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Proceedings of the

CUMBERLAND-SHENANDOAH FRUIT WORKERS CONFERENCE 73RD ANNUAL MEETING

November 20 and 21, 1997
Winchester Holiday Inn
Winchester, Virginia

Conference Chair,
James F. Walgenbach
North Carolina State University
Mountain Horticultural Crops Research and Extension Center
Extension Entomologist

1997 AGENDA

73RD CUMBERLAND-SHENANDOAH FRUIT WORKERS CONFERENCE

THURSDAY MORNING, NOV. 20

8:30 Registration

9:00 Welcome and Call of States

9:30 General Session Part I: Food Quality Protection Act

Overview of the 1996 Food Quality Protection Act. Paul Lewis, EPA. Washington, D.C.

The 1996 Food Quality Protection Act From the Pesticide Registrant Perspective. Beth Carroll, Novartis Crop Protection. Greensboro, NC.

10:45 Break

11:00 General Session Part II: A Travel Guide of Fruit Production and Pest Management in Europe

Fruit Production in Central Europe: Poland, Hungary, Romania. Mark Brown, USDA Appalachian Fruit Research Station. Kearneysville, WV.

Pesticides and Pest Management in Ukraine. Doug Pfeiffer, VPI&SU. Blacksburg, VA.

Delivery of IPM Programs to Fruit Growers in Italy. Dean Polk, Rutgers Fruit Research and Extension Center. Cream Ridge, NJ.

12:00 Buffet Lunch

THURSDAY AFTERNOON, NOV. 20

1:00 Break-out Sessions: Horticulture, Plant Pathology, Entomology

FRIDAY MORNING, NOV. 21

8:30 Break-out Sessions: Horticulture, Plant Pathology, Entomology

10:30 Break

11:00 Summary and Business Meeting

12:00 Adjourn

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BREAKOUT SESSIONS

HORTICULTURE: **TITLE/AUTHOR(S)**

ENTOMOLOGY: TITLE/AUTHOR(S)

New Jersey State Report - 1997
Cumberland-Shenandoah Fruit Workers Conference

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Low temperatures April 4, 5, 10, and May 3 caused scattered peach flower damage and low temperatures during bloom caused widespread poor peach set. In many places fruit not pollinated failed to develop. Only one frost event occurred during apple bloom, which did little damage, but the cool wet bloom weather resulted in poor apple fruit set. Still, the year was not a complete wash out. New Jersey sold 65 million pounds of **apples**, slightly down from the 5 year average of 66 million pounds, and 68 million pounds of **peaches** putting 1997 about 20% less than 1996. Cool weather is blamed for russetted finish on nectarines. Following the cool spring was a 6-week drought through June into July, which put off fruit size further, and caused hardship for newly planted trees.

Disease: Stone fruit crop was lighter than normal and a lot of fruit were culled due to split pit and subsequent brown rot. Bacterial spot was severe in many locations and caught many growers by surprise. Dry weather provided false confidence that the disease would be light, but the inoculum level was high from the wet 1996 season. 20-30% bacterial spot infected fruit was common. Fusicoccum epidemic continues where severely infected blocks can have up to 20 - 40% of current shoots infected.

Insects: European apple sawfly was more prevalent in South Jersey than in previous years. Confirm was used against tufted apple budmoth in several orchards and "grower testimonials" indicated that they has considerably less TABM damage than in the past.

STATE REPORT FOR NORTH CAROLINA

The 1997 tree fruit crop in North Carolina was significantly reduced from freezing temperatures in April. March was very mild and the trees were progressing towards an earlier then average bloom. Peaches were the most adversely affected when they were subject to a freeze at approximately 3/8 -1/2 inch diameter state, which resulted in approximately a 50% crop state wide. A secondary problem in some areas was that peaches did not size well due to seed injury without the fruit abscising. The apple crop was also reduced approximately 30-40% due to the cold temperatures in April. In addition, cloudy, cool, wet weather followed bloom, during the cell division stage of development, which we speculate resulted in reduced fruit size at harvest. The greatest crop loss was to the earlier blooming varieties such as Red Delicious and Mutsu. However, there were also areas which had a very good crop and some of the newer varieties, Ginger Gold, Gold Rush, Pink Lady, HoneyCrisp, Gala, etc., seemed to come through the cold weather fairly well. There were no outstanding insect or disease problems, although codling moth damaged continued to increase in many areas.

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"Call of the States" - Pennsylvania

Above average temperatures in February and March pushed bud development. A freeze, with temperatures of 23 and 20°F on 9 and 10 April in Biglerville, killed king blossoms on Delicious, caused some losses in peach, and eliminated much of the pear crop. The season continued cooler and drier than normal. Rainfall from April through October was about 4 inches below normal, compared to 17 inches above normal in 1996.

Pressure from apple scab was light to moderate and from fireblight was light. Dry conditions lead to low incidence of sooty blotch and flyspeck and of summer rots.

European red mite populations were generally high. Agri-Mek applied more than a week after petal fall failed to give residual control. Pyramite was used extensively to control summer mite populations. Tufted apple bud moth caused low to moderate injury, although Confirm provided excellent control. Obliquebanded leafroller injury was severe in isolated cases in Adams County. Pear psylla was abundant in orchards on a limited spray program due to lack of crop.

Fruit finish was excellent. Fruit size was below normal due to poor thinning and drought conditions. Cool weather delayed ripening. Overall crop volume was average.

STATE REPORT FOR WEST VIRGINIA

Horticulture. The winter of 1996-'97 arrived early in November with below normal temperatures. Normal conditions through January 1997 were followed by mild conditions in February and March. Snowfall was below normal and most precipitation occurred as rain. Warm temperatures in March advanced bud development, and some cultivars like 'Delicious', 'Empire', and 'Stayman' were near full bloom on April 10 when a hard freeze was recorded. Temperatures as low as -7°C (19°F) were reported the morning of April 10. Examination of fruit buds indicated a wide range of bud kill: 'Golden Delicious' - 12 to 52%; 'Gala' - 12%; 'Empire' - 87%; 'Delicious' - 90%; 'Fuji' - 55 to 93% and 'York' - 18 to 22%. The few sweet cherries in the region suffered a near 100% loss as they were in full bloom at the time of the freeze. Most apple varieties set a crop of fruit, and overall the area saw about a 40% reduction in the apple crop. Peach losses were related to variety and location. Near record cool conditions prevailed in April and May, and certainly affected fruit growth and ultimate size of apples. Goldens were one of the few varieties requiring thinning and they proved very easy to thin. The growing season was generally cool and very dry. Only 55 cm (21.7 in) of precipitation was recorded from January through October, compared to 131 cm (51.6 in) for the same period in 1996. Peach quality was good to excellent, but some nectarine varieties experienced an unusual high rate of skin cracking. The small size in apples was not aided by irrigation, and fruit cracking was observed in several varieties ('Fuji' and 'Gala'), in addition to the normal cracking of 'Stayman' even where trees were regularly irrigated. Conditions appeared to favor pre-harvest fruit drop, but drop was generally considered light. Cool temperatures in August aided color development in most varieties, however, 'Jonagold' exhibited very poor color even when allowed to hang until mid-October. Except for the latest varieties like 'Granny Smith', fruit generally matured about seven days later than normal.

Plant Pathology. Eight primary Mills infection periods occurred during the period from 23 March through 30 May. Conidia of the apple scab fungus were first observed in late April. Ten additional infection periods favorable for continued disease development occurred from 1 June through 30 August, with 4 infection periods in June, 5 in July, and 1 in August. Total precipitation in April, May, June, July, and August was 1.3, 1.3, 1.9, 3.5, and 2.6 inches, respectively, and was well below normal. Incidence of primary scab was moderate in experimental plots (about half of that observed in 1996), and secondary scab development was also light to moderate, with only intermittant rains and moderate temperatures during the summer. Overwintering cedar-apple rust inoculum generally was light to moderate, although five infection periods from mid-May through mid-June were favorable for infection. Rust infection of foliage was moderate in some unprotected orchards. The long bloom period of the 1997 season was relatively cool. We recorded four fire blight infection periods (5/1, 5/3, 5/18, and 5/19, with two additional infection periods on extremely late blossoms on 5/24 and 5/25). First symptoms of fire blight were observed on 19 May. Growers who made one well-timed streptomycin application to protect against the early May infections were generally free of the disease in 1997. Summer disease pressure was low to moderate in commercial orchards, due to generally fewer opportunities for infection (relative to 1995 and 1996); however, incidences of sooty blotch, flyspeck, and summer rot diseases, although delayed in their appearance, were moderate to high in research plots.

Entomology. On peaches, green peach aphid was quite abundant in many orchards during mid to late May. The population of lesser peachtree borer was comparable to 1996, but peachtree borer and Oriental fruit moth were lower. Emergence of peachtree borer and first generation of lesser peachtree borer was approximately three to four weeks later than in 1996. Populations of catfacing insects and their injury appeared to be about average. Japanese beetle was more abundant than in 1996. On apples, a few problems were encountered with rosy apple aphid, but generally this insect was not very troublesome. The period of spirea aphid abundance was shorter than last year, probably aided by the drought which caused terminal growth to harden off sooner. Predation from ladybird beetles, especially the Multicolored Asian Ladybeetle, also helped to suppress aphid populations. Woolly apple aphid was more abundant, whereas leafhoppers and leafminers were less abundant than last year. Conditions were quite favorable for both European red mite and apple rust mite. Pheromone trap counts of tufted apple bud moth were comparable to last year, however, fruit injury was less. A few cases of internal worms in fruit at harvest occurred, with one sample identified as Oriental fruit moth and the remainder codling moth.

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(Not for publication or distribution)

The Influence of Hydrophobic Particle Sprays on Insect, Disease, Photosynthesis, Fruit Thinning, Fruit Quality, and Pre-harvest Fruit Drop of 'Rome' Apples

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Introduction

Mineral particles are widely used as carriers in the formulation of pesticides. Mineral particles may be treated with coatings that produce highly hydophobic particles. Several years ago I had an objective of making fruit trees water repellent to inhibit fruit cracking and fruit russet from dew and rain . The primary problem at the time was that the product could not be immersed in water because of its hydrophobicity. In 1987, I used organic solvents such as methanol, ethanol, and acetone to make a sprayable suspensions. Airblast applications these particles in a 4:96 ethanol/water suspensions (4% organic solvent) with water were used in a 'Stayman' cracking experiment in 1988. Fruit cracking was reduced slightly but not very much. The failure of the coating was thought to be caused by poor retention in rains, since observations during the rains indicated that the particles tended to float. Further development was abandon due to the inability of getting a good attachment to the plant while maintaining hydrophobicity, technical problems with application of material with typical commercial airblast sprayers, and lack of funding and interest by the companies supplying materials.

Interest in these particles has been revived by D. M. Glenn, G. J. Puterka, T. vanderZwet, and C. Feldhake (1997) of the USDA, Kearneysville, WV. Effects on insect, disease, and tree physiology are now being studied extensively on many crops by the USDA and company representatives.

The objectives of the experiment reported here was 1) to compare a full season airblast applications of hydrophobic particles on 2) insect, 3) disease, 4) photosynthesis, 5) fruit thinning, 6) fruit quality, and 7) pre-harvest fruit drop of apple to a conventional protectant spray program and a non-sprayed control.

Materials and Methods

Experiment 1. In a 14-year-old 'Rome'/MM111 planting, eighteen nine-tree plots were selected and were blocked according to row and terrain 6 blocks for 3 treatments listed in Table 1. A non-sprayed control was compared to a conventional protectant Sulfur + Ziram program and hydrophobic particles (M-96-018). Specific information about spray application dates and chemical rates are reported in Table 1. All applications were made at 100 gal/acre.

Data on insect, disease, photosynthesis, fruit thinning, fruit quality, and pre-harvest fruit drop of apple are summarized in Table 1. Ten shoots were examined randomly for each of 12 sample dates from 29 Apr to 13 July. Specifically leaves were examined for Rosy aphids, Green aphids, Wooly aphids, Leaf hoppers, leafhopper damage, and leafminers. In addition, leaves were further examined for leafspots, apple rust lesions, powdery mildew, and apple scab on each of the 10 shoots. Twenty five leaves were taken from each tree and mechanically brushed on to a glass plate for counting all destructive mite species and their eggs for each of five dates from 15 July to 13 Aug. All species were combined and presented in Table 1.

At harvest, the number of fruit/cm2 cross sectional area limb were counted (limbs were selected prior the thinning the whole block with NAA when fruit were approximately 10 mm in fruit diameter), and crop load was visually estimated as a percentage of a full crop in Sept. (full crop=100%). A 10 fruit sample was taken 13 Oct for determining fruit diameter, firmness, SSC, and rated for starch and red color as previously described.

Photosynthesis (CO_2 mol/m^2/sec), transpiration, stomatal conductance were determined with a portable LiCor Infrared CO_2 analyzer. Chlorophyll levels were determined by % absorbance using a Spectometer 20. A 7 mm disk was taken from 10 randomly selected leaves and placed in 10 ml methanol for 24 hours in the dark at room temperature. Leaf area was determined using a Licor 3000 area meter.

A one bushel sample was taken from each tree, and the total number numbers of fruit per tree was estimated from the total weight (yield/tree) of fruit/tree harvested divided by the number of fruit in the bushel on 13 Oct. These fruit were also evaluated for insect damage and disease incidence.

A 50 leaf samples/tree was also taken for nutrient analysis.

<u>Experiment 2&3</u>. A 10 acre section in a block of 'Delicious'/seedling and 'Stayman'/seedling was sprayed by a grower with M-96-018 and an adjacent larger acreage was sprayed a conventional spray program. Ten trees of similar terrain and location in the block were chosen for monitoring insects, disease, and fruit quality for both cultivars/treatments. A one bushel sample was taken on 12 Sept. from each tree for observations regarding insect disease, and fruit quality for both cultivars

<u>Experiment 4.</u> In 1997, sixty six 'Golden Delicious'/M.27 apple trees were selected for uniform crop and were blocked according to row and terrain into six blocks for 11 treatments listed in each table (Tables 4). Specific information about chemical

rates are listed table 4. M-96-018 was applied alone (trt 5) or with or without three typical thinning combinations (Sevin+Ethrel; Sevin+Accel; or Sevin+NAA). Thinning treatments were applied either without (trts 2,3,4) M-96-018, tank mixed with M-96-018 (trts 6,7,8), or applied just after an application of M-96-018 (trts 9,10,11).

Results and Discussion

Experiment 1. M-96-018 gave no control of rosy or green aphids; but was equally effective as the conventional program for leafhopper numbers and damage, and leafminer damage control was as good as the conventional protectant program (Table 1A). Leafspots from various causes was increased by M-96-018 (Table 1B). Rust infections were increased by M-96-018 (Table 1B). Total mites and eggs were very low but the M-96-018 had fewer numbers than the control or the conventional (Table 1B).

NAA caused more fruit thinning of the conventional trees than the control or the M-96-018 trees (Table 1 C&D). For this reason fruit diameter was greater (Table 1 C&D). Yield/tree was increased by the M-96-018 and the single fruit weight was greater than the control which had less fruit per tree or per CSA (Table 1 D). Leaf condition also appeared to be better for the M-96-018 treatment and less fruit drop occurred (Table 1 D) than the with untreated control. However, the conventional treatment had a similar drop as the M-96018, and the leaves appeared to be in poorer condition.

Transpiration, stomatal conductance, chlorophyll, and leaf weight were greater for the M-96-018(Table 1 E). In addition, N, P, Ca were higher than either trt #1 or trt#2 (Table 1F). The zinc and sulfur levels were higher for trt #2 than trts 1&3 because Ziram and Sulfur were used as fungicides even though leaves were washed.

The M-96-018 gave some control of Brooks spot, Fly speck, but not of Scab, Rots, Sooty blotch, or Powdery mildew (Tables 1G). In addition, M-96-018 gave some control of Tufted apple bud Moth, Leaf roller, but levels of Plum curculio, codling moth, and scale were too low to determine differences (Tables 1H).

Experiment 2. Green aphids were lower on the M-96-018 treated 'Delicious' trees, but Wooly aphids, leafhoppers, leafhopper damage, and scab on leaves was higher (Table 2A). A sample of fruit near harvest indicated M-96-018 treated fruit had higher firmness, lower red color, higher russet, and scarf skin finish. From the one bushel sample fruit scab was increased and Tufted apple bud moth and bitter pit were increased in the M-96-018 treated fruit.

Experiment 3. Green aphids were lower on the M-96-018 treated 'Stayman' trees, but Wooly aphids, leafminer, leafspots, powdery mildew, and scab on leaves was higher (Table 3A). From the one bushel sample fruit scab brooks spot, sooty blotch, fly speck, russet and opalescence (scarf skin) were increased the M-96-018 treated fruit (Table 3A&B).

Experiment 4. Pre-treating or tank mixing M-96-018 with various thinner combinations (Sevin+Ethrel; Sevin+Accel; or Sevin+NAA) did not interfere with thinning of 'Golden Delicious'/M.27 trees. One would expect that if absorption of a growth regulator was required to obtain thinning, the application of a hydrophobic material just prior to the application of the growth regulator (trts 9,10,11) would inhibited thinning. It apparently did not.

Acknowledgements

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References

Glenn, D. M. G. J. Puterka, T. vanderZwet, C. Feldhake, and R. E. Byers. 1997. Hydorphobic particles—A new paradigm for pest control. Journal of Economic Entomology. (Submitted)

Table 1A. Effect of airblast sprays of M-96-018 on 'Law Rome' (1997).

No.	Treatment[z,y]	Rate/ 100 gal /acre	Rate	Sample date Apr 29	May 6	May 13	May 20	May 27	June 3	June 10	June 17	June 25	July 3	July 8	July 13
				Rosy aphids(number leaves infested / 10 shoots)											
1	No treatment			1.5 a[x]	2.3 a	2.8 a	12.5 a	22.3 a	45.3 a	16.0 a	0.0 a	1.3 a	0.0 a	0.0 a	0 a
2	Ziram 76DF	4 lbs	3 lbs/75 gal	0.6 a	2.2 a	2.4 a	30.4 a	10.0 a	17.0 a	2.2 b	0.8 a	0.0 a	0.0 a	0.0 a	0 a
	+ Microfine Sulfur	4 lbs	3 lbs/75 gal												
3	M-96-018	75 lbs	56.3 lbs	2.3 a	3.0 a	1.7 a	17.2 a	11.5 a	33.2 a	18.2 a	0.0 a	5.0 a	0.0 a	0.0 a	0 a
				Green aphids(number leaves infested / 10 shoots)											
1	No treatment			0.0 a	0.0 a	0.0 a	0.3 a	10.8 a	7.5 b	18.0 a	23.2 b	10.2 a	28.2 ab	23.2 b	2.8 b
2	Ziram 76DF	4 lbs	3 lbs/75 gal	0.0 a	0.0 a	0.0 a	1.6 a	4.2 a	6.2 b	3.0 b	39.2 a	0.6 b	35.2 a	39.2 a	12.6 a
	+ Microfine Sulfur	4 lbs	3 lbs/75 gal												
3	M-96-018	75 lbs	56.3 lbs	0.0 a	0.8 a	0.0 a	0.3 a	5.7 a	16.5 a	15.3 a	12.0 b	11.2 a	10.7 b	12.0 b	6.7 ab
				Wooly aphids(number leaves infested / 10 shoots)											
1	No treatment										2.0 a	0.3 a	0.8 a	2.0 a	0.2 a
2	Ziram 76DF	4 lbs	3 lbs/75 gal								0.0 a	0.0 a	0.0 a	0.0 a	0.0 a
	+ Microfine Sulfur	4 lbs	3 lbs/75 gal												
3	M-96-018	75 lbs	56.3 lbs								1.3 a	0.8 a	0.2 a	1.3 a	1.7 a
				Leafhoppers(number leaves infested / 10 shoots)											
1	No treatment										3.8 a	0.0 a	1.2 a	3.8 a	4.3 a
2	Ziram 76DF	4 lbs	3 lbs/75 gal								0.6 a	0.0 a	0.2 a	0.0 b	0.2 b
	+ Microfine Sulfur	4 lbs	3 lbs/75 gal												
3	M-96-018	75 lbs	56.3 lbs								0.3 a	0.0 a	0.0 a	0.2 b	0.3 b
				Leafhopper damage(number leaves infested / 10 shoots)											
1	No treatment													0.0 a	13.2 a
2	Ziram 76DF	4 lbs	3 lbs/75 gal											0.6 a	2.8 b
	+ Microfine Sulfur	4 lbs	3 lbs/75 gal												
3	M-96-018	75 lbs	56.3 lbs											0.2 a	3.3 b
				Leafminer damage(number leaves infested / 10 shoots)											
1	No treatment													2.3 a	10.2 a
2	Ziram 76DF	4 lbs	3 lbs/75 gal											0.2 a	3.0 b
	+ Microfine Sulfur	4 lbs	3 lbs/75 gal												
3	M-96-018	75 lbs	56.3 lbs											1.2 a	2.7 b

[z]Spray treatment dates for trt # 2 and 3: April 3, 11, 16, 25, May 2, 9, 17, 23, 30, June 6, 14, 23, and July 8, 16, 25, Aug 2, 10, 26.

[y]Additional applications to trt # 2 (Conventional program) = Supracide + Oil, Dithane and Rubigan was applied April 3; Guthion was applied June 6, 14, and July 8, 25, Aug 10, 26; Guthion + Lannate SP was applied May 23.

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

Byers # 5

Table 1B. Effect of airblast sprays of M-96-018 on 'Law Rome' (1997).

No.	Treatment[z,y]	Rate/ 100 gal /acre	Rate	Apr 29	May 6	May 13	May 20	May 27	June 3	June 10	June 17	June 25	July 3	July 8	July 13
							Sample date								
							Leafspots (number leaves infected / 10 shoots)								
1	No treatment									0.0 a[x]	0.0 a	0.0 a	1.0 a	3.3 a	2.5 b
2	Ziram 76DF	4 lbs	3 lbs/75 gal							0.0 a	0.0 a	0.0 a	0.8 a	0.8 a	0.0 b
	+ Microfine Sulfur	4 lbs	3 lbs/75 gal												
3	M-96-018	75 lbs	56.3 lbs							0.0 a	0.0 a	0.0 a	0.2 a	0.8 a	19.5 a
							Rust (number leaves infected / 10 shoots)								
1	No treatment									0.0 a	0.0 a	0.0 a	4.7 b	5.0 b	18.0 a
2	Ziram 76DF	4 lbs	3 lbs/75 gal							0.0 a	0.0 a	0.0 a	0.0 b	0.2 b	1.4 b
	+ Microfine Sulfur	4 lbs	3 lbs/75 gal												
3	M-96-018	75 lbs	56.3 lbs							0.0 a	0.0 a	0.0 a	12.2 a	17.8 a	16.2 a
							Powdery mildew (number leaves infected / 10 shoots)								
1	No treatment									0.7 a	0.2 a	0.0 a	0.0 a	9.2 a	0.2 a
2	Ziram 76DF	4 lbs	3 lbs/75 gal							0.0 a	0.0 a	0.0 a	0.2 a	1.6 b	0.0 a
	+ Microfine Sulfur	4 lbs	3 lbs/75 gal												
3	M-96-018	75 lbs	56.3 lbs							0.0 a	0.0 a	0.0 a	0.0 a	9.3 a	0.8 a
									Scab						
1	No treatment									0.0 a	0.0 a	0.0 a	0.0 a	0.7 a	0.2 a
2	Ziram 76DF	4 lbs	3 lbs/75 gal							0.0 a	0.0 a	0.0 a	0.0 a	0.4 a	0.0 a
	+ Microfine Sulfur	4 lbs	3 lbs/75 gal												
3	M-96-018	75 lbs	56.3 lbs							0.0 a	0.0 a	0.0 a	0.5 a	2.0 a	0.0 a

No.	Treatment	Rate/ 100 gal /acre	Rate	July 15	July 22	July 30	Aug 8	Aug 13
						Mites / leaf		
1	No treatment			0.7 a	3.7 a	5.8 a	0.9 a	0.2 a
2	Ziram 76DF	4 lbs	3 lbs/75 gal	0.0 b	0.4 b	0.9 b	0.6 a	0.1 ab
	+ Microfine Sulfur	4 lbs	3 lbs/75 gal					
3	M-96-018	75 lbs	56.3 lbs	0.1 b	0.0 b	0.0 b	0.04 a	0.0 b
						Eggs / leaf		
1	No treatment			0 a	3.5 a	7.4 a	4.0 a	3.8 a
2	Ziram 76DF	4 lbs	3 lbs/75 gal	0 a	0.6 ab	0.6 b	1.5 ab	4.1 a
	+ Microfine Sulfur	4 lbs	3 lbs/75 gal					
3	M-96-018	75 lbs	56.3 lbs	0 a	0.0 b	0.2 b	0.1 b	0.1 b

[z]Spray treatment dates for trt # 2 and 3: April 3, 11, 16, 25, May 2, 9, 17, 23, 30, June 6, 14, 23, and July 8, 16, 25, Aug 2, 10, 26.

[y]Additional applications to trt # 2 (Conventional program) = Supracide + Oil, Dithane and Rubigan was applied April 3; Guthion was applied June 6, 14, and July 8, 25, Aug 10, 26; Guthion + Lannate SP was applied May 23.

[x]Mean separation within columns by Duncan's new multiple range test, P≤0.05.

Byers # 6

Table 1C. Effect of airblast sprays of M-96-018 on 'Law Rome' (1997).

No.	Color	Treatment[zy]	Rate/ 100 gal /acre	Rate	Fruit/cm^2 cross sectional area limb (June 12)	Estimated crop load (%) Aug 27	Fruit diameter (cm) (Oct 13)	Fruit firmness (lb) (Oct 13)	Soluble solids (%) (Oct 13)	Starch (1-8) (Oct 13)	Red color (%) (Oct 13)
1	W	No treatment			9.53 a[x]	179 a	7.37 b	18.35 b	11.1 c	5.83 a	97.6 a
2	B	Ziram 76DF	4 lbs	3 lbs/75 gal	8.36 a	85 b	8.25 a	19.72 a	13.1 a	5.32 b	97.3 a
		+ Microfine Sulfur	4 lbs	3 lbs/75 gal							
3	R	M-96-018	75 lbs	56.3 lbs	10.2 a	154 a	7.59 b	20.37 a	12.3 b	5.50 ab	98.6 a

[z]Spray treatment dates for trt # 2 and 3: April 3, 11, 16, 25, May 2, 9, 17, 23, 30, June 6, 14, 23, and July 8, 16, 25, Aug 2, 10, 26.
[y]Additional applications to trt # 2 (Conventional program) = Supracide + Oil, Dithane and Rubigan was applied April 3; Guthion was applied June 6, 14, and July 8, 25, Aug 10, 26; Guthion + Lannate SP was applied May 23.

[x]Mean separation within columns by Duncan's new multiple range test, P≤0.5.

Table 1D. Effect of airblast sprays of M-96-018 on 'Law Rome' (1997).

Byers # 7

No.	Color	Treatment[zy]	Rate/ 100 gal/ acre	Rate	Yield/tree (kg) (Oct 13)	Yield cross sectional area (kg/cm2) (Oct 13)	Fruit drop /cm^2 cross sectional area (Oct 13)	Pull force (kg) (Oct 9)	Single fruit weight (g) (Oct 13)	Estimated total number fruit harvested /tree (Oct 13)	Estimated number fruit harvested/cm^2 cross sectional area trunk (Oct 13)
1	W	No treatment			114.48 b[x]	0.472 b	2.650 a	2.66 b	146.4 b	777 b	3.243 b
2	B	Ziram 76DF	4 lbs	3 lbs/75 gal	102.56 b	0.435 b	0.566 b	2.95 ab	220.5 a	475 c	2.022 b
		+ Microfine Sulfur	4 lbs	3 lbs/75 gal							
3	R	M-96-018	75 lbs	56.3 lbs	178.76 a	0.822 a	0.827 b	3.22 a	171.7 b	1063 a	5.000 a

[z]Spray treatment dates for trt # 2 and 3: April 3, 11, 16, 25, May 2, 9, 17, 23, 30, June 6, 14, 23, and July 8, 16, 25, Aug 2, 10, 26.
[y]Additional applications to trt # 2 (Conventional program) = Supracide + Oil, Dithane and Rubigan was applied April 3; Guthion was applied June 6, 14, and July 8, 25, Aug 10, 26; Guthion + Lannate SP was applied May 23.

[x]Mean separation within columns by Duncan's new multiple range test, P≤0.5.

Table 1E. Effect of airblast sprays of M-96-018 on 'Law Rome' (1997).

No.	Color	Treatment[z,y]	Rate/ 100 gal /acre	Assimilation rate (CO_2 mol/m^2/sec) (Sept 10)	Transpiration mol/m^2/sec (Sept 10)	Stomatal conductance mol/m^2/sec (Sept 10)	Chlorophyll (% absorbance at 661 mu) (Sept 10)	Leaf area (cm^2) (Sept 10)	Leaf weight (g) (Sept 10)	Specific leaf weight (g/cm^2) (Sept 10)
1	W	No treatment		8.2 b[x]	0.0035 b	0.145 c	0.87 b	43.0 a	0.50 a	0.0116 b
2	B	Ziram 76DF	4 lbs	8.5 b	0.0043 b	0.209 b	0.85 b	38.3 a	0.50 a	0.0128 a
		+ Microfine Sulfur	4 lbs							
3	R	M-96-018	75 lbs	13.6 a	0.0058 a	0.299 a	1.03 a	43.9 a	0.54 a	0.0122 ab

[z]Spray treatment dates for trt # 2 and 3: April 3, 11, 16, 25, May 2, 9, 17, 23, 30, June 6, 14, 23, and July 8, 16, 25, Aug 2, 10, 26.
[y]Additional applications to trt # 2 (Conventional program) = Supracide + Oil, Dithane and Rubigan was applied April 3; Guthion was applied June 6, 14, and July 8, 25, Aug 10, 26; Guthion + Lannate SP was applied May 23.

[x]Mean separation within columns by Duncan's new multiple range test, P≤0.5.

Table 1F. Effect of airblast sprays of M-96-018 on 'Law Rome' (1997).

No.	Color	Treatment[z,y]	Rate/ 100 gal /acre	Leaf nutrients (%)					Leaf nutrients (ppm)					
				N	P	K	Ca	Mg	S	B	Cu	Fe	Mn	Zn
1	W	No treatment		2.18 b[x]	0.12 b	1.13 b	1.23 b	0.30 a	0.13 b	31.5 a	10.7 a	79.7 ab	54.0 a	31.3 b
2	B	Ziram 76DF	4 lbs	2.10 b	0.12 b	1.45 a	1.07 c	0.27 a	0.22 a	31.4 a	9.4 a	86.2 a	52.7 a	645.5 a
		+ Microfine Sulfur	4 lbs											
3	R	M-96-018	75 lbs	2.57 a	0.15 a	1.35 a	1.43 a	0.27 a	0.16 b	29.8 a	8.0 a	77.7 b	52.7 a	16.3 c

[z]Spray treatment dates for trt # 2 and 3: April 3, 11, 16, 25, May 2, 9, 17, 23, 30, June 6, 14, 23, and July 8, 16, 25, Aug 2, 10, 26.
[y]Additional applications to trt # 2 (Conventional program) = Supracide + Oil, Dithane and Rubigan was applied April 3; Guthion was applied June 6, 14, and July 8, 25, Aug 10, 26; Guthion + Lannate SP was applied May 23.

[x]Mean separation within columns by Duncan's new multiple range test, P≤0.5.

Table 1G. Effect of airblast sprays of M-96-018 on 'Law Rome' (1997).

No.	Color	Treatment[zy]	Rate/ 100 gal /acre	% fruit infected				% fruit area infected			Total number fruit evaluated
				Scab	Rust	Active rots	Brooks spot	Sooty blotch	Fly speck	Powdery mildew	
1	W	No treatment		2.7 a[x]	0.0 a	2.7 a	7.0 a	0.81 a	1.14 a	0.09 a	594
2	B	Ziram 76DF	4 lbs	3.4 a	0.0 a	3.4 a	0.2 b	0.00 b	0.00 b	0.03 a	391
		+ Microfine Sulfur	4 lbs								
3	R	M-96-018	75 lbs	1.3 a	0.3 a	1.3 a	0.8 b	0.06 b	0.02 b	0.03 a	556

[z]Spray treatment dates for trt # 2 and 3: April 3, 11, 16, 25, May 2, 9, 17, 23, 30, June 6, 14, 23, and July 8, 16, 25, Aug 2, 10, 26.

[y]Additional applications to trt # 2 (Conventional program) = Supracide + Oil, Dithane and Rubigan was applied April 3; Guthion was applied June 6, 14, and July 8, 25, Aug 10, 26; Guthion + Lannate SP was applied May 23.

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

Table 1H. Effect of airblast sprays of M-96-018 on 'Law Rome' (1997).

No.	Color	Treatment[zy]	Rate/ 100 gal /acre	% of fruit infested					Russet rating[w] (0-5)	Opalescence rating[w] (0-5)	Total number fruit evaluated
				Tufted Apple Moth	Red-banded Leaf Roller	Codling Moth	Plum Curculio	Scale			
1	W	No treatment		8.4 a[x]	1.2 a	1.7 a	0.2 a	0.0 a	1.3 b	0.9 b	594
2	B	Ziram 76DF	4 lbs	1.1 b	0.0 b	0.0 b	0.0 a	0.0 a	1.9 a	2.8 a	391
		+ Microfine Sulfur	4 lbs								
3	R	M-96-018	75 lbs	1.7ab	0.2 b	0.3 ab	1.1 a	0.0 a	1.1 b	1.1 b	556

[z]Spray treatment dates for trt # 2 and 3: April 3, 11, 16, 25, May 2, 9, 17, 23, 30, June 6, 14, 23, and July 8, 16, 25, Aug 2, 10, 26.

[y]Additional applications to trt # 2 (Conventional program) = Supracide + Oil, Dithane and Rubigan was applied April 3; Guthion was applied June 6, 14, and July 8, 25, Aug 10, 26; Guthion + Lannate SP was applied May 23.

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

Table 2A. Effect of airblast sprays of M-96-018 on 'Red Delicious' (1997).

No.	Treatment[zy]	Rate/ 100 gal /acre	Sample date June 20	July 1	July 18	Aug 4	Aug 27	Aug 27
			Rosy aphids(number leaves infested / 10 shoots)					
1	Conventional treatment		0.0 a[y]	0.0 a	0.0 a	0.0 a	0.0 a	
2	M-96-018	50 lbs	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	
			Green aphids(number leaves infested / 10 shoots)					
1	Conventional treatment		1.5 a	22.0 a	24.5 a	0.1 a	0.0 a	
2	M-96-018	50 lbs	0.4 a	3.9 b	4.5 b	0.0 a	0.0 a	
			Wooly aphids(number leaves infested / 10 shoots)					% tree infested
1	Conventional treatment		1.1 a	1.3 b	5.6 a	1.2 a	--	0.1 b
2	M-96-018	50 lbs	0.3 a	6.0 a	2.8 a	6.6 a	--	7.9 a
			Leafhoppers(number leaves infested / 10 shoots)					
1	Conventional treatment		0.2 a	0.1 a	0.1 b	0.0 a	0.0 a	
2	M-96-018	50 lbs	0.4 a	0.4 a	1.3 a	0.0 a	0.0 a	
			Leafhopper damage(number leaves infested / 10 shoots)					
1	Conventional treatment		--	0.2 b	0.0 a	0.5 b	0.0 a	
2	M-96-018	50 lbs	--	11.4 a	0.0 a	18.1 a	0.0 a	
			Leafminer (number leaves infested / 10 shoots)					
1	Conventional treatment		--	0.5 a	0.0 a	0.1 b	0.1 b	
2	M-96-018	50 lbs	--	0.0 a	0.0 a	2.5 a	2.7 a	
			Leafspots (number leaves infected / 10 shoots)					
1	Conventional treatment		0.0 a	0.0 a	0.2 a	3.5 a	1.8 a	
2	M-96-018	50 lbs	0.0 a	0.2 a	0.5 a	1.5 a	0.9 b	
			Rust (number leaves infected / 10 shoots)					
1	Conventional treatment		0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	
2	M-96-018	50 lbs	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	
			Powdery mildew (number leaves infected / 10 shoots)					
1	Conventional treatment		0.0 a	0.0 a	0.4 a	0.1 a	0.0 a	
2	M-96-018	50 lbs	1.3 a	1.1 a	1.8 a	2.4 a	0.0 a	
			Scab (number leaves infected / 10 shoots)					
1	Conventional treatment		0.0 a	0.0 a	0.0 b	0.0 b	0.0 b	
2	M-96-018	50 lbs	0.0 a	0.3 a	10.7 a	7.9 a	4.9 a	

[y]Mean separation by t-test, $P \leq 0.05$.

Table 2B. Effect of airblast sprays of M-96-018 on 'Red Delicious' (1997).

No.	Treatment[z,y]	Rate/ 100 gal /acre	Fruit diameter (cm) (Sept 12)	Fruit firmness (lb) (Sept 12)	Soluble solids (%) (Sept 12)	Starch (1-8) (Sept 12)	Red color (%) (Sept 12)	Russet rating (0-5) (Sept 12)	Scarf finish (0-5) (Sept 12)
1	Conventional		6.79 a[y]	19.9 b	11.2 b	3.4 a	90 a	1.19 b	0.36 b
2	M-96-018	50 lbs	6.57 a	20.8 a	11.9 a	3.2 a	86 b	1.83 a	0.93 a

[y]Mean separation by t-test, $P \leq 0.05$.

Table 2C. Effect of airblast sprays of M-96-018 on 'Red Delicious' (1997).

No.	Treatment[z,y]	Rate/ 100 gal /acre	% fruit infected				% fruit area infected			Total number fruit evaluated
			Scab	Rust	Active rots	Brooks spot	Sooty blotch	Fly speck	Powdery mildew	
1	Conventional		0.0 b[y]	0 a	0 a	0 a	0.0 b	0.0 b	0 a	473
2	M-96-018	50 lbs	47.5 a	0 a	0 a	0 a	6.4 a	1.1 a	0 a	784

[y]Mean separation by t-test, $P \leq 0.05$.

