3.00 b
Control (water)	5.00 a	5.00 a

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

APPLE: _Malus domestica_ Borkhauser
'Ace Red Delicious'
White apple leafhopper (WALH);
Typhlocyba pomaria McAtee
Rose leafhopper (RLH);
Edwardsinia rosae Beam

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APPLE, EVALUATION OF CYGON 400 (DIMETHOATE) AND CARZOL 92SP (FORMETANATE HYDROCHLORIDE) FOR CONTROL OF WHITE APPLE LEAFHOPPER IN VIRGINIA. Some fruit growers in Virginia experienced difficulty in controlling leafhoppers on apple in recent years. Mixed populations of WALH and RLH are sometimes present and it was our objective to determine efficacy of two insecticides and find out if different timing of application or if different toxicants would be required to control each leafhopper species. Unfortunately, no RLH were found in the test orchard during the experiment. Treatments were applied to runoff with a Bean hydraulic sprayer operating at 400 psi on 8 May. The test trees were 4 year old Ace Red Delicious. Treatment plots (single trees) were arranged in a randomized block design. Each treatment and the control was replicated 4 times. The total number of live leafhoppers on 20 leaves from each replicate was determined on 9 May and the mean calculated. These means were statistically analyzed and significance of differences determined. Both Carzol and Cygon provided excellent and significant control of first generation WALH in this experiment.

Number of live WALH/replicate (24 hours post-treatment)

Treatment	Rate/100 gal (378.5 l)	WALH
Control (water)	--	12.5 a
Carzol 92SP	8.0 oz (226.8 g)	0.0 b
Cygon	8.0 oz (226.8 g)	0.0 b

Numbers in the same column followed by the same letter are not significantly different, (P = .05, DMRT).

HISTORY OF THE FIRST 50 YEARS OF THE

CUMBERLAND-SHENANDOAH FRUIT WORKERS' CONFERENCE

Compiled and edited from the minutes of the meetings by John H. Thomas, Virginia Gruver, Clarence H. Hill and with consultation by Walter S. Hough.

FIRST MEETING

The first meeting was held in Winchester on July 20, 1925. This was a conference of station workers concerned with problems of the fruit industry of the Shenandoah-Cumberland valleys, comprising the states of Virginia, West Virginia, Maryland, and Pennsylvania.

At this meeting the chairman, H. G. Knight, Director of the West Virginia Experiment Station in Morgantown, West Virginia, explained that the purpose of the conference was to consider the feasibility of closer cooperation between station workers who deal with problems of the fruit industry in the Shenandoah-Cumberland region. The similarity of the problems in the four states concerned indicated that the stations in the region could better serve fruit growers by suitable correlation of experimental undertakings and by effective cooperation.

In the afternoon of that first conference the members resolved into groups of horticulturists, entomologists, and plant pathologists, with the understanding that the groups would report back to the conference at the night session.

The horticultural group reported the need to make a survey of the condition of the apple industry in the region and to make necessary readjustments to meet the competition more effectively. This group also planned a project to improve apple rootstocks by striving for uniformity in influence on scion, resistance to disease and insect attack.

The plant pathologists agreed with the horticulturists that improvement of rootstocks was necessary. It was also decided that a study of apple spray programs and spray services of the different states should be made to determine the points of agreement and disagreement. From this study the reasons for disagreement would be understood and a correlation of recommendations attempted.

The entomologists indicated that if no other benefit was gained, the mere meeting and exchange of ideas was well worth the conference. The need for future meetings to be held on a date near the first of December was expressed. At such meetings recommendations to be incorporated in the spray circulars and extension programs would be agreed upon to prevent discrepancies due to state lines. At this first conference five committees were established. These included a committee on rootstocks, committee on the economics of orcharding, committee on uniform spray service, committee on correlation of current research projects, and a committee to study the apple rosy aphid problem.