Table 2D. Effect of airblast sprays of M-96-018 on 'Red Delicious' (1997).

No.	Treatment[z,y]	Rate/ 100 gal /acre	% of fruit infested				Bitter pit (% fruit)	Russet rating (0-5)	Opalescence rating (0-5)
			Tufted Apple Moth	Red-banded Leaf Roller	Codling Moth	Plum Curculio			
1	Conventional		0.0.b[y]	0 a	0.0 a	0 a	0.0 b	1.5 a	1.5 a
2	M-96-018	50 lbs	0.5 a	0 a	0.8 a	0 a	0.8 a	1.3 a	1.6 a

[y]Mean separation by t-test, $P \leq 0.05$.

Table 3A. Effect of airblast sprays of M-96-018 on 'Stayman' (1997).

No.	Treatment[z]	Rate/ 100 gal /acre	Sample date June 20	July 1	July 18	Aug 4	Aug 27	Aug 27
			Rosy aphids(number leaves infested / 10 shoots)					
1	Conventional treatment		0.0 a[y]	0.0 a	0.0 a	0.0 a	0.0 a	
2	M-96-018	50 lbs	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	
			Green aphids(number leaves infested / 10 shoots)					
1	Conventional treatment		0.9 a	6.2 a	11.0 a	0.3 a	0.0 a	
2	M-96-018	50 lbs	0.5 a	3.2 a	3.2 b	0.0 a	0.0 a	
			Wooly aphids(number leaves infested / 10 shoots)					% tree infested
1	Conventional treatment		0.3 a	5.9 a	6.5 a	7.2 a	--	0.38 a
2	M-96-018	50 lbs	1.0 a	6.1 a	14.5 b	12.5 a	--	0.15 a
			Leafhoppers(number leaves infested / 10 shoots)					
1	Conventional treatment		0.0 a	0.2 a	0.2 a	0.0 a	0.0 a	
2	M-96-018	50 lbs	0.3 a	0.4 a	0.1 a	0.0 a	0.0 a	
			Leafhopper damage(number leaves infested / 10 shoots)					
1	Conventional treatment		--	1.4 a	0.0 a	0.0 a	0.0 a	
2	M-96-018	50 lbs	--	4.9 a	0.0 a	0.5 a	0.0 a	
			Leafminer (number leaves infested / 10 shoots)					
1	Conventional treatment		--	0.1 a	0.0 a	0.0 b	0.0 b	
2	M-96-018	50 lbs	--	0.1 a	0.7 b	2.2 a	0.6 a	
			Leafspots (number leaves infected / 10 shoots)					
1	Conventional treatment		0.0 a	1.6 b	1.0 b	2.4 b	1.2 a	
2	M-96-018	50 lbs	0.2 a	7.8 a	9.7 a	12.7 a	2.9 a	
			Rust (number leaves infected / 10 shoots)					
1	Conventional treatment		0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	
2	M-96-018	50 lbs	0.0 a	0.5 a	0.1 a	0.0 a	0.0 a	
			Powdery mildew (number leaves infected / 10 shoots)					
1	Conventional treatment		0.0 a	0.0 b	0.1 a	0.0 b	0.0 a	
2	M-96-018	50 lbs	0.0 a	1.6 a	0.9 a	4.5 a	0.0 a	
			Scab (number leaves infected / 10 shoots)					
1	Conventional treatment		0.0 a	0.2 b	0.1 b	0.5 b	0.3 b	
2	M-96-018	50 lbs	0.1 a	3.7 a	22.7 a	12.6 a	5.1 a	

[y]Mean separation by t-test, $P \leq 0.05$.

Table 3B. Effect of airblast sprays of M-96-018 on 'Stayman' (1997).

No.	Treatment[z]	Rate/ 100 gal /acre	% fruit infected				% fruit area infected			Total number fruit evaluated
			Scab	Rust	Active rots	Brooks spot	Sooty blotch	Fly speck	Powdery mildew	
1	Conventional		0.0 b[y]	--	--	0.06 a	0.0 b	0.01 b	--	1228 a
2	M-96-018	50 lbs	0.6 a	--	--	0.00 b	11.3 a	3.43 a	--	1210 a

[y]Mean separation by t-test, $P \leq 0.05$.

Table 3C. Effect of airblast sprays of M-96-018 on 'Stayman' (1997).

No.	Treatment[z]	Rate/ 100 gal /acre	% of fruit infested				Russet rating (0-5)	Opalescence rating (0-5)
			Tufted Apple Moth	Red-banded Leaf Roller	Codling Moth	Plum Curculio		
1	Conventional		0.0 a[y]	0.4 a	0.0 a	--	1.74 b	2.12 b
2	M-96-018	50 lbs	0.4 a	0.4 a	0.4 a	--	2.64 a	2.95 a

[y]Mean separation by t-test, $P \leq 0.05$.

Table 4. Effect of growth regulators on fruit thinning and fruit finish of 'Golden Delicious'/M.27 before and after M-96-018 sprays (1997).

No.	Color	Treatment^{zy}	Application timing	Rate/ 100 gal	Rate/ 3.5 liter	Fruit/cm^2 cross sectional area limb (11 June)	Fruit diameter (cm)	Length/ diameter ratio (cm)	Russet rating (0-5)	Stem-end russet rating^w (0-5)	Backround color (0-5)
1.	W	Control	None			18.7 ab	6.86 a	0.923 a	1.58 ab	1.14 a	3.40 ab
2.	R	Sevin+	None	1 pt	4.4 ml	12.2 def	6.97 a	0.931 a	1.55 ab	1.04 a	3.62 ab
		Ethrel		1.5 pt	6.6 ml						
3.	B	Sevin+	None	1 pt	4.4 ml	14.7 bcde	7.02 a	0.936 a	1.65 ab	0.95 a	3.52 ab
		Accel		2 pt	8.8 ml						
4.	FO	Sevin	None	1 pt	4.4 ml	9.3 f	6.84 a	0.946 a	1.67 ab	1.12 a	3.63 ab
		+ NAA 200		10 ppm	0.676 ml						
5.	Y	M-96-018	Tank mixed	25 lb	105 g	21.2 a	6.90 a	0.919 a	1.71 ab	1.07 a	3.67 ab
6.	RS	Sevin	Tank mixed	1 pt	4.4 ml	17.8 abc	6.91 a	0.929 a	1.68 ab	1.20 a	3.67 ab
		+ Ethrel		1.5 pt	6.6 ml						
		+ M-96-018		25 lb	105 g						
7.	BS	Sevin+	Tank mixed	1 pt	4.4 ml	17.9 abc	6.99 a	0.942 a	1.73 ab	1.06 a	3.60 ab
		+ Accel		2 pt	8.8 ml						
		+ M-96-018		25 lb	105 g						
8.	OD	Sevin	Tank mixed	1 pt	4.4 ml	13.2 cdef	7.05 a	0.936 a	1.94 a	1.12 a	4.08 a
		+ NAA 200		10 ppm	0.676 ml						
		+ M-96-018		25 lb	105 g						
9.	RD	Sevin	Pre-trt same day	1 pt	4.4 ml	16.5 abcd	5.75 a	0.932 a	1.37 b	0.84 a	3.00 b
		+ Ethrel		1.5 pt	6.6 ml						
		+ M-96-018		25 lb	105 g						
10.	BD	Sevin+	Pre-trt same day	1 pt	4.4 ml	17.1 abcd	6.98 a	0.921 a	1.75 ab	1.05 a	3.55 ab
		+ Accel		2 pt	8.8 ml						
		+ M-96-018		25 lb	105 g						
11.	BK	Sevin+	Pre-trt same day	1 pt	4.4 ml	10.1 ef	5.89 a	0.941 a	1.51 ab	0.87 a	2.97 b
		+ NAA 200		10 ppm	0.676 ml						
		+ M-96-018		25 lb	105 g						

Byers # 14

Table 4 (continued)

Contrasts:	Comparisons :	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F
1 Vs 2	Control Vs Sevin+Ethrel	**	ns	ns	ns	ns	ns
1 Vs 3	Control Vs Sevin+Accel	ns	ns	ns	ns	ns	ns
1 Vs 4	Control Vs Sevin+NAA 200	***	ns	ns	ns	ns	ns
1 Vs 5	Control Vs M-96-018	ns	ns	ns	ns	ns	ns
1 Vs 6	Control Vs Sevin+Ethrel+M-96-018 (tank mixed)	ns	ns	ns	ns	ns	ns
1 Vs 7	Control Vs Sevin+Accel+M-96-018 (tank mixed)	ns	ns	ns	ns	ns	ns
1 Vs 8	Control Vs Sevin+NAA 200+M-96-018 (tank mixed)	***	ns	ns	ns	ns	ns
2 Vs 6	Sevin+Ethrel VsTank mixed (Sevin+Ethrel+M-96-018)	**	ns	ns	ns	ns	ns
2 Vs 9	Sevin+Ethrel Vs Tank mixed (Sevin+Accel+M-96-018)	*	ns	ns	ns	ns	ns
3 Vs 7	Sevin+Accel Vs Tank mixed (Sevin+Accel+M-96-018)	ns	ns	ns	ns	ns	ns
3 Vs 10	Sevin+Accel Vs Pre-treated (Sevin+Accel+M-96-018)	ns	ns	ns	ns	ns	ns
4 Vs 8	No M-96-018 Vs Tank mixed (Sevin+NAA 200+M-96-018)	ns	ns	ns	ns	ns	ns
4 Vs 11	No M-96-018 Vs Pre-treated (Sevin+NAA 200)	ns	ns	ns	ns	ns	ns
5 Vs 6	Tank mixed (M-96-018) Vs Tank mixed (Sevin+Ethrel+M-96-018)	ns	ns	ns	ns	ns	ns
5 Vs 7	Tank mixed (M-96-018) Vs Tank mixed (Sevin+Accel+M-96-018)	ns	ns	ns	ns	ns	ns
5 Vs 8	Tank mixed (M-96-018) Vs Tank mixed (Sevin+NAA 200+M-96-018)	***	ns	ns	ns	ns	ns
5 Vs 10	Tank mixed (M-96-018) Vs Pre-treated (Sevin+Accel+M-96-018)	*	ns	ns	ns	ns	ns
5 Vs 11	Tank mixed (M-96-018) Vs Pre-treated (Sevin+NAA 200+M-96-018)	***	ns	ns	ns	ns	ns
6 Vs 9	Tank mixed Vs Pre-treated (Sevin+Ethrel+M-96-018)	ns	ns	ns	ns	*	ns
7 Vs 10	Tank mixed Vs Pre-treated (Sevin+Accel+M-96-018)	ns	ns	ns	ns	ns	ns
8 Vs 11	Tank mixed Vs Pre-treated (Sevin+NAA 200+M-96-018)	**	ns	ns	ns	ns	ns
2,3,4 Vs 6,7,8	No M-96-018 Vs Tank mixed with M-96-018	**	ns	ns	ns	ns	ns
2,3,4 Vs 9,10,11	No M-96-018 Vs Pre-treated with M-96-018	*	ns	ns	ns	ns	ns
6,7,8 Vs 9,10,11	Tank mixed Vs Pre-treated with M-96-018	ns	ns	ns	*	ns	ns

[z]Full bloom occurred 25 April 97.
[y]Treatments were applied with a low pressure hand-wand sprayer on 19 May 1997 when fruit diameter was 13 mm.
[v]Mean separation within columns by Duncan's new multiple range test;($P \leq 0.05$).

Effect of Production Risk on the Selection of Apple Rootstocks

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Abstract. Fifteen apple rootstock were evaluated for acceptance by fruit producers with different attitudes towards risk. In terms of average net returns, M.26ELMA, P.1, and P.18 appear to be good rootstock choices. In most cases, however, variability increases as net returns increase. Using stochastic dominance with respect to a function techniques, M.4 would be the preferred choice for moderately risk preferring growers. M.26ELMA would be the choice of slightly risk preferring to slightly risk averse growers and P.18 would be the choice favored by moderately to strongly risk averse growers.

Introduction. Selection of a suitable rootstock is a critical aspect in the production of any tree fruit. The cost of establishing an apple orchard makes it imperative that a fruit producer have the most complete information available when selecting a rootstock. The choice of rootstock will affect the future profitability of the orchard through its impact on productivity and tree mortality. Evaluating the economic feasibility of alternative rootstocks is vital to preserving and improving the competitive position of Mid-Atlantic apple growers.

Materials and Methods. As part of the NC-140 regional apple rootstock trial, fifteen rootstocks with the scion variety 'Starkspur Supreme Delicious' were planted in 1984 at Biglerville. Data were collected annually on yield, fruit weight, tree mortality, and various measures of tree size.

In order to evaluate the effect of yield and tree mortality on profitability, net return streams were projected for each of the alternative rootstocks. Cost of production estimates for the various rootstocks were estimated by adjusting budgets found in Harper (1996). One primary consideration is tree spacing for the various rootstocks which affect the number of trees planted and pruning expenses. Tree spacing was estimated from tree width measurements made in 1990. Allowing for an additional 1 foot between trees and 6 feet between rows, tree densities were determined according to Ritter (1978). Another consideration was harvest cost, which depends on yield and was charged at 5.8¢/kg. ($1.25/bu.). Annual per acre yields were calculated by multiplying the estimated tree density by the average yield for the trees in each rootstock treatment. Average yields used reflect the death of trees in each treatment. Using this yield and a ten-year (1986-1994) average price for fresh-market apples of 40.0¢/kg. (Pennsylvania Agricultural Statistics Service), gross returns were calculated for each rootstock for each year. Net returns were then calculated by subtracting the appropriate production, planting, pruning, and harvest expenses from gross returns.

One way to select a profitable rootstock would be to compare the average net returns generated by each alternative and select the highest one. Although the simplicity of this approach is attractive, maximizing net return overlooks the variability of returns and ignores the role that the attitude of the individual fruit producer towards risk plays in the selection of a rootstock. A better way to evaluate this type of decision-making process is to employ procedures which take into account the distribution and variability of net returns and rank alternatives based on different assumptions about producer attitudes towards risk. Harper and Greene (1997) used similar procedures to evaluate the selection of peach rootstocks.

Stochastic dominance is a risk analysis technique that chooses between a set of risky alternatives by comparing the distribution of possible incomes for each alternative, selecting preferred alternatives based on risk preferences. Three stochastic dominance tools are available to the researcher: first-degree stochastic dominance (FSD), second-degree stochastic dominance (SSD), and stochastic dominance with respect to a function (SDRF). The first two analyze the problem for generalized categories of risk behavior, while SDRF analyzes specific intervals which approximate specific risk categories. For SDRF, preferred alternatives are identified by comparing the cumulative density function of net returns from each alternative for the risk categories of interest. A summary of stochastic dominance efficiency criteria can be found in Cochran, Robison, and Lodwick (1985).

Stochastic dominance uses risk preference intervals determined with the Pratt absolute risk aversion function, $R(x) = -U''(x)/U'(x)$, which represents the ratio of derivatives from the decision maker's utility function, $U(x)$. FSD rules identify strategies preferred by the individual whose utility is a positive function of income. The criteria are consistent for individuals who prefer more income to less. SSD criteria identify strategies preferred by individuals receiving greater satisfaction from increases in low levels of income than increases at high levels of income.

This study utilizes SDRF to analyze the peach rootstock selection decision. SDRF is a generalized version of FSD and SSD and is more flexible and discriminating, though it does require more specific information about the decision maker's preferences (King and Robison, 1984). For SDRF, risk preference intervals bounded by lower and upper risk aversion coefficients, $R_1(x)$ and $R_2(x)$, are established by the researcher. Six risk preference intervals approximating risk attitudes ranging from moderate risk preference (risk-takers) to strong risk aversion (risk avoiders) were used for the peach rootstock analysis. The Pratt-Arrow risk aversion coefficients used in this study were originally elicited by Cochran (1982) for a 10-acre orchard block and were adjusted to a per acre basis using a scale transformation (Raskin and Cochran, 1986). The analysis itself was conducted using a generalized stochastic dominance computer program developed by Cochran and Raskin (1988).

Results and Discussion. Descriptive statistics for the alternative rootstocks are given in Table 1. Estimated tree densities varied from a low of 152 trees/A for P.18 to a high of 1,266 trees/A for P.22. Yield and net returns were calculated assuming that dead trees were not replaced. Average percent of mature trees gives an indication of tree mortality over the productive life of the orchard (1986-1994). Mortality was not high for the rootstock trial overall; 11 of the fifteen rootstock treatments had an average of over 90% live trees per acre. Seven rootstocks had no trees die. AL.800, M.4, and MAC.39 had 20-30% tree mortality early in the trial (before 1986). Average yield per acre varied greatly between the various rootstocks and the impact of tree mortality is only part of the story. Certainly, the high mortality of AL.800 and MAC.39 have a lot to do with their relatively low average yields, but some rootstocks with low mortality also had low average yields. In terms of average net returns, M.26ELMA, P.1, and P.18 appear to be good rootstock choices. As indicated by the standard deviation, however, it appears that in many cases variability increases as net returns increase.

The results of the SDRF analysis are summarized in Table 2, where the top 3 rootstocks for each risk attitude interval are ranked. Producers who are willing to accept a fair amount of risk would select M.4 as their best rootstock choice. This rootstock had the highest single year net return ($7,138), which would be attractive to growers who want to attain the highest yields and profitability. For slightly risk preferring to slightly risk averse producers, M.26ELMA appears to be their best choice, with P.1 a close second. M.26ELMA had the highest average net return and a lower standard deviation than M.4 or P.18. For more risk averse producers, P.18 would be the preferred rootstock choice. P.18 has a lower average net return, but slightly higher standard deviation than M.26ELMA. The attraction of moderately to strongly risk averse growers for P.18, and to a lesser extent M.7ELMA, P.1, and CG.24, is that their lowest annual net returns (-$1,579 for P.18) are less severe than for M.26ELMA (-$2,496). This is a good example of growers employing maxi-min decision-making criteria. In other words, their objective is to maximize the minimum values, thereby avoiding the worst possible outcome. Only P.18 was regularly ranked in the top three across all risk intervals. M.4 only occurs in the risk preferring intervals and CG.24 in the strongly risk averse interval.

Conclusions. Stochastic dominance with respect to a function (SDRF) is a useful tool for evaluating production alternatives under risk. When applied to the problem of apple rootstock selection, the ability of SDRF to rank alternatives provides the producer with information as to the preferred rootstock and possible alternatives.

Additional evaluation of the NC-140 data is underway. First, the effect of replanting will be analyzed. Commercial growers would replace dead trees, especially early in the life of the orchard. For example, M.4 had 20% mortality, but it still ended up as the preferred choice for moderately risk preferring growers. If trees were replaced, it may have a wider acceptance across risk intervals. Second, extensive apple quality data were collected in the last year of the study. It is apparent from initial evaluation of this data that significant quality differences exist between the various rootstocks. Incorporation of quality data into the rootstock evaluation will be especially valuable to fresh-market growers who strive for well-colored, large fruit.

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Table 1. Estimated tree densities, tree mortality, yield, and net returns for 'Starkspur Supreme Delicious' on 15 rootstock treatments (1986-1994).

Rootstock	Estimated Tree Density (trees/A)	Average % Live Trees (1986-94)	Average Yield 1986-1988 (kg/A)	Average Yield 1989-1991 (kg/A)	Average Yield 1992-1994 (kg/A)	Average Net Return ($/A)	S.D. for Net Return ($/A)
AL.800	261	70.0	717.2	3545.1	9941.1	28.50	1715.86
CG.10	421	100.0	1694.9	3999.6	9982.0	-56.17	1828.59
CG.24	153	100.0	388.5	1861.7	7274.6	-379.59	1340.17
Domestic seedling	163	100.0	585.4	2743.2	8939.8	-172.03	1719.68
M.7ELMA	171	100.0	1181.6	3444.0	9075.5	-67.57	1665.41
M.26ELMA	258	100.0	2633.1	7373.5	14550.6	840.08	2247.55
M.4	196	80.0	733.6	3180.4	11778.2	215.87	2423.85
M.20	251	96.7	1141.5	4807.2	10481.8	174.13	1759.88
MAC.1	164	100.0	615.1	3631.1	9331.3	-62.94	1817.33
MAC.39	341	70.0	1201.0	4251.1	8065.5	-77.65	1447.95
P.1	204	100.0	1828.3	5745.0	11885.7	489.60	1987.37
P.2	680	90.0	2790.7	7617.5	12578.8	287.38	2436.52
P.16	1040	90.0	3457.0	7396.8	8788.7	-227.07	2743.30
P.18	152	98.9	683.5	4967.2	14334.8	503.30	2436.59
P.22	1266	85.6	3895.9	4845.7	6317.8	-813.48	2928.75

Table 2. Ranking of top 3 apple rootstocks based on general classes of grower risk preferences.

Approximate Risk Attitude	Range of Pratt-Arrow Risk Aversion Coefficients	Ranking of Alternative Apple Rootstocks
Moderately Risk Preferring	-.003 to -.001	1 M.4 2 P.18 3 M.26ELMA
Slightly Risk Preferring	-.001 to 0.0	1 M.26ELMA 2 P.18 3 M.4
Risk Neutral	-.001 to +.001	1 M.26ELMA 2 P.1 3 P.18
Slightly Risk Averse	0.0 to +.001	1 M.26ELMA P.1 (tied) 2 P.18
Moderately Risk Averse	+.001 to +.003	1 P.18 2 M.7ELMA 3 P.1
Strongly Risk Averse	+.003 to +.005	1 P.18 2 CG.24 3 M.7ELMA

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INFLUENCE OF A REFLECTIVE GROUNDCOVER ON APPLE COLOR AND QUALITY

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Red color is an important criterion in consumer selection of apples. Apple breeders place a high priority on color and often make selections for near 100 percent surface red color. Growers and fruit tree nurseries are ever watchful for mutations that display a greater amount or intensity of surface red color than occurs on the parent cultivar. 'Delicious' and some newer apple cultivars, such as 'Empire', 'Jonagold', or 'Fuji', often produce poor or marginal red color when grown under the warm, humid environmental conditions of the mid-Atlantic region. Many factors, directly or indirectly, influence color development in apples: temperature, light, nutrition, pruning, and plant growth regulators.

Light is required for color development in apples, and this has encouraged researchers to investigate practical means of providing supplemental light to enhance red color. Moreshet et al. (1975) increased size, color, and sugar content of apples harvested from the lower half of hedgerow trees with a reflective material placed on the ground between the tree rows. Doud and Ferree (1980) increased light by 35% and red fruit color at harvest on mature 'Delicious'/M.9 apple trees with reflective material placed under the tree canopy from tight cluster to harvest. The greatest effect was observed in the lower half of the canopy. In a two-year study on 'Fuji' apples trained as a Lincoln canopy or as central leader trees, reflective materials (plastic or foil) increased surface red color and color intensity, and resulted in 35% more fruit harvested during the first picking (Andris and Crisosto, 1996). Fruit quality was not affected by any of the reflective material treatments. Commercial orchard trials in New Zealand (Toye, 1995) with reflective mulches have reported improved fruit color with fewer pickings required for cultivars like 'Fuji', 'Gala', and 'Braeburn'. Not all commercial experiences have been positive and some problems have been identified with the use of reflective materials. Materials must be positioned so light can strike them which can be difficult in some high density plantings and the materials are subject to tearing from vehicular and worker trafficing (Warner, 1997).

The objective of this investigation was to determine the effect of a metalized reflective plastic groundcover on color and quality in several apple cultivars grown under mid-Atlantic conditions. A white and a black polyethylene material were included in the 1997 tests for comparison.

Methods

1996 Trials. Studies with reflective groundcovers (RGCs) were initiated in 1996 on bearing apple trees planted in north-south (N-S) oriented rows. The orchard floor was maintained with a weed-free strip from the trunk to the outer edge of the canopy (drip line) and sod drive middles. Three cultivars, 'Hardibrite Spur Delicious', 'Empire', and 'Fuji' were used. 'Delicious' trees were on MM.111 rootstock and trained to a 'Y' trellis system. The 'Empire' trees included trees on M.9 trained to a 'Y' trellis, semi-dwarf interstem trees on M.9/MM.106 and full size trees on seedling rootstock trained as freestanding central leader trees. The 'Fuji' trees were on EMLA.7 and trained to the central leader form. Trees ranged in age from 7- to 10-years-old. All trees in the study were estimated to have 75 to 100% of a full crop. The RGC was a 1.6 m (64") wide 1.25 mil thick metalized silver low-density polyethylene film (Clarke Ag Plastics, Greenwood, VA 22943) supplied on a roll that could be cut to individual lengths to accommodate various canopy widths. The RGC was placed on the east (E) and west (W) sides of the tree centered on the trunk and extending 1 m beyond the canopy in the N-S directions. One edge of the RGC material was placed just under the drip line of the tree with the opposite edge extending into the drive middle between the tree rows. The grass sod in the drive middle to be covered by the RGC was killed with a contact herbicide (paraquat), prior to applying the RGC, so the material would lie flat. The RGC was secured at points along the edges with steel or plastic landscape pins reinforced with pieces of heavy cardboard (approx. 8 X 12 cm) at the points of pinning. Guard trees were used on either side of RGC treated trees. The RGC material was applied 5 weeks before the expected harvest date (EHD) of each cultivar. The EHD was based on bloom date and historical records. At harvest, two, ten-apple samples were collected per tree - one from the E side of the canopy and one from the W side of the canopy. All samples were stored for several days in a refrigerated cold storage before analysis. Fruit were removed from cold storage and allowed to equilibrate to room temperature overnight. All fruit quality factors were measured on individual fruits with 10 fruit per sample. Color was determined from CIE (Commission Internationale de l'Eclairage) L*a*b* values with a hand-held MiniScan XE Model D/8-5 spectrophotometer (Hunter Associate Laboratory, Inc., Reston, VA 22090). Instrument standards and calibration were as follows: illuminant = D65; and illuminant/viewing geometry = black glass, 45/0. A single reading was taken per fruit in an area visually perceived as the darkest red color. Hue angle (h°) was calculated from a* and b* readings according to McGuire (1992). Surface red color was visually estimated as percent of total fruit surface showing dark red color. Flesh firmness was recorded with a McCormick Model FT-327 penetrometer (McCormick Fruit Tech, Yakima, WA98908) mounted in a drill press stand. Soluble solids concentration (SSC) was determined with an Atago PR100 digital refractometer (NSG Precision Cells, Inc., Farmingdale, NY 11735) from a composite juice sample from the 10 apple sample. Starch-iodine index was visually rated using a 1 to 9 scale (Ontario Min. Agric. Food Factsheet 88-090 and 88-117).

Multiple, low-dose (100 to 125 mg•liter^{-1}) sprays of the plant bioregulator, ethephon, were included in these trials and data is shown here only for comparative purposes. All treatments were arranged in randomized complete blocks with four individual tree replications. Data was subjected to ANOVA and means separated using Duncan's new multiple range test. Data for percentage surface red color was transformed to the arcsin for analysis with actual measured values shown in the tables.

1997 Trials. Two studies were conducted with RGCs in 1997. All trees were growing on a 'Y' trellis system and oriented in N-S rows. The first study involved the 9-year-old 'Hardibrite Spur Delicious'/MM.111 used in the 1996 trials. The canopy covered about a 2.5 m height on each arm of the trellis and the trees were bearing an estimated 50 to 80% of a full crop. There were three treatments: 1) 1.6 m wide metalized RGC (Clarke Ag Plastics) placed under the tree canopy at the base of the tree and extending into the drive middle, 2) the same RGC material as in treatment 1 but placed in the center of the drive middle, and 3) a control with herbicide strip under the canopy and sod drive middle. Treatments were applied to 3-tree plots and replicated four times beginning four weeks before harvest.

Three-year-old 'Fuji'/M.9 trees were used in the second study. The canopy covered about a 2.0 m height on the trellis and the trees were bearing about 70% of a full crop load. Four treatments were arranged in a randomized complete block with 4-tree plots per replication: 1) 1.2 m wide metalized RGC (Clarke Ag Plastics), 2) a 1.3 m wide white high density polyethylene (manufacturer unknown), 3) standard 6-mil black polyethylene film (Warp Bros., Chicago, IL 60651) cut to 1.2 m wide, and 4) a control with herbicide strip under the canopy and a sod drive middle. RGC treatments were established 7 weeks before the first harvest.

The following parameters were monitored during the study on selected days between August 15 and October 6, 1997: canopy temperature, fruit surface temperatures, photosynthetically active radiation (PAR), and red/far red light. Canopy temperature was recorded with Optic StowAway data loggers (Spectrum Technologies, Inc., Plainfield IL 60544) placed in small weather shelters located about half way up the side of the canopy in the plane of the canopy and shielded from direct sunlight during the period from 1000 to 1500 hours but exposed to any reflected light. Surface temperature of fruit was recorded with a Raynger ST6LSU infrared temperature sensor (Raytek Corp., Santa Cruz, CA 95060) with an emissivity value of 0.95. A single reading was recorded on 50 individual fruits per treatment exposed to reflected light, indirect light, and direct sunlight. The level of PAR reflected from the ground or the RGC material was measured with a Sunfleck SF80 Ceptometer (Decagon Devices, Inc., Pullman WA 99163). Six readings were taken per replication. To take readings the light bar was placed horizontally in a N-S direction with the sensor bar angled with the plane of the canopy and pointing away from the canopy toward the RGC material. The ratio of red:far red (660:730 nm) light was recorded in the same position as PAR readings using an SKR100/116 Red/Far Red Light Sensor with fiber optic probe (Skye-Probetech, Perkasie, PA 18944). All light readings were taken between 1030 and 1200 hours eastern standard time on the E side of the canopy. Days were used as replications.

Fruit was harvested one week before the EHD and on the EHD (except 'Fuji' which was initially harvested 9 days before the EHD). Each side of the canopy was divided at the mid point between top and bottom and a 10 apple sample was harvested from each of the four resulting locations (designated "low east, high east, high west, low west"). Fruit color and quality was determined as in 1996 except four color space readings were recorded on each individual fruit to obtain an average color reading per fruit.

Results and Discussion

1996 Trials. The RGC, when placed in the orchard drive middle of 8-year-old 'Hardibrite Delicious'/MM.111 apple trees trained to a 45° 'Y' trellis 5 weeks before harvest, increased the percent surface red color and resulted in darker (lower L*), redder (lower h°) colored apples at harvest (Table 1). Fruit size and quality was unaffected. Fruit from RGC treated trees had a lower starch index (SI) rating (indicates less mature) but, the difference was small and may be of little or no practical significance. Fruit from the E side of the canopy was darker red than from the W side of the canopy (data not shown).

The RGC had no effect on color or quality of 'Empire' apples on semi-dwarf or standard size trees except that starch levels were higher (lower SI rating) at the EHD indicating that the RGC material had delayed fruit maturity (data not shown). The RGC increased surface red color 2 weeks before the EHD of 'Empire'/M.9 on the 'Y' trellis (Table 2). Fruit from the E side of the canopy had a darker, redder color than fruit from the W side of the canopy. In these trials, bi-weekly ethephon sprays also produced a darker, redder color and more surface with dark red color (Table 2). Surface red color of RGC treated fruit did not differ from controls at the later harvests. There was a significant location X treatment interaction for L* and h° at the EHD (P=0.02). The RGC increased red color on fruit from the west canopy (h°= 22.2° treated vs. 29.2° control) but not from the east canopy (20.9° RGC treated vs 20.5° control) at the EHD. Fruit from the RGC treated 'Empire'/M.9 were smaller (an average of 20 to 30 g) than untreated fruit at each of the three harvest dates (data not presented). The RGC applied to semi-dwarf 'Fuji'/EMLA.7 had no effect on lightness (L*) of color (Table 3), flesh firmness, or SSC at any of the three harvest dates (data not shown). There was a trend toward more surface red color on RGC treated fruit one week before the EHD with significant differences evident at the EHD.

Detailed measurements were not made of light levels in RGC treated canopies in 1996 but, field observations and preliminary measurements suggested a significant increase in canopy light due to the RGC material. Statistically significant but limited response in red color (more red or darker red) was observed on fruit from the smaller statured trees which tends to agree with an earlier published report (Doud and Ferree, 1980) and suggests that additional studies were warranted.

1997 Trials. The average difference in canopy temperature between the RGC canopy and a control canopy was calculated from mean hourly temperatures recorded between 0900 and 1800 hours (Eastern Standard Time) on 16 selected days between September 19 and October 17, 1997 in 'Hardibrite Delicious'(E side canopy only). The temperature within the RGC canopy averaged 2.1°C higher than non-RGC canopy. Peak differences consistently occurred between 1100 and 1300 hours (EST). The greatest difference recorded was 11.0°C between 1200 and 1300 hours on September 21, 1997 (Fig. 1). The greatest differences generally occurred on bright sunny days but, not always. Fruit surface temperatures for fruit exposed to reflected light were higher (+3.6°C) than fruit in indirect light but less (-4.8°C) than the surface temperature of fruit with direct sunlight exposure (Table 4).

Measurement of PAR in 3-year-old 'Fuji'/M.9 growing on a 'Y' canopy form trellis showed an average increase in available PAR under the canopy of 28.5% from the metalized RGC and a 15% increase from a white polyethylene film compared to a bare soil under canopy/sod drive middle control (Table 5). The metalized RGC and the white poly increased the ratio of red:far red light available to the under canopy (Table 5). While the levels of red and far red light were both increased the greatest increases were associated with red light.

In general the RGCs increased the red color in 'Hardibrite Delicious'/MM.111 (Fig. 2 and 3) and 'Fuji'/EMLA.7 (Fif. 4 and 5) on 'Y' trained canopies producing a darker redder color and more surface red color than fruit harvested from control trees one week before the EHD and on the EHD. There was a significant Treatment X Fruit Sample Position interaction for color in both 'Hardibrite Delicious' and 'Fuji'(Fig. 2 thru 5).

Positioning the RGC under the canopy adjacent to the tree trunk resulted in a lower hue angle (redder color) on fruit from the bottom half of the canopy compared to fruit from the upper canopy (Fig. 2 thru 5, east and west low vs. east and west high). Fruit from the upper canopy generally had less red color on the RGC treatments; control fruit was generally redder from the upper half of the canopy especially on the E side of the trellis.

The RGCs had little or no effect on fruit weight, flesh firmness, SSC, or starch levels (data not shown). The decrease in fruit maturity observed in 1996 was not found in 1997 and in fact fruit from the 'Hardibrite Delicious' trees had a slightly elevated SI rating where the RGC was placed in the drive middle (data not shown).

Conclusions

The results of these studies indicate that a metalized RGC can enhance red color in certain apple cultivars when placed on the orchard floor 5 to 7 weeks before the expected harvest date. This response may be limited to dwarf and some semi-dwarf trees in high density plantings; no advantage is evident in lower density plantings of larger size trees. Placement of the RGC material in relation to the canopy can influence the area of the canopy receiving increased light and thus the degree of color response. Based on these studies there appears to be little or no effect on other fruit quality parameters (weight, flesh firmness, SSC, or starch). The effect of the increased light levels, PAR and red/far red, on fruit bud formation have not been determined. These areas are worthy of further investigation. Any effect that increased canopy temperatures may have on the fruit or the tree needs to be determined.

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Table 1. Effect of a reflective groundcover (RGC) on color and starch index in 'Hardibrite Delicious'/MM.111 apples trained to a 'Y" form trellis canopy. Fruit harvested September 24, 1996.

Treatment	L*[z]	Hue angle[y]	% Surface red color	Starch index
Sod	40.2 a[x]	28.6 a	28 b	5.7 a
RGC	38.3 b	24.3 b	37 a	4.9 b
Killed Sod	41.1 a	30.6 a	21 c	5.5 a

[z] L*= lightness (0=black, 100=white)
[y] Hue angle = arctangent b*/a* (0=red-purple, 90=yellow)
[x] Means separation within columns by Duncan's new multiple range test, P=0.05.

Table 2. Effect of a reflective groundcover (RGC) or ethephon on color of 'Empire'/M.9 pples trained to a 'Y' form trellis canopy and harvested 2 weeks before the expected maturity date. 1996.

Main Treatment	Ethephon dose (ppm)	L*[z]	Hue angle[y]	% Surface red color
Location				
East	---	39.3 b[x]	27.6 b	34 a
West	---	41.1 a	31.9 a	31 a
Treatment				
Ethephon, weekly	100	38.8 b	27.4 bc	31 bc
Ethephon, bi-weekly	125	37.5 b	26.3 c	42 a
RGC	0	42.1 a	31.2 ab	34 b
Control	0	43.0 a	34.3 a	25 c

[z] L*= lightness (0=black, 100=white)
[y] Hue angle = arctangent b*/a* (0=red-purple, 90=yellow)
[x] Means separation within columns by Duncan's new multiple range test, P=0.05.

Table 3. The effect of a reflective groundcover (RGC) or ethephon on color of 'Fuji'/EMLA.7 apples on central leader trained trees harvested 1 week before and again on the expected maturity date. 1996.

Treatment	Ethephon dose (ppm)	L^{*z}	Hue angle[y]	% Surface red color
		------ 1 week before expected maturity date -----		
Ethephon, weekly	100	57.9 a[x]	71.0 ab	9.2 ab
Ethephon, bi-weekly	125	56.4 a	69.8 b	10.2 a
RGC	0	57.0 a	71.5 ab	8.2 ab
Control	0	59.0 a	81.1 a	4.0 b
		------ expected maturity date ------		
Ethephon, weekly	100	55.4 a	57.7 ab	22.7 ab
Ethephon, bi-weekly	125	54.0 a	50.6 bc	26.3 a
RGC	0	52.8 a	47.6 c	24.2 a
Control	0	55.5 a	59.3 a	13.3 b

[z] L* = lightness (0=black, 100=white).
[y] Hue angle = arctangent b*/a* (0=red-purple, 90=yellow).
[x] Means separation within columns by Duncan's new multiple range test, P=0.05.

Table 4. Fruit surface temperature of 'Hardibrite Delicious'apples grown on a 'Y' canopy as affected by a reflective groundcover. 1997.

Fruit illumination	Fruit surface temperature - °C (°F)
Indirect light	24.2 c (75.6)
Reflected light	27.8 b (82.0)
Direct sunlight	32.6 a (90.8)

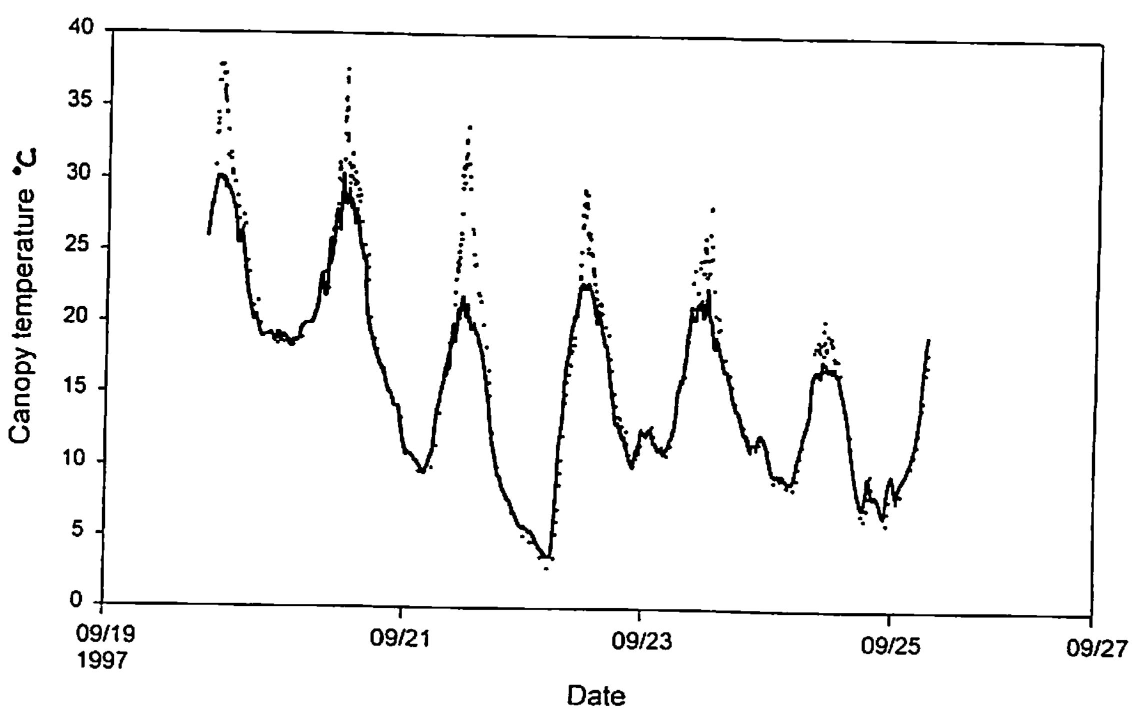
Ambient air temperature approx. 23°C

Table 5. Effect of various reflective groundcovers on percent full sun and red:far red light available to the under canopy of young 'Fuji'/M.9 apple trees trained to a 'Y' form trellis canopy. 1997.

Groundcover Material	Mean % full sunlight available[z]	% Change (+/-) from control	Mean red:far red light available[y]	% Change (+/-) from control
Black poly	8.5 c[x]	- 0.8	0.36 c	+ 2
White poly	24.3 b	+15.0	0.80 b	+ 128
Metalized poly	37.8 a	+28.5	1.09 a	+ 211
Bare soil (control)	9.3 c	--	0.35 c	---

[z] Light measured as PAR with Decagon SF-80 light bar.
[y] Red:far red light determined with SKR 100/116 light sensor with fiber optic probe.
[x] Means separation within columns by Duncan's new multiple range test, P=0.05.

Figure 1. Effect of metalized reflective groundcover on canopy temperature in 9-year-old 'Hardibrite Spur Delicious'/MM.111 apple trees trained to a 'Y" canopy form. Temperature recorded on data loggers in weather shelters placed 1.75 m above orchard floor in east side canopy. Control ——, RGC ·····



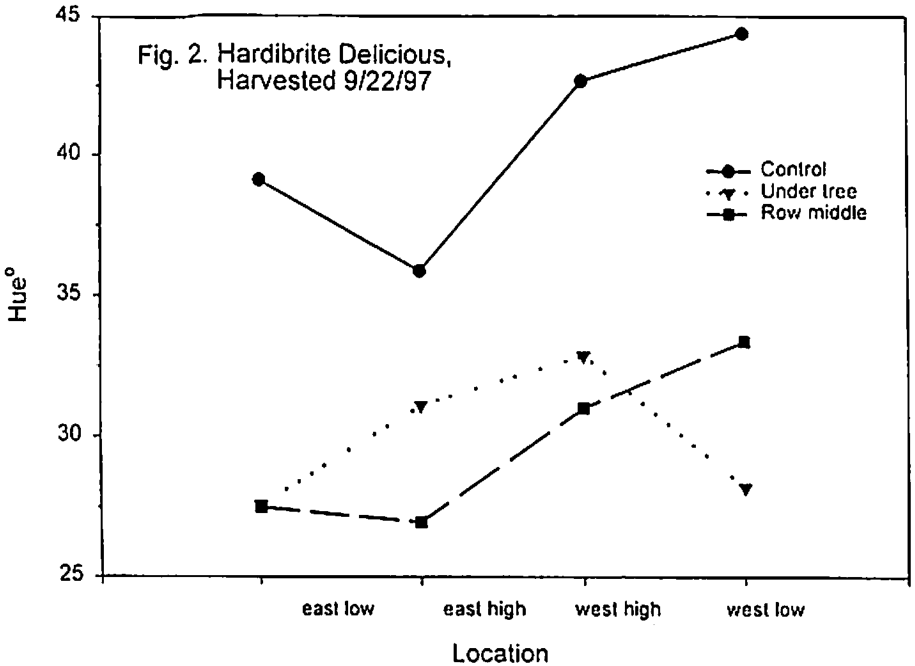


Fig. 2. Hardibrite Delicious, Harvested 9/22/97

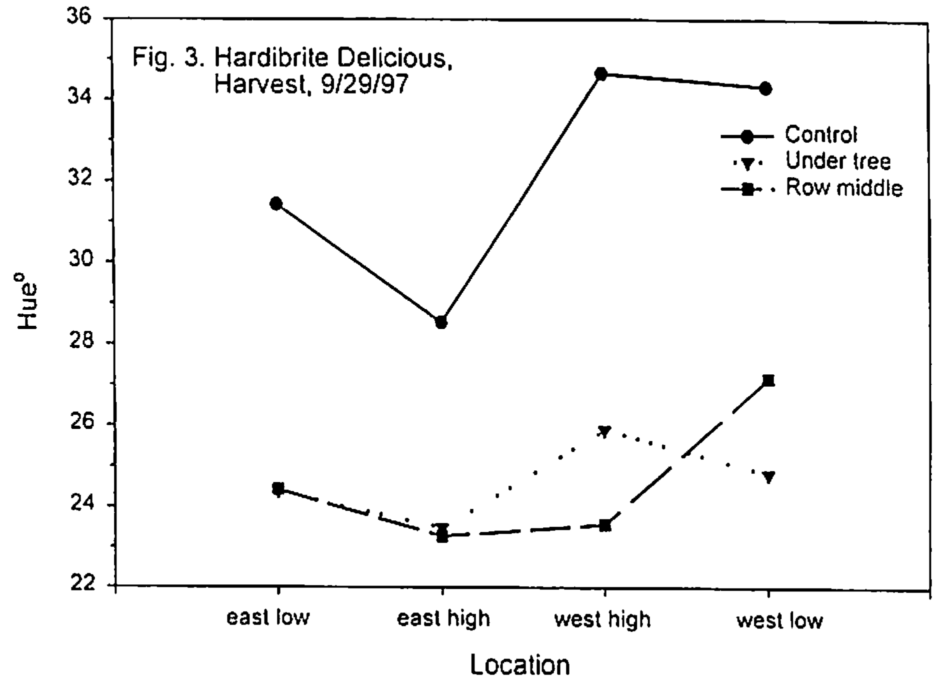


Fig. 3. Hardibrite Delicious, Harvest, 9/29/97

Fig. 2,3,4, & 5. Effect of metalized reflective groundcover on apple color (hue angle).

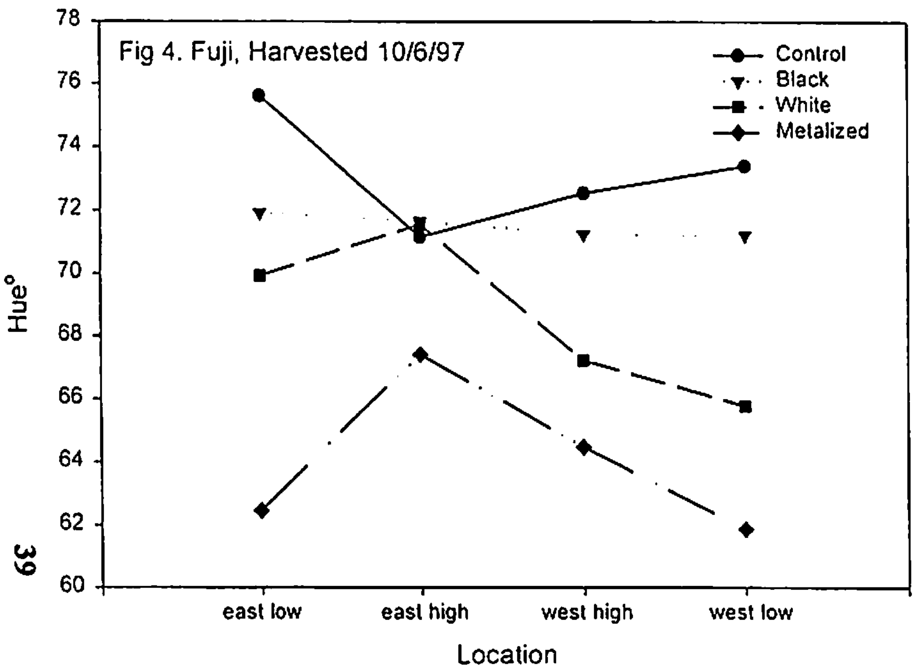


Fig 4. Fuji, Harvested 10/6/97

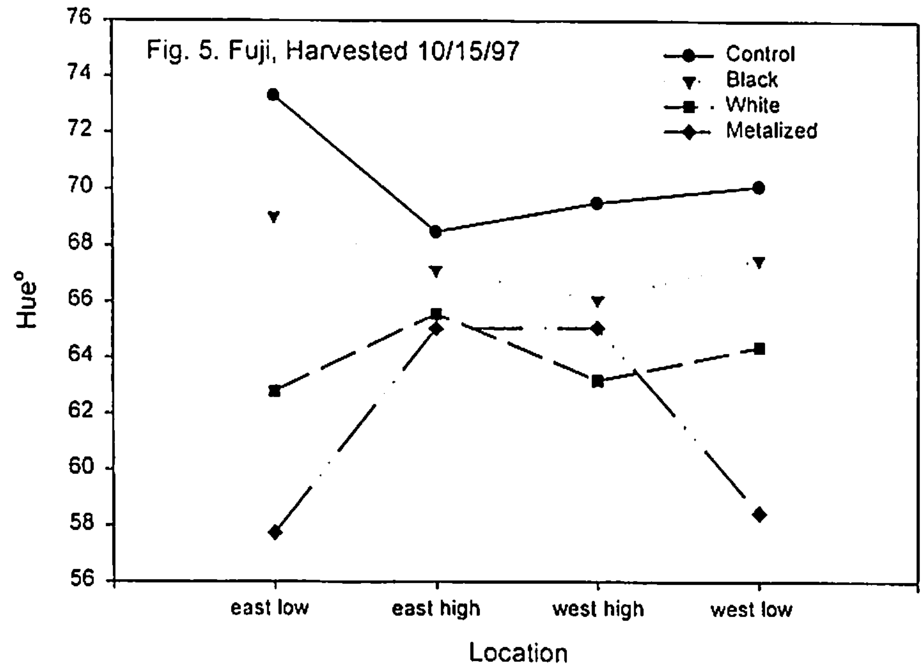


Fig. 5. Fuji, Harvested 10/15/97

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CONTROLLING SHOOT GROWTH IN APPLE WITH PROHEXADIONE CALCIUM (BAS 125W)

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Maximizing the bearing canopy is a primary objective in the orchard and involves both vegetative and reproductive processes. Initially the grower must encourage vegetative growth to develop a suitable framework and to efficiently fill the allotted orchard space as soon as possible. Optimum production and plant efficiency is achieved, however, only when vegetative growth and fruiting are balanced. Fruit growers recognize the need for this balance and devote a considerable amount of their input to cultural manipulations (pruning, fertilization, application of plant bioregulators, etc.) to achieve optimum production.

Climatic and edaphic conditions in most eastern fruit producing regions favor vigorous vegetative growth. Excessive vegetative growth is a major factor associated with overcrowding, delayed bearing, poor cropping, poor fruit quality (e.g. poor color), and pest problems (e.g. fire blight, aphid infestation, etc.) in the eastern U.S. Developing and maintaining the delicate balance between vegetative growth and cropping is a major challenge for the orchardist. Vegetative growth control by chemical means can help eliminate unwanted growth, limit tree size, or restrict growth at a particular time to produce a better balance between vegetative growth and fruiting. For many years daminozide (Alar) was the primary PGR used to suppress growth and encourage flowering. Later, a combined spray of daminozide + ethephon was recommended. At the present time only ethephon (Ethrel) is labeled for this purpose. NAA is also registered and used for vegetative growth control, but it has limited application. In the 1980's several triazole derivatives, which inhibited gibberellin biosynthesis, were shown to have powerful growth regulating properties in fruit trees (Miller, 1988) but, because of the residual nature of these compounds and their ability to be quickly absorbed through the roots, these compounds never reached registration in the U.S. Recently a new class of compounds, the acylcyclohexanediones (Rademacher et al., 1992) have been shown to possess growth regulating properties through GA biosynthesis inhibition (Griggs et al., 1991; Nakayama, et al., 1992). This class includes prohexadione. Preliminary reports have indicated that prohexadione calcium can reduce vegetative growth in apple trees (Byers and Yoder, 1997; Greene, 1997; and Unrath, 1997).

The present report deals with studies of prohexadione calcium (BASF Corp., Agric Products, Research Triangle Park, NC; product codes: BAS 9054W and BAS 125W) for vegetative growth control in apples. The objective was to determine the growth regulating capacity of BAS 125W, and the effect of application timing, concentration, and dose.

Materials and Methods

Studies were conducted between 1994 and 1997 on mature bearing apple trees at the Appalachain Fruit Research Station. All sprays were applied with a single nozzle handgun roller pump sprayer at approx. 690 kPa (100 psi) to the point of drip. All data was analyzed using ANOVA and means separated by Duncan's new multiple range test, P=0.05.

1994 Tests. Prohexadione calcium (BAS 9054W) was applied to 5-year-old 'Redchief Delicious cv. Mercier'/MM.106 at various concentrations and timings to examine the effect on shoot growth and fruit quality. Eight treatments, shown in Table 1, were arranged in a randomized complete block design with four whole-tree replications per treatment. The adjuvant, Regulaid was included in all sprays at 0.1% (v/v). Shoot growth was recorded on 10 tagged shoots on the outside of the canopy on four dates during the growing season. At harvest all fruit were removed and total weight was recorded. A subsample of 10 fruits was selected at random for determination of fruit quality (flesh firmness, soluble solids concentration, starch index rating, color intensity, and percent surface red color). The crop from each tree was sized on an electronic fruit weight sizer (Durand-Wayland OmniSort) with fruit separated into 15 size classes from 48 to 216 count size. At bloom in 1995, flower clusters were counted on a limb at least 10 cm in circum. and the number of clusters per cross sectional area determined.

1995 Tests. Three treatments of prohexadione calcium (henceforth referred to as BAS 125W) were applied to 16-year-old 'Law Rome'/MM.111 trees: single sprays of 125 ppm or 250 ppm at the 5 to 12 cm growth stage (5/15/95) or a multiple spray of 125 ppm applied on May 15, 1995 and 4 weeks later on June 16. There were eight single tree replications per treatment. All sprays contained Regulaid at 0.03% (v/v). Trees were vigorous, central leader form trees planted 5.5 m X 6.1 m and were carrying a heavy bloom. Twenty terminals were tagged on the periphery of the canopy between 1 and 3 m above the ground and measured on the day of initial treatment, at 4, 8, 12, and 16 weeks after treatment, and again at the end of the growing season. Trees were harvested, total yield recorded, fruit sized, and fruit quality determined from a 10 apple subsample for each treatment as in 1994. No treatments were applied in 1996 but yield and shoot growth measurements were taken from trees in each treatment.

1996 Tests. Single sprays of BAS 125W at 125 or 250 ppm were applied to six whole-tree plots of 8-year-old 'Kidd's Gala'/M.7A 10 days after full bloom (DAFB). Shoot growth was measured periodically as in 1994/95 during the growing season. Canopy volume was calculated from canopy depth, width, and height measurements assuming the canopy was an inverted cone. Pruning time per tree was recorded in the dormant season. In April, 1997, a limb 10 to 15 cm in circumference was selected and the blossom clusters counted. A freeze event on May 10 eliminated all fruit on the test trees so only shoot growth data was available.

A test was initiated in a high density [1132 trees/ha (459 trees/acre)] block of 8-year-old 'Starkspur Golden Delicious'/seedling apples trained to a 'Y' canopy form to evaluate a higher total dosage level of PGR applied in a split application. Trees were planted in a north-south orientation with the canopy forming a solid hedgerow. Average canopy height at the beginning of the growing season was 2.5 m. Twenty-four trees were treated with an initial spray of 375 ppm BAS 125W on May 10, 1996 (10 DAFB). On May 26, one half of the treated trees were trunk scored with a 1.7 mm thick hacksaw blade making a spiral cut midway on the tree trunk between the ground and the lowest scaffold branches. At the end of the growing season shoot growth on 20 terminals per tree was recorded. Because the test trees carried less than 10% of a full crop load, no fruit data was taken in this study.

1997 Tests. The excessively vigorous 9-year-old 'Starkspur Golden Delicious'/seedling used in the 1996 tests were again selected for treatment. Three multiple spray treaments of BAS 125W (Table 5) were applied to four-tree subplots in each of five rows (treatment blocks) in a randomized complete block design. The initial spray for each treatment was applied on May 7, one week after petal fall (PF). Successive sprays were applied at 2 week intervals (except the last spray was after a 3-week interval) at various concentrations from 0 to 250 ppm. Each treatment received a total dose of 625 ppm BAS 125W for the season with the last spray for each treatment applied on July 25. At least one guard tree was positioned between each subplot treatment in a block. An unsprayed control plot was included in each block. The adjuvant Regulaid was included in all sprays at 0.03% (v/v). At harvest (September 24, 1997) 20 fruit were collected at random from each side (east and west) of the canopy for fruit size measurements. Shoot growth was measured at the end of the growing season (October 30). Five current-season's watersprouts (suckers) were removed from the center of each tree at the base of their growth and the length recorded. In addition five terminal shoots in the lower canopy (up to 1.5 m above ground) and five terminals in the upper canopy (above 2.0 m height) were selected at random on the east and west side of the canopy from each tree and the current season's growth measured.

Eighteen-year-old 'Law Rome'/MM.111, used in the 1995 tests, were selected for multiple spray treatments. The objective was to evaluate various concentrations and timings and dose level of BAS 125W for growth control and ability to suppress canker development from natural fireblight infection (this block had suffered severe fireblight infection in 1995 and 1996). Treatments ranged from no BAS 125W applied during the season to a total of 3, 4, 5, or 6 individual sprays with concentration level per spray ranging from 60 to 250 ppm (Table 6). Total season dosage was 240 ppm, 360 ppm or 480 ppm. Treatments were arranged in randomized complete blocks with 6 blocks and single whole-tree treatments. On May 2, the initial treatment date, 10 terminals were selected on the periphery of the canopy between 1.5 and 2.5 m above the ground, tagged and shoot growth measurements taken. Shoots were measured again at 4, 8, and 12 weeks after initial treatment and at the end of the growing season. Increase in shoot growth and total growth was computed from periodic measurements. In early September measurements on canopy width, depth and height were recorded for each tree and the tree row volume (TRV) calculated for each treatment. On a uniform overcast day and again on a cloudless day in early September, light as photosynthetically active radiation (PAR) was measured at the base of each tree under the canopy with a Sunfleck SF80 Ceptometer light bar (Decagon Devices, Inc., Pullman WA 99163). Four readings were recorded per tree one each in the north, east, south and west quadrant of the canopy. Full sun measurements were taken in the open drive middles between tree rows at each of the 6 replicated blocks. Mean percent full sunlight reaching the lowest level of the canopy was computed. Five of the trees treated at the 360 ppm BAS 125W rate were selected in September before harvest for detailed spray coverage data collection. A 4 m tall metal pole was placed in the center of the canopy near the central leader. Water-sensitive paper cards (52 X 76 mm) (Ciba-Geigy Ltd., Application Services, Basle, Switzerland) were secured to the pole with double-sided tape at 1.2, 2.1, 3.0, and 3.7 m above the ground. Trees were sprayed with a John Bean PTO driven airblast sprayer calibrated and driven to deliver 935 l/ha

(100 gpa). Cards were collected and the size of the stained area determined by computer image analysis using Sigma Scan Pro software. Mean percent spray coverage at each of the four heights in the canopy were calculated and the increase/decrease in spray coverage compared to check trees was determined. At harvest a 20 apple fruit sample was collected from each tree for fruit quality measurements. Total yield and percent fruit in individual fruit size classes was determined by harvesting each tree and passing the fruit over an electronic fruit grader.

Results and Discussion

1994 Tests. Prohexadione calcium (BAS 125W) at all concentrations and timings reduced shoot growth in spur 'Redchief Delicious'/MM.106 apple trees (Table 1). Shoot growth reduction ranged from 39% when BAS 125W was applied at 125 ppm 7 days after petal fall (DAPF) to 69% growth reduction at 375 ppm applied 7 DAPF. Average growth reduction over all treatments was 55%. Differences in growth were maifested in the first 12 weeks after treatment. Treatment with four sprays at 50 ppm each was as effective as single sprays at 125, 250, or 375 ppm. Shoot growth mesurements suggested that higher concentrations and applications closer to (PF) may result in greater reductions in shoot growth compared to lower rates and later timings. BAS 125W treatments had no effect on fruit quality (flesh firmness, soluble solids concentration, starch index, or color)(data not shown). The percentage fruit grading 150 size class or smaller was about 3 times more than for control fruit at the higher rate treatments applied at or soon after petal fall (250 or 375 ppm 7 DAPF and 250 ppm at PF)(data not shown). No phototoxicity was observed on fruit or foliage in any of the treatments. Blossom cluster density in 1995 was unaffected by the BAS 125W treatments in 1994.

1995 Tests. A single spray of 250 ppm BAS 125W applied at the 5 to 12 cm growth stage or two sprays applied at 125 ppm each, the first at the 5 to 12 cm growth stage and the second applied 4 weeks later, reduced terminal shoot growth in large mature 'Law Rome'/MM.111 apple trees (Table 2). Yields were not affected in the year of treatment or the year after BAS 125W sprays but, yield for the multiple BAS 125W treatment at 125 ppm did result in the highest return crop and significantly more than trees receiving a single spray at 125 ppm. There was no carryover effect on shoot growth in 1996 from the treatments applied in 1995 (Table 2). Fruit size and fruit quality parameters measured were unaffected in 1995 (year of treatment) or 1996 (year after treatment)(data not shown).

1996 Tests. The study on 'Kidd's Gala' was originally designed to examine effect of BAS 125W on fruit size but, a freeze soon after bloom eliminated the crop. With loss of crop these trees presented an excellent opportunity to confirm earlier results on shoot growth control. BAS 125W at 125 or 250 ppm applied 10 DAFB reduced shoot growth (Table 3). There was a trend for greater shoot growth reduction at the higher concn. but mean total growth did not differ at the end of the growing season. BAS 125W at concentrations used in this test did not affect pruning time, canopy volume, or blossom density in the year after treatment but, there was a trend for the higher rate (250 ppm) to reduce pruning time and canopy volume and increase blossom density (Table 3). Shoot growth measured in 1997 did not differ among treatments but there was a trend toward greater growth for the BAS 125W treated trees (data not shown). Results enforce earlier observations that on some sites and under some conditions concentrations above 250 ppm may be required to obtain the desired level of growth control.

The 8-year-old 'Starkspur Golden Delicious'/seedling trees selected for study in 1996 had been pruned annually since planting, were quite open to light (except the lower underside portion of the canopy's 'Y' form), and regularly produced in excess of 60 to 80 cm of terminal growth. These trees presented an extreme test of BAS 125W's shoot growth control capabilities. Two sprays of BAS 125W applied 4 weeks apart at a total dosage of 500 ppm resulted in a 53% reduction in shoot growth in these trees (Table 4). Scoring the trunk of BAS 125W treated trees resulted in a 64% reduction in shoot growth. The level of shoot growth achieved by BAS 125W sprays (40 cm) in this study would be considered at the upper limits of acceptability for these trees and canopy architecture. Periodic shoot growth measurements were not taken during the growing season. However, observations soon after the initial spray at 375 ppm clearly showed the strong growth controlling properties of BAS 125W at this higher concentration. When the second application at 125 ppm was made in mid-June, average shoot growth in the top and upper side of the canopy in treated trees was estimated at 10 cm or less while control trees had easily exceeded 25 cm. Approximately one month after the final BAS 125 spray shoot growth in treated trees was estimated to be 15 to 20 cm and control trees at nearly 40 cm or more. The 1996 growing season was characterized as warm and wet with rainfall nearly 80% above normal. These conditions resulted in continued growth late into the season. Growth nearly doubled on all trees from July until October (new shoot growth was observed as late as the last week in September with shoot blight infections from fireblight in neighboring apple blocks). Because of this, season-long shoot growth control was not achieved and growth in BAS 125W treated trees exceeded a more desireable level of 20 to 30 cm. The results further emphasized earlier observations that greater latitude in the application of BAS 125W may be needed (ie., higher rates and/or later timings) to obtain the desired growth response under the variable conditions in the eastern U.S. Scoring the trunks of these vigorous trees tended to enhance the degree of growth control.

1997 Tests. Treatments with four or five sprays of BAS 125W beginning May 7 (7 DAPF) with the final spray on July 25 and a total of 625 ppm applied per treatment reduced watersprout growth and growth of all other shoots on vigorous 9-year-old 'Starkspur Golden Delicious'/seedling apple trees trained to a 'Y' canopy form (Table 5). All treatments were equally effective in reducing shoot growth. BAS 125W reduced watersprout and lower canopy shoot growth an average of 43% and upper canopy shoot growth by 50%. Growth response did not differ between the east and west sides of the canopy and average growth for the two sides was similar (data not shown). The level of growth control in the these 'Starkspur Golden Delicious' apples with BAS 125W was more desireable compared to the lower dose, fewer spray treatments applied to the same trees in 1996 (Table 4). While rainfall for the season was 38% below normal (in contrast to 1996 when rainfall was 80% above normal) and may have been a contributing factor in the reduced growth, supplemetal water was applied during the season through drip irrigation. Average growth of all shoots in 1997 was about 68 cm compared to 86 cm in 1996. None of the BAS 125W treatments had an effect on average fruit weight or fruit length:diameter (data not shown).

The 1997 growing season was unfavorable for the spread of fireblight and natural infection did not occur as in 1995 and '96. Only several shoots were observed with fireblight symtoms in the 'Law Rome'/MM.111 trees. Therefore, no data was collected on the effect of BAS 125W on shoot blight development. All dose levels of BAS 125W effectively reduced shoot growth (Table 6).

Growth control response was generally dose related, ie., the higher dose (480 ppm) reduced shoot growth more than the lower dose (240 ppm), however, growth control at 360 ppm did not differ from that at 480 ppm but there was a trend to less growth as rate was increased from 360 ppm to 480 ppm. While there was little or no difference between treatments that received a total dose of 360 ppm, those that received the lowest concentration (60 ppm) as an initial spray tended to have less effect on growth than those that received the higher rate (120 or 240 ppm) as the initial spray. These results agree with earlier multiple spray studies indicating that total dose has more impact on growth response than rate of the individual sprays at least within the range of concentrations studied. Furthermore, the results strongly suggest that an initial spray of 240 ppm or greater is likely to reduce growth more than lower doses of 60 or 120 ppm.

Multiple sprays of BAS 125W did not affect the canopy volume enough to produce differences in the calculated tree row volume (TRV) or the percent full sunlight reaching the underside of the canopy at the base of the tree (data not shown). There were trends toward reduced TRV and more light penetration when BAS 125W was applied but differences were not significant. Three to six multiple sprays of BAS 125W at a total dose of 360 ppm increased the overall average spray coverage in large mature 'Law Rome' trees by 10.6% (Table 7). The major increase in spray coverage occurred in the lower half of the canopy.

Fruit quality parameters and fruit size of 'Law Rome' was unaffected by the multiple BAS 125W spray treatments at total dosage levels from 240 to 480 ppm.

Conclusions

The gibberellin biosynthesis inhibitor prohexadione calcium, code name BAS 125W, is an effective shoot growth inhibitor in apple. Application at or near PF will suppress growth more than a similar application 2 to 3 weeks after PF. Response to BAS 125W is concentration dependent. Multiple sprays at lower concentrations are as effective as single sprays at a higher rate. Under prolonged growing conditions, BAS 125W spray applications may need to extend past mid-season to obtain adequate season-long growth control. BAS 125W at the rates and timings used in these studies has no effect on canopy volume, pruning time, fruit quality or fruit size. There are trends toward reduced canopy volumes, reduced pruning time and reduction in fruit size that may occur at higher rates but, there appears to be little or no basis for applications above 240 ppm as a single spray or multiple sprays beyond 600-700 ppm as a total season dose. At these suggested rates, negative responses have not occurred.

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Table 1. Vegetative growth control with prohexadione calcium (BAS125W) in 5-year-old 'Mercier Redchief Delicious'/MM.106 apple trees. 1994.

Treatment[z]		Increase in shoot growth (cm) at: Weeks after petal fall				Mean Total Growth
Conc.(ppm)	Timing[y]	4	8	12	16	
125	7 DAPF	6.1 bcd[x]	4.8 b	4.7 a	2.4 a	18.0 b
250	7 DAFB	4.3 bcd	2.3 b	1.8 b	3.0 a	11.4 b
375	7 DAPF	4.2 cd	2.1 b	1.1 b	1.9 a	9.3 b
250	PF	3.2 d	1.9 b	1.9 ab	3.2 a	10.2 b
250	14 DAPF	8.2 ab	4.1 b	2.4 ab	2.5 a	17.2 b
250	21 DAPF	7.4 abc	3.9 b	1.6 b	0.5 a	13.5 b
50	PF, 7, 14 and 21 DAPF	4.9 bcd	2.3 b	2.8 ab	2.0 a	12.0 b
0	Control	10.4 a	15.4 a	2.9 ab	0.6 a	29.3 a

[z] Dilute whole-tree sprays with handgun.
[y] DAPF = days after petal fall; PF = petal fall.
[x] Means separation within columns by Duncan's multiple range test, P=0.05

Table 2. Vegetative growth control in 16-year-old 'Law Rome'/MM.111 apple trees with single and multiple sprays of BAS125W. 1995.

Treatment[z]	Concn. (ppm)	Average terminal shoot growth (cm)		Yield (kg/tree)	
		1995	1996	1995	1996
Single	125	48.1 ab[y]	43.9 a	165 a	30 b
Single	250	41.4 bc	44.1 a	153 a	88 ab
Multiple	125 + 125	40.0 c	44.0 a	122 a	161 a
Control	0	54.7 a	42.7 a	119 a	84 ab

[z] Single sprays applied with handgun at 5 to 12 cm growth stage (5/15/95). Multiple sprays applied at 5 to 12 cm shoot growth stage and again 4 weeks later (6/16/95).
[y] Means separation within columns by Duncan's multiple range test, P=0.05.

Table 3. Effect of BAS 125W on terminal shoot growth, pruning time, canopy volume, and return bloom in 8-year-old 'Kidd's Gala'/M.7A apple trees. 1996.

Treatment concn.[z]	Mean total shoot growth	Pruning time	Canopy volume[y]	Blossom clusters in 1997
(ppm)	(cm)	(min/tree)	(cu m/tree)	(No./sq cm csa[x])
0	46.3 a[w]	7.9 a	31.2 a	3.8 a
125	34.9 b	7.3 a	30.9 a	4.2 a
250	29.6 b	6.1 a	26.5 a	4.7 a

[z] Sprays applied 10 days after full bloom, 5/10/96.
[y] canopy volume = 1/3(area of base)(height - 0.7m).
[x] csa = cross sectional area
[w] Means separation within columns by Duncan's new multiple range test, P=0.05.

Table 4. Effect of multiple BAS125W sprays alone or with scoring on terminal shoot growth in vigorous 8-year-old 'Golden Delicious'/seedling apple trees trained to a 'Y' canopy form. 1996.

Treatment[z]	Mean terminal shoot growth (cm)
Control	85.8 a[y]
375-0-0-0-125	40.4 b
375-0-0-0-125 + scoring[x]	30.5 b

[z] Sprays applied with handgun sprayer. Treatment is concn. (ppm) and weekly interval, ie., 375 = spray @ 375 ppm applied 10 days after full bloom, 0 = no spray, and 125 = 125 ppm applied 4 weeks later.
[y] Mean separation by Duncan's new multiple range test, P=0.05.
[x] Trunk scored with a standard hacksaw blade in a spiral pattern.

Table 5. Effect of multiple BAS125W sprays on shoot growth in vigorous 9-year-old 'Starkspur Golden Delicious'/seedling apple trees trained to a 'Y' form canopy. 1997.

	Mean shoot growth (cm) for:[z]			
Treatment Code[y] (ppm)	Water-sprouts	Lower canopy	Upper canopy	All shoots
75-75-125-0-250-100	96.5 b[x]	15.7 b	33.0 b	38.8 b
125-125-0-125-0-250	81.3 b	15.9 b	28.0 b	33.8 b
250-0-125-0-125-125	95.5 b	16.5 b	33.1 b	39.0 b
0-0-0-0-0-0	159.4 a	28.2 a	62.5 a	68.1 a

[z] Watersprouts taken from center of canopy; lower canopy shoots from orchard floor to 1.5 m height; upper canopy from above 2 m height.
[y] Individual bi-weekly sprays at designated ppm beginning 7 days after petal fall except last spray applied at 3 week interval. Total dose applied to all treatments = 625 ppm.
[x] Means separation within columns by Duncan's new multiple range test, P=0.05.

Table 6. Effect of multiple BAS125W sprays on shoot growth in 18-year-old 'Law Rome'/MM.111 apple trees. 1997.

Treatment Code[z]	Total dose applied (ppm)	Increase in shoot growth (cm) week after treatment: 4	8	12	Total growth
120-0-0-120-0-120-0	360	7.4 de	1.8 b	0.5 ab	13.4 bcd
120-60-60-60-60-0-0	360	7.7 cde	1.5 b	0.7 ab	13.6 bcd
60-60-60-60-0-60-60	360	9.0 bcd	1.4 b	0.5 ab	13.4 bcd
240-0-0-120-0-0-0	360	7.1 de	1.4 b	0.5 ab	12.4 cd
60-60-120-0-0-120-0	360	9.7 bc	1.2 b	0.4 b	14.4 bc
240-0-120-0-120-0-0	480	6.0 e	1.5 b	0.4 b	10.1 d
60-60-0-120-0-0-0	240	10.6 b	2.8 b	1.1 ab	16.8 b
0-0-0-0-0-0-0	0	19.7 a	11.3 a	1.3 a	34.5 a

[z] Individual sprays applied at 10 day intervals beginning at petal fall at designated ppm per spray.
[y] Means separation within columns by Duncan's new multiple range test, P=0.05.

Table 7. Effect of BAS125W on spray coverage in 18-year-old 'Law Rome'/MM.111 apple trees. 1997.

Height of water-sensitive card above orchard floor[z]	% spray coverage[y] BAS125W 360 ppm	Check	Increase (+) Decrease (-)
1.2 m	48.5	19.6	+ 28.9
2.1 m	26.7	6.9	+ 19.8
3.0 m	3.1	0.6	+ 2.5
3.7 m	2.3	11.4	- 9.1
Average	20.2	9.6	+ 10.6

[z] water-sensitive spray cards, 5.1 X 7.6 cm placed on metal pole in center of canopy. Airblast sprayer calibrated to deliver 935 l/ha (average tree row volume = 3740 l/ha).
[y] Sigma Scan Pro software used to determine percent surface impacted by spray.

(Not for publication or distribution)

The Influence of AVG on Pre-Harvest Fruit Drop of Apple, and Harvest Date and Fruit Quality of Peach and Apple

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Introduction

AVG is an ethylene-biosynthesis inhibitor (Yu and Yang, 1979, Shafer et al., 1995) that suppresses ethylene production in apples (Malus domestica Borkh.)(Autio and Bramlage, 1982; Bangerth, 1978). When applied within 1 month of harvest, AVG delays fruit ripening, suppresses preharvest and postharvest flesh softening, reduces watercore, reduces pre-harvest fruit drop, and increases fruit removal force (Autio and Bramlage, 1982; Bangerth, 1978; Williams, 1980).

Dips of AVG delayed softening of peach and nectarine fruit. If pre-harvest sprays of AVG would delay softening and harvest of peaches, the continued fruit growth might cause greater fruit size and yields since fruit are rapidly increasing in fruit diameter in the final swell. In a previous experiment, sprays of AVG did not substantially delay peach fruit maturation (Byers, 1997a).

The objectives of these experiments were to investigate: 1) adjuvants for potentiation of AVG for control of preharvest fruit drop, 2) AVG and NAA combinations on preharvest drop control and fruit quality, and 3) AVG sprays on peaches and apples for delay of fruit maturity, increased fruit size, yields, and color development.