It was decided that the time for the next meeting of the conference should be determined by the chairman, who would issue a call for the meeting as circumstances made it desirable. On motion the historic first Shenandoah-Cumberland Conference was adjourned.

*On December 11, **1925** the committees on uniform spray service and correlation of current research projects, and the committee to study the apple rosy aphid problem met at the Berkeley Hotel in Martinsburg, West Virginia. At this meeting apple and peach spray schedules were prepared. The apple schedule of sprays consisted of a delayed dormant, pre-bloom, petal fall, and the three covers. The peach sprays were dormant, petal fall, shuck, and three covers. No minutes were recorded at this meeting though it is known that G. R. Lyman, Dean of Agriculture at Morgantown, West Virginia was chairman, and E. C. Sherwood, extension pathologist in West Virginia was the secretary. This meeting is considered the second official Shenandoah-Cumberland Conference.*

The early meetings of the conference usually involved reports of the activities of the standing committees and plans for the future. During this era, the Aphid Committee was renamed the Entomologists Committee, and then the Insect and Disease Committee was formed out of the Entomologists, Plant Pathologists, and Uniform Spray Service Committees. During these formative years the Horticulturists Committee continued to report on rootstocks and began a project to study the relationship between orchard soil fertility and production.

*At the sixth meeting on November 22, **1929** the following recommendations were made concerning orchard spraying:*

1. *Spraying is the best means for controlling orchard insects and diseases.*
2. *An orchard should be so equipped with spray facilities that the maximum time required to make one application should not exceed four to six days.*
3. *The minimum size spray machine for orchard work should have a six to eight horsepower engine, and a pump capacity of 15 to 17 gallons/minute.*
4. *Rods are preferable to guns under conditions existing in Maryland, West Virginia, and Virginia.*

There is no hint of the Depression in the minutes of the conference during the early 1930's. The different committees had become well established and were attacking different problems from a variety of angles.

Sod rotation was advocated by the horticulturists for improving orchard organic matter. Cover crops of milletts with sweet clover, or field corn with soybeans, or rye and vetch were recommended to be planted in cultivated orchards.

*The committee on economics was studying factors of farm organization, operation and marketing that affect profits on farms producing apples. At the eighth, or November 23, **1931**, meeting it was stated that the average grower did not have his labor, power, and equipment organized and controlled so that he could perform the various jobs at reasonable expense and yet intelligently, thoroughly and effectively. (We certainly have moved away from this situation, haven't we?)*

The Insect and Disease Control Committee was busy consolidating spray recommendations. The eighth meeting was the first where experimental results were recorded. This was a comparison of material for control of scab and leaf spot.

At this conference a motion was made to have meetings permanently scheduled at Winchester and amended by J. R. Magness of U. S. D. A. to the effect that the meeting be held in Winchester the next year, but future conferences were to be decided according to circumstances.

It was also suggested that the minutes of 1931 and future meetings be sent to a complete mailing list, made up from attendance records of all conferences. These minutes were recorded and distributed every year after this recommendation. The conferences through the rest of the 1930's were meetings of three major committees: Economics, Horticulture and Rootstocks (meeting as one), and Insect and Disease Control.

*The thirteenth meeting was held at the Shenandoah Hotel in Martinsburg, West Virginia on November 28, **1936**. At this meeting a motion was accepted to invite the states of Delaware and New Jersey to send representatives. The following year the New Jersey station expressed regrets at being unable to attend, and Dr. L. A. Stearns, representing the Delaware station attended the conference in 1937.*

*The conference held in **1938** marked the beginning of two-day meetings. The members assembled at the Hotel Anthony Wayne in Waynesboro, Pennsylvania on Friday night, November 25. Rates at the meeting were $1.25 for double rooms with running water to $2.50 for a single room with a bath.*

It was voted that the conference be limited to state and federal workers but that commercial men may be invited to attend upon the vote of the entire conference. The weight of opinion indicated a feeling that the presence of commercial representatives would act as a brake on the free discussion of the merits and demerits of various spray materials, and that an invitation would open the gates to salesmanship.