Materials and Methods

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

Experiment 1. In 1996, ninety 19-year-old 'Redspur Delicious'/MM.111 trees, selected for uniform crop, were blocked according to row and terrain into 6 blocks for 15 treatments. NAA or ABG 3168 (ReTain, a formulation of AVG) was applied to each treatment 3 Sept 96 3 weeks before the optimum harvest date (26 Sept). The spray treatments are listed in Table 1. The sprays were applied with a Swanson 3-pt hitch airblast sprayer with both fans adjusted to one side to double air output. Trees were considered 75% Tree-Row-Volume (TRV) dilute.

Three limbs/tree (approximately 50 fruits/tree) were selected and tagged on for determining fruit drop . At intervals of about 7 days, fruit on limbs were counted and the percentage fruit drop was calculated based on fruit remaining on the five limbs/tree. Fruit remaining on each limb were counted on 22 Oct. In addition, a sample of 10 fruits was collected from each tree for determining fruit firmness, % soluble solids concentration (SSC), and ratings for watercore, starch, and fruit color on 26 Sept. and 21 Oct.

In addition, ten fruit samples from the 26 Sept. And 21 Oct. harvest dates were stored in a commercial cold storage at 32 F and tested on 16 Dec, 11 Feb. and 31 Mar.

Experiment 2. In 1997, sixty-six 14-year-old 'Law Rome'/MM.111 trees, selected for uniform crop, were blocked according to row and terrain into 6 blocks for 11 treatments. NAA or ABG 3168 (ReTain) was applied to each treatment 15 Sept 96, 4 weeks before the optimum harvest date (15 Oct). The spray treatments are listed in Table 2. The sprays were applied with a Swanson 3-pt hitch airblast sprayer with both fans adjusted to one side to double air output. Trees were considered 70% Tree-Row-Volume (TRV) dilute.

Three limbs/tree (approximately 50 fruits/tree) were selected and tagged on for determining fruit drop . At intervals of about 7 days, fruit on limbs were counted and the percentage fruit drop was calculated based on fruit remaining on the five limbs/tree. Fruit remaining on each limb were counted on 29 Oct. In addition, a sample of 10 fruits was collected from each tree for determining fruit firmness, % soluble solids concentration (SSC), and ratings for watercore, starch, and fruit color on 17 Oct. and 3 Nov.

In addition, ten fruit samples from the 17 Oct. and 3 Nov. harvest dates were stored in a commercial cold storage at 32 F and tested in January 1998.

Experiment 3. In 1997, thirty 13-year-old 'Cresthaven' trees were selected for uniform crop and were blocked according to row and terrain into 6 blocks for 5 treatments. ABG 3168 was applied at either 200g/acre or 1000g/acre to each treatment either 11 or 29 days before the first harvest date (22 Aug.). The spray treatments are listed in Table 3. The sprays were applied with a Swanson 3-pt hitch airblast sprayer with both fans adjusted to one side to double air output. Trees were considered 50% Tree-Row-Volume (TRV) dilute. Six harvests were made from 22 August until 9 Sept. The number and weight of all fruit from each tree were recorded. At each harvest a 10 fruit sample was taken from each tree and fruit diameter, estimated % red color, %SSC, and fruit firmness was taken.

Experiment 4. In 1997, twenty-eight 'Gala '/M27 trees, selected for uniform crop, were blocked according to row and terrain into 7 blocks for 4 treatments. Three applications of Accel were applied at 10g/acre each on May 1, May 8, and May 15, and ABG 3168 was applied to each treatment 21 August 97 2 weeks before the optimum harvest date of non-treated Gala's on 3 Sept. The spray treatments are listed in Table 4. The Accel sprays were applied with a Swanson 3-pt hitch airblast sprayer, and the ABG 3168 was applied with a low pressure hand-wand sprayer. Trees were considered 20% Tree-Row-Volume (TRV) dilute.

At intervals of about 7 days, 3 fruit/tree were harvested for determining ethylene evolution, fruit firmness, % soluble solids concentration (SSC), and ratings for watercore, starch, and fruit color on 3 Sept. and 25 Sept. In addition, 5 fruit were tagged and fruit diameters were taken each week.

Results and Discussion

Experiment 1. ABG-3168 (50 g/A) reduced fruit drop of 'Redspur''Delicious'/MM111 slightly better than 20 ppm of NAA (Table 1). ABG-3168 (50 g/A) at the optimum harvest date maintained fruit firmness approximately 1 lb higher than the non-treated control and the NAA treatment on the 30 Sept. harvest date (Table 1B). ABG-3168 (50 g/A) maintained fruit firmness 3.0 lbs higher than the non-treated control, and 3.5 lbs higher than the NAA treatment when harvest about 4 weeks (22 Oct) after the optimum harvest date (30 Sept) (Table 1C).

Fruit samples from the 30 Sept and 22 October harvest dates were followed during regular cold storage for softening, starch, SSC, and watercore. Fruit harvested on 30 Sept. Were more firm at each time fruit were taken out of cold storage (16 Dec, 11 Feb, and 31 Mar). by aproximately 2 lbs. Fruit harvested on 21 October were not as firm for all treatments as if harvested on 30 Sept. However, the AVG treatments harvested 21 October were as firm as the controls from the 30 Sept harvest when tested on 16 Dec, 11 Feb, and 31 Mar (Tables 1B&C). Water core in the late harvested fruit disappeared in cold storage by 1 Apr. On 21 Oct. AVG at the higher rate (trt#s 5, 9, 13, 15) and with surfactant reduced water core substantially.

Experiment 2. ABG-3168 (50 g/A) + reduced fruit drop of 'Rome'/MM111 better than 20 ppm of NAA (Table 2A). NAA had unacceptable control of fruit drop. No differences were found between the 40g or 50g rates of ABG-3168. The use of either surfactant (ABG-7011 or BBG-7042 at 0.1% or 0.05% did not appear to potentiate ABG-3168 (Table 2A).

ABG-3168 (50 g/A) at the optimum harvest date (Oct 17) maintained fruit firmness approximately 1.5 lb higher than the non-treated control, and 4.2 lb. higher than the NAA treatment (Table 2B). ABG-3168 (50 g/A) maintained fruit firmness 3.9 lbs higher than the non-treated control, and 4.1 lbs higher than the NAA treatment when harvest about 2 weeks after the optimum harvest date (3 Nov)(Table 2B). Interestingly, the ABG-3168 (trt 5) on Nov. 3 was 1.1 lb more firm than the NAA treated fruit (trt 2)on Oct 17. The combination of NAA and ABG-3168 (trt 11) was just as firm as the NAA treatment on Oct 17 (Table 2B).

Experiment 3. ReTain delayed harvest (Table 3A), delayed red color (Table 3B)and increased firmness (Table 3B) of 'Cresthaven' peach fruit, and did not affect the average fruit weight of all fruit (Table 3A). However, the single fruit weight for individual pick dates were different with the highest rate closest to harvest reducing fruit weight the greatest (Table 3C). The 1000g/acre application 11 days prior to harvest was more effective than at 29 days prior to harvest, and the 1000 g rate was more effective than the 200 g rate.

Fruit from the 1000g/acre application harvested 29 August, stored for 5 days at room temperature (24 C) (Table 3D), were more firm than the control, delayed red color, fruit diameter was smaller and single fruit weight lower, but SSC was unaffected.

Experiment 4. Approximately 2/3 of the fruit were hand thinned from these trees due to a heavy fruit set to a uniform crop load. Data from the 10 fruit sample indicated fruit diameter was smaller for treatments 2&3. Since fruit were smaller, this may have affected data on fruit firmness, SSC, Starch, etc. (Table 4A). The L/D ratio was increased by Accel (trts 2&4), but fruit weight did not appear to be affected in the second pick (25 Sept.). ReTain + Accel increased fruit firmness where as Accel may have reduced it (25 Sept.). Soluble solids and color were reduced and starch increased by ReTain (Trt #s 3&4) (Table 4A).

Data from the 3 fruit sample taken Aug 28, Sept 4, Sept 11, and Sept 18 indicated no differences in fruit diameter, fruit weight or fruit firmness, but Accel appeared to increase the L/D ratio in treatment #2&4 for Sept 18. Retain reduced SSC on Sept 11 and Starch red color and ethylene on Sept 4, Sept 11 and Sept 18 (Table 4C).

Acknowledgements

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Table 1A. Effect of ABG 3168 and NAA on fruit drop of 'Redspur Delicious'/111 (1996).

No.		Treatment[Z]	Rate g/acre (gallon)	Rate/ 50 gal	% Fruit Drop Sept 18	Sept 24	Oct 2	Oct 9	Oct 17	Oct 22
1.	W	Control			0.594 a[y]	4.52 a	9.81 a	14.0 a	28.28 a	40.09 a
2.	R	NAA 20 ppm	438 ml/100	219 ml	0.000 a	0.00 b	1.19 b	2.14 bc	8.87 bc	13.77 bc
3.	B	ABG-3168 + ABG-7011 (0.1%)	50g/400	41.7g 189.5 ml	0.273 a	0.27 b	1.37 b	2.18 bc	3.89 bc	4.44 cde
4.	FO	ABG-3168 + ABG-7011 (0.1%)	50g/200	83.3g 189.5 ml	0.000 a	0.31 b	0.60 b	0.91 bc	2.37 c	2.65 de
5.	LG	ABG-3168 + ABG-7011 (0.1%)	50g/100	167g 189.5 ml	0.513 a	1.08 b	1.91 b	2.45 bc	2.77 c	4.47 cde
6.	PBKS	ABG-3168 + ABG-7011 (0.1%)	40g/400	33.6g 189.5 ml	0.260 a	0.26 b	0.26 b	0.51 bc	1.97 c	2.78 de
7.	OBKS	ABG-3168 + ABG-7011 (0.1%)	30g/400	25.0g 189.5 ml	0.617 a	1.23 b	1.86 b	2.50 bc	4.39 c	5.31 cde
8.	RBKS	ABG-3168 + ABG-7011 (0.1%)	30g/200	50.0g 189.5 ml	0.000 a	0.00 b	0.58 b	0.85 bc	2.87 c	4.04 cde
9.	BBKS	ABG-3168 + ABG-7011 (0.1%)	30g/100	100.0g 189.5 ml	0.000 a	0.30 b	1.10 b	1.10 bc	3.92 bc	4.83 cde
10.	YBKS	ABG-3168	50g/200	83.3g	0.000 a	0.00 b	1.16 b	2.11 bc	7.16 bc	12.24 bcd
11.	RS	ABG-3168	40g/200	67.26g	0.000 a	0.28 b	0.28 b	0.28 c	1.61 c	2.73 de
12.	BS	ABG-3168	30g/200	50.0g	0.000 a	1.28 b	2.54 b	4.05 b	13.72 b	20.25 b
13.	RD	ABG-3168 + ABG-7011 (0.05%)	50g/200	83.3g 95 ml	0.000 a	0.00 b	0.61 b	0.61 bc	1.51 c	2.76 de
14.	BD	ABG-3168 + ABG-7011 (0.05%)	30g/200	50.0g 95 ml	0.000 a	0.29 b	0.29 b	1.22 bc	2.63 c	3.81 cde
15.	Y	ABG-3168 + ABG-7011 (0.05%)	100g/200	167g 95 ml	0.000 a	0.00 b	1.44 b	1.44 bc	2.09 c	2.64 e

Contrasts:	Comparisons	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F
1 Vs 2	Control Vs NAA	ns	***	***	***	***	***
2 Vs 3,4,5,10,13	NAA Vs ABG (50g)	ns	ns	ns	ns	*	*
2 Vs 5	NAA Vs ABG 50g+0.1% surfactant	ns	ns	ns	ns	ns	ns
2 Vs 6	NAA Vs ABG (40g)	ns	ns	ns	ns	*	*
2 Vs 7,8,9	NAA Vs ABG (30g)	ns	ns	ns	ns	ns	*
2 Vs 12	NAA Vs 30g (no surfactant)	ns	ns	ns	ns	ns	ns
2 Vs 13	NAA Vs ABG 50g+0.05% surfactant	ns	ns	ns	ns	*	*
2 Vs 14	NAA Vs ABG 30g (0.05% surfactant)	ns	ns	ns	ns	ns	*
13 Vs 15	ABG (50g Vs 100g)	ns	ns	ns	ns	ns	ns
3,4,5 Vs 7,8,9	ABG (50g Vs 30g)	ns	ns	ns	ns	ns	ns
3,4,5,6,7,8,9 Vs 10,11,12	Surfactant Vs no surfactant	ns	ns	ns	ns	**	***
4,8 Vs 13,14	Surfactant (0.01% Vs 0.05%)	ns	ns	ns	ns	ns	ns

Regression of water rate	trts3,4,5,7,8,9	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F
100 gal to 400 gal / acre	L	ns	ns	ns	ns	ns	ns
	Q	ns	ns	ns	ns	ns	ns
	L + Q	ns	ns	ns	ns	ns	ns
Regression of chemical rate	trts						
0 to 50g	1,3,4,5,6,7,8,9,10,11, 12,13,14						
	L	ns	ns	ns	ns	ns	ns
	Q	ns	ns	ns	ns	ns	ns
	L + Q	ns	ns	ns	ns	*	ns

[Z]All treatments were applied with an airblast machine at 100 gals/acre on 3 Sep 96. Tree size was considered to be 75% TRV.

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

Table 1B. Effect of ABG 3168 and NAA on fruit quality of 'Redspur Delicious'/111 harvested 26 Sept 1996.

No.	Treatment[z]	Chemical rate g/acre	Water volume gal/acre	Fruit firmness (lb.)				Starch (1-5 rating)			Soluble solids(%)				Water Core (% Fruit)		
				Sept 26	Dec 16	Feb 11	Mar 31	Sept 26	Dec 16	Feb 11	Sept 26	Dec 16	Feb 11	Mar 31	Sept 26	Dec 16	Feb 11
1.	Control			16.0 d[y]	14.9 c	13.6 c	13.3 b	4.2 ab	5.0 a	5.0 a	10.3 a	11.3 a	11.2 ab	11.1 ab	0 a	0 a	0 a
2.	NAA	23	100	16.6 cd	14.5 c	13.6 c	13.6 b	4.4 a	5.0 a	5.0 a	10.4 a	11.2 a	11.3 ab	10.9 abc	0 a	0 a	0 a
5.	ABG-3168 +ABG-7011 (0.1%)	50	100	17.2 bc	16.1 b	15.4 ab	14.3 ab	4.1 b	5.0 a	5.0 a	9.9 a	10.9 ab	11.0 ab	10.8 abc	0 a	0 a	0 a
9.	ABG-3168 +ABG-7011 (0.1%)	30	100	18.0 a	16.2 ab	15.7 ab	14.9 a	4.1 b	5.0 a	3.5 b	9.8 a	10.8 ab	10.7 bc	10.6 bc	0 a	0 a	0 a
10.	ABG-3168	50	200	17.0 bc	16.4 ab	15.2 ab	14.1 ab	4.2 ab	5.0 a	5.0 a	10.2 a	11.0 ab	11.2 ab	10.8 abc	0 a	0 a	0 a
12.	ABG-3168	30	200	17.4 b	16.0 b	15.0 ab	14.1 ab	4.2 ab	5.0 a	5.0 a	10.3 a	11.2 a	11.4 a	11.4 a	0 a	0 a	0 a
13.	ABG-3168 +ABG-7011 (0.05%)	50	200	17.0 bc	16.0 b	14.8 b	14.2 ab	4.1 ab	5.0 a	5.0 a	10.1 a	11.2 a	11.6 a	11.2 ab	0 a	0 a	0 a
15.	ABG-3168 +ABG-7011 (0.05%)	100	200	17.2 bc	16.9 a	15.9 a	15.0 a	4.3 ab	5.0 a	5.0 a	9.8 a	10.4 b	10.3 c	10.2 c	0 a	0 a	0 a
Contrasts	Comparisons																
1 Vs 2	Control Vs NAA			ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
2 Vs 5	NAA Vs ABG (50g+0.1% surfactant)			ns	***	***	ns	*	ns	ns	ns	ns	ns	ns	ns	ns	ns
2 Vs 9	NAA Vs ABG (30g)			***	***	***	*	*	ns	ns	*	ns	ns	ns	ns	ns	ns
2 Vs 10	NAA Vs ABG (50g)			ns	***	***	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
2 Vs 12	NAA Vs 30g (no surfactant)			*	***	***	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
2 Vs 13	NAA Vs ABG (50g+0.05% surfactant)			ns	***	**	ns	*	ns	ns	ns	ns	ns	ns	ns	ns	ns
2 Vs 15	NAA Vs ABG (100g+0.05% surfactant)			ns	***	***	**	ns	ns	ns	ns	*	**	*	ns	ns	ns
5 Vs 9	ABG (50g Vs 30g)			**	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
5 Vs 10	Surfactant Vs no surfactant			ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
5 Vs 13	ABG (0.1% Vs 0.05% surfactant)			ns	ns	ns	ns	ns	ns	ns	ns	ns	*	ns	ns	ns	ns
13 Vs 15	ABG (50g Vs 100g)			ns	*	*	ns	ns	ns	ns	ns	*	***	**	ns	ns	ns
5,9 Vs 10,12	Surfactant Vs no surfactant			ns	ns	ns	ns	ns	ns	ns	ns	ns	*	ns	ns	ns	ns

[z]All treatments were applied with an airblast machine at 100 gal/ acre on 3 Sep 96. Tree size was considered to be 75% TRV.
[Y]Mean separation within columns by Duncan's new multiple range test;($P \leq 0.05$).

Byers # 6

Table 1C. Effect of ABG 3168 and NAA on fruit quality of 'Delicious'/111 harvested 21 Oct 1996.

No.	Treatment[Z]	Chemical rate g/acre	Water volume gal/acre	Fruit firmness (lb.)				Starch (1-5 rating)			Soluable solids(%)				Water Core (% Fruit)			
				Oct 21	Dec 17	Feb 10	Apr 1	Oct 21	Dec 17	Feb 10	Oct 21	Dec 17	Feb 10	Apr 1	Oct 21	Dec 17	Feb 10	Apr 1
1.	Control			13.5 b[Y]	12.6 cd	11.9 c	10.5 c	4.9 a	5.0 a	5.0 a	11.7 a	11.8 a	11.4 a	11.2 a	73 ab	48 ab	5 a	0.0 a
2.	NAA	23	100	13.0 b	12.2 d	11.8 c	10.3 c	4.9 a	5.0 a	5.0 a	11.4 abc	11.8 a	11.2 a	11.4 a	82 a	60 a	8 a	0.1 a
5.	ABG-3168 +ABG-7011 (0.1%)	50	100	16.2 a	15.3 ab	13.7 ab	11.0 ab	4.6 b	5.0 a	5.0 a	10.8 abc	11.0 ab	11.0 a	10.9 a	10 c	2 c	0 a	0.1 a
9.	ABG-3168 +ABG-7011 (0.1%)	30	100	16.0 a	15.7 ab	13.8 ab	12.3 ab	4.6 ab	5.0 a	5.0 a	10.6 c	11.0 ab	11.5 a	11.0 a	3 c	17 bc	0 a	0.0 a
10.	ABG-3168	50	200	15.6 a	14.3 bc	12.5 bc	11.2 bc	4.7 ab	5.0 a	5.0 a	11.48 abc	11.6 a	11.4 a	11.4 a	51 b	27 abc	0 a	0.0 a
12.	ABG-3168	30	200	15.5 a	13.9 bcd	12.6 bc	10.4 c	4.8 ab	5.0 a	5.0 a	11.5 ab	11.5 ab	11.7 a	11.5 a	63 ab	27 abc	0 a	0.0 a
13.	ABG-3168 +ABG-7011 (0.05%)	50	200	15.9 a	14.8 b	12.8 bc	11.1 bc	4.7 ab	5.0 a	5.0 a	11.48 abc	11.8 a	11.3 a	11.5 a	18 c	3 c	0 a	0.0 a
15.	ABG-3168 +ABG-7011 (0.05%)	100	200	16.1 a	17.0 a	15.2 a	12.6 a	4.7 ab	5.0 a	5.0 a	10.7 bc	10.6 b	10.9 a	10.5 a	5 c	0 c	0 a	0.0 a
Contrasts	Comparisons																	
1 Vs 2	Control Vs NAA			ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
2 Vs 5	NAA Vs ABG (50g+0.1% surfactant)			***	***	*	**	*	ns	ns	ns	ns	ns	ns	***	**	ns	ns
2 Vs 9	NAA Vs ABG (30g)			***	***	*	**	*	ns	ns	*	*	ns	ns	***	**	ns	ns
2 Vs 10	NAA Vs ABG (50g)			***	*	ns	ns	ns	ns	ns	ns	ns	ns	ns	*	*	ns	ns
2 Vs 12	NAA Vs 30g (no surfactant)			***	*	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
2 Vs 13	NAA Vs ABG (50g+0.05% surfactant)			***	**	ns	ns	ns	ns	ns	ns	ns	ns	ns	***	**	ns	ns
2 Vs 15	NAA Vs ABG (100g+0.05% surfactant)			***	***	***	***	ns	ns	ns	ns	**	ns	ns	***	**	ns	ns
5 Vs 9	ABG (50g Vs 30g)			ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
5 Vs 10	Surfactant Vs no surfactant			ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	**	ns	ns	ns
5 Vs 13	ABG (0.1% Vs 0.05% surfactant)			ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
13 Vs 15	ABG (50g Vs 100g)			ns	*	**	*	ns	ns	ns	ns	**	ns	*	ns	ns	ns	ns
5,9 Vs 10,12	Surfactant Vs no surfactant			ns	*	*	**	ns	ns	ns	**	ns	ns	ns	***	ns	ns	ns

[Z]All treatments were applied with an airblast machine at 100 gal/ acre on 3 Sep 96. Tree size was considered to be 75% TRV.
[Y]Mean separation within columns by Duncan's new multiple range test;($P \leq 0.05$).

Table 2A. Effect of ABG 3168 and NAA on fruit drop of 'Law Rome'/111 (1997).

No.	Color	Treatment[z]	Rate (g/acre) (gallons/acre)	Rate/ 50 gal	% Fruit Drop Sept 17	Sept 24	Oct 1	Oct 8	Oct 15	Oct 22	Oct 29
1.	W	Control			0 a	0 a	1.0 ab	13 a	41 a	59 a	73 a
2.	R	NAA	292 ml/100	146 ml	0 a	0 a	5.0 a	13 ab	29 ab	45 ab	71 a
		+ ABG-7011 (0.1%)		189.5 ml							
3.	B	ReTain (15%)	50g/100	167 g	0 a	0 a	1.0 ab	4 bc	12 bc	21 cd	25 bc
4.	FO	ReTain (15%)	40g/100	134 g	0 a	0 a	1.0 ab	3 c	6 cd	13 cd	22 bcd
5.	HP	ReTain (15%)	50g/100	167 g	0 a	0 a	0.4 ab	1 c	4 cd	10 de	13 cd
		+ ABG-7011 (0.1%)		189.5 ml							
6.	Y	ReTain (15%)	50g/100	167 g	0 a	0 a	2.0 ab	5 bc	9 cd	17 cd	22 bcd
		+ ABG-7011 (0.05%)		95 ml							
7.	BK	ReTain (15%)	40g/100	134 g	0 a	0 a	0.0 b	3 bc	15 bc	28 bc	34 b
		+ ABG-7011 (0.1%)		189.5 ml							
8.	FOBKS	ReTain (15%)	40g/100	134 g	0 a	0 a	2.0 ab	3 bc	12 bc	18 cd	28 bc
		+ ABG-7011 (0.05%)		95 ml							
9.	PBKS	ReTain (15%)	50g/100	167 gg	0 a	0 a	0.4 ab	2 c	8 cd	17 cd	19 bcd
		+ ABG-7042 (0.1%)		189.5 ml							
10.	RD	ReTain (15%)	50g/100	167 g	0 a	0 a	1.0 ab	2 c	6 cd	10 cde	12 cd
		+ ABG-7042 (0.05%)		95 ml							
11.	BD	ReTain (15%)	50g/100	167 g	0 a	0 a	0.0 b	1 c	1 d	2 e	9 d
		+ ABG-7011 (0.1%)		189.5 ml							
		NAA	292 ml/100	146 ml							

Contrasts:	Comparisons	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F
1 vs 2	Control Vs NAA+ ABG-7011	ns	ns	ns	ns	ns	ns	ns
2 vs 5	NAA + ABG-7011 vs ReTain (50g)+ ABG-7011 (0.1%)	ns	ns	ns	**	**	***	***
2 vs 11	NAA vs + ABG-7011 NAA + ReTain (50g)+ ABG-7011 (0.1%)	ns	ns	*	**	**	***	***
3 vs 4	40g vs 50g Retain	ns	ns	ns	ns	ns	ns	ns
3 vs 5	ABG-7011 vs none (ReTain 50g)	ns	ns	ns	ns	ns	ns	ns
4 vs 7	ABG-7011 vs none (ReTain 40g)	ns	ns	ns	ns	ns	ns	ns
5 vs 7	ReTain (50g) + ABG-7011 (0.1%) vs ReTain (40g)+ ABG-7011 (0.1%)	ns	ns	ns	ns	ns	*	**
6 vs 8	ReTain 50g + ABG-7011 (0.05%) vs ReTain (40g)+ ABG-7011 (0.05%)	ns	ns	ns	ns	ns	ns	ns
5,7,9 vs 6,8,10	0.1% vs 0.5% surfactant (ReTain 50g)	ns	ns	*	ns	ns	ns	ns
5 vs 11	ReTain (50g) + ABG-7011 (0.1%) vs NAA + ReTain (50g)+ ABG-7011 (0.1%)	ns	ns	ns	ns	ns	ns	ns
3,4 vs 5,6,7,8	no surfactant vs ABG 7011 (ReTain 50g)	ns	ns	ns	ns	ns	ns	ns
3 vs 9,10	ReTain (50g) vs ReTain (50g) + ABG 7042	ns	ns	ns	ns	ns	ns	ns

[z]All treatments were applied with an airblast machine at 100 gals/acre on 15 Sept 97. Tree size was considered to be 50% TRV.

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

Byers # 8

Table 2B. Effect of ABG 3168 and NAA on fruit quality of 'Law Rome'/111 harvested Oct 17 and Nov 3 (1997).

No. Treatment[z]	Chemical rate g/acre/100g	Rate/ 50 gal	Fruit firmness (lb.) Oct 17	Fruit firmness (lb.) Nov 3	Starch (1-8 rating) Oct 17	Starch (1-8 rating) Nov 3	Soluble solids (%) Oct 17	Soluble solids (%) Nov 3	Water Core (1-5) Oct 17	Water Core (1-5) Nov 3	Red color (%) Oct 17	Red color (%) Nov 3
1. Control			17.8 b[y]	12.4 b	7.00 a	7.77 a	12.0 ab	12.2 a	0.0 b	0.0 a	93.8 bcd	98.0 ab
2. NAA	292 ml/100	146 ml	15.2 c	12.2 b	7.06 a	7.66 a	12.7 a	12.4 a	0.0 b	0.0 a	98.3 a	98.4 a
3. ReTain (15%)	50g/100	167 g	19.6 a	15.8 a	7.02 a	7.70 a	12.0 ab	12.4 a	0.0 b	0.0 a	91.2 d	96.1 b
5. ReTain (15%) + ABG-7011 (0.1%)	50g/100 379g/100	167 g 189.5 ml	19.4 a	16.3 a	6.48 b	7.46 b	12.7 a	13.1 a	0.0 b	0.0 a	97.0 ab	97.8 ab
9. ReTain (15%) + ABG-7042 (0.1%)	50g/100 379g/100	167 g 189.5 ml	19.0 a	15.0 a	7.10 a	7.72 a	11.6 b	12.2 a	0.6 a	0.0 a	93.0 cd	96.4 ab
11. ReTain (15%) +ABG-7011 (0.1%) +NAA	50g/100 379g/100 292 ml/100	167 g 189.5 ml 146 ml	18.9 a	15.7 a	6.68 ab	7.58 ab	12.7 a	13.1 a	0.2 ab	0.4 a	95.5 abc	97.5 ab
Contrasts	Comparisons		Pr>F	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F
1 Vs 2	Control Vs NAA		***	ns	ns	ns	ns	ns	ns	ns	*	ns
2 Vs 5	NAA + ABG-7011 vs ReTain (50g)+ ABG-7011 (0.1%)		***	***	**	*	ns	ns	ns	ns	ns	ns
2 Vs 9	NAA Vs ABG (30g)		***	**	ns	ns	*	ns	*	ns	**	*
2 Vs 11	NAA vs + ABG-7011 NAA + ReTain (50g)+ ABG-7011 (0.1%)		***	**	ns	ns	ns	ns	ns	ns	ns	ns
3 Vs 5	ABG7011 vs none (ReTain 50g)		ns	ns	*	**	ns	ns	ns	ns	**	ns
3 Vs 9	ReTain (50g) vs ReTain (50g) + ABG 7042		ns	ns	ns	ns	ns	ns	*	ns	ns	ns
5 Vs 9	ABG-7011 (0.1%) Vs ABG-7042 (0.1%)		ns	ns	**	**	*	ns	*	ns	*	ns

[z]All treatments were applied with an airblast machine at 100 gals/acre on 15 Sept 97. Tree size was considered to be 50% TRV.

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

Byers # 9

Table 3A. Effect of airblast AVG (Retain) on 'Cresthaven' fruit weight and quality (1997).

No.	Color	Treatment[z,y]	Rate / acre	Rate 100gal / acre	Application date (days before Pick 1) (Pick 1= Aug 22)	Cumulative % fruit weight in each pick /cm^2 cross sectional area (kg)						Cumulative % fruit picked / tree /cm^2 (based on number) cross sectional area						Avg. cumulative fruit wt. picked /cm^2 cross sectional area (kg)						Avg. wt. / fruit (g)
						Aug 22	Aug 26	Aug 29	Sept 2	Sept 5	Sept 9	Aug 22	Aug 26	Aug 29	Sept 2	Sept 5	Sept 9	Aug 22	Aug 26	Aug 29	Sept 2	Sept 5	Sept 9	Sept 9
1	W	Control				7 a[x]	29 a	57 a	93 a	96 a	100 a	6 a	20 a	49 a	88 a	94 a	100 a	0.05 a	0.22 a	0.43 a	0.66 a	0.68 a	0.71 a	237 a
2	B	AVG Retain + ABG-7011	200g 473 ml	1,333 g 473 ml	29	--	20 ab	46 abc	81 a	92 ab	100 a	--	16 a	41 a	78 a	89 ab	100 a	--	0.12 a	0.28 ab	0.50 ab	0.56 a	0.60 a	228 a
3	R	AVG Retain + ABG-7011	1000g 473 ml	6,667 g 473 ml	29	--	16 b	39 bc	65 b	86 b	100 a	--	13 a	35 ab	61 b	83 b	100 a	--	0.10 a	0.23 b	0.38 b	0.50 a	0.59 a	222 a
4	Y	AVG Retain + ABG-7011	200g 473 ml	1,333 g 473 ml	11	6 a	27 b	52 ab	85 a	95 a	100 a	5 a	19 a	43 a	80 a	93 a	100 a	0.03 a	0.15 a	0.29 ab	0.47 ab	0.54 a	0.57 a	244 a
5	FO	AVG Retain + ABG-7011	1000g 473 ml	6,667 g 473 ml	11	--	16 b	32 c	52 b	74 c	100 a	--	13 a	26 b	47 c	72 c	100 a	--	0.11 a	0.22 b	0.35 b	0.51 a	0.69 a	233 a

[z]Full Bloom: (3 April). Harvest dates: Aug 22, Aug 26, Aug 29, Sept 2, Sept 5, Sept 9.
[y]All treatments including the control were hand thinned prior to treatments June 7-10.
[x]Mean separation within columns by Duncan's new multiple range test, $P \le 0.05$.

Table 3B. Effect of airblast AVG (Retain) on 'Cresthaven' fruit weight and quality (1997).

No.	Color	Treatment[z,y]	Rate / acre	Rate 100gal/ acre	Application date (days before Pick 1) (Pick 1=Aug 22)	Fruit diameter (cm)						Red Color (%)						Fruit firmness (lbs)					
						Aug 22	Aug 26	Aug 29	Sept 2	Sept 5	Sept 9	Aug 22	Aug 26	Aug 29	Sept 2	Sept 5	Sept 9	Aug 22	Aug 26	Aug 29	Sept 2	Sept 5	Sept 9
1	W	Control				7.77 a[x]	8.07 a	8.13 a	8.04 a	--	--	45 a	56 a	62 a	70 a	--	--	18.3 b	15.6 b	12.0 c	8.2 c	--	--
2	B	AVG Retain + ABG-7011	200g 473 ml	1,333 g 473 ml	29	7.65 ab	7.87 a	8.12 a	8.11 a	7.83 b	7.90 a	40 a	51 ab	58 a	63 bc	62 a	78 a	19.9 ab	18.3 ab	14.2 bc	11.6 b	10.2 a	7.6 a
3	R	AVG Retain + ABG-7011	1000g 473 ml	6,667 g 473 ml	29	7.43 b	7.63 a	7.93 a	7.87 a	7.94 ab	7.75 a	35 a	47 b	57 a	64 bc	68 a	60 b	21.9 a	19.5 a	14.5 b	12.9 ab	12.3 a	10.1 a
4	Y	AVG Retain + ABG-7011	200g 473 ml	1,333 g 473 ml	11	7.87 a	8.07 a	8.16 a	8.25 a	8.60 a	--	39 a	51 ab	60 a	67 ab	73 a	--	20.7 a	16.7 b	14.1 bc	10.9 b	13.8 a	--
5	FO	AVG Retain + ABG-7011	1000g 473 ml	6,667 g 473 ml	11	7.34 b	7.75 a	7.82 a	7.89 a	8.00 ab	7.84 a	35 a	46 b	50 b	60 c	65 a	78 a	21.5 a	20.5 a	19.6 a	14.7 a	14.4 a	12.1 a

[z]Full Bloom: (3 April). Harvest dates: Aug 22, Aug 26, Aug 29, Sept 2, Sept 5, Sept 9.
[y]All treatments including the control were hand thinned prior to treatments June 7-10.
[x]Mean separation within columns by Duncan's new multiple range test, $P \le 0.05$.

Byers # 10

Table 3C. Effect of airblast AVG (Retain) on 'Cresthaven' fruit weight and quality (1997).

No.	Color	Treatment[zy]	Rate / acre	Rate 100gal/ acre	Application date (days before Pick 1) (Pick 1= Aug 22)	Soluble solids concentration (%)						Single fruit wt. (g)					
						Aug 22	Aug 26	Aug 29	Sept 2	Sept 5	Sept 9	Aug 22	Aug 26	Aug 29	Sept 2	Sept 5	Sept 9
1	W	Control				12.2 a[x]	12.4 a	12.9 a	13.0 a	--	--	226.3 ab	247.4 a	257.8 ab	258.9 a	--	--
2	B	AVG Retain + ABG-7011	200g 473 ml	1,333 g 473 ml	29	11.7 a	12.1 a	12.5 a	12.7 a	11.4 c	11.0 a	218.3 abc	228.2 a	257.5 ab	259.4 a	224.0 b	226.8 a
3	R	AVG Retain + ABG-7011	1000g 473 ml	6,667 g 473 ml	29	11.9 a	12.2 a	12.6 a	13.0 a	13.1 ab	13.3 a	201.3 bc	213.8 a	247.7 ab	232.9 a	240.6 b	221.8 a
4	Y	AVG Retain + ABG-7011	200g 473 ml	1,333 g 473 ml	11	12.1 a	12.3 a	12.8 a	13.3 a	12.0 bc	--	233.4 a	244.8 a	265.8 a	267.4 a	306.2 a	--
5	FO	AVG Retain + ABG-7011	1000g 473 ml	6,667 g 473 ml	11	12.2 a	12.5 a	12.6 a	13.3 a	13.6 a	13.4 a	193.7 c	222.1 a	224.4 b	238.1 a	244.3 ab	214.9 a

[z]Full Bloom: (3 April). Harvest dates: Aug 22, Aug 26, Aug 29, Sept 2, Sept 5, Sept 9.
[y]All treatments including the control were hand thinned prior to treatments June 7-10.
[x]Mean separation within columns by Duncan's new multiple range test, $P \leq 0.05$.

Table 3D. Effect of pre-harvest sprays of AVG (Retain) on 'Cresthaven' peach fruit quality after 5 days of storage at 24°C (1997).

No.	Color	Treatment[zy]	Rate / acre	Rate 100gal/ acre	Application date (days before Pick 1) (Pick 1= Aug 22)	Fruit firmness (lbs)		Soluble solids conc. (%)		Red Color (%)		Fruit diameter (cm)		Single fruit wt. (g)	
						Aug 29	Sept 3	Aug 29	Sept 3	Aug 29	Sept 3	Aug 29	Sept 3	Aug 29	Sept 3
1	W	Control				12.0 c[x]	2.48 b	12.9 a	13.0 a	62 a	69 a	8.13 a	7.96 a	257.8 ab	252.6 a
2	B	AVG Retain + ABG-7011	200g 473 ml	1,333 g 473 ml	29	14.2 bc	2.98 b	12.5 a	12.4 a	58 a	62 b	8.12 a	7.98 a	257.5 ab	251.4 a
3	R	AVG Retain + ABG-7011	1000g 473 ml	6,667 g 473 ml	29	14.5 b	4.20 b	12.6 a	12.6 a	57 a	63 b	7.93 a	7.70 ab	247.7 ab	220.9 a
4	Y	AVG Retain + ABG-7011	200g 473 ml	1,333 g 473 ml	11	14.1 bc	2.97 b	12.8 a	13.0 a	60 a	66 ab	8.16 a	7.97 a	265.8 a	250.9 a
5	FO	AVG Retain + ABG-7011	1000g 473 ml	6,667 g 473 ml	11	19.6 a	9.12 a	12.6 a	12.9 a	50 b	52 c	7.82 a	7.58 b	224.4 b	222.8 a

[z]Full Bloom: (3 April). Harvest dates: Aug 22, Aug 26, Aug 29, Sept 2, Sept 5, Sept 9.
[y]All treatments including the control were hand thinned prior to treatments June 7-10.
[x]Mean separation within columns by Duncan's new multiple range test, $P \leq 0.05$.

Byers # 11

Table 4A. Effect of Accel and Retain on fruit growth and fruit quality of 'Gala'/M. 27 (1997).

No.	Color	Treatment[z,y]	Rate/acre 100 gal/ acre (airblast)	Rate/ 100 gal	Rate g or ml/liter (hand sprayer)	Spray timing	Fruit/cm² cross sectional area trunk (May 30) Hand thinned: Before	After	Fruit diameter (cm)	Length/ diameter ratio	Fruit weight (gm)	Fruit firmness (lb.)	Soluble solids (%)	Starch (1-8 rating)	Red color (%)	Stem end Cracking (%)
									Pick # 1 (3 Sept)							
1.	W	Control					16.5 a[x]	5.5 a	6.77 a	0.84 c	--	22.3 ab	15.7 a	6.3 a	81 a	5 a
2.	B	Accel	10 g	526 ml		PF	19.3 a	5.6 a	6.55 b	0.88 ab	--	21.8 b	15.2 b	6.8 a	76 a	0 a
		+ Accel	10 g	526 ml		PF + 7										
		+ Accel	10 g	526 ml		PF + 14										
3.	R	Retain (AVG)			0.882 g (132 ppm)	Aug. 21	18.3 a	5.8 a	6.50 b	0.82 bc	--	22.8 ab	14.8 c	5.5 b	57 b	0 a
		+ ABG 7011			1 ml											
4.	FO	Retain (AVG)			0.882 g (132 ppm)	Aug. 21	18.4 a	5.7 a	6.63 ab	0.89 a	--	23.1 a	14.5 c	4.2 c	50 c	0 a
		+ ABG 7011			1 ml											
		+ Accel	10 g	526 ml		PF										
		+ Accel	10 g	526 ml		PF + 7										
		+ Accel	10 g			PF + 14										
									Pick # 2 (25 Sept)							
1.	W	Control					16.5 a	5.5 a	6.79 a	0.841 b	142.5 a	19.1 b	17.1 a	7.5 a	92 a	3 a
2.	B	Accel	10 g	526 ml		PF	19.3 a	5.6 a	6.63 a	0.857 ab	134.8 a	17.1 c	17.1 a	7.7 a	90 ab	5 a
		+ Accel	10 g	526 ml		PF + 7										
		+ Accel	10 g	526 ml		PF + 14										
3.	R	Retain (AVG)			0.882 g (132 ppm)	Aug. 21	18.3 a	5.8 a	6.89 a	0.846 b	148.5 a	19.9 b	15.8 b	6.5 b	85 bc	2 a
		+ ABG 7011			1 ml											
4.	FO	Retain (AVG)			0.882 g (132 ppm)	Aug. 21	18.4 a	5.7 a	6.83 a	0.874 a	151.8 a	21.6 a	15.7 b	6.4 b	83 c	2 a
		+ ABG 7011			1 ml											
		+ Accel	10 g	526 ml		PF										
		+ Accel	10 g	526 ml		PF + 7										
		+ Accel	10 g			PF + 14										

[z]Full bloom occurred 25 April 1997. PF occurred 1 May 1997.

[y]Accel treatments were applied 1 May, 8 May, and 15 May . Airblast sprayer was calibrated for 100 gal/acre (trees were 20 feet between rows, tree wideth was 4 feet, and tree height was 10 ft (20% TRV). Retain treatments were applied with a hand-wand sprayer on Aug.21.

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

Byers # 12

Table 4B. Effect of Accel and Retain on fruit growth and fruit quality of 'Gala'/M. 27 (1997).

No. Treatment[z,y]	Rate/acre 100 gal/ acre (airblast)	Rate g or ml/liter (hand sprayer)	Spray timing	Fruit/cm² cross sectional area trunk (May 30) Hand thinned: Before	After	Fruit diameter (cm): Aug 28	Sept 4	Sept 11	Sept 18	Length/diameter ratio: Aug 28	Sept 4	Sept 11	Sept 18
1. Control				16.5 a[x]	5.5 a	6.47 a	6.29 a	6.91 a	6.92 a	0.878 a	0.875 a	0.838 b	0.838 b
2. Accel	10 g		PF	19.3 a	5.6 a	6.44 a	6.37 a	6.78 a	6.84 a	0.888 a	0.887 a	0.867 ab	0.862 ab
+ Accel	10 g		PF + 7										
+ Accel	10 g		PF + 14										
3. Retain (AVG)		0.882 g (132 ppm)	Aug. 21	18.3 a	5.8 a	6.35 a	6.19 a	6.72 a	6.87 a	0.878 a	0.891 a	0.874 a	0.840 b
+ ABG 7011		1 ml											
4. Retain (AVG)		0.882 g (132 ppm)	Aug. 21	18.4 a	5.7 a	6.54 a	6.39 a	6.92 a	6.97 a	0.912 a	0.897 a	0.865 ab	0.878 a
+ ABG 7011		1 ml											
+ Accel	10 g		PF										
+ Accel	10 g		PF + 7										
+ Accel	10 g		PF + 14										
						Fruit weight (gm)				Fruit firmness (lb)			
1. Control				16.5 a	5.5 a	137.0 ab	129.6 a	148.0 a	146.7 a	24.2 a	21.4 a	19.8 ab	18.3 b
2. Accel	10 g		PF	19.3 a	5.6 a	138.9 ab	131.6 a	146.3 a	147.6 a	23.7 a	20.7 a	19.6 b	18.6 b
+ Accel	10 g		PF + 7										
+ Accel	10 g		PF + 14										
3. Retain (AVG)		0.882 g (132 ppm)	Aug. 21	18.3 a	5.8 a	132.9 b	124.2 a	140.0 a	146.4 a	24.2 a	22.0 a	21.1 a	20.4 a
+ ABG 7011		1 ml											
4. Retain (AVG)		0.882 g (132 ppm)	Aug. 21	18.4 a	5.7 a	148.4 a	136.5 a	151.6 a	157.4 a	24.4 a	22.4 a	21.2 a	20.1 a
+ ABG 7011		1 ml											
+ Accel	10 g		PF										
+ Accel	10 g		PF + 7										
+ Accel	10 g		PF + 14										

[z]Full bloom occurred 25 April 1997. PF occurred 1 May 1997.

[y]Accel treatments were applied 1 May, 8 May, and 15 May . Airblast sprayer was calibrated for 100 gal/acre (trees were 20feet between rows, tree wideth was 4 feet, and tree height was 10 ft (20% TRV). Retain treatments were applied with a hand-wand sprayer on Aug.21.

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

Byers # 13

Table 4C. Effect of Accel and Retain on fruit growth and fruit quality of 'Gala'/M. 27 (1997).

No. Treatment[z,y]	Rate/acre 100 gal/ acre (airblast)	Rate g or ml/liter (hand sprayer)	Spray timing	Fruit/cm² cross sectional area trunk (May 30) Hand thinned: Before	After	Soluble solids (%): Aug 28	Sept 4	Sept 11	Sept 18	Starch (1-8): Aug 28	Sept 4	Sept 11	Sept 18
1. Control				16.5 a	5.5 a	14.51 a	15.4 a	16.2 a	16.1 a	5.38 a	7.00 a	7.43 a	7.52 a
2. Accel	10 g		PF	19.3 a	5.6 a	14.47 ab	15.5 a	15.9 a	16.1 a	5.96 a	7.23 a	7.43 a	7.67 a
+ Accel	10 g		PF + 7										
+ Accel	10 g		PF + 14										
3. Retain (AVG)		0.882 g (132 ppm)	Aug. 21	18.3 a	5.8 a	14.29 ab	14.8 b	14.9 b	15.2 a	5.58 a	5.14 b	5.57 b	6.00 b
+ ABG 7011		1 ml											
4. Retain (AVG)		0.882 g (132 ppm)	Aug. 21	18.4 a	5.7 a	13.97 b	14.6 b	14.8 b	16.7 a	5.38 a	4.19 b	5.57 b	6.05 b
+ ABG 7011		1 ml											
+ Accel	10 g		PF										
+ Accel	10 g		PF + 7										
+ Accel	10 g		PF + 14										

No. Treatment	Rate/acre	Rate	Spray timing	Before	After	Red color (%): Aug 28	Sept 4	Sept 11	Sept 18	Ethylene (ug/l/hr): Aug 28	Sept 4	Sept 11	Sept 18
1. Control				16.5 a	5.5 a	69 ab	83 a	91 a	92 a	3.15 a	3.17 a	6.97 a	7.05 b
2. Accel	10 g		PF	19.3 a	5.6 a	73 a	83 a	88 a	92 a	3.20 a	3.13 a	7.10 a	8.86 a
+ Accel	10 g		PF + 7										
+ Accel	10 g		PF + 14										
3. Retain (AVG)		0.882 g (132 ppm)	Aug. 21	18.3 a	5.8 a	67 ab	60 b	71 b	83 b	0.22 b	0.16 b	0.70 b	1.22 c
+ ABG 7011		1 ml											
4. Retain (AVG)		0.882 g (132 ppm)	Aug. 21	18.4 a	5.7 a	62 b	55 b	69 b	79 b	0.23 b	0.17 b	0.62 b	1.72 c
+ ABG 7011		1 ml											
+ Accel	10 g		PF										
+ Accel	10 g		PF + 7										
+ Accel	10 g		PF + 14										

[z]Full bloom occurred 25 April 1997. PF occurred 1 May 1997.

[y]Accel treatments were applied 1 May, 8 May, and 15 May . Airblast sprayer was calibrated for 100 gal/acre (trees were 20feet between rows, tree wideth was 4 feet, and tree height was 10 ft (20% TRV). Retain treatments were applied with a hand-wand sprayer on Aug.21.

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

Byers # 14

USE OF VYDATE TO REDUCE THE CROP LOAD OF 'YORK IMPERIAL' APPLES

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Introduction:

Reducing the crop load of apples remains a scientifically and practically complex problem. Since apples produce way more flowers and fruitlets than are needed for a commercial crop the reduction of fruit numbers is essential to allow the tree to produce a marketable crop in the year of treatment and to enhance return bloom the following year.

Materials and Methods:

A trial to determine the influence of Vydate, alone and in combination with other thinners, on the fruit load of 'York Imperial' apples was conducted in the Barn Block of the Mapleton Division of Crestmont Orchards, Inc. The cooperating orchardist was C. J. Tyson III, and for his excellent cooperation and that of his crew we are thankful. This Vydate thinner trial was part of a larger trial that used a randomized complete block design with seven statistical blocks. The treatments are listed in Table 1 and involved an Untreated Check (Treatment 8), Vydate plus NAA and surfactant (Treatment 4), Vydate plus Accel (Treatment 5), Vydate and surfactant (Treatment 6) and Vydate plus ethephon (Treatment 7). The trees in this orchard were planted in 1974 and were 'York Imperial' on M.106 rootstock. Four rows in the middle of the orchard had excessive tree loss in an area of poor soil drainage. Therefore, in 1984 four rows were planted with the same cultivar on M.111 rootstock. Blocks 5 and 6 were placed on these replanted trees which were 10 years younger than the main part of the block.

The size of the fruitlets in this orchard was checked periodically. On May 28 mean fruitlet size was 12.3 with a range from 9 to 16 mm but most were between 10 and 14 mm. Two data limbs per tree, with approximately 25 to 30 fruitlets per limb, were set up on May 29. The treatments were applied on May 30 between 7:45 and 11:00 am. It was calm, overcast and the temperature was approximately 50^{o} F. Sprays were applied with a Durand-Wayland AF 100-32 model airblast sprayer calibrated to deliver 100 gallons per acre on 22 ft rows. Since the row width in this block was 24 ft the sprayer actually delivered 91.7 gallons per acre under these conditions.

On June 5 the limb circumference of each data limb was measured which was used to determine the limb cross-sectional area. The number of fruit per data limb was counted on July 14 and 29. A sample of fruit from each tree was harvested in the fall which was put in storage for later evaluation of gross fruit characteristics and for detailed determinations of size distribution and seed numbers in certain fruit categories. On Oct. 23 the crop on the trees was rated according to the following scale: 1 = no crop, 2 = very light crop, 3 = light crop, 4 = moderate crop, 5 = fairly heavy crop, 6 = heavy crop, 7 = very heavy crop.

Results and Discussion:

The fruit on each of the two data limbs on each tree were counted on May 29, July 14, and July 29 (Table 2). Treatment 8 is the Untreated Check. There were some differences on May 29 prior to the treatment applications with the Vydate + surfactant treatment having the most fruitlets per limb. By July 14 there were significant differences with Vydate and ethephon having the lowest number of fruit per limb. The counts by July 29 did not change appreciably and at this date Vydate + ethephon had significantly fewer fruit than many other treatments.

Perhaps a more accurate way to look at the treatment effect is to analyze the percentage of fruits as they decrease over time. It can be seen that Treatment 7 (Vydate + ethephon) had only 40% as many fruit on July 14 as it had on May 29. The next most effective treatment was Vydate + NAA and surfactant which had 52% as many fruit in July compared to May. Treatments causing nonsignificant reductions were: Vydate + Accel and Vydate with surfactant.

As might have been expected there were no significant differences in the two July counts and the counts from May 29 to July 29 had similar trends to those from May 29 to July 14. Vydate + ethephon was the most effective treatment. Vydate + NAA + surfactant had 48% as many fruit and Vydate + surfactant had 49%. Vydate + Accel did not differ from the Untreated Check.

Limb cross-sectional area was calculated from measurements made of limb circumference. Therefore, the number of fruit per limb cross-sectional area could be determined and on May 29, there were no significant differences between the treatments (Table 3). With data expressed this way, on July 14 Vydate + ethephon remained the most effective treatment followed by Vydate + NAA and surfactant and then by Vydate + surfactant. A treatment causing nonsignificant reductions compared to the check was Vydate + Accel. There were some slight reductions in fruit numbers from July 14 to the 29th but the statistical separation was the same on both dates.

If we look at a percent of fruit on successive dates expressed as fruit per limb cross-sectional area we again see that the Vydate + ethephon was the most efficacious treatment and the Vydate + NAA + surfactant treatment also caused thinning. Treatments causing nonsignificant thinning were: Vydate + Accel, and Vydate + surfactant. There were not significant differences when comparing the two July dates and the data for May 29 compared to July 29 were similar to the earlier July-May comparisons.

Vydate + NAA + surfactant and Vydate + ethephon had the two lowest crops according to the crop ratings that were made on Oct. 23 (Table 4). Vydate + Accel also had a lower rating than the check but Vydate + surfactant did not. Fruit size was inversely related to crop load. The Vydate + ethephon combination that had the lowest crop rating was the only treatment that had significantly heavier fruit than the Check treatment.

It appears that Vydate in combination with other thinners can be an effective thinning material. Vydate + ethephon appeared to be more effective than other treatments but depending on the amount of thinning that is needed Vydate + NAA and surfactant, and Vydate with surfactant can be effective treatments. It appears that Vydate + Accel is the weakest of the thinning combinations that were investigated in this study.

Table 1. List of treatments for the test of Vydate as a fruitlet thinner on 'York Imperial' apples (Expt. MS97DU).

Treatment no. and name	Timing	Chemical	Rate	Method[z]
4. Vydate + NAA + Surf.	8 - 12 mm fruit size	Vydate Fruitone N Regulaid	2 pints per acre 3 ppm 0.25% v/v	Airblast @ 100 GPA
5. Vydate + Accel	8 - 12 mm fruit size	Vydate Accel	2 pints per acre 30 grams ai per acre	Airblast @ 100 GPA
6. Vydate + Surf.	8 - 12 mm fruit size	Vydate Regulaid	2 pints per acre 0.25% v/v	Airblast @ 100 GPA
7. Vydate + ethephon	8 - 12 mm fruit size	Vydate ethephon	2 pints per acre 3 pints per acre	Airblast @ 100 GPA
8. Untreated Check	--	--	--	--

[z]Tree width = 18 ft., Row width = 24 ft., Tree height = 15 ft., Tree row volume = 85.9%. At 400 GPA times 85.9% a full dilute spray would be 343.6 GPA. However a factor of 70% is used for tree openness so a dilute spray at this time of year would be 240 GPA. Since the row width is 24 ft. and the sprayer is calibrated to deliver 100 GPA on 22 ft rows it will deliver 91.7 GPA on the 24 ft rows in this block. Therefore the sprays were applied at 38% of full dilute water rate.

Table 2. The influence of Vydate on the fruit load of 'York Imperial' apple trees (Expt. MS97DU).

Treatment no. & name	Fruit per limb 5/29 (no.)	Fruit per limb 7/14 (no.)	Fruit per limb 7/29 (no.)	Ratio of fruit per limb on two dates 7/14 - 5/29 (no./no.)	Ratio of fruit per limb on two dates 7/29 - 7/14 (no./no.)	Ratio of fruit per limb on two dates 7/29 - 5/29 (no./no.)
4. Vydate & NAA & Surf.	26.0 bc	13.9 bc	12.7 bc	.52 ab	.93 a	.48 ab
5. Vydate & Accel	28.2 bc	16.6 c	15.4 c	.60 bcd	.95 a	.55 bc
6. Vydate & Surf.	30.5 c	16.0 c	14.4 bc	.54 abc	.90 a	.49 ab
7. Vydate & ethephon	26.1 bc	10.6 ab	9.9 ab	.40 a	.96 a	.38 a
8. Untreated Check	24.7 b	17.4 c	17.1 c	.71 cd	.98 a	.70 c
AOV Prob. Value Table						
Block	.0672	.1293	.0669	.0279	.8344	.0262
Treatment	.0001	.0001	.0001	.0017	.3241	.0010

[z]Means within columns followed by the same letter(s) are not significantly different according to the Duncan's New Multiple Range Test at the 5 percent level of probability.

Table 3. The influence of Vydate on the fruit load of 'York Imperial' apple trees (Expt. MS97DU).

Treatment no. & name	Fruit per limb cross-sectional area 5/29 (no./cm^2)	7/14 (no./cm^2)	7/29 (no./cm^2)	Ratio of fruit per LCSA on two dates 7/14-5/29	7/29-7/14	7/29-5/29
4. Vydate & NAA & Surf.	11.1 a	5.8 ab	5.4 ab	.52 ab	.93 a	.48 ab
5. Vydate & Accel	19.3 a	9.0 bc	8.6 bc	.60 bcd	.95 a	.55 bc
6. Vydate & Surf.	13.2 a	6.2 ab	5.6 ab	.54 abc	.90 a	.49 ab
7. Vydate & ethephon	10.9 a	4.1 a	3.9 a	.40 a	.96 a	.38 a
8. Untreated Check	18.9 a	11.4 c	11.2 c	.71 cd	.98 a	.70 c
AOV Prob. Value Table						
Block	.0091	.0049	.0047	.0279	.8344	.0262
Treatment	.0797	.0002	.0001	.0017	.3241	.0010

[z]Means within columns followed by the same letter(s) are not significantly different according to the Duncan's New Multiple RangeTest at the 5 percent level of probability.

Table 4. The influence of Vydate on the crop rating of 'York Imperial' apple trees (Expt. MS97DU).

Treatment no. & name	Crop rating[z] (1-7)	Fruit weight (g)
4. Vydate & NAA & Surf.	4.1 a	130 ab
5. Vydate & Accel	4.7 b	122 a
6. Vydate & Surf.	5.0 bc	125 a
7. Vydate & ethephon	3.7 a	141 b
8. Untreated Check	5.4 c	123 a
AOV Prob. Value Table		
Block	.0001	.1072
Treatment	.0001	.0163

[z]Crop rating scores: 1 = no crop, 2 = very light crop, 3 = light crop, 4 = moderate crop, 5 = fairly heavy crop, 6 = heavy crop, 7 = very heavy crop

[y]Means within columns followed by the same letter(s) are not significantly different according to the Duncan's New Multiple Range Test at the 5 percent level of probability.

(Not for publication or distribution)

Results of 1997 Apple and Peach Thinning Trials

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Introduction

Apple and peach growers in different regions obtain different responses from chemical thinning sprays which may be due to differences in climate, cultural practices, rootstocks, tree age, etc. Due to the recent cancellation of Elgetol in the Northwestern U.S.A., considerable interest has developed in pollination and fertilization inhibitors for thinning. In 1996, Wilthin was registered for thinning apples and peaches in bloom, and Thinex was registered for thinning apples. In addition, several other chemical companies have an interest in registration of pollination and fertilization inhibitors for bloom thinning. In 1994, a federal registration was obtained by Abbott Labs for Accel (6-BA + low rate of GA_{4+7}); and in 1996, Dupont obtained a registration for thinning apples with Vydate.

The objectives of the experiments reported here were 1) to further investigate various chemical combinations for flower and fruit thinning and 2) to observe chemical injuries to fruit and foliage.

Materials and Methods

Chemicals were applied to whole trees with a Swanson 3-point-hitch airblast sprayer (Durand Wayland, Inc., LaGrange, Georgia)(both fans adjusted to one side to double air output). Specific water and chemical rates for the airblast sprayer for each experiment is listed in each table (see Tables). Because airblast applications to single peach trees in bloom do not account for the drift from adjacent rows (Byers et. al., 1985), application rates applied to single trees in experiments 3 & 4 were increased to 160% of a designated block rate to account for drift from adjoining rows. Previous published and unpublished data indicate approximately 40 to 70% of the deposit on peach trees from an airblast spray at bloom time will come from adjacent rows (Byers, et al. 1985).

Crop density (fruit/cm2 cross sectional area limb, CD) was determined by counting fruit on 3 pre-selected limbs per tree. Three limbs per tree were tagged during late pink. At the point where limbs were tagged, limb circumferences were measured. The number of fruit on each limb were counted about 50 to 55 days after bloom after unfertilized fruit dropped. Crop density (CD) on sample limbs was expressed as fruit•cm^2 trunk cross-sectional area limb. Ten fruit were harvested from each tree near harvest and fruit diameter was determined with a band-type hand caliper and fruit were examined for scarring injury at harvest. No hand thinned control was included (except in experiment 1). Past experience has indicated that when using these techniques that the desirable crop load is approximately 4 to 6 fruit•cm^{-2} trunk cross-sectional area limb after thinning (Byers and Lyons 1984, 1985; Byers, et. al. 1985).

Data for crop density, fruit diameter, and vegetative injury were analyzed with SAS (Sas Institute, Cary, N. C.), general linear model (GLM procedures) to evaluate the linear and quadratic effects and pre-planned single-degree of freedom contrasts of interest. The experimental designs for all experiments were randomized complete block and were block by location within rows. All experiments had 6 blocks.

Experiments 1 & 2. Apple trees were selected for uniform flowering at bloom and were blocked according to row and terrain into six blocks for the number of treatments listed in each table (Tables 1 & 2). Specific information about tree size, spray application dates, chemical rates, stage of development, and temperatures are reported in each table.

Experiment 3: In 1997, sixty 'Cresthaven' 6-year-old peach trees were selected for uniformity of flowering, and were blocked according to row and terrain into six blocks of 10 treatments (Table 3). Spray treatments listed in Table 3 were applied on 3 April after approximately 85-95% of the flowers had opened. Vegetative shoot injury was rated 7 Apr. The number of fruit on each tree was counted 4 June, 62 days after 90% bloom and expressed as CD. Ten fruit were harvested from each tree on 21 Aug for determining fruit diameter.

Experiments 3 and 4 were located in adjacent blocks of 'Cresthaven' with the expectation that time of bloom might be somewhat different. The older block Experiment 4 was not as advanced in bloom as the younger block (Experiment 3) at the time of spraying.

Experiment 4: In 1997, sixty 'Cresthaven' 13-year-old peach trees were selected for uniformity of flowering, and were blocked according to row and terrain into six blocks of 10 treatments (Table 4). Spray treatments listed in Table 4 were applied on 3 April after approximately 50-75% of the flowers had opened. Vegetative shoot injury was rated 7 Apr. The number of fruit on each tree was counted 29 May, 56 days after 90% bloom and expressed as CD. Ten fruit were harvested from each tree on 21 Aug for determining fruit diameter.

Experiment 5. In 1996,12-year-old 'Redhaven' peach trees were selected for uniformity and blocked according to row and terrain into six blocks of 9 treatments (Table 5A&B). Single row airblast applications of 127 ppm or 300 ppm GA_3 was applied to 'Redhaven' peach trees at 44, 47, 75, 111 DAFB (Table 5A&B). In the dormant season of 1977, flower bud numbers were counted on the top and bottom half of 5 shoots collected from each tree, and the number of buds on the basal 5 nodes were recorded (Table 5A). In the spring and summer data on fruit numbers and weight during hand thinning (June 6) and fruit diameter of 10 fruits / tree at harvest were collected (Table 5B).

Results and Discussion

Experiment 1. In 1997, applications of pollination inhibitors and growth regulators caused flower and fruit thinning of 'York'/MM111 trees and are reported in Table 1. More thinning occurred with the pollination inhibitors than expected. The primary fungicide used at this location was Sulfur. Sulfur applications were applied 10 days prior and 1 day after these treatments. We are suspicious that the Sulfur may have caused additional flower and vegetative shoot injury. Chemical rates in this experiment were similar to experiment 2, but on a different cultivar. (Due to the 9 April freeze this experiment was intended for Red Delicious but was moved to a grower location on York since was seriously hurt by the freeze Red Delicious).

Experiment 2. In 1996, applications of pollination inhibitors caused flower and fruit thinning of 'Ace Delicious'/MM111 trees and are reported in Table 2. Far less thinning and injury occurred than in the 1997 'York' experiment (Table 1). These data are present for comparison to rates of pollination inhibitors (Table1).

Experiment 3. A freeze on April 9, 1997, 5 days after bloom, killed of over 50% the flower pistils presumably across treatments; thus the data represent the combined effect of the thinning chemicals and this freeze. Endothall, Thinex (pelargonic acid), Wilthin™, Armorthin, and ATS reduce the number of flowers setting fruit when compared to the control (Table 3). If one expected the natural fruit set of the control to be double this number and if no freeze had occurred, then the crop density (CD) for most of the treatments might have been in the 4 to 6 fruit/cm^2 cross sectional area limb; however, the rates of Armorthin obviously over thinned. When trees were sprayed on 3 April, more flowers were open in Experiment 3 (85-95% open) than Experiment 4 (50-75% open). Trees in Experiment 4 were sprayed at the same time as Experiment 3 using the same sprayer calibration and chemical treatment.

Experiments 3 and 4 were located in adjacent blocks of 'Cresthaven' with the expectation that time of bloom would be somewhat different. The older block (Experiment 4) was not as advanced in bloom as the younger block (Experiment 3). Fruit set for the controls in experiments 3 & 4 were similar, but fruit thinning by these materials were more effective in Experiment 3 when more flowers were open.

Experiment 4. A freeze on April 9, 1997, 5 days after bloom, killed of over 50% the flower pistils presumably across treatments; thus, the data represent the combined effect of the thinning chemicals and this freeze. Thinex (pelargonic acid), Wilthin™, Armorthin, and ATS reduced crop load to about ½ or more of the control and increased fruit diameter. All treatments were not as effective as in Experiment 3 for reducing the number of flowers setting fruit when compared to the control (Table 3 vs 4). The lower percentage of flowers open probably contributed to the poorer efficacy. Endothall did not show significant thinning, but the CD appeared to be slightly reduced and fruit diameter increased from the control. If one expected fruit set to be double the number had no freeze occurred, then the thinning level for most of the treatments might have been in the range of 9 to 15 fruit/cm^2 cross sectional area limb which would not have been enough thinning. The high rate of Armorthin was the only treatment which might have been about right had no freeze occurred. When trees were sprayed on 3 April, fewer flowers were open in Experiment 3 than in Experiment 4, and this may have accounted for less thinning since fewer pistils were exposed to the chemical treatment.

The caustic materials used in these experiments all appeared to be effective bloom thinning agents for apple and peach trees. However, fruit trees thinned at bloom were still vulnerable to further reductions in crop load due to late spring freezes after the application. In the 1997 peach experiments (Experiments 3 & 4), a freeze reduced crop load substantially below the desirable crop load (approximately 5 fruit/cm^2 cross sectional area limb) because of previously applied pollination inhibitors. The controls still required hand thinning, but many treatments had less than 50% of a crop (Experiment 3, Table 3). These data suggest that bloom thinning in certain years may not be desirable when fruit trees bloom extremely early or when a killing frost is predicted.

Experiment 5. GA_3 at 300 ppm applied on 16 June 57 DAFB was more effective for reducing flower buds than the earlier and later dates (Table 5A). In 1997, the 127 ppm rate appeared to be as effective as the 300 ppm rate for reducing the numbers of fruit that needed to be removed by hand thinning. The individual fruit weights removed at hand thinning were increase by the GA3 treatments in 1996. However, at harvest fruit diameter was not greatly affected (21 July). A freeze on April 9, 1997, 5 days after bloom, killed of over 50% the flower pistils presumably across treatments; thus, the data represent the combined effect of the thinning chemicals and this freeze. Perhaps the fruit diameter differences would have been greater between the control and the treatments if crop load would have been greater. In addition, a 10 fruit sample maybe to small to detected the fruit size at harvest.

The use of GA3 for flower bud inhibition has the potential of further reductions in flower numbers from winter and spring freezes. Pollination/fertilization inhibitors have the potential of further reductions from spring freeze during and after bloom, but frequently weather forecasts can give a grower 4 or 5 days advanced notice of a possible damaging freeze.

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Table 1. Effect of growth regulators on fruit set of 'York' /MM 111 (1997).

No.	Color	Treatment[z,y]	Rate/acre 100 gal/ acre	Rate/ 100 gal	Spray timing	Fruit/cm^2 cross sectional area limb (31 May)	Visual crop load estimate (%) (5 Aug.)	Fruit diameter (cm) (15 Oct)	Length/ diameter ratio (cm) (15 Oct)	Side russet rating (0–5) (15 Oct)
1.	W	Control				5.32 a[x]	103 a	6.79 a	0.790 a	1.68 f
2.	R	Vydate	2 pt	946ml	13 mm	2.48 b	65 bcd	6.82 a	0.823 a	2.72 cd
		+ NAA 2.5 ppm	16.8ml	16.8ml						
		+ Regulaid	1 pt	473ml						
3.	B	Vydate	2 pt	946ml	13 mm	2.26 bc	65 bcd	6.87 a	0.831 a	2.30 de
		+ Accel	30 g	1,578ml						
4.	FO	Vydate	2 pt	946ml	13 mm	2.32 bc	47 def	6.86 a	0.829 a	2.53 cd
		+ Regulaid	1 pt	473ml						
5.	HP	Vydate	2 pt	946ml	13 mm	2.50 b	56 cde	7.09 a	0.831 a	2.29 de
		+ Ethrel	3 pt	1,419ml						
		+ Regulaid	1 pt	473ml						
6.	DG	Sevin XLR	3 lb	1,420ml	13 mm	5.16 a	72 bc	6.93 a	0.819 a	1.88 ef
		+ Accel	30 g	1,578ml						
7.	Y	Sevin XLR	3 lb	1,420ml	13 mm	5.47 a	88 ab	6.91 a	0.822 a	1.88 ef
		+ NAA 2 ppm	14 ml	14.0ml						
		+ Regulaid	1 pt	473 ml						
8.	BK	Wilthin	12 pt	5,676ml	Bloom	4.79 a	76 bc	7.20 a	0.805 a	1.90 ef
		+ Regulaid	1 pt	473ml						
9.	RBKS	Wilthin	18 pt	8,514ml	Bloom	2.28 bc	39 efg	7.48 a	0.789 a	2.25 de
		+ Regulaid	1 pt	473ml						
10	BBKS	Wilthin	24 pt	11,352ml	Bloom	0.80 bcd	22 ghi	6.32 a	0.838 a	2.40 d
		+ Regulaid	1 pt	473ml						
11.	FOBKS	Wilthin	18 pt	8,514ml	Bloom	0.16 d	9 hi	7.10 a	0.842 a	2.94 bc
		+ Regulaid	1 pt	473ml						
		Vydate	2 pt	946ml	13 mm					
		+ NAA 2.5 ppm	16.8ml	16.8ml						
		+ Regulaid	1 pt	473ml						
12	PBKS	Endothall	3 pt	1,419ml	Bloom	0.14 d	8 hi	6.59 a	0.802 a	2.77 cd
13	GBKS	Endothall	4 pt	1,892ml	Bloom	0.00 d	1 i	--	--	--
14	YBKS	Endothall	6 pt	2,838ml	Bloom	0.00 d	0.4 i	--	--	--
15	RS	Endothall	4 pt	1,892ml	Bloom	0.02 d	2 hi	--	--	--
		Vydate	2 pt	946ml	13 mm					
		+ NAA 2.5 ppm	16.8ml	16.8ml						
		+ Regulaid	1 pt	473ml						
16	BS	MYX4801	12 pt	5,676ml	Bloom	0.93 bcd	23 ghi	7.35 a	0.835 a	2.58 cd
		+ Regulaid	1 pt	473ml						
17	OS	MYX4801	12 pt	5,676ml	Bloom	0.56 bcd	11 hi	7.12 a	0.838 a	3.28 ab
		+ Regulaid	1 pt	473ml						
		Vydate	2 pt	946 ml	13 mm					
		+ NAA 2.5 ppm	16.8ml	16.8ml						
		+ Regulaid	1 pt	473ml						
18	RD	ATS	6 gal	22,710ml	Bloom	1.06 bcd	28 fgh	7.41 a	0.830 a	2.42 d
19	BD	ATS	6 gal	22,710ml	Bloom	0.36 cd	13 hi	7.47 a	0.813 a	3.63 a
		Vydate	2 pt	946 ml						
		+ NAA 2.5 ppm	16.8ml	16.8ml	13 mm					
		+ Regulaid	1 pt	473ml						

[z]Full bloom occurred 23 April 1997 (??).

[y]Treatments were applied at bloom (21 Apr 97, and on 19 May 97 when fruit diameter was 12.7 mm. Airblast sprayer was calibrated for 100 gal/acre (trees were 24 feet between rows, tree wideth was 12 feet, and tree height was 14 ft (50% TRV).

Side russet rating: 0 = smooth; 1 = raised lenticels; 2 = raised to touch with light russet; 3 = russet in lenticels; 4 = heavy russet in lenticels; 5 = very heavy russet.

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

Table 2. Effect of pollination inhibitors on 'Ace Delicious'/MM 111 fruit set (1996).