*By the **early 1940's** the conference had evolved a format similar to the current meeting. The sessions began to separate into two discussion groups; one as a committee on insects and diseases, and the other as a committee on horticulture and related subjects. The work of the different researchers was presented, a banquet was often held, and on the following day more papers were presented.*

The committee on Horticulture discussed rootstocks, tree removal, the status of mulching, potash fertilization, phosphorus applications, boron deficiencies, measles, and red color sports. The committee on Insects and Diseases concerned itself primarily with insecticides, fungicides and changes in spray recommendations.

*The eighteenth meeting on November 21-22, **1941**, was the first time the title "Cumberland-Shenandoah Fruit Workers' Conference" was used. It was an appropriate title because workers from the entire region were present. The states of West Virginia, Virginia, Pennsylvania, Maryland, New Jersey, Delaware, North Carolina, South Carolina and the federal government were all represented.*

*In **1942** there was no general meeting held due to war-time conditions. The 25 members of the Insect and Disease Committee met in Martinsburg, West Virginia. Dr. H. W. Thurston, Jr. of Pennsylvania was elected to act as chairman because H. N. Worthy, the previously elected chairman, was in the army. B. A. Porter and J. G. Leach spoke briefly concerning the work of the National War Emergency Committees for Entomology and Plant Pathology, and told the prospects of shortages of certain insecticides, fungicides and spray machinery.*

1945-1974

*The **mid 40's** saw the first commercial use of the speed sprayer. At this time, it was noted that under most conditions the speed sprayer seemed to be as effective as a high pressure rig. In mid 1940's some materials being tested included Elgetol for fruit thinning, naphthaleneacetic acid dust with a methylene glycol extender for stop-drop, Ferbam for diseases, and DDT for insects.*

*The **late 1940's** saw the discussion groups deviate from the planned attack of a regional problem to work on the specific problems confronting the researchers in the different areas. In 1947 the horticulturists discussed the outlook for the fruit industry, varieties, bud sports and breeding, growth regulators, fruit processing, nutrition, and the first recorded discussions of mouse control to prevent orchard decline.*

*Both the **1947** and **48** meetings were known as the twenty-fourth meeting of the conference. This was done to correct the chronological numbering with the number of years the members had been meeting together.*

*The twenty-fifth annual meeting was held November 25-26, **1949** at George Washington Hotel in Winchester. No recognition of the anniversary was recorded in the minutes of the conference. A major change was instituted in the Insect and Disease Committee. This was the first year the papers were presented by state rather than as a meandering discussion covering all topics of interest. The Horticulture session still covered the work on a problem by problem basis. One of the major concerns of the late 40's and early 50's was Stayman cracking.*

*In **1951** several individuals voiced an objection to the custom of holding the conference during the week-end following Thanksgiving Day. A motion was passed that the conference meet one or two weeks before the Thanksgiving week-end.*

*In **1953**, E. O. Hamstead of U.S.D.A. presented a motion in three parts and each part was considered separately. The first part dealt with the fact that not all of the states having delegates in attendance had full membership. The motion "that the U.S.D.A. and all states represented at the conference be officially recognized as members of the conference," passed unanimously. The second part of the motion was that the custom of having the four original states and the U.S.D.A. act in rotation as host be discontinued; however, it was voted not to discontinue the practice. The third part of Hamstead's motion was "that a permanent meeting place for the conference be adopted." After some discussion, it was pointed out that some years earlier, the members had voted to make Winchester, Virginia the permanent meeting place and that this action had never been rescinded. The motion to adopt a permanent meeting place was lost, and the chair interpreted this as rescinding the earlier vote to make Winchester, Virginia the permanent meeting place.*

*In **1955**, the meeting dates were changed from Friday-Saturday to Thursday-Friday. This change was recommended at the 1954 session and was approved by mail ballot of the members in January, 1955. It was done so more workers would be able to stay to the end of the conference.*

The workers from Delaware, North Carolina and New Jersey seemed unsure whether they were official members, so the suggestion was made and they were officially elected to membership and encouraged to attend the meetings. The conferences were held at the Alexander Hotel in Hagerstown, Maryland for the remainder of the 1950's. The 1950's closed with the members approving the election of a custodian of records whose duties included; maintenance of a current mailing list of members, maintenance of a complete file of the Proceedings, maintenance of a file of the By-laws and motions passed in general sessions. The office was to be held for 5 years duration.