No.		Treatment[z,y,x]	rate/ 25 gal	Rate/ 100 gal	Rate/ acre	Fruit/cm² cross sectional area limb (23 May)	Fruit diameter (30 Aug)	Length/ diameter ratio (30 Aug)	Crop load (%)[w]	Crop load upper 1/3 (%)[w]	Crop load lower 2/3 (%)[w]	Net fruit russet rating[x] (30 Aug)	Injury (% of fruit with marking)[v]	Bloom return 1997 (rating 1-10)
1	W	Control				4.6 ab[u]	6.99 cd	0.935 abc	138 a	115 ab	150 a	0.45 cd	0 c	3.8 abcd
2	R	Wilthin (300 gal) + Regulaid	473 ml	4 pt	12 pt	4.5 ab	6.98cd	0.938 ab	130 abc	97 abc	145 a	0.60 abcd	0 c	3.5 abcd
3	LB	Wilthin (300 gal) + Regulaid	710 ml	6 pt	18 pt	3.6 abc	7.10 abcd	0.926 abc	106 abc	76 abcd	121 ab	0.50 bcd	0 c	4.5 abc
4	FO	Wilthin (300 gal) + Regulaid	946 ml	8 pt	24 pt	3.2 abc	7.22 abcd	0.945 a	100 c	81 abc	110 bc	0.58 abcd	0 c	3.9 abcd
5	HP	Wilthin (100 gal) + + Regulaid	2,129 ml	18 pt	18 pt	4.1 abc	6.97 cd	0.929 abc	119 abc	100 abc	129 ab	0.52 bcd	0 c	1.2 bcd
6	Y	MYX4801 (300 gal/acre) + Regulaid	236 ml	2 pt	6 pt	4.1 abc	7.06 abcd	0.920 abc	137 ab	123 a	144 a	0.45 cd	0 c	2.8 abcd
7	BK	MYX4801 (300 gal/acre) + Regulaid	354 ml	3 pt	9 pt	5.2 a	6.89 d	0.911 bc	107 abc	73 bcd	124 ab	0.63 abc	0.67 c	1.7 bcd
8	DG	MYX4801 (300 gal/acre) + Regulaid	473 ml	4 pt	12 pt	3.0 bc	7.36 a	0.927 abc	66 d	27 ef	86 cd	0.57 abcd	3.58 b	4.7 ab
9	PBKS	MYX4801 (300 gal/acre) + Regulaid	626 ml	5.3 pt	16 pt	3.8 abc	7.35 ab	0.906 c	63 d	22 f	84 cd	0.79 a	7.33 a	5.4 a
10	OBKS	MYX4801 (100 gal/acre) + Regulaid	1,419 ml	12 pt	12 pt	2.5 c	7.17 abcd	0.930 abc	64 d	36 def	64 d	0.69 ab	5.92 a	3.8 abcd
11	GBKS	Endothall (300 gal/acre)	118 ml	1 pt	3 pt	4.4 abc	6.88 d	0.926 abc	134 ab	123 a	140 ab	0.37 d	0 c	0.3 d
12	RBKS	Endothall (300 gal/acre)	177 ml	1.5 pt	4.5 pt	4.4 abc	6.91 cd	0.936 abc	125 abc	95 abc	140 ab	0.44 cd	0 c	0.9 cd
13	BS	Endothall (300 gal/acre)	236 ml	2 pt	6 pt	3.4 abc	7.12 abcd	0.927 abc	116 abc	103 abc	123 ab	0.54 bcd	0 c	1.2 bcd
14	RS	Endothall (100 gal/acre)	531 ml	4.5 pt	4.5 pt	4.1 abc	7.08 abcd	0.931 abc	108 abc	72 bcd	127 ab	0.58 abcd	0 c	1.7 bcd
15	YS	ATS (300 gal/acre)	1,261.7 ml	1.33 gal	4 gal	4.1 abc	7.01 bcd	0.924 abc	126 abc	100 abc	138 ab	0.45 cd	0 c	2.2 abcd
16	RD	ATS (300 gal/acre) + + Regulaid	1,261.7 ml 118 ml	1.33 gal	4 gal	4.0 abc	7.11 abcd	0.920 abc	107 abc	65 cde	128 ab	0.43 cd	0 c	4.2 abc
17	OS	ATS (100 gal/acre)	3,785 ml	4 gal	4 gal	4.9 ab	7.00 cd	0.931 abc	119 abc	90 abc	134 ab	0.43 cd	0 c	2.1 abcd
18	BD	ATS (300 gal/acre)	1,892 ml	2 gal	6 gal	3.1 bc	7.26 abc	0.914 bc	105 bc	76 abcd	119 ab	0.52 bcd	0 c	4.2 abc

Byers # 6

Table2 (continued)

Contrast	Comparision	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F
1 Vs 4	Control Vs Willhin+Regulaid	ns	ns	ns	**	ns	**	ns	ns	ns
1 Vs 9	Control Vs MYX4801+Regulaid	ns	*	*	***	***	***	***	***	ns
1 Vs 13	Control Vs Endothall	ns	ns	ns	ns	ns	ns	ns	ns	ns
1 Vs 18	Control Vs ATS	ns	ns	ns	*	ns	*	ns	ns	ns
3 Vs 5	100gal Vs 300gal (Willhin)	ns	ns	ns	ns	ns	ns	ns	ns	*
8 Vs 10	100gal vs 300gal (MYX4801)	ns	ns	ns	ns	ns	ns	ns	**	ns
11 Vs 14	100gal vs 300gal (Endothall)	ns	ns	ns	ns	*	ns	*	ns	ns
15 Vs 16	Regulaid Vs none (ATS)	ns	ns	ns	ns	ns	ns	ns	ns	ns
15 Vs 17	100gal vs 300gal (ATS)	ns	ns	ns	ns	ns	ns	ns	ns	ns
15 Vs 18	4gal vs 6gal rate (ATS)	ns	ns	ns	ns	ns	ns	ns	ns	ns
3,8,11,15 Vs 5,10,14,17	300gal vs 100gal	ns	ns	ns	ns	ns	ns	ns	ns	ns
Regression	trt 1,2,3,4 (Willhin rate (0 to 24 pt/acre)									
	L	ns	ns	ns	*	ns	*	ns	ns	ns
	Q	*	ns	ns	*	ns	*	ns	ns	ns
	L+Q	ns	ns	ns	ns	ns	ns	ns	ns	ns
Regression	trt 1,6,7,8,9 (MYX4801(0 to 16pt/acre)									
	L	ns	*	ns	***	***	***	**	***	ns
	Q	ns	**	ns	***	***	***	**	***	ns
	L+Q	ns	ns	ns	ns	ns	ns	ns	**	ns
Regression	trt 1,11,12,13 (Endothall(0 to 6 pt/acre)									
	L	ns	ns	ns	ns	ns	ns	ns	ns	ns
	Q	ns	ns	ns	ns	ns	ns	ns	ns	ns
	L+Q	ns	ns	ns	ns	ns	ns	ns	ns	*
Regression	trt 1,15,18 (ATS(0 to 6 gal/acre)									
	L	ns	ns	ns	*	ns	ns	ns	ns	ns
	Q	*	*	ns	*	ns	*	ns	ns	ns
	L+Q	ns	ns	ns	ns	ns	ns	ns	ns	ns

[z]Full bloom occurred 28 April 1996.
[y]Treatments were applied at 95% (28 Apr) open flowers. Airblast sprayer was calibrated for 935 vs 2805 liter•ha^{-1}(100 or 300 gal/acre) (trees were 22 feet between rows, tree width was 12 feet, and tree height was 12 ft (50% TRV). [x]Side russet rating: 0 = no net side russet; 5 = heavy net russet.
[w]Crop load was visually estimated as % crop load in the upper 1/3 and lower 2/3 of the tree canopy (100%= full crop).
[v]Fruit injury showing as a net russet of specific type was visually estimated on the tree as the % of fruit with marking.
[u]Mean separation within columns by Duncan's New Multiple Range test, ($P \leq 0.05$).
Bloom rating: spurs flowering: 0 = no flowers; 5 = 50% flowering; 10 = 100% flowering.

Table 3. Effect of airblast chemical thinning treatments on 'Cresthaven' (young block) fruit set and diameter sprayed 3 April (1997).

No.	Color	Treatment[z,y]	Rate 160% (single row rate)	Single row rate/ acre	Rate/ 25 gal (block rate)	Rate/ 100 gal (block rate)	Fruit/cm² cross sectional area limb 4 June	Vegetative shoot injury rating (0-10)	Fruit diameter (inches) 18 Aug
1	W	Control					9.4 a[x]	1.0 c	2.61 c
2	B	Endothall (100 gal/acre)	378 ml	3.2 pt	237 ml	2 pt	2.6 bcd	1.1 c	2.98 ab
3	R	Endothall (100 gal/acre)	568 ml	4.8 pt	355 ml	3 pt	2.9 bcd	1.2 abc	2.91 ab
4	Y	Thinex (100 gal/acre) + Regulaid	2,272 ml	19.2 pt	1420 ml 118 ml	12 pt 1 pt	3.9 b	1.5 a	2.88 ab
5	FO	Thinex (100 gal/acre) + Regulaid	3,026 ml	25.6 pt	1892 ml 118 ml	16 pt 1 pt	1.1 cd	1.3 abc	3.05 a
6	BK	Wilthin (100 gal/acre) + Regulaid	1513 ml	12.8 pt	946 ml 118 ml	8 pt 1 pt	2.7 bcd	1.4 ab	2.95 ab
7	OBKS	Wilthin (100 gal/acre) + Regulaid	3,026 ml	25.6 pt	1892 ml 118 ml	16 pt 1 pt	2.3 cd	1.5 a	2.96 ab
8	RS	Armorthin	1513 ml	12.8 pt	946 ml	8 pt	0.8 cd	1.4 ab	3.04 a
9	BS	Armorthin	3,026 ml	25.6 pt	1892 ml	16 pt	0.32 d	1.4 ab	3.01 a
10	RD	Thinset-ATS (100 gal/acre)	5664 ml	6 gal	3540 ml	3.75 gal	3.5 bc	1.1 c	2.82 b

Contrasts:	Comparisons:	Pr>F	Pr>F	Pr>F
1 Vs 2,3	Control vs Endothall	***	ns	***
1 Vs 4,5	Control vs Thinex	***	**	***
1 Vs 6,7	Control vs Wilthin	***	***	***
1 Vs 8,9	Control vs Armothin	***	***	***
1 Vs 10	Control vs Thinset-ATS	***	ns	**
2 Vs 3	High vs Low rate (Endothall)	ns	ns	ns
4 Vs 5	High vs Low rate (Thinex)	*	ns	*
6 Vs 7	High vs Low rate (Wilthin)	ns	ns	ns
8 Vs 9	High vs Low rate (Armothin)	ns	ns	ns

[z]Full Bloom: (3 April—85-95% flowers open (young block)). A freeze occurred on April 9 that killed over 50% of the flower buds on the control. Adjacent rows were not sprayed, but to compensate for drift, the chemical rate was increased to 160% of the block rate. The water rate was held constant.

[y]All treatments including the control were hand thinned June 2-7.

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

Table 4. Effect of airblast chemical thinning treatments on 'Cresthaven' (old block) fruit set and diameter sprayed 3 April (1997).

No.	Color	Treatment[zy]	Rate 160% (single row rate)	Single row rate/ acre	Rate/ 25 gal (block rate)	Rate/ 100 gal (block rate)	Fruit/cm^2 cross sectional area limb 29 May	Vegetative shoot injury rating (0-10)	Fruit diameter (inches) 18 Aug
1	W	Control					9.4 a[x]	0.5 c	2.82 d
2	B	Endothall (100 gal/acre)	378 ml	3.2 pt	237 ml	2 pt	7.5 ab	0.86 bc	2.91 cd
3	R	Endothall (100 gal/acre)	568 ml	4.8 pt	355 ml	3 pt	7.4 ab	1.0 abc	2.96 bcd
4	Y	Thinex (100 gal/acre)	2,272 ml	19.2 pt	1420 ml	12 pt	5.6 bc	1.5 a	3.09 ab
		+ Regulaid			118 ml	1 pt			
5	FO	Thinex (100 gal/acre)	3,026 ml	25.6 pt	1892 ml	16 pt	5.1 bc	1.3 ab	3.04 bc
		+ Regulaid			118 ml	1 pt			
6	BK	Wilthin (100 gal/acre)	1513 ml	12.8 pt	946 ml	8 pt	5.0 bc	1.0 abc	2.96 bcd
		+ Regulaid			118 ml	1 pt			
7	OBKS	Wilthin (100 gal/acre)	3,026 ml	25.6 pt	1892 ml	16 pt	4.5 bc	1.1 ab	3.01 bc
		+ Regulaid			118 ml	1 pt			
8	RS	Armorthin	1513 ml	12.8 pt	946 ml	8 pt	4.5 bc	0.94 abc	3.06 bc
9	BS	Armorthin	3,026 ml	25.6 pt	1892 ml	16 pt	2.6 c	1.3 ab	3.21 a
10	RD	Thinset-ATS (100 gal/acre)	5664 ml	6 gal	3540 ml	3.75 gal	6.4 ab	1.1 ab	2.99 bc

Contrasts:	Comparisons:	Pr>F	Pr>F	Pr>F
1 Vs 2,3	Control vs Endothall	ns	*	ns
1 Vs 4,5	Control vs Thinex	**	***	***
1 Vs 6,7	Control vs Wilthin	***	**	*
1 Vs 8,9	Control vs Armothin	***	**	***
1 Vs 10	Control vs Thinset-ATS	*	*	*
2 Vs 3	High vs Low rate (Endothall)	ns	ns	ns
4 Vs 5	High vs Low rate (Thinex)	ns	ns	ns
6 Vs 7	High vs Low rate (Wilthin)	ns	ns	ns
8 Vs 9	High vs Low rate (Armothin)	ns	ns	*

[z]Full Bloom: (3 April—50-75% flowers open (old block)). A freeze occurred on April 9 that killed over 50% of the flower buds on the control. Adjacent rows were not sprayed, but to compensate for drift, the chemical rate was increased to 160% of the block rate. The water rate was held constant.

[y]All treatments including the control were hand thinned June 2-7.

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

Table 5A. Effect of GA_3 on Redhaven peach flower bud inhibition (1996).

No.	Color	Treatment[z,y]	Date applied (1996)	Rate of Pro-Gib (4%) /25 gal	Spray timing (days AFB)	Nodes/cm (1997) Whole shoot	Nodes/cm (1997) Top shoot	Nodes/cm (1997) Bottom shoot	Internode length (cm) Whole shoot	Internode length (cm) Top shoot	Internode length (cm) Bottom shoot	Flower buds/cm Whole shoot	Flower buds/cm Top shoot	Flower buds/cm Bottom shoot	Flower buds/node Whole shoot	Flower buds/node Top shoot	Flower buds/node Bottom shoot	Flower buds/ basal 5 nodes	Flower buds/ distal 5 nodes
1	W	Control				0.57 ab[x]	0.57 a	0.58 abc	1.75 ab	1.76 ab	1.75 bc	0.51 a	0.44 abc	0.57 a	0.89 a	0.78 ab	1.00 ab	3.13 ab	1.90 ab
4	HP	GA_3 127 ppm	3 June	300 ml	44	0.57 ab	0.59 a	0.55 bc	1.78 ab	1.72 ab	1.85 ab	0.48 ab	0.50 a	0.47 b	0.85 a	0.84 a	0.85 bc	1.67 cd	2.27 a
7	OBKS	GA_3 127 ppm	16 June	300 ml	57	0.55 ab	0.54 a	0.55 bc	1.83 ab	1.85 a	1.81 abc	0.36 d	0.42 abc	0.30 c	0.66 bc	0.77 ab	0.55 e	1.57 cd	2.07 a
2	R	GA_3 127 ppm	3 July	300 ml	75	0.59 ab	0.60 a	0.58 ab	1.71 b	1.69 ab	1.74 bc	0.41 bcd	0.37 bcd	0.46 b	0.71 b	0.63 bcd	0.80 cd	2.30 bc	1.33 b
6	PBKS	GA_3 127 ppm	8 Aug	300 ml	111	0.53 b	0.55 a	0.51 c	1.89 a	1.82 ab	1.98 a	0.47 ab	0.41 abc	0.52 ab	0.86 a	0.75 ab	1.03 a	3.67 a	2.15 a
5	FO	GA_3 300 ppm	3 June	710 ml	44	0.55 ab	0.56 a	0.53 bc	1.85 ab	1.81 ab	1.89 ab	0.39 cd	0.46 ab	0.32 c	0.71 b	0.83 a	0.59 e	0.65 de	2.25 a
9	BD	GA_3 300 ppm	16 June	710 ml	57	0.60 a	0.58 a	0.62 a	1.68 b	1.74 ab	1.62 c	0.24 e	0.39 bcd	0.10 d	0.40 d	0.66 bc	0.16 f	0.22 e	1.93 a
3	B	GA_3 300 ppm	3 July	710 ml	75	0.59 a	0.60 a	0.59 ab	1.69 b	1.66 b	1.72 bc	0.34 d	0.31 d	0.37 c	0.57 c	0.51 d	0.64 de	1.48 cd	1.32 b
8	RD	GA_3 300 ppm	8 Aug	710 ml	111	0.56 ab	0.58 a	0.55 bc	1.78 ab	1.74 ab	1.82 abc	0.44 abc	0.34 cd	0.54 ab	0.77 ab	0.59 cd	0.97 ab	3.77 a	1.65 ab
Contrasts:		Comparison:																	
1 Vs 2,4,6,7		Control Vs 127 ppm				ns	ns	ns	ns	ns	ns	••	ns	•••	•	ns	••	•	ns
1 Vs 3,5,8,9		Control Vs 300 ppm				ns	ns	ns	ns	ns	ns	•••	ns	•••	•••	•	•••	•••	ns
2,4,6,7 Vs 3,5,8,9		127 ppm Vs 127 ppm				ns	ns	ns	ns	ns	ns	•••	ns	•••	•••	•	•••	•	ns
5 Vs 9		44 days Vs 57 days (300 ppm)				•	ns	••	•	ns	••	•••	ns	•••	•••	•	•••	ns	ns
5 Vs 3		44 days Vs 75 days (127 ppm)				ns	ns	ns	ns	ns	ns	ns	•	•	ns	•••	ns	ns	••
5 Vs 8		44 days Vs 111 days (300 ppm)				ns	ns	ns	ns	ns	ns	ns	•	•••	ns	••	•••	•••	•
9 Vs 3		57 days Vs 75 days (127 ppm)				ns	ns	ns	ns	ns	ns	••	ns	•••	•••	ns	•••	•	ns
9 Vs 8		57 days Vs 111 days (127 ppm)				ns	ns	•	ns	ns	•	•••	ns	•••	•••	ns	•••	•••	ns
3 Vs 8		75 days Vs 111 days (127 ppm)				ns	ns	ns	ns	ns	ns	ns	ns	••	•	ns	••	•••	ns
4 Vs 5		127 ppm Vs 300 ppm (44 DAFB)				ns	ns	ns	ns	ns	ns	•	ns	•••	•	ns	••	ns	ns
7 Vs 9		127 ppm Vs 300 ppm (57 DAFB)				•	ns	•	ns	ns	•	••	ns	•••	•••	ns	•••	•	ns
2 Vs 3		127 ppm Vs 300 ppm (75 DAFB)				ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
6 Vs 8		127 ppm Vs 300 ppm (111 DAFB)				ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
4,5 Vs 7,9		44 Vs 57 (127 ppm + 300 ppm)				ns	ns	•	ns	ns	•	•••	•	•••	•••	•	•••	ns	ns
4,5 Vs 2,3		44 Vs 75 (127 ppm + 300 ppm)				ns	ns	ns	ns	ns	ns	ns	•••	ns	•	•••	ns	•	•••
4,5 Vs 6,8		44 Vs 111 (127 ppm + 300 ppm)				ns	ns	ns	ns	ns	ns	ns	••	•••	ns	••	•••	•••	ns
7,9 Vs 2,3		57 Vs 75 (127 ppm + 300 ppm)				ns	ns	ns	ns	•	ns	•••	ns	•••	••	•	•••	••	••
7,9 Vs 6,8		57 Vs 111 (127 ppm + 300 ppm)				ns	ns	•	ns	ns	•	•••	ns	•••	•••	ns	•••	•••	ns
2,3 Vs 6,8		75Vs 111 (127 ppm + 300 ppm)				ns	ns	ns	•	ns	•	•	ns	••	••	ns	•••	•••	•
Regression:			Comparison:																
trt#s 3,5,8,9			L			ns	ns	ns	ns	ns	ns	ns	•	•••	ns	•	•••	•••	ns
(regression of 300 ppm by days)			Q			•	ns	ns	ns	ns	ns	•	ns	•••	•	ns	•••	•••	ns
			L+Q			•	ns	•	•	ns	•	•	•	ns	••	••	•	ns	•

[z]Full Bloom was 20 April 1996.

[y]Airblast sprayer was calibrated for , and 6 whole single tree reps were sprayed per treatment in and randomized complete block design.48 g ai/acre = 127 ppm/100gal/A

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

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Table 10. Effect of GA_3 applied in 1996 on Redhaven hand thinning and fruit diameter in 1997.

No.	Color	Treatment[z,y]	Date applied (1996)	Rate of Pro-Gib (4%) /25 gal	Spray timing (days AFB)	Hand thinning (6 Jun 97) Number of fruit removed per tree	Number fruit removed/cm^2 cross sectional area trunk	Individual fruit weight (g)	Fruit weight(g)/cm^2 cross sectional area trunk	Fruit diameter (inches) near harvest (21 July 97)
1	W	Control				250 a[x]	0.97 a	24.2 bc	22.9 a	2.64 b
4	HP	GA_3 127 ppm	3 June	300 ml	44	92 bc	0.42 cd	26.3 ab	10.6 cd	2.71 b
7	OBKS	GA_3 127 ppm	16 June	300 ml	57	19 c	0.09 d	28.4 a	2.4 d	3.04 a
2	R	GA_3 127 ppm	3 July	300 ml	75	165 b	0.80 ab	26.3 ab	20.6 ab	2.74 b
6	PBKS	GA_3 127 ppm	8 Aug	300 ml	111	84 bc	0.35 cd	22.6 c	7.8 cd	2.63 b
5	FO	GA_3 300 ppm	3 June	710 ml	44	43 c	0.20 cd	28.5 a	5.5 cd	2.77 b
9	BD	GA_3 300 ppm	16 June	710 ml	57	55 c	0.20 cd	28.8 a	5.4 cd	2.98 a
3	B	GA_3 300 ppm	3 July	710 ml	75	112 bc	0.55 bc	25.5 bc	13.6 bc	2.79 b
8	RD	GA_3 300 ppm	8 Aug	710 ml	111	40 c	0.16 cd	24.8 bc	3.8 d	2.79 b

Contrasts:	Comparison:	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F
1 Vs 2,4,6,7	Control Vs 127 ppm	***	***	ns	***	**
1 Vs 3,5,8,9	Control Vs 300 ppm	***	***	**	***	***
2,4,6,7 Vs 3,5,8,9	127ppm Vs 300 ppm	ns	ns	ns	ns	ns
5 Vs 9	44 Vs 57 DAFB (300 ppm)	ns	ns	ns	ns	ns
5 Vs 3	44 Vs 75 DAFB (300 ppm)	ns	*	*	*	ns
5 Vs 8	44 Vs 111 DAFB (300 ppm)	ns	ns	ns	ns	ns
9 Vs 3	57 Vs 75 DAFB (300 ppm)	ns	*	*	*	*
9 Vs 8	57 Vs 111 DAFB (300 ppm)	ns	ns	ns	ns	*
3 Vs 8	75 Vs 111 DAFB (300 ppm)	ns	*	*	*	ns
4 Vs 5	127 ppm Vs 300 ppm (44 DAFB)	ns	ns	ns	ns	ns
7 Vs 9	127 ppm Vs 300 ppm (57 DAFB)	ns	ns	ns	ns	ns
2 Vs 3	127 ppm Vs 300 ppm (75 DAFB)	ns	ns	ns	ns	ns
6 Vs 8	127 ppm Vs 300 ppm (111 DAFB)	ns	ns	ns	ns	*
4,5 Vs 7,9	44 Vs 57 (127 ppm + 300 ppm)	ns	ns	ns	ns	***
4,5 Vs 2,3	44 Vs 75 (127 ppm + 300 ppm)	*	**	**	**	ns
4,5 Vs 6,8	44 Vs 111 (127 ppm + 300 ppm)	ns	ns	ns	ns	ns
7,9 Vs 2,3	57 Vs 75 (127 ppm + 300 ppm)	***	***	***	***	***
7,9 Vs 6,8	57 Vs 111 (127 ppm + 300 ppm)	ns	ns	ns	ns	***
2,3 Vs 6,8	75Vs 111 (127 ppm + 300 ppm)	**	***	***	***	ns

[z]Full Bloom was 20 April 1996. Whole block was sprayed with ATS on 8 April and again 9 April with 3.5gal/A at 300 gal/acre in each application to thin flowers.
[y]Airblast sprayer was calibrated for 200 gal/acre, and 6 whole single tree reps were sprayed per treatment in and randomized complete block design.
[x]Mean separation within columns by Duncan's multiple range test, 5% level.
48 g ai/acre=127 ppm/100gal/A

Byers # 11

"Not for Citation"

EVALUATION OF ANNUAL PLASTICULTURE AND JUNE MATTED ROW STRAWBERRIES: 1997 WREC

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As many of you know, we have been looking at both the normal June bearing production system and annual plasticulture for the last five seasons. The work has been partially funded by the Maryland Horticulture Society and by SARE. There are several key points that one must keep in mind when it comes to annual plasticulture in Maryland with Chandler.

1. The system is highly management intensive with high input costs. $5,000-$6,000 per acre.
2. The system with Chandler annual plasticulture is generally limited in the state to the lower shore and southern Maryland.
3. Plug plants are preferred.
4. Row covers are needed for winter protection and from protection from cold late winter winds. (A real must), heavy covers preferred.
5. Deer exclusion is a must. Deer just love those nice strawberry leaves both in the fall and the early spring.
6. Frost protection is a must as we get blooms earlier than the normal June bearing system.
7. A high well formed bed is a must. Along with good fertility and pest management spray schedules.
8. Marketing is the key to success.
9. Don't U - pick the fields or you'll never get your customers to pick the matted row system again.
10. Make sure the fruit is ripe to the tip for local sales if you want flavor.
11. Have your drip line hooked up and running in the fall.

These are just a few thoughts and observations I have made on the system. Strawberry production is changing. Efforts are being made in New Jersey by Dr. Joe Fiola to see how far north plasticulture of annual strawberries can go but its going to be different varieties and techniques that make it happen. Otho Wells in New Hampshire is growing them in high tunnels; anything is possible if the dollars work out. He claims he can grow them in the Yukon.

Plasticulture Historical Yield Averages at the Wye
From Plug Plants with 2 Yr. Averages or More

Year	Planting Date	Chandler	Planting Date	Sweet Charlie	Planting Date	Camarosa	Planting Date	Cavendish
1993	9/19/92	14,342	---	---	---	---	---	---
1994	9/23/93	11,328	9/23/93	4,890	---	---	---	---
1995	9/22/94	19,242	---	---	---	---	9/19/94	15,506
1996	9/7/95	8,337	9/1/95	9,971	9/7/95	14,249	---	---
1997	9/5/96	17,672	9/5/95	18,900	9/5/96	16,598	9/5/96	30,871
Average (5 yr)		14,184	(3 yr)	11,254	(2 yr)	15,424	(2 yr)	23,188

Comments:

Time of planting is critical for each variety. There is a different planting window for each variety and location. Our work at the Wye Research and Education Center will be to look at a number of varieties and breeding lines as to planting window, yields and fruit quality and marketability. The management and nitrogen requirements can also vary on some varieties and breeding lines. A big yield of a soft unmarketable fruit is not acceptable or profitable - neither is a nice big berry with poor flavor. Try a new variety on a limited scale until you have answers to those questions.

1997 Variety Trial Time of Planting Study Annual
Plasticulture, Plug Plants
Planted 8/15/96 and 9/5/96
Wye Research and Education Center

Variety	Planting Date -- September 5, 1996			Comments
	Harvest Dates	x̄ Gram Berry Wt.	9/5/96 Lbs/A	
Cavendish	5/9 - 6/13	16.9 B	30,871 A	Possible white shoulder problem, Canadian variety, possible potential variety when Chandler can't be grown
Allstar	5/12 - 6/18	15.4 BC	26,906 A	USDA. release, light color, has done well where Chandler can't be grown
B27	5/9 - 6/18	19.5 A	26,635 A	Breeding line, large berry, flavor questionable
Idea	5/19 - 6/20	20.0 A	26,116 A	Italian berry, soft fruit, light color, Easy with nitrogen
Jewel	5/14 - 6/13	13.7 D	19,910 B	N.Y. Release
Sweet Charlie	5/2 - 6/20	13.1 D	19,563 B	Florida release, early, good flavor, must be frost protected
Chandler	5/7 - 6/20	16.5 B	19,034 B	California variety, standard good flavor when ripe to tip, holds well
Camarosa	5/7 6/18	15.6 BC	16,467 B	California berry, firm, flavor variable
NJ 8614-2	5/7 - 6/2	12.8 D	10,394 C	Breeding line
NJ 8607-2	5/7 -6/2	10.3 E	9,525 C	Breeding line
Delmarvel	5/7 - 6/6	14.1 CD	9,332 C	Great flavor, low yields
NJ8826-11	5/7 - 5/30	16.8 B	7,534 C	Large berry, good flavor, yield comes over two week period

Statistical Significant Difference of Planting Date at .05 Level			
Variety	8/15	9/5	Comments
Cavendish	25,996 B	30,871 AB	No significant differences
Allstar	16,798 CD	26,906 B	Later planting date better
Idea	33,190 A	26,116 B	Earlier planting date better
Jewel	20,061 C	19,910 C	No significant differences
Sweet Charlie	11,981 DE	19563 C	Later planting date better
Delmarvel	7,172 E	9,332 E	No significant differences

1997. Results 4th Season, June Bearing Matted Row Variety Block

Variety	Avg Gram Berry Wt 25 Berries	$\bar{x}$ Gram Berry Wt	Yield lb/Acre	Comments
Primetime	275 BC	11.0 BC	28,338 A	USDA new variety, nice fruit and bed in fourth season
Cavendish	327 A	13.1 A	24,558 AB	Canadian variety, large fruit, possible white shoulder problem, not observed at Wye
Glooscap	213 DE	8.5 DE	24,252 AB	Small fruit
Latestar	281 BC	11.2 BC	22,473 BC	USDA release real promise as late variety
Mohawk	210 EF	8.4 EF	22,100 BC	USDA release, early, small fruit size, has done well at Wye
Blomidon	250 CD	10.0 CD	19,047 BCD	Yellows problem, variety no longer available, Canadian variety
Earliglow	175 F	7.0 F	18,431 CD	Early, standard variety, great flavor, small fruit size, USDA
Allstar	306 AB	12.2 AB	17,587 CDE	Mid season standard, light fruit color, USDA
Annapolis	207 EF	8.3 EF	15,727 DE	Canadian variety
Lateglow	206 EF	8.2 EF	15,160 DE	USDA. Release
Jewel	289 B	11.6 B	14,868 DE	New York Release
Delmarvel	225 DE	9.0 DE	12,211 E	USDA release, great flavor, low yield at Wye
Seneca	0	0	0	No plants left alive after 2nd harvest year.

MATTED ROW JUNE BEARING
TRIAL YIELD RESULTS IN LBS/ACRE 1994 - 1997

VARIETY	1994		1995		1996		1997		TOTAL	4 Yr. Avg.	
Glooscap	14,040	(5)	26,334	(3)	17,264	(8)	24,252	(3)	81,890	20,472	(4)
Blomidon	11,280	(11)	22,682	(7)	17,943	(7)	19,047	(6)	70,952	17,738	(9)
Cavendish	20,770	(1)	25,088	(6)	19,621	(5)	24,558	(2)	90,037	22,509	(2)
Earliglow	10,460	(12)	25,583	(5)	20,454	(4)	18,431	(7)	74,928	18,732	(7)
Allstar	19,370	(2)	21,568	(8)	19,271	(6)	17,587	(8)	77,796	19,449	(6)
Lateglow	7,140	(13)	19,690	(10)	10,570	(11)	15,160	(10)	52,560	13,140	(12)
Jewel	12,470	(9)	14,597	(12)	12,286	(12)	14,868	(11)	54,221	13,555	(11)
Seneca	12,620	(8)	4,978	(13)	0	(13)	0	(13)	17,598	4,399	(13)
Annapolis	13,430	(6)	25,856	(4)	23,508	(1)	15,727	(9)	78,521	19,630	(5)
Primetime	15,860	(3)	32,945	(1)	22,095	(3)	28,388	(1)	99,238	24,809	(1)
Delmarvel	11,540	(10)	17,874	(11)	16,849	(9)	12,211	(12)	58,474	14,618	(10)
Mohawk	14,980	(4)	28,953	(2)	22,357	(2)	22,100	(5)	88,390	22,097	(3)
Latestar	12,690	(7)	20,680	(9)	15,339	(10)	22,473	(4)	71,182	17,795	(8)

( ) number is yearly ranking or overall ranking

(Not for publication or distribution)

The Influence Soybean Oil on Apple and Peach Phenology and Fruit Set.

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Introduction

Freezing temperatures during the period of cold deacclimation of peach and apple trees can cause killing of flower buds and drastically reduce yields. Farrar and Kelley (1935); Call and Seeley (1989) and Deyton et al. (1992) retarded flower bud development of either apple or peach trees with dormant oils. Multipule applications and rates over 15% were phytotoxic. Call and Seeley (1989) showed increases flower bud hardiness and delayed bud phenology.

The objective of the experiments reported here were to investigate single and multiple application of soybean oil for delaying flower bud phenology of two peach and three apple cultivars.

Materials and Methods

All trees were selected for uniform size and were blocked according to row and terrain into five blocks for the six treatments listed in each table. Unfortunately during the dormant season, apple flower buds are not readily distinguishable; and thus, a wide variation in numbers of flowers/tree was evident at bloom. Single applications of 8 gallons/100 gal. were applied on Feb 7 and March 24. Multiple applications were begun on Feb 7 at 8 gal/100 gal. Subsequent applications were applied at 5 gal/100 gal. each.

Experiment 1. In 1997, thirty 6-year-old 'Redhaven' trees were selected for uniformity and blocked by row and terrain into 5 blocks of 6 treatments listed in Table 1. On May 28, the number of large and button fruit/cm2 cross sectional area of limb on 3 limbs per tree were counted. On 8 April, the number of flowers/cm2 cross sectional area limb and on 26 July fruit diameter was taken on 10 fruit/tree. On March 27, five short shoots (approximately 10 cm in length) and 5 long shoots (approximately 24 cm in length) were collected from each tree and the number of buds in each stage of development were counted (Table 1). On April 30, the numbers of buds not open, bud scars, and the number of fruit/5 shoots (approximately 34 cm in length) were recorded.

Experiment 2. In 1997, thirty 6-year-old 'Bisco' trees were selected for uniformity and blocked by row and terrain into 5 blocks of 6 treatments listed in Table 2. On 1 April, 5 long shoots (approximately 40 cm in length) were collected from each tree, and the number of buds in each stage of development were counted (Table 2).

Experiment 3. In 1997, thirty 6-year-old 'Jonagold/M.27 ' trees were selected for uniformity and blocked by row and terrain into 5 blocks of 6 treatments listed in Table 3. At intervals of time from 18 March to 14 April a visual rating of buds was taken for each tree. In addition, the number of fruit/tree were counted on 12 June.

Experiment 4. In 1997, thirty 6-year-old 'Mutsu/M.27 ' trees were selected for uniformity and blocked by row and terrain into 5 blocks of 6 treatments listed in Table 4. At interval of time from 18 March to 14 April a visual rating of buds was taken for each tree. In addition, the number of fruit/tree were counted on 12 June.

Experiment 5. In 1997, thirty 15-year-old 'Stayman'/Seedling trees were selected for uniformity and blocked by row and terrain into 5 blocks of 6 treatments listed in Table 5. At interval of time from 18 March to 14 April a visual rating of buds was taken for each tree. In addition, the number of fruit/tree were counted on 12 June.

Results and Discussion

Experiment 1. On 'Redhaven' trees, a single 8 gal/100 gal. application was more effective when applied 7 Feb than 12 Mar. Fruit numbers of large and button fruit was reduced by oil (Table 1A). Fruit diameter was increased when fruit numbers/tree decreased (Table 1A). Flower bud phenology was delayed more by the single 7 Feb than the 24 March application (Table 1B&1C&1D). Multiple applications did not appear to be any more effective than a single early application.

Many buds that were delay in their development had non-functional or dead flower parts. Buds that were in the First swell and dormant stages on March 27, probably never set fruit and if the more advanced flowers had been killed by a freeze I question whether these later developing buds would have set fruit.

Experiment 2. Since differences in stages of bud phenology of 'Bisco' trees between treatments were not very evident on 1 Apr., a detailed study of this cultivar was not conducted (Table 2).

Experiment 3. Since the number of flower buds per 'Jonagold' tree was quite variable, difference is bud phenology were not easily detectable (Table 3A). However there was a trend to some reduction in Flower cluster/CSAL (Table 3A.

Experiment 4. Since the number of flower buds per 'Mutsu' tree was quite variable, difference is bud phenology were not detectable (Table 4A). The number of fruit/tree was widely variable because some trees were in a biennial cycle (Table 4B).

Experiment 5. In this experiment 'Stayman' trees were older and showed less of a difference in biennial bearing, but differences in bud phenology were not consistently detectable (Table 5A). The number of fruit/CSAL was not affected by the treatments.

On apple, further study of more effective oils seem to be needed, since little or no delay in flowering was obtained by the treatments. In peach trees, the effect of low winter temperatures on bud survival is a question. The bud death of the later developing peach buds in the Redhaven experiment (Exp #1) cause me to question whether these later developing buds would have set fruit at all even if more advanced flowers had been killed by a freeze.

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Table 1A. Effect of handgun sprays of soybean oil on 'Redhaven' peach trees (1997).

No.	Color	Treatment[z]	Total amount/ 100 gal (all appl.)	Rate/100 gal (application date) Feb 7	Feb 25	Mar 12	Mar 24	Fruit/cm² cross sectional area limb (Large fruit) 28 May	Fruit/cm² cross sectional area limb (Button fruit) 28 May	Fruit/cm² cross sectional area limb (Total fruit) 28 May	Flowers/cm² cross sectional area limb 8 April	Fruit diameter (inches) near harvest 26 July
1	W	Control						4.9 a[y]	1.0 a	6.0 a	42 a	2.61 b
2	R	Oil	8	8				1.0 b	0.4 b	1.4 b	15 b	2.86 a
3	B	Oil	13	8	5			0.8 b	0.3 b	1.1 b	17 b	2.90 a
4	FO	Oil	18	8	5	5		0.8 b	0.2 b	1.0 b	10 b	2.86 a
5	Y	Oil	23	8	5	5	5	1.1 b	0.3 b	1.4 b	12 b	2.86 a
6	BK	Oil	8			8		3.7 a	1.0 a	4.6 a	43 a	2.78 ab

[z]Full Bloom: (3 April--90% flowers open). A freeze occurred on April 9 that killed over 50% of the flower buds on the control.
[y]Mean separation within columns by Duncan's new multiple range test, P≤0.05.

Table 1B. Effect of handgun sprays of soybean oil on 'Redhaven' bud development (five 10 cm shoots/tree) (1997).

No.	Color	Treatment[zy]	Total amount/ 100 gal. (all appl.)	Rate/100 gal (application date) Feb 7	Feb 25	Mar 12	Mar 24	Stages of bud phenology (buds/50 cm)[y] (March 27,1997) Dormant	First swell	Green bud	Early red bud	Red bud	Pink	Bloom
1	W	Control						0.4 c[x]	0.6 b	3.6 b	6.2 a	9.0 a	14.2 a	0 a
2	R	Oil	8	8				1.0 bc	9.6 a	7.0 ab	3.0 a	5.2 a	5.0 b	0 a
3	B	Oil	13	8	5			2.0 ab	11.4 a	5.8 ab	3.6 a	4.6 a	5.2 b	0 a
4	FO	Oil	18	8	5	5		2.0 ab	13.8 a	7.0 ab	3.6 a	4.6 a	3.2 b	0 a
5	Y	Oil	23	8	5	5	5	2.4 a	9.4 a	9.8 a	4.0 a	6.6 a	3.6 b	0 a
6	BK	Oil	8			8		1.5 abc	1.3 b	5.5 ab	5.0 a	8.8 a	8.0 b	0 a

[z]Full Bloom: (3 April--90% flowers open). A freeze occurred on April 9 that killed over 50% of the flower buds on the control.
[x]Mean separation within columns by Duncan's new multiple range test, P≤0.05.
[y]Bud phenology: 1 = Dormant (none swollen); 2 = first swell (split scale) ; 3 = green caylx ; 4 red caylx ; 5 = first pink ; 6 = first bloom.

Table 1C. Effect of handgun sprays of soybean oil on 'Redhaven' bud development (five 24 cm shoots/tree) (1997).

No.	Color	Treatment[zy]	Total amount/ 100 gal. (all appl.)	Rate/100 gal (application date)				Stages of bud phenology (buds/120 cm)[y] (March 27,1997)						
				Feb 7	Feb 25	Mar 12	Mar 24	Dormant	First swell	Green bud	Early red bud	Red bud	Pink	Bloom
1	W	Control						0.2 b[x]	12 b	40 a	21 a	17 a	16 a	0 a
2	R	Oil	8	8				1.2 ab	42 a	22 a	9 b	7 b	6 ab	0 a
3	B	Oil	13	8	5			1.6 a	46 a	20 a	8 b	9 b	8 ab	0 a
4	FO	Oil	18	8	5	5		0.0 b	50 a	31 a	8 b	5 b	5.6 b	0 a
5	Y	Oil	23	8	5	5	5	0.0 b	36 a	26 a	9 b	9 b	9 ab	0 a
6	BK	Oil	8			8		0.3 b	16 b	31 a	25 a	23 a	14 ab	0 a

[z]Full Bloom: (3 April--90% flowers open). A freeze occurred on April 9 that killed over 50% of the flower buds on the control.
[x]Mean separation within columns by Duncan's new multiple range test, $P \leq 0.05$.
[y]Bud phenology: 1 = Dormant (none swollen); 2 = first swell (split scale) ; 3 = green caylx ; 4 red caylx ; 5 = first pink ; 6 = first bloom.

Byers # 5

Table 1D. Effect of handgun sprays of soybean oil on 'Redhaven' bud development (five 34 cm shoots/tree) (1997).

No.	Color	Treatment[zy]	Total amount/ 100 gal. (all appl.)	Rate/100 gal (application date)				Stages of bud phenology (buds/170 cm)[y] (April 30,1997)		
				Feb 7	Feb 25	Mar 12	Mar 24	Buds not open/ 5 shoots	Bud scars/ 5 shoots	Number fruit/ 5 shoots
1	W	Control						50 a[x]	22 c	20 a
2	R	Oil	8	8				42 ab	35 ab	3 c
3	B	Oil	13	8	5			39 b	37 a	3 c
4	FO	Oil	18	8	5	5		39 b	38 a	1 c
5	Y	Oil	23	8	5	5	5	39 b	41 a	2 c
6	BK	Oil	8			8		48 a	30 ab	12 b

[z]Full Bloom: (3 April--90% flowers open). A freeze occurred on April 9 that killed over 50% of the flower buds on the control.
[x]Mean separation within columns by Duncan's new multiple range test, $P \leq 0.05$.
[y]Bud phenology: 1 = Dormant (none swollen); 2 = first swell (split scale) ; 3 = green caylx ; 4 red caylx ; 5 = first pink ; 6 = first bloom.

Table 2. Effect of handgun sprays of soybean oil on 'Bisco' bud development (five 40 cm shoots/tree) (1997).

No.	Color	Treatment[zy]	Total amount/ 100 gal. (all appl.)	Rate/100 gal (application date) Feb 7	Feb 25	Mar 12	Mar 24	Stages of bud phenology (buds/200 cm)[w] (April 1 1997) Dormant	First swell	Green bud	Early red bud	Red bud	Pink	Bloom
1	W	Control						0.0 a[x]	0.4 b	0.4 b	4.4 b	14.2 a	23.6 a	73.0 a
2	B	Oil	8	8				0.8 a	1.2 ab	9.4 ab	8.4 b	14.4 a	26.2 a	47.4 b
3	R	Oil	13	8	5			0.0 a	0.8 b	1.8 b	7.2 b	16.8 a	36.2 a	56.4 ab
4	FO	Oil	18	8	5	5		0.0 a	1.8 ab	9.0 ab	9.4 b	13.4 a	32.8 a	52.0 b
5	Y	Oil	23	8	5	5	5	0.0 a	4.4 a	17.2 a	17.6 a	18.0 a	28.6 a	37.6 b
6	BK	Oil	8			8		0.0 a	3.0 ab	2.5 b	5.8 b	17.3 a	38.5 a	42.5 b

[z]Full Bloom: (21 April--90% flowers open). A freeze occurred on April 9 that killed over 50% of the flower buds on the control.
[y]All treatments including the control were hand thinned June 2-7.
[x]Mean separation within columns by Duncan's new multiple range test, $P \leq 0.05$.
[w]Bud phenology: 1 = Dormant (none swollen); 2 = first swell (split scale) ; 3 = green caylx ; 4 red caylx ; 5 = first pink ; 6 = first bloom.

Table 3A. Effect of handgun sprays of soybean oil on 'Jonagold' flowering (1997).

No.	Color	Treatment^zy	Total amount 100 gal. (all appl.)	Rate/100 gal (application date) Feb 7	Feb 25	Mar 12	Mar 24	Bud rating^w Mar 18	Apr 1	Apr 8	Flower clusters /cm² cross sectional area limb Apr 14
1	W	Control						2.63 a^x	4.70 a	6.94 a	10.0 ab
2	B	Oil	8	8				2.50 ab	4.58 ab	6.13 bc	6.5 b
3	R	Oil	13	8	5			2.25 ab	4.45 bc	6.25 bc	16.0 a
4	FO	Oil	18	8	5	5		2.31 ab	4.38 c	6.00 c	6.75 b
5	Y	Oil	23	8	5	5	5	2.07 b	4.45 bc	6.31 bc	4.75 b
6	BK	Oil	8			8		2.44 ab	4.53 bc	6.75 ab	8.25 ab

^zFull Bloom: (21 April--90% flowers open).
^yAll treatments including the control were hand thinned June 2-7.
^xMean separation within columns by Duncan's new multiple range test, P≤0.05.
^wBud rating : 1 = Dormant (none swollen); 2 = silver tip; 3 = green tip; 4 =1/2"green; 5 = tight cluster; 6 = first pink ; 7 = full pink ; 8 = first bloom.

Byers # 7

Table 3B. Effect of handgun sprays of soybean oil on 'Jonagold' fruiting (1997).

No.	Color	Treatment^zy	Total amount/ 100 gal (all appl.)	Rate/100 gal (application date) Feb 7	Feb 25	Mar 12	Mar 24	Number fruit per tree 12 June	Fruit/cm² cross sectional area trunk 12 June	Fruit diameter (cm) 25 Sept	Length diameter ratio 25 Sept
1	W	Control						83 a	7.1 a	7.09 b	0.87 a
2	B	Oil	8	8				50 ab	5.6 a	7.30 ab	0.87 a
3	R	Oil	13	8	5			57 ab	5.2 a	7.28 ab	0.88 a
4	FO	Oil	18	8	5	5		49 ab	4.2 a	7.75 ab	0.89 a
5	Y	Oil	23	8	5	5	5	30 b	2.8 a	7.78 ab	0.87 a
6	BK	Oil	8			8		44 ab	4.0 a	8.18 a	0.89 a

^zFull Bloom: (21 April--90% flowers open).
^yAll treatments including the control were hand thinned June 2-7.
^xMean separation within columns by Duncan's new multiple range test, P≤0.5.

Table 4A. Effect of handgun sprays of soybean oil on 'Mutsu' flowering (1997).

No.	Color	Treatment[zy]	Total amount/ 100 gal. (all appl.)	Rate/100 gal (application date) Feb 7	Feb 25	Mar 12	Mar 24	Bud rating[w] Mar 18	Apr 1	Apr 8	Flower clusters /cm^2 cross sectional area limb Apr 14
1	W	Control						2.94 a[x]	4.93 a	7.06 a	7.50 b
2	B	Oil	8	8				2.88 a	4.74 b	6.81 a	11.3 ab
3	R	Oil	13	8	5			2.44 b	4.60 b	5.00 a	2.75 b
4	FO	Oil	18	8	5	5		2.75 ab	4.69 b	6.94 a	18.3 a
5	Y	Oil	23	8	5	5	5	2.94 a	4.66 b	6.88 a	5.25 b
6	BK	Oil	8			8		2.44 b	4.69 b	6.88 a	2.50 b

[z]Full Bloom: (21 April--90% flowers open).
[y]All treatments including the control were hand thinned June 2-7.
[x]Mean separation within columns by Duncan's new multiple range test, $P \leq 0.05$.
[w]Bud rating : 1 = Dormant (none swollen); 2 = silver tip; 3 = green tip; 4 =1/2''green; 5 = tight cluster; 6 = first pink ; 7 = full pink ; 8 = first bloom.

Table 4B. Effect of handgun sprays of soybean oil on 'Mutsu' fruiting (1997).

No.	Color	Treatment[zy]	Total amount/ 100 gal. (all appl.)	Rate/100 gal (application date) Feb 7	Feb 25	Mar 12	Mar 24	Number fruit per tree 12 June	Fruit/cm^2 cross sectional area trunk 12 June	Fruit diameter (cm) 1 Oct	Length/ diameter ratio 1 Oct
1	W	Control						6.3 b[x]	0.5 b	8.11 a	0.96 ab
2	B	Oil	8	8				77.5 a	5.1 a	7.84 a	0.89 b
3	R	Oil	13	8	5			4.5 b	0.3 b	8.05 a	0.89 b
4	FO	Oil	18	8	5	5		41.8 ab	2.8 ab	8.06 a	0.92 ab
5	Y	Oil	23	8	5	5	5	6.8 b	0.5 b	7.63 a	0.91 ab
6	BK	Oil	8			8		2.8 b	0.3 b	8.32 a	0.98 a

[z]Full Bloom: (21 April--90% flowers open).
[y]All treatments including the control were hand thinned June 2-7.
[x]Mean separation within columns by Duncan's new multiple range test, $P \leq 0.05$.

Table 5A. Effect of handgun sprays of soybean oil on 'Stayman' flowering (1997).

No.	Color	Treatment[zy]	Total amount/ 100 gal. (all appl.)	Rate/100 gal (application date) Feb 7	Feb 25	Mar 12	Mar 24	Bud rating[w] Mar 18	Apr 1	Apr 8	Flower clusters/cm² cross sectional area limb Apr 14
1	W	Control						2.50 a[x]	4.38 a	7.31 a	21.7 a
2	B	Oil	8	8				2.50 a	4.59 a	7.20 ab	18.8 ab
3	R	Oil	13	8	5			2.32 abc	4.40 a	7.15 ab	17.7 ab
4	FO	Oil	18	8	5	5		2.10 bc	4.31 a	7.09 b	14.0 b
5	Y	Oil	23	8	5	5	5	2.05 c	4.45 a	7.20 ab	24.0 a
6	BK	Oil	8			8		2.35 ab	4.45 a	7.29 a	17.6 ab

[z]Full Bloom: (21 April--90% flowers open).
[y]All treatments including the control were hand thinned June 2-7.
[x]Mean separation within columns by Duncan's new multiple range test, $P \leq 0.05$.
[w]Bud rating : 1 = Dormant (none swollen); 2 = silver tip; 3 = green tip; 4 = 1/2''green; 5 = tight cluster; 6 = first pink ; 7 = full pink ; 8 = first bloom.

Table 5. Effect of handgun sprays of soybean oil on 'Stayman' fruiting (1997).

No.	Color	Treatment[zy]	Total amount/ 100 gal. (all appl.)	Rate/100 gal (application date) Feb 7	Feb 25	Mar 12	Mar 24	Number fruit/cm² cross sectional area limb 2 June	Fruit diameter 2 Oct	Length/ diameter ratio 2 Oct
1	W	Control						8.08 a[x]	7.52 ab	0.843 ab
2	B	Oil	8	8				7.68 a	7.46 b	0.858 a
3	R	Oil	13	8	5			7.65 a	7.90 a	0.838 b
4	FO	Oil	18	8	5	5		8.03 a	7.67 ab	0.862 a
5	Y	Oil	23	8	5	5	5	7.92 a	7.67 ab	0.846 ab
6	BK	Oil	8			8		7.73 a	7.73 ab	0.829 b

[z]Full Bloom: (21 April--90% flowers open).
[y]All treatments including the control were hand thinned June 2-7.
[x]Mean separation within columns by Duncan's new multiple range test, $P \leq 0.05$.

(Not for publication or distribution)

The Influence of Low Light and Temperature on Apple Fruit Set and Chemical Thinning

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Introduction

Personal field observations have recently caused me to believe that under low light conditions (natural or artificial), cool temperatures do not cause as much fruit abscission as when temperatures are warm. In addition, most books on chemical thinning report that chemical thinning is temperature dependent (Westwood, 1978; Williams, 1979). However, much of the literature suggests that the temperature at the time of the chemical thinning sprays may determine the amount of thinning and suggests that the cause for more thinning is related to greater chemical absorption.

In a previous report, two or three consecutive days of 92% artificial shade (92% polypropylene shade material) reduced fruit set of 'Delicious' apple when trees where shaded in the 14 to 28 day period after bloom. Low light from cloudy periods of 3 to 4 days were calculated to be equivalent to 2 to 3 days of 92% artificial shade. If 1 to 2 days of artificial sun light separated the 2 or 3 days of artificial shade, less fruit abscission occurred. In addition, natural "June" fruit drop appeared to be related to 2 to 3 days of cloudy weather. When carbaryl was applied on the first day of artificially shaded trees, more thinning occurred than if trees were not shaded. If artificially shaded trees were exposed to one day of full sun before the thinner was applied, the thinner caused less thinning. Two days of artificial shade induced more fruit drop than chemical thinners (Carbaryl, Ethephon, or NAA) (Byers, et al., 1991).

The objective of these experiments was to investigate 1) the influence of temperature on low light abscission, 2) the influence of increasing day time temperature on fruit thinning of Carbaryl sprays, and 3) to determine if sorbitol sprays or injections could over come the effect of fruit abscission by shading the tree.

Materials and Methods

To exacerbated low light stresses, total elimination of light during the day and night period was used in three of these experiments to better determine the effect of temperature during the dark period on fruit abscission/retention. The placement of field-grown trees in total darkness in the laboratory was intended to determine the effect high vs low temperature on the physiological process (respiration, ethylene, etc.) that causes fruit abscission under conditions of low light conditions in the field. In 1997, one naturally occurring low light period occurred May 31 to June 3. PAR light levels of 32%, 12%, 13%, and 38% of full sunlight were measured with a LiCor sensor attached to a polycorder. The average day and night temperatures was 62.5F° for the 4 day period. We believe this low light period triggered a significant 'June' drop about 7 days later. This low light period was calculated to be equivalent to approximately 3.0 days of total darkness in a 4 day period. The intermittent sunlight during the period in my opinion kept the majority of fruit from abscising.

Experiment 1. In 1995, twenty field-grown 4-year-old-'Elstar'/M.27 apple trees were dug from the field and placed in 19 Liter plastic buckets 2 days prior to moving trees into growth chambers. Trees were blocked into two groups by crop load and two trees each were assigned to the following treatments: 1) Control—trees were undisturbed and remained in the field, 2) Control—trees were undisturbed but shaded for 3 days with 92% polypropylene shade material; 3), 4), & 5) were moved into growth chambers and held in the dark for 2, 3, or 4 days respectively beginning 8 am 23 May at a constant temperature of 40F°; 6), 7) ,8) trees were moved into growth chambers and held in the dark for 2, 3, or 4 days respectively beginning 8 am 23 May at a constant temperature of 70F°. Trees were removed 8 am 25 May, 26 May and 27 May respectively, and were transplanted in the field and watered. Fruit numbers/tree were counted before placement into the growth rooms, May 22, and again after fruit abscission on 26 Jun.

Experiment 2. In 1996, forty field grown 5-year-old-'Braeburn'/M.27 apple trees were dug from the field and placed in root bags in the dormant season for acclimation purposes to reduce transplant shock. Two days prior to moving trees into growth chambers trees were dug and placed in 19 Liter plastic buckets. Trees were blocked into four groups by crop load and four trees each were assigned to the following treatments: 1) Control—trees were undisturbed and remained in the field, 2) Control—trees were undisturbed but sprayed with Carbaryl + Accel, 3) trees were dug placed in buckets and remained outside; 4) trees were dug placed in buckets and remained outside but sprayed with Carbaryl + Accel; 5-8) trees were moved into growth chambers and held in the dark for 2 days beginning 8 am 17 May at a constant temperatures of 40F°, 50F°, 60F°, or 70F°; 9-12) trees were moved into growth chambers and held in the dark for 3 days beginning 8 am 17 May at a constant temperatures of 40F°, 50F°, 60F°, or 70F°; 13-16) trees sprayed at 1 pm 17 May with Carbaryl + Accel and then were moved into growth chambers at 4:00 pm and held in the dark for 2 days beginning 8 am 17 May at a constant temperatures of 40F°, 50F°, 60F°, or 70F°. 17-20) trees sprayed at 1 pm 17 May with Carbaryl + Accel and then were moved into growth chambers at 4:00 pm and held in the dark for 3 days beginning 8 am 17 May at a constant temperatures of 40F°, 50F°, 60F°, or 70F°. Trees were removed 8 am 21 May and were transplanted in the field and watered. Fruit numbers/tree were counted before placement into the growth rooms, May 17, and again after fruit abscission on 11 Jun.

Experiment 3. In 1997, seventy-two field grown 6-year-old-'Stayman'/M.27 apple trees were dug from the field and placed in root bags in the dormant season of 1996 for acclimation purposes to reduce transplant shock. Two days prior to moving trees into growth chambers trees were dug and placed in 19 Liter plastic buckets. Trees were blocked into four groups by crop load and four trees each were assigned to the following treatments: 1)

Control—trees were undisturbed and remained in the field, 2) trees were dug placed in buckets and remained outside; 2-6) trees were moved into growth chambers and held in the dark for 63 hours at a constant temperatures of 40F°, 50F°, 60F°, or 70F°; 7-10) trees sprayed at 1 pm 27 May with Carbaryl and then were moved into growth chambers at 4:00 pm 27 May and held in the dark for 63 hours at a constant temperatures of 40F°, 50F°, 60F°, or 70F°; 11-14) trees sprayed at 1 pm 27 May with NAA+Regulaid and then were moved into growth chambers at 4:00 pm 27 May and held in the dark for 63 hours at a constant temperatures of 40F°, 50F°, 60F°, or 70F°; 15-18) trees sprayed at 1 pm 27 May with Ethrel and then were moved into growth chambers at 4:00 pm 27 May and held in the dark for 63 hours at a constant temperatures of 40F°, 50F°, 60F°, or 70F°. Trees were removed 8 am 30 May and were transplanted in the field and watered. Fruit numbers/tree were counted before placement into the growth rooms, May 27, and again after fruit abscission on 17 Jun.

Experiment 4. In 1996, 36 Empire/Mark apple trees were blocked into four groups by crop load and four trees each were assigned to the following treatments: 1) Control—unsprayed, or 2-9) sprayed with Carbaryl every 2 hours beginning at 6 AM until 8 PM, respectively (Table 4). Temperatures varied from 64F° to 96F°.

Experiment 5. In 1997, 72 Fuji/M. 27 apple trees were blocked into six groups by crop load and six trees each were assigned to 12 treatments: 1) Control -- no treatment, 2) Shade 92%, 3) Ferbam + Regulaid, 4) Carbon Black, 5) Shade 92% + Carbaryl+Regulaid, 6) Ferbam + Carbaryl+Regulaid, 7) Carbon Black + Carbaryl+Regulaid, 8) Carbaryl+Regulaid, 9) Shade 92%+Sorbitol (injected), 10) Shade 92%+Sorbitol+Regulaid (sprayed), 11)Shade 92%+GA4+7+Sorbitol+Regulaid, 12)Shade 92%+Accel+Sorbitol+Regulaid.

Results and Conclusions

Experiment 1. In 1995, we found that Elstar/M.27 apple trees placed in the dark for 3 or 4 days and returned to natural sunlight conditions abscised all of their fruit at 70°F dark temperature but were retained if the dark period was 40°F.

Experiment 2. In 1996, we found that Braeburn/M.27 apple trees placed in the dark for 2 days and returned to natural sunlight conditions abscised all of their fruit at 60°F and 70°F dark temperature, but were retained if the dark temperature was 40°F. These data indicated that the lower dark period temperatures were very important for fruit retention (fruit set). In addition, Carbaryl+Accel caused the development of more pigmy fruit at all temperatures. It also appeared to be related to the combined effects of trees dug and treated with (Carbaryl + Accel trt#4 vs trt#2 and trt#3).

We suspect that higher temperatures caused either higher respiration rates or higher natural ethylene production promoted fruit abscission whether treated with a thinner or not.

Experiment 3. In 1997, we found that Stayman/M.27 apple trees placed in the dark for 2 days and returned to natural sunlight conditions abscised most of their fruit at 70°F dark temperature, but were retained if the dark period was 40°F. Fruit thinning occurred at 50°F and 60°F. Additional fruit thinning was significantly promoted by Carbaryl or NAA + Regulaid over the range of temperatures (40°F to 70°F) but appeared to be most promoted at 70°F dark temperature. Ethrel caused fruit thinning at all temperatures from 40°F to 70°F but unexpectedly did not appear to be affected by temperature (probably because Ethrel defruited all trees at all temperatures). This data suggests that Ethrel might be rather effective as a thinner during cool temperatures, but the literature suggests a strong increasing temperature effect on thinning with Ethrel.

Experiment 4. Carbaryl sprays applied at 2 hour intervals beginning at 6 AM until 8 PM to Empire/Mark trees caused similar thinning when applied at temperatures ranging from 64F° to 96F°. These data suggest that no differences were related to daytime temperature. Note however the night time temperatures for the day of spraying and the nights before and after were not different between treatments.

Experiment 5. Since temperatures were rather cool during the period, Fuji trees were shaded (92% shading) for a 5 day period (instead of an anticipated 3 days that might have been sufficient if temperatures had been higher). Shade (92%) caused about half of the fruit to abscise (Table 5). Ferbam, Carbon Black, with or without Carbaryl, did not cause thinning (trts 3,4,5,6). Carbaryl did not increase the thinning caused by shade (trts 2 vs 8). The addition of Sorbitol (injected) maintained fruit on shaded trees better than no sorbitol (trt 2 vs 9). Sorbitol sprayed on shaded trees (trt 2 vs 10) may have maintained some fruit on the trees. Sorbitol sprayed or injected into trees shaded maintained seeds in 33 mm fruit sizes better than no sorbitol (trt 2 vs 9 or 10). GA or Accel maintained fruit on the trees (trt 2 vs 11 or 2 vs 12) but did not maintain seed in (33 mm fruit sized fruit). Also pigmy fruit were found only on Accel treated trees. The additional pigmy fruit may account for the increased fruit set from the control (trt 1 vs 12).

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Table 1. Effect of shade and night temperature on 'Elstar/M27' fruit set (1995).

No.	Color	Treatment[zy] Night temp (F)	Hours dark (25 days after full bloom)	In darkness	Out of darkness	Tree removed from the soil	Number of fruit/tree (22 May)	Number of fruit/tree (26 June)	Fruit drop(%)
1	W	Control	0			in soil	85	35.5 a	61 d
2	B	Control	(shaded 3 days)			in soil	99	21.0 ab	72 d
3	PBKS	40	48	8 am 23May	8 am 25 May	dug	56	17 ab	66 cd
4	OBKS	40	72	8 am 23May	8 am 26 May	dug	58	10 ab	87 abc
5	Y	40	96	8 am 23May	8 am 27 May	dug	69	8.5 ab	93 ab
6	FO	70	48	8 am 23May	8 am 25 May	dug	86	8 ab	93 ab
7	P	70	72	8 am 23May	8 am 26 May	dug	103	0.0 b	100 a
8	G	70	96	8 am 23May	8 am 27 May	dug	79	0.0 b	100 a
Contrast: 3,4,5 Vs 6,7,8			Comparison: Night temp (40F Vs 70F)					0.0159**	0.0336*

[z]Full bloom occurred 22 April 1995. Two whole tree reps / treatment
[y]Mean separation within columns by Duncan's multiple range test, 5% level.

Byers # 5

Table 2. Effect of dark temperature on 'Braeburn/M27' fruit set (1996).

No.	Color	Treatment[zY] Night temp °(F)	Hours dark (21 days after full bloom)	Chemical /100 gal (Carbaryl 1 pt Accel 2 pt)	In darkness	Out of darkness	Tree removed from the soil	Fruit/cm2 cross sectional area (17 May)	Fruit/cm2 cross sectional area (11 June)	Fruit set (%)	Full size fruit (%)	Pigmy fruit (%)	Number of fruit / tree
1.	W/W	Control	0				in soil in bag	12.0 a[x]	1.3 efgh	10 cdef	10.0 ab	0.0 d	8.7 def
2.	W/R	Control	0	Carbaryl + Accel			in soil in bag	13.4 a	2.0 cdefg	15 cde	14.7 a	0.0 d	9.3 def
3.	W/B	Control	0				dug (outside)	12.5 a	0.8 gh	7 defg	6.6 abc	0.0 d	5.3 def
4.	W/G	Control	0	Carbaryl + Accel			dug (outside)	11.9 a	3.3 abcd	26 abc	3.8 bc	21.9 bc	20.0 bc
5.	R	40	48 (=2 days dark)		4 pm 17May	8 am 20 May	dug	10.5 a	0.8 gh	9 defg	7.9 abc	1.0 d	5.0 def
6.	B	50	48 (=2 days dark)		4 pm 17May	8 am 20 May	dug	9.2 a	0.3 gh	5 fghi	4.2 bc	0.4 d	1.8 f
7.	G	60	48 (=2 days dark)		4 pm 17May	8 am 20 May	dug	10.0 a	0.0 h	0 i	0.0 b	0.0 d	0.0 f
8.	Y	70	48 (=2 days dark)		4 pm 17May	8 am 20 May	dug	11.3 a	0.0 h	0 i	0.0 b	0.0 d	0.0 f
9.	HP	40	72 (=3 days dark)		4 pm 17May	8 am 21 May	dug	8.8 a	3.0 abcde	35 ab	9.7 abc	25.3 abc	15.0 cd
10.	FO	50	72 (=3 days dark)		4 pm 17May	8 am 21 May	dug	10.0 a	0.4 gh	5 efghi	3.9 bc	0.1 d	2.8 ef
11.	BK	60	72 (=3 days dark)		4 pm 17May	8 am 21 May	dug	10.2 a	0.1 h	0 hi	1.0 bc	0.0 d	0.3 f
12.	RS	70	72 (=3 days dark)		4 pm 17May	8 am 21 May	dug	9.6 a	0.1 h	2 ghi	1.0 bc	1.0 d	1.0 f
13.	BS	40	48 (=2 days dark)	Carbaryl + Accel	4 pm 17May	8 am 20 May	dug	9.6 a	3.7 abc	39 a	6.7 abc	32.1 ab	31. 0a
14.	OS	50	48 (=2 days dark)	Carbaryl + Accel	4 pm 17May	8 am 20 May	dug	12.2 a	2.7 abcdef	23 abcd	7.7 abc	15.4 bcd	15.8 cd
15.	YS	60	48 (=2 days dark)	Carbaryl + Accel	4 pm 17May	8 am 20 May	dug	10.2 a	2.1 bcdefg	18 bcde	4.2 bc	13.6 cd	13.0 cde
16.	RD	70	48 (=2 days dark)	Carbaryl + Accel	4 pm 17May	8 am 20 May	dug	10.3 a	1.0 fgh	11 cdef	2.2 bc	8.5 cd	5.8 def
17.	BD	40	72 (=3 days dark)	Carbaryl + Accel	4 pm 17May	8 am 21 May	dug	10.1 a	3.8 ab	44 a	1.2 bc	42.4 a	29.8 a
18.	OD	50	72 (=3 days dark)	Carbaryl + Accel	4 pm 17May	8 am 21 May	dug	9.9 a	3.9 a	42 a	1.7 bc	40.6 a	26.8 ab
19.	BKS	60	72 (=3 days dark)	Carbaryl + Accel	4 pm 17May	8 am 21 May	dug	10.7 a	1.8 defgh	16 bcde	4.4 bc	11.7 cd	10.3 cdef
20.	LG	70	72 (=3 days dark)	Carbaryl + Accel	4 pm 17May	8 am 21 May	dug	10.9 a	0.7 gh	7 efgh	3.7 bc	3.0 d	4.0 ef

Contrast:	Comparison:	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F
5,6,7,8 Vs 9,10,11,12	2 days Vs 3 days (no thinners)	ns	ns	ns	ns	ns	ns
13,14,15,16 Vs 17,18,19,20	2 days Vs 3 days (thinners)	ns	ns	ns	ns	ns	ns
5,6,7,8 Vs 13,14,15,16	no thinners Vs thinners (2 day)	ns	***	***	ns	***	***
9,10,11,12 Vs 17,18,19,20	no thinners Vs thinners (3 day)	ns	***	***	ns	***	***
5,9 Vs 6,10	40°F Vs 50°F	ns	**	**	ns	*	*
6,10 Vs 7,11	50°F Vs 60°F	ns	ns	ns	ns	ns	ns
7,11 Vs 8,12	60°F Vs 70°F	ns	ns	ns	ns	ns	ns
6,10 Vs 8,12	50°F Vs 70°F	ns	ns	ns	ns	ns	ns
1,3 Vs 2,4	thinner outside Vs none	ns	*	*	ns	ns	*
1,2 Vs 3,4	dug Vs not dug (outside)	ns	ns	ns	*	ns	ns

Byers # 6

Table 2 (continued).

Regression: 2 days (40°F, 50°F, 60°F, 70°F)	trt 5,6,7,8	Pr≥F	Pr≥F	Pr≥F	Pr≥F	Pr≥F	Pr≥F
	L	ns	**	*	*	ns	ns
	Q	ns	**	*	*	ns	ns
	L+Q	ns	ns	ns	ns	ns	ns
Regression: 3 days (40°F, 50°F, 60°F, 70°F)	trt 9,10,11,12						
	L	ns	**	**	*	*	*
	Q	ns	**	**	ns	*	*
	L+Q	ns	*	*	ns	*	ns
Regression: 2 days Carbaryl + Accell (40°F, 50°F, 60°F, 70°F)	trt 13,14,15,16						
	L	ns	*	*	ns	ns	ns
	Q	ns	*	*	ns	ns	ns
	L+Q	ns	ns	ns	ns	ns	ns
Regression: 3 days Carbaryl + Accell (40°F, 50°F, 60°F, 70°F)	trt 17,18,19,20						
	L	ns	***	**	ns	***	**
	Q	ns	***	***	ns	***	**
	L+Q	ns	ns	ns	ns	***	ns

[z]Full bloom occurred 26 April 1996. Four whole tree reps/treatment. Temperatures--May 20 (Hi - 96°F, Lo - 68°F).
[y]Spray treatments were : Carbaryl 4.4 ml/3.5 liter + Accel 8.8 ml/3.5 liter
[x]Mean separation within columns by Duncan's new multiple range test;($P \leq 0.05$).

Table 3A. Effect of dark temperature on 'Stayman/M27' fruit set (1997).

No.	Color	Treatment[zy] Night temp (°F)	Hours dark starting 32 days AFB	Chemical spray (3.5 L)	In darkness	Out of darkness	Tree removed from the soil	Fruit/cm² cross sectional area trunk (27 May)	Fruit/cm² cross sectional area trunk (17 June)	Fruit set (%) (17 June)	Number of fruit/tree (27 May)	Number of fruit/tree (17 June)
1.	W	Control	0				in soil in bag	9.8 a[y]	6.3 a	68 a	83 a	55 a
2.	PBKS	Control	0				dug (outside)	8.4 a	5.3 a	65 a	40 a	26 bc
3.	HP	40°F	63	None	5 pm 27 May	8 am 30 May	dug	8.0 a	3.9 b	49 ab	61 a	29 b
4.	FO	50°F	63	None	5 pm 27 May	8 am 30 May	dug	9.0 a	2.9 bc	41 bc	59 a	21 bcd
5.	BBKS	60°F	63	None	5 pm 27 May	8 am 30 May	dug	11.7 a	0.8 efg	8 ef	93 a	8 efghi
6.	LG	70°F	63	None	5 pm 27 May	8 am 30 May	dug	9.3 a	1.5 def	27 cde	52 a	8 efghi
7.	OD	40°F	63	Carbaryl	5 pm 27 May	8 am 30 May	dug	9.1 a	3.4 bc	38 bc	61 a	22 bcd
8.	R	50°F	63	Carbaryl	5 pm 27 May	8 am 30 May	dug	10.2 a	2.3 cd	27 cde	54 a	13 defg
9.	B	60°F	63	Carbaryl	5 pm 27 May	8 am 30 May	dug	10.1 a	2.0 cde	30 bcd	54 a	13 defg
10.	BS	70°F	63	Carbaryl	5 pm 27 May	8 am 30 May	dug	10.3 a	0.04 g	0.1 f	57 a	0.3 l
11.	YS	40°F	63	NAA + Regulaid	5 pm 27 May	8 am 30 May	dug	8.7 a	2.6 bcd	32 bcd	63 a	19 bcde
12.	OS	50°F	63	NAA + Regulaid	5 pm 27 May	8 am 30 May	dug	8.2 a	2.3 cd	26 cde	57 a	15 cdef
13.	BK	60°F	63	NAA + Regulaid	5 pm 27 May	8 am 30 May	dug	11.9 a	2.6 bcd	25 cde	57 a	12.5 defgh
14.	RS	70°F	63	NAA + Regulaid	5 pm 27 May	8 am 30 May	dug	9.0 a	0.8 efg	12 def	68 a	6 fghi
15.	RD	40°F	63	Ethrel	5 pm 27 May	8 am 30 May	dug	11.2 a	0.3 fg	3 f	79 a	2 ghi
16.	BD	50°F	63	Ethrel	5 pm 27 May	8 am 30 May	dug	9.6 a	0.1 fg	0 f	61 a	0.5 i
17.	RBKS	60°F	63	Ethrel	5 pm 27 May	8 am 30 May	dug	10.8 a	0.0 g	0 f	70 a	0.0 i
18.	OBKS	70°F	63	Ethrel	5 pm 27 May	8 am 30 May	dug	11.1 a	0.2 fg	1 f	68 a	1 hi

Byers #8

<u>Temperature regressions:</u>

			Pr>F	Pr>F	Pr>F	Pr>F	Pr>F
Regression:(40°F,50°F,60°F,70°F)	trt 3,4,5,6	No thinner					
	L		ns	*	ns	ns	***
	Q		ns	*	ns	ns	**
	L+Q		ns	*	ns	ns	**
Regression:(40°F,50°F,60°F,70°F)	trt 7,8,9,10	Carbaryl					
	L		ns	**	ns	ns	ns
	Q		ns	**	ns	ns	*
	L+Q		ns	*	ns	ns	ns
Regression:(40°F,50°F,60°F,70°F)	trt 11,12,13	NAA					
	L		ns	*	*	ns	**
	Q		ns	*	*	ns	**
	L+Q		ns	*	*	ns	*
Regression:(40°F,50°F,60°F,70°F)	trt 15,16,17,18	Ethrel					
	L		ns	ns	ns	ns	ns
	Q		ns	ns	ns	ns	ns
	L+Q		ns	ns	ns	ns	ns

Table 3A (continued).

3 vs 7	40°F (No thinner vs Carbaryl)	ns	ns	ns	ns	ns
3 vs 11	40°F (No thinner vs NAA + Regulaid)	ns	ns	ns	ns	ns
3 vs 15	40°F (No thinner vs Ethrel)	***	***	***	*	***
7 vs 11	40°F (Carbaryl vs NAA + Regulaid)	ns	ns	ns	ns	ns
7 vs 15	40°F (Carbaryl vs Ethrel)	*	***	***	ns	***
11 vs 15	40°F (NAA + Regulaid vs Carbaryl)	**	**	***	ns	**
4 vs 8	50°F (No thinner vs Carbaryl)	ns	ns	ns	ns	ns
4 vs 12	50°F (No thinner vs NAA + Regulaid)	ns	ns	ns	ns	ns
4 vs 16	50°F (No thinner vs Ethrel)	ns	***	***	ns	***
8 vs 12	50°F (Carbaryl vs NAA + Regulaid)	ns	ns	ns	ns	ns
8 vs 16	50°F (Carbaryl vs Ethrel)	ns	***	**	ns	*
12 vs 16	50°F (NAA + Regulaid vs Ethrel)	ns	***	**	ns	**
5 vs 9	60°F (No thinner vs Carbaryl)	*	ns	**	*	ns
5 vs 13	60°F (No thinner vs NAA + Regulaid)	ns	*	ns	ns	ns
5 vs 17	60°F (No thinner vs Ethrel)	ns	ns	ns	ns	ns
9 vs 13	60°F (Carbaryl vs NAA + Regulaid)	**	ns	ns	ns	ns
9 vs 17	60°F (Carbaryl vs Ethrel)	ns	***	***	ns	**
13 vs 17	60°F (NAA + Regulaid vs Ethrel)	*	***	ns	ns	*
6 vs 10	70°F (No thinner vs Carbaryl)	ns	*	**	ns	ns
6 vs 14	70°F (No thinner vs NAA + Regulaid)	ns	ns	ns	ns	ns
6 vs 18	70°F (No thinner vs vs Ethrel)	ns	*	**	ns	ns
10 vs 14	70°F (Carbaryl vs Ethrel)	ns	ns	ns	ns	ns
10 vs 18	70°F (Carbaryl vs Ethrel)	ns	ns	ns	ns	ns
14 vs 18	70°F (NAA + Regulaid vs Ethrel)	ns	ns	ns	ns	ns
3,4,5,6 vs 7,8,9,10	No thinner vs Carbaryl (all temperatures)	ns	ns	ns	ns	ns
3,4,5,6 vs 11,12,13	No thinner vs NAA (all temperatures)	ns	ns	ns	ns	ns
3,4,5,6 vs 15,16,17,18	No thinner vs Ethrel (all temperatures)	ns	***	***	ns	***
7,8,9,10 vs 11,12,13	Carbaryl vs NAA (all temperatures)	ns	ns	ns	ns	ns
7,8,9,10 vs 15,16,17,18	Carbaryl vs Ethrel (all temperatures)	ns	***	***	ns	***
11,12,13 vs 15,16,17,18	NAA vs Ethrel (all temperatures)	ns	***	***	ns	***

[z]Full bloom occurred 25 April 1997. Four whole tree reps / treatment. Chemical rates were: Carbaryl 1 pt/100 gal (4.4ml/3.5L); NAA200 10 ppm (0.676 ml/3.5L) + Regulaid 1pt/100gal (4.4ml/3.5L); Ethrel 1.5pt/100gal (6.45 ml/3.5L).
[y]Mean separation within columns by Duncan's new multiple range test, $P \leq 0.05$.

Byers # 9

Table 3B. Effect of dark temperature on 'Stayman/M27' fruit set (1997).