*The thirty-seventh (**1961**) meeting opened with suggestions for changes. A proposal was made to begin collecting fees from members to defray costs of the host group. This proposal was rejected. A proposal was made that a list of conference policies regarding the annual meeting should be drawn and published each year with the Proceedings. However, "in order to retain the informality and the ease with which meetings have been conducted in the past, it was decided to leave matters of policy largely up to the host group. It was felt that this is a refreshing change from the rules and regulations which govern most other groups in the society in which we live."*

*In **1963**, Fred Lewis, secretary for the Entomology-Plant Pathology section, lamented that a problem had developed in that the sessions were becoming more and more formal. It was stated "No easy solution to this is in sight." At this meeting the official dates were changed to one week before Thanksgiving. The conferences continued to be held at the Hotel Alexander in Hagerstown, Maryland.*

*In **1965** the conference moved to the Hotel Francis Scott Key in Frederick, Maryland because the Hotel Alexander had closed. In 1966 the conference moved back to Hagerstown and was held at the Alexandria Motor Inn. The management insisted upon a rental fee and a voluntary collection of $1.00 each was made. At this meeting a moment of silence was observed in respect for A. B. Groves, who expired that year, and had been keeping the permanent records for the conference since 1959.*

*In **1967** the conference moved once again, this time to the George Washington Hotel in Wichester. The conference developed financial difficulties in paying for the social hour and coffee breaks. There was a total deficit of 64 cents after two passes of the hat. It is not recorded who sacrificed the sum. The meetings for the remainder of the 1960's were held in Winchester.*

The topics of discussion during the 60's varied in the Horticultural section covering nutrition and irrigation, bitter pit, weed control, apple scald, chemical thinning, mouse and deer control and growing conditions. Starting in 1963 there was a noticeable increase in the number of papers concerned with small fruits (strawberries, raspberries, etc.).

The Entomology-Plant Pathology section concerned itself with strengthening existing spray programs with the use of Guthion, Sevin and lead arsenate for insect control, and Cyprex and Captan for disease control. During this period, chemical thinning and spray machines received close attention. Mites were focused on and numerous materials were tested for control ability.

*At the **1970** meeting the members welcomed the addition of South Carolina workers as official members of the conference. Apparently the supper party held at this meeting was less than satisfactory. The program committee apologized for the supper. Members were assured that the committee had nothing to do with the preparation of the food. It was suggested that another location be fournd, but the forty-seventh annual meeting was again held in Winchester on November 18-19, 1971.*

At this meeting the members were assessed a $2.00 registration fee. This was enough to cover the room use fee of the George Washington Hotel. Also, the offices of Pomology secretary and Entomology-Plant Pathology secretary were discontinued. It was decided that the section chairman could appoint an assistant if necessary. In 1973 there was a return to the election of a secretary for the two sections.

*On the 50th anniversary (**1974**) of the Cumberland-Shenandoah Fruit Workers' Conference the host was Virginia. The meeting was held in the same place as the original gathering. It is indeed a tribute to the many members, both past and present, that a united attack on the problems of the fruit industry of the region has been mounted and maintained for a half century by this loosely organized group of workers. In the words of the first general secretary, Dr. A. W. Drinkard, Jr., director of the Virginia Agricultural Experiment Station, "The expressed willingness of the workers to enter into cooperative relations forecasts the success which will come out of this movement."*