No.	Color	Treatment[zy] Night temp (°F)	Hours dark starting 32 days AFB	Chemical spray (3.5 L)	In darkness	Out of darkness	Tree removed from the soil	Fruit diameter (cm) Oct 3	Length diameter ratio Oct 3	Viable seeds Oct 3	Aborted seeds Oct 3
1.	W	Control	0				in soil in bag	6.71 a[y]	0.827 ab	4.33 a	0.40 c
2.	PBKS	Control	0				dug (outside)	6.09 ab	0.804 b	4.03 ab	0.33 c
3.	HP	40°F	63	None	5 pm 27 May	8 am 30 May	dug	5.95 ab	0.806 b	3.87 ab	1.07 abc
4.	FO	50°F	63	None	5 pm 27 May	8 am 30 May	dug	5.97 ab	0.795 b	4.28 a	0.68 abc
5.	BBKS	60°F	63	None	5 pm 27 May	8 am 30 May	dug	4.22 ab	0.862 ab	2.54 abc	1.09 abc
6.	LG	70°F	63	None	5 pm 27 May	8 am 30 May	dug	3.25 b	0.900 ab	2.02 bc	0.65 bc
7.	OD	40°F	63	Carbaryl	5 pm 27 May	8 am 30 May	dug	6.25 ab	0.810 ab	4.35 a	0.63 bc
8.	R	50°F	63	Carbaryl	5 pm 27 May	8 am 30 May	dug	6.47 ab	0.810 ab	4.02 ab	1.17 abc
9.	B	60°F	63	Carbaryl	5 pm 27 May	8 am 30 May	dug	6.74 a	0.808 ab	4.08 ab	1.37 abc
10.	BS	70°F	63	Carbaryl	5 pm 27 May	8 am 30 May	dug	--	--	--	--
11.	YS	40°F	63	NAA + Regulaid	5 pm 27 May	8 am 30 May	dug	5.63 ab	0.799 b	3.60 abc	1.60 ab
12.	OS	50°F	63	NAA + Regulaid	5 pm 27 May	8 am 30 May	dug	6.20 ab	0.804 b	3.67 abc	1.29 abc
13.	BK	60°F	63	NAA + Regulaid	5 pm 27 May	8 am 30 May	dug	5.62 ab	0.796 b	2.81 abc	1.79 a
14.	RS	70°F	63	NAA + Regulaid	5 pm 27 May	8 am 30 May	dug	3.16 b	0.910 a	1.59 c	0.76 abc
15.	RD	40°F	63	Ethrel	5 pm 27 May	8 am 30 May	dug	--	--	--	--
16.	BD	50°F	63	Ethrel	5 pm 27 May	8 am 30 May	dug	--	--	--	--
17.	RBKS	60°F	63	Ethrel	5 pm 27 May	8 am 30 May	dug	--	--	--	--
18.	OBKS	70°F	63	Ethrel	5 pm 27 May	8 am 30 May	dug	--	--	--	--

Temperature regressions:

			Pr>F	Pr>F	Pr>F	Pr>F
Regression:(40°F,50°F,60°F,70°F)	trt 3,4,5,6	No thinner				
	L		ns	ns	ns	ns
	Q		ns	ns	ns	ns
	L+Q		ns	ns	ns	ns
Regression:(40°F,50°F,60°F,70°F)	trt 7,8,9,10	Carbaryl				
	L		ns	ns	ns	ns
	Q		ns	ns	ns	ns
	L+Q		ns	ns	ns	ns
Regression:(40°F,50°F,60°F,70°F)	trt 11,12,13	NAA				
	L		ns	*	*	ns
	Q		ns	*	*	ns
	L+Q		ns	*	ns	ns

Byers # 10

Table 3B (continued).

Contrasts		Pr>F	Pr>F	Pr>F	Pr>F
3 vs 7	40°F (No thinner vs Carbaryl)	ns	ns	ns	ns
3 vs 11	40°F (No thinner vs NAA + Regulaid)	ns	ns	ns	ns
7 vs 11	40°F (Carbaryl vs NAA + Regulaid)	ns	ns	ns	ns
4 vs 8	50°F (No thinner vs Carbaryl)	ns	ns	ns	ns
4 vs 12	50°F (No thinner vs NAA + Regulaid)	ns	ns	ns	ns
8 vs 12	50°F (Carbaryl vs NAA + Regulaid)	ns	ns	ns	ns
5 vs 9	60°F (No thinner vs Carbaryl)	ns	ns	ns	ns
5 vs 13	60°F (No thinner vs NAA + Regulaid)	ns	ns	ns	ns
9 vs 13	60°F (Carbaryl vs NAA + Regulaid)	*	*	**	ns
6 vs 14	70°F (No thinner vs NAA + Regulaid)	ns	ns	ns	ns
3,4,5,6 vs 11,12,13	No thinner vs NAA (all temperatures)	ns	ns	ns	ns

[z]Full bloom occurred 25 April 1997. Four whole tree reps / treatment. Chemical rates were: Carbaryl 1 pt/100 gal (4.4ml/3.5L); NAA200 10 ppm (0.676 ml/3.5L) + Regulaid 1pt/100gal (4.4ml/3.5L); Ethrel 1.5pt/100gal (6.45 ml/3.5L).

[y]Mean separation within columns by Duncan's new multiple range test, $P \leq 0.05$.

Byers # 11

Table 4. Effect of application time on fruit thinning of Empire/Mark by Sevin XLR (1996).

No.	Color	Application time[z]	Fruit/cm^2 cross sectional area trunk (18 June)	Temperature (°F) 20 May	Relative humidity (%)
1	W	No treatment	10.6 a[y]	--	--
2	Y	6:00 AM	8.5 ab	64	82
3	BK	8:00 AM	8.7 ab	81	60
4	DG	10:00 AM	8.1 ab	85	59
5	LG	12:00 AM	6.0 b	90	49
6	P	2:00 PM	7.8 ab	96	40
7	FO	4:00 PM	6.4 b	96	38
8	R	6:00 PM	7.4 b	95	42
9	B	8:00 PM	7.9 ab	86	64
Regression of temperature on FCSA:				$P<0.05$	
		L		ns	
		Q		ns	
		L + Q		ns	

[z]Applications were made on May 20, 1996 when fruit diameter was 14.9 mm.
[y]Mean separation within columns by Duncan's new multiple range test, $P\leq0.05$.

Table 5. Effect of low light, growth regulators, and sorbitol on fruit set of 'Fuji'/M.27 (1997).

No.	Color	Treatment[zy]	Application type	Rate/ 3.5 liter	Date applied: May 20 Temp 72°/53°	May 21 Temp 62°/35°	May 22 Temp 66°/43°	May 23 Temp 74°/40°	May 24 Temp 82°/44°	Fruit/cm2 cross sectional area June 16	Number of fruit / tree June 16	Pigmy fruit (%) (22mm or less) June 30	Viable seeds/fruit (33 mm to 34 mm) June 30	Viable seeds/fruit (40 mm to 42 mm) July 3
1	W	Control								15.2 bc[x]	178 abc	0 b	7.7 a	8.0 ab
2	R	Shade (92%)			x	x	x	x	x	7.2 d	106 cd	1 b	5.2 d	8.2 a
3	B	Ferbam		200g/3.5 L	x					16.1 bc	186 ab	0 b	7.7 a	8.3 a
		+ Regulaid	Sprayed	4.4 ml	x									
4	FO	Carbon Black		200g/3.5 L	x					14.9 bc	143 bcd	0 b	7.4 a	8.2 a
		+ Regulaid	Sprayed	4.4 ml	x									
5	Y	Ferbam		200g/3.5 L	x					13.3 bc	190 ab	0 b	7.1 abc	8.2 a
		+ Sevin XLR		4.4 ml	x									
		+ Regulaid	Sprayed	4.4 ml	x									
6	BKS	Carbon Black		200g/3.5 L	x					17.4 ab	207 ab	0 b	7.3 ab	8.1 a
		+ Sevin XLR		4.4 ml	x									
		+ Regulaid	Sprayed	4.4 ml	x									
7	RS	Shade (92%)			x	x	x	x	x	6.6 d	94 d	1 b	6.1 c	7.4 abc
		+ Sevin XLR		4.4 ml	x									
		+ Regulaid	Sprayed	4.4 ml	x									
8	RD	Sevin XLR		4.4 ml	x					13.5 bc	187 ab	0 b	7.4 ab	8.0 ab
		+ Regulaid	Sprayed	4.4 ml	x									
9	BS	Shade (92%)			x	x	x	x	x	12.3 bc	172 abc	0 b	7.7 a	8.6 a
		+ Sorbitol (5%)	Injected	175 g	x	x	x	x	x					
10	OD	Shade (92%)			x	x	x	x	x	10.9 cd	131 bcd	0 b	6.4 bc	8.4 a
		+ Sorbitol (10%)		350 g	x	x	x	x	x					
		+ Regulaid	Sprayed	4.4 ml	x	x	x	x	x					
11	BK	Shade (92%)			x	x	x	x	x	14.2 bc	220 a	0 b	0.4 e	7.0 bc
		+GA4+7		35 ml	x									
		Provide	Sprayed	4.4 ml	x									
		+ Regulaid												
12	DG	Shade (92%)			x	x	x	x	x	21.3 a	196 ab	8 a	0.9 e	6.6 c
		+ Accel		35 ml	x									
		+ Regulaid	Sprayed	4.4 ml	x									

Byers # 13

Table 5 (continued).

Contrasts:	Comparisons:	Pr>F	Pr>F	Pr>F	Pr>F	Pr>F
2 Vs 7	Shade Vs Shade + Sevin + Regulaid	ns	ns	ns	ns	ns
2 Vs 9	Shade Vs Shade + Sorbitol (Injected)	*	*	ns	***	ns
2 Vs 10	Shade Vs Shade + Sorbitol (Sprayed)	ns	ns	ns	*	ns
2 Vs 11	Shade Vs Shade + GA4 + 7 Provide + Regulaid	**	***	ns	***	*
2 Vs 12	Shade Vs Shade + Accel + Regulaid	***	**	***	***	***
3 Vs 4	Ferbam + Regulaid Vs Carbon Black + Regulaid	ns	ns	ns	ns	ns
3 Vs 5	Ferbam + Regulaid Vs Ferbam + Sevin + Regulaid	ns	ns	ns	ns	ns
3 Vs 8	Ferbam + Regulaid Vs Sevin + Regulaid	ns	ns	ns	ns	ns
4 Vs 6	Carbon Black + Regulaid Vs Carbon Black + Sevin + Regulaid	ns	ns	ns	ns	ns
5 Vs 6	Ferbam + Sevin + Regulaid Vs Carbon Black + Sevin + Regulaid	ns	ns	ns	ns	ns
5 Vs 7	Ferbam + Sevin + Regulaid Vs Shade + Sevin + Regulaid	**	**	ns	ns	ns
6 Vs 7	Ferbam + Sevin + Regulaid Vs Shade + Sevin + Regulaid	***	***	ns	*	ns
9 Vs 10	Shade + Sorbitol (Injected) Vs Shade + Sorbitol (Sprayed)	ns	ns	ns	**	ns
9 Vs 11	Shade + Sorbitol (Injected) Vs Shade + GA4 + 7 Provide + Regulaid	ns	ns	ns	***	**
9 Vs 12	Shade + Sorbitol (Injected) Vs Shade + Accel + Regulaid	***	ns	***	***	***
10 Vs 11	Shade + Sorbitol (Sprayed) Vs Shade + Accel + Regulaid	ns	**	ns	***	**
10 Vs 12	Shade + Sorbitol (Sprayed) Vs Shade + Accel + Regulaid	***	*	***	***	***
11 Vs 12	Shade + Accel + Regulaid Vs Shade + Accel + Regulaid	**	ns	***	ns	ns
2 Vs 7,9,10,11,12	Shade Vs Shade + Chemicals	**	*	ns	*	ns
1,3,4,5,6,8 Vs 2,7,9,10,11,12	No shade Vs Shade	**	*	***	***	*

[z]Full bloom occurred 25 April 1997. Fruit diameter at time of application was 13.9 mm.
[Y]Spray treatments were applied with a low pressure hand-wand sprayer on 19 May.
[x]Mean separation within columns by Duncan's new multiple range test;($P \leq 0.05$).

Byers # 14

Pre and Postharvest application of ABG-3168 affects Peach Maturity and Storage

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Objectives

Determine the effectiveness of ABG-3168 on maturity, storage and fruit quality of three cultivars of peach. Additionally, comparisons were made of conventional refrigerated storage vs. controlled atmosphere (low oxygen, high co2) on fruit quality over time.

Materials and Methods

In 1997, seven trees of each of 3 cultivars of peaches were selected from Rutgers Fruit Research Center at Cream Ridge, New Jersey. The cultivars of peach selected were 10 year old 'Red Haven', 'Biscoe' and 'Encore' which are commercially important in the region.

Preharvest

Spray treatments were 1) Control, (No AVG application) or 2) 130ppm ABG-3168 at 7 days before anticipated harvest. Postharvest treatments included 4 concentrations of ABG (0, 50, 500,2000ppm) applied to fruit in a 60 sec dip.

Postharvest

Immediately following harvest fruit not previously treated with ABG were divided into 195 samples of 10 fruit. Samples were distributed among samples by size and maturity. Maturity was determined by the amount of green in the ground color. Three samples were immediately evaluated for diameter, weight, ethylene evolution, fruit flesh firmness, soluble sugars and extractable juice. The remaining 192 samples were divided into 4 groups of 48 samples each group was submerged for 60 seconds in a postharvest fungicide, 3-(3,5-dichlorophenyl)-5-ethenyl-5-methyl-2,4-oxazolidinedione at a rate of 2 pounds per 100 gallons, and [S]-trans-2-Amino-4-(2-aminoethoxy)-3-butenoic acid hydrochloride known as ABG-3168 (Abbott Laboratories, North Chicago, IL 60064) at 0, 50, 500 or 2000ppm. Each dip also included the surfactant ABG –7011 at 0.05%. One half of the samples were placed in refrigerated storage, the other half was placed in controlled atmosphere storage containers.

Results

Flesh firmness measurements need to be converted to Newtons, but the relationship of pounds to Newtons is linear. Flesh firmness was increased in Red Haven and Encore with treatment with increased ABG concentration. Flesh firmness increased, but not significantly in Biscoe with increased ABG concentration. Soluble solids were increased with ABG indicating either more mature, or smaller fruit, even though other maturity parameters indicate untreated fruit were more advanced in ripening.

Note this data is currently under analysis and even data entry. Values for ethylene evolution are not calculated in the correct units, however, relative comparisons and standard deviations are useful and correct. Ethylene evolution from the fruit was significantly reduced by ABG treatment in all cases. Color measurements of the ground color using Hunter L*a*b measurements did not provide consistent nor significant separation of treatments.

For the 3 cultivars, ABG tests resulted in what look like linear increases in fruit flesh firmness with concentration. Variability of stone fruit samples makes interpretation of these results difficult without proper analysis. Levels of variability indicate that perhaps larger sample sizes will be needed (SAS will determine optimum sample size which is dependent on variation component. Results of the CA storage component of this work is not yet analyzed.

Discussion –

I estimate there was a 3 to 5 day delay in fruit maturity from the single130ppm ABG application one week before anticipated harvest. This can have significant implications for stone fruit production. Applications to major cultivars have the effect of lengthening the harvest season. Traditionally, breeders have labored to create new cultivars to spread out and fill in the harvest season. It is now possible to extend the season of particularly good or particularly late season cultivars. This has the advantage of allowing more effective use of labor by spreading out harvest over a broader window. Additionally, growers will be better able to extend the peach season into periods where fruit is in short supply and thereby of higher value.

Although ethylene production was completely suppressed throughout the 8 week storage of fruit, fruit quality due to flesh browning and water loss diminished the marketability of this fruit completely by the 4th week after harvest. Extending the storage of peaches with postharvest dip treatment of ABG did not improve fruit quality enough to justify the cost of application or labeling. I do consider preharvest application of ABG for delay of maturity and extending the harvest season is a significant and important crop management tool. For that purpose alone, ABG should be pursued for further field trials on stone fruit.

Additional Information

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Table 1 Effect of 130ppm application of ABG-3168, applied 7 days before anticipated harvest, on fruit maturity indicators at harvest for Red Haven, Biscoe, and Encore peach.

	Fruit Maturity Parameters at Harvest							
	Flesh Firmness[z]		Soluble Solids		Ethylene Evolution[x]		Ground Color[y]	
Red Haven								
Control	9.37	±4.9	10.70	±0.5	0.098	±0.024	8.75	±3.36
Treated	14.88	±5.6	11.47	±0.9	0.082	±0.046	7.16	±3.80
Biscoe								
Control	5.82	±3.6	11.23	±0.06	0.037	±0.007	5.79	±3.41
Treated	7.80	±4.2	13.00	±0.5	0.018	±0.008	7.54	±3.80
Encore								
Control	7.16	±3.2	12.83	±0.2	0.034	±0.015	1.53	±3.51
Treated	11.03	±3.4	13.30	±0.5	0.010	±0.004	1.35	±2.99

Z Measured in pounds using a 0.7cm tip.(convert to Newtons)

X Measured as (ethylene /g/min)*5000 (formula needs checking but relativity is correct)

Y Hunter Color measurement *a , coordinate of the green to red shift.

Table 2 Effect of ABG-3168 concentration on fruit quality indicators during storage of Red Haven peach. Means represent an average of 30 fruit with standard deviations.

	Duration after Harvest									
	At Harvest		14 days		28 days		42 days		56 days	
Flesh Firmness										
Control	9.37	±4.92	1.34	±0.34	1.31	±1.01	1.55	±1.01	-	
50ppm			2.58	±1.91	1.96	±1.77	1.44	±1.27	-	
500ppm			3.27	±2.45	2.21	±1.68	1.27	±0.99	-	
2000ppm			4.09	±3.77	2.48	±2.32	1.96	±1.51	-	
Preharvest	14.88	±5.55	2.06	±0.65	3.15	±3.02	2.86	±2.23	-	
Mealiness										
Control	60.44	±10.92	41.6	±16.8	43.9	±17.1	30.8	±13.7	-	
50ppm			27.0	±13.7	36.8	±13.9	29.4	±13.4	-	
500ppm			37.7	±17.2	34.9	±9.4	30.8	±9.7	-	
2000ppm			35.5	±15.0	29.5	±10.6	33.1	±15.8	-	
Preharvest	68.14	±8.48	30.7	±10.7	39.1	±16.4	30.4	±13.7	-	
Soluble Sugars										
Control	10.70	±0.46	11.90	±0.50	11.17	±1.07	10.70	±0.26	-	
50ppm			11.87	±0.91	11.63	±0.57	11.23	±0.65	-	
500ppm			10.83	±2.41	13.03	±2.12	11.83	±0.85	-	
2000ppm			12.10	±1.65	12.60	±0.44	10.70	±0.52	-	
Preharvest	11.47	±0.91	13.43	±0.90	11.43	±0.25	12.17	±0.93	-	
Ethylene evolution										
Control	0.098	±0.024	0.379	±0.084	-		0.776	±0.157	-	
50ppm			0.031	±0.011	-		0.094	±0.016	-	
500ppm			0.002	±0.002	-		0.012	±0.001	-	
2000ppm			0.000	±0.000	-		0.001	±0.002	-	
Preharvest	0.082	±0.046	0.300	±0.099	-		0.415	±0.134	-	

Table 3 Effect of ABG-3168 concentration on fruit quality indicators during storage of Biscoe peach. Means represent an average of 30 fruit with standard deviations.

	Duration after Harvest									
	At Harvest		14 days		28 days		42 days		56 days	
Flesh Firmness										
Control	5.82	±3.57	1.18	±0.45	1.30	±0.94	2.02	±1.87	1.18	±1.04
50ppm			2.10	±1.18	1.91	±1.88	1.69	±1.89	1.68	±2.05
500ppm			2.48	±1.73	2.74	±2.24	2.50	±2.23	1.37	±1.49
2000ppm			2.67	±2.43	2.66	±2.22	2.34	±1.26	2.53	±2.03
Preharvest	7.80	±4.16	2.18	±1.89	4.38	±3.38	4.38	±3.46	4.08	±2.85
Mealiness										
Control	56.07	±14.32	55.21	±13.52	27.48	±11.78	27.56	±12.34	22.33	±11.04
50ppm			41.16	±14.50	26.66	±11.86	25.89	±12.13	15.77	±2.87
500ppm			37.34	±9.82	29.50	±17.22	23.23	±10.77	21.94	±12.64
2000ppm			37.46	±13.40	29.58	±14.41	25.26	±11.45	26.83	±12.94
Preharvest	63.98	±9.69	35.73	±14.76	34.13	±19.64	29.79	±13.34	30.21	±13.62
Soluble Sugars										
Control	11.23	±0.06	11.43	±0.42	12.63	±0.12	11.40	±0.30	12.37	±0.51
50ppm			11.77	±0.60	11.93	±0.32	11.73	±0.46	13.40	±0.61
500ppm			11.47	±0.38	11.50	±0.35	12.00	±0.44	12.83	±1.51
2000ppm			11.73	±1.21	10.97	±0.49	12.37	±0.12	12.73	±0.68
Preharvest	13.00	±0.46	12.60	±0.17	12.27	±0.55	12.90	±0.78	13.07	±0.15
Ethylene evolution										
Control	0.037	±0.007	0.142	±0.087	0.130	±0.075	0.121	±0.118	0.147	±0.024
50ppm			0.010	±0.006	0.011	±0.001	0.034	±0.010	0.011	±0.009
500ppm			0.000	±0.000	0.000	±0.000	0.003	±0.001	0.004	±0.002
2000ppm			0.000	±0.000	0.000	±0.000	0.000	±0.000	0.003	±0.006
Preharvest	0.018	±0.008	0.054	±0.040	0.070	±0.038	0.051	±0.007	0.012	±0.006

Table 4 Effect of ABG-3168 concentration on fruit quality indicators during storage of Encore peach. Means represent an average of 30 fruit with standard deviations.

	Duration after Harvest								
	At Harvest		14 days		28 days		42 days		56 days
Flesh Firmness									
Control	7.16	±3.23	1.69	±1.09	3.56	±2.09	4.28	±2.17	-
50ppm			4.72	±3.62	5.83	±2.19	6.35	±2.84	-
500ppm			5.55	±3.36	6.63	±2.87	5.82	±3.73	-
2000ppm			6.28	±2.81	5.72	±2.93	5.93	±2.42	-
Preharvest	11.03	±3.42	6.20	±5.22	6.19	±2.57	5.81	±3.49	-
Mealiness									
Control	50.52	±12.79	25.59	±12.89	27.60	± 9.02	23.59	±14.99	-
50ppm			34.99	±24.87	42.02	±12.46	30.86	±17.10	-
500ppm			37.23	±14.24	44.23	± 8.42	34.42	±14.00	-
2000ppm			38.23	±17.54	44.06	±14.92	33.86	±18.32	-
Preharvest	66.36	±6.57	30.46	±12.95	35.38	±13.55	18.14	±15.35	-
Soluble Sugars									
Control	12.83	±0.23	12.07	±0.25	11.70	±0.26	11.93	±0.49	-
50ppm			12.47	±0.45	11.43	±0.55	12.03	±0.23	-
500ppm			12.13	±0.21	12.00	±0.17	12.43	±0.15	-
2000ppm			12.10	±0.36	12.33	±1.21	12.23	±0.31	-
Preharvest	13.30	±0.52	13.77	±0.15	13.50	±0.53	13.47	±0.47	-
Ethylene evolution									
Control	0.034	±0.015	0.121	±0.036	0.227	±0.057	0.058	±0.048	-
50ppm			0.018	±0.002	0.057	±0.008	0.026	±0.013	-
500ppm			0.004	±0.004	0.014	±0.006	0.004	±0.001	-
2000ppm			0.000	±0.000	0.003	±0.001	0.002	±0.002	-
Preharvest	0.010	±0.004	0.040	±0.010	0.052	±0.015	0.027	±0.009	-

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Peach (Prunus persica 'Redhaven')
Brown rot; Monilinia fructicola

EFFICACY OF FUNGICIDE PROGRAMS AGAINST PEACH BROWN ROT, 1997: This experiment was conducted on 4th leaf trees (planted in 1994) spaced 5.4 metres between rows and 4.5 metres between trees within the row. The orchard is located in Vineland fine sandy loam at Jordan Station, Ontario, Canada. Eight treatments were applied to plots arranged in a randomized complete block design with 4 replications. Each Vangard treated plot consisted of 6 trees to ensure enough fruit for both efficacy evaluation and residue analysis, while the plots of the other treatments consisted of 4 trees. As there were no guard trees between plots, a large plastic screen was held between trees to minimize unwanted spray drift between plots. Five applications were made as dilute sprays with a hydraulic sprayer using a hand-held gun operated with a line pressure of 1380 KPa, delivering up to 8 litres per tree (3000 litres per ha) (3-4 litres per tree during the bloom period and 6-8 litres during the pre-harvest period). Spray concentrations were based on 3000 litres per ha. Application dates were: 7 May (5% bloom), 14 May (full bloom), 20 May (100% petal fall), 8-9 August and 19-20 August. On 8 August, the Vangard, Rovral, Indar and Topas treatments were applied; IPM and TM402 treatments were applied on 9 August. On 19 August, Vangard, Rovral, TM402 were applied; while IPM, Topas and Indar were applied 20 August. All treatments had at least 5 hours of drying before any rainfall events. Rainy and windy conditions delayed the final pre-harvest application. The last two applications were stretched over two days because of windy conditions.

Sampling of fruit (24 fruit per plot for Vangard and the Rovral standard and 12 fruit per plot for the other treatments) for residue analysis was done sequentially on 20, 21, 22, 23, 24, 25 August to correspond with 1,3 and 5 days PHI. Additional checks for residue analysis (for Indar, Topas, TM402) was taken from another Redhaven block that had been treated with fungicide only during bloom (Captan @ 5 May; Rovral @ 12 May and 20 May). Air temperature during spray applications was 5-26°C. The orchard was disced prebloom and was sown with annual orchard ryegrass in mid-July. A low incidence of blossom blight was detected in the unsprayed check during shuck, but no inoculum was introduced artificially. Despite applications of Lorsban 50 W @ 3.4 kg/ha on 11 June and Decis 5 EC @ 200 ml/ha on July 11, July 25 and Aug. 12, a moderate infestation of oriental fruit moth (OFM) (Cydia molesta) was detected around the borders of the orchard. Only OFM infested fruit were removed from the trees prior to the application of pre-harvest sprays to limit secondary brown rot development as a result of infection by OFM-infested fruit. On 20 August, the incidence of brown rot infected fruit in the unsprayed check was less than 4% .but, the incidence in the treated plots was not assessed. Rainy conditions delayed the picking of ripe fruit until 25 August. For each plot, 60 firm ripe fruit were picked and immediately taken to the laboratory, and a sub-sample of 40 premium unblemished fruits were arranged in two paper-lined plastic trays with the fruits supported on inverted 38 mm diameter jar lids. Postharvest incubation was at 24.0°C and greater than 95% relative humidity. The incidence of brown rot was evaluated on 2,4 and 5 days after picking and fruits with M. fructicola sporodochia were counted and discarded. The percentage data were transformed (arcsin √%) prior to ANOVA. Student-Newman-Keuls means separation test ($P \leq 0.05$) was applied to the transformed means. On day 4 and day 5 the treatment effects were compared with the unsprayed check excluded from the analysis.

At harvest on 25 August, the incidence of brown rot had increased in the check plots from that on the 20 August, but no field assessments were made because some fruit had already been harvested from the treated plots as samples for residue analysis. On day 2, all fungicide treatments were significantly different from the unsprayed check, but there was no difference between the fungicide treatments. However on day 4 Indar was significantly better than Vanguard, IPM, Rovral and the low rate of TM402, but was similar to Topas and the high rate TM402. On day 5 Indar was significantly better than all of the other fungicides and the IPM program. None of the treatments caused any phytotoxicity to blossoms, foliage or fruit.

Overall, the incidence of brown rot was 95.6% in the unsprayed check and 51.3% in the Rovral standard indicating good brown rot pressure in 1997 (Table 1). During the bloom to shuck fall period, May 07-30, there were 16 rain events, totaling 46.6 mm. During the pre-harvest period, Aug. 08 - Aug. 25 there were 10 rain events totaling 55.6 mm. Meteorological data are attached as Tables 2 and 3.

Table 1: Post-harvest development of brown rot on Redhaven peaches treated with full season* fungicide programs.

Material	Product Rate/ha	Percent fruit infected after storage at 24°C 2 days	4 days	5 days
Indar 75WSP	0.14 kg	0 a***	0.6 a	3.1a
TM402 50WG	3.40 kg	0 a	5.0 ab	18.1b
Topas 250E	0.50 L	0.6 a	6.9 ab	18.3b
Vangard75WG	0.74 kg	1.3 a	15.0 b	40.3b
IPM (see footnote)**		0.6 a	10.6 b	41.9b
TM402 50 WG	1.70 kg	0 a	16.3 b	43.1b
Rovral 50WP	1.50 kg	0.6 a	16.3 b	51.3b
Unsprayed Check	-	52.5 b	88.1 c	95.6c

*Spray Dates:
1. 7 May
2. 14 May
3. 20 May
4. 8-9 August
5. 19-29 August

** IPM program treatments: 1. Indar; 2. Vangard; 3. Bravo (500F 9L/ha); 4. Vangard; 5. Rovral

***Means in the same column followed by the same letter are not significantly different ($p \leq 0.05$) using Student-Newman-Keuls means separation test. Percentage data were transformed (arcsin √ percent) prior to ANOVA. On day 4 and day 5 the treatment effects were compared with the unsprayed check excluded from each analysis.

Table 3: Automated Weather Readings at Vineland Station

Date	Temperature (°C)			Rainfall
	Max	Min	Ave	(mm)
August 7	28.3	13.7	21.0	0.0
August 8	28.7	15.9	22.2	0.0
August 9	30.9	14.4	22.1	0.0
August 10	29.6	17.5	24.5	0.0
August 11	22.8	15.9	19.7	2.4
August 12	23.9	15.3	19.7	0.8
August 13	24.4	16.8	21.1	6.0
August 14	24.5	11.4	18.1	0.0
August 15	26.6	14.2	20.9	11.6
August 16	30.2	22.0	25.2	0.0
August 17	24.2	17.0	19.4	1.4
August 18	22.7	13.9	18.6	0.0
August 19	22.5	11.7	17.7	0.0
August 20	20.6	15.1	17.1	14.2
August 21	21.9	14.6	17.2	12.0
August 22	19.4	13.5	16.1	5.4
August 23	22.2	12.8	17.2	0.2
August 24	22.1	11.3	16.5	1.6
August 25	21.2	14.2	17.6	0.0
August 26	21.1	14.3	17.9	0.0
August 27	27.0	16.9	21.3	1.4
August 28	24.5	16.0	19.6	0.2
August 29	23.9	17.4	19.7	0.0
August 30	22.0	14.0	18.7	0.0
August 31	20.9	16.9	19.1	1.0
September 1	23.0	17.1	20.3	0.0
September 2	26.5	15.8	19.9	0.0
September 3	18.4	13.9	15.6	0.0
September 4	21.5	11.4	16.8	0.0
September 5	25.3	9.9	17.6	0.0
September 6	25.9	14.7	21.0	9.6
September 7	19.1	15.9	17.9	2.0
September 8	18.8	11.5	15.9	0.0

Table 2: Automated Weather Readings at Vineland Station

Date	Temperature (°C)			Rainfall
	Max	Min	Ave.	(mm)
May 1	20.5	4.2	10.2	0.2
May 2	13.3	2.4	8.3	7.0
May 3	14.7	5.6	7.5	6.2
May 4	14.3	4.0	8.2	
May 5	17.9	3.4	11.5	8.2
May 6	12.6	2.7	8.3	
May 7	13.1	1.7	7.1	
May 8	13.5	3.2	10.5	4.4
May 9	13.0	8.0	10.5	0.6
May 10	11.4	6.7	9.0	0.1
May 11	17.8	4.9	11.4	3.2
May 12	15.7	6.0	10.8	3.1
May 13	16.9	6.2	12.4	0.8
May 14	10.0	4.8	7.2	4.4
May 15	13.1	4.6	8.8	4.2
May 16	12.0	5.2	8.3	2.2
May 17	12.6	5.0	7.4	
May 18	10.7	1.4	6.9	1.6
May 19	12.2	5.1	7.5	0.4
May 20	13.5	5.7	9.2	0.1
May 21	13.2	4.9	8.8	
May 22	14.8	4.6	9.4	
May 23	18.5	4.7	11.8	
May 24	18.1	7.8	13.8	0.8
May 25	13.0	7.4	10.1	0.2
May 26	16.7	5.3	10.0	
May 27	14.4	4.3	9.6	
May 28	15.5	3.7	10.5	
May 29	18.6	8.0	13.8	1.2
May 30	20.6	13.3	16.8	
May 31	16.3	9.4	13.7	12.6

NECTARINE DISEASE CONTROL USING AZOXYSTROBIN

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Azoxystrobin represents a new class of fungicides, the strobilurins. These compounds, which are based on naturally occurring products found in mushrooms, have been found to inhibit mitochondrial respiration in many groups of fungi. Consequently, azoxystrobin has broad spectrum fungicidal activity against Ascomycetes, Basidiomycetes, Deuteromycetes, and Oomycetes. Furthermore, because its biochemical mode of action is novel, azoxystrobin exhibits no cross-resistance to currently used fungicides such as the ergosterol biosynthesis inhibitors (EBI), dicarboximides, benzimidazoles, and phenylamides.

Given the broad spectrum capability of azoxystrobin, there is much potential for this fungicide to be integrated into disease management programs. For stone fruit crops, this integration is particularly important because of the reliance on EBI fungicides and the potential for development of resistance to these materials. For example, the incorporation of azoxystrobin into either or both the bloom blossom blight and preharvest brown rot sprays should lessen selection pressure for EBI resistant *Monilinia fructicola*.

The objective of this field study was to examine the efficacy of various concentrations of azoxystrobin for control of blossom blight canker, scab, brown rot, and Rhizopus rot of nectarine. An understanding of the degree of control capability would allow proper integration of this new fungicide into the overall disease management program. Particular attention was given to scab, caused by *Cladosporium carpophilum*, since very few efficacy studies targeting this pathogen have been conducted on nectarine.

Materials and Methods

Experimental Design. The test block consisted of 15-year old Redgold nectarine trees, planted at 18 ft x 20 ft row spacing, located at the Rutgers Fruit Research and Extension Center, Cream Ridge, NJ. Fungicide treatments consisted of four concentrations of Abound SC, a standard program, and a non-treated control (Table 1). Each treatment was replicated four times in a randomized complete block design with single tree plots. A single nozzle hand-gun sprayer set at 290 psi was used to apply fungicides dilute to the point of run-off (200 gal/A equivalent).

Application Timing. A total of four blossom blight and scab treatment applications were applied on the following dates and tree growth stages: 11 Apr (Full bloom), 21 Apr (Petal fall), 08 May (Shuck split), and 20 May (First cover). Three preharvest treatment applications were made for fruit rot control: 05Aug (22-days pre-harvest), 15Aug (12-days pre-harvest), and 26Aug (1-day pre-harvest). Summer maintenance sprays applied to all fungicide treatment trees were: Captan 50W at 4 lb/A and sulfur at 8 lb/A on 05Jun (Second cover) and Captan 50W at 4 lb/A every two-weeks thereafter until the preharvest sprays. Bacterial spot and insect maintenance sprays were: Tenn-Cop 5E at 8 oz/A and Imidan 50WP at 1 lb/A (shuck split) and Mycoshield 17WP at 1.25 lb/A and Imidan 50WP at 1 lb/A (cover sprays).

TABLE 1. Fungicide treatment rates and application timings

Fungicide*	a.i. / Acre	Rate / Acre	Application Timing
Nontreated Control	———	———	———
Abound SC 2.08	0.150 lb	9.2 fl oz	B, PF, SS, 1C, PH1, PH2, PH3
Abound SC 2.08	0.175 lb	10.7 fl oz	B, PF, SS, 1C, PH1, PH2, PH3
Abound SC 2.08	0.200 lb	12.3 fl oz	B, PF, SS, 1C, PH1, PH2, PH3
Abound SC 2.08	0.250 lb	15.3 fl oz	B, PF, SS, 1C, PH1, PH2, PH3
Standard: Orbit EC Bravo WS	1.670 fl oz 3.094 lb	4.0 fl oz 4.125 pt	B, PF PH1, PH2, PH3 SS, 1C

* All Abound SC treatments applied with Latron B-1956 at 2 fl oz / 100 gal

Disease Assessment. Blossom blight canker evaluations were made on 13 Jun by assessing canker incidence on 25 shoots selected from around the periphery of each tree. For pre-harvest evaluations, the total number of fruit and total number of infected fruit were counted on four branches selected from each tree on 27 Aug. For postharvest fruit rot evaluations, 40 healthy fruit were harvested from each tree on 27 Aug and placed on benches maintained at 22-25C. At 3 and 6 days postharvest, the incidence of brown rot and Rhizopus rot was assessed as the percent of diseased fruit per tree.

Data Analysis. An analysis of variance was performed for each dependent variable (disease assessment). Fisher's least significance difference (LSD) was calculated for treatment mean comparisons at the $P <= 0.05$ level.

Results and Discussion

Blossom Blight Canker and Preharvest Brown Rot. Canker development from blossom blight and preharvest fruit brown rot levels were moderate as indicated by the 35% and 35.7% disease incidence, respectively, on the control (Fig. 1 and 2). In contrast, all the fungicide treatments for these two forms of brown rot were not significantly different from each other. Nevertheless, higher rates of Abound provided numerically better control, which was was particularly evident in the preharvest brown rot assessment results. These results indicate that azoxystrobin would be a viable candidate for integration into current fungicide programs for management of *Monilinia fructicola*.

Postharvest Disease. The postharvest disease assessments showed a slow increase in disease during the 6 days following harvest. This may be attributed to the fact that the final fungicide application occurred on the day before harvest. At 3-days postharvest, all fungicide treatments provided excellent brown rot and Rhizopus rot control and all had significantly less disease than the control (Fig. 3 and 4). Although disease levels increased several-fold by 6-days postharvest, the higher rates of Abound and the standard Orbit still provided good control relative to the nontreated fruit. These data show good residual activity of azoxystrobin for continued protection when sprays are applied close to harvest.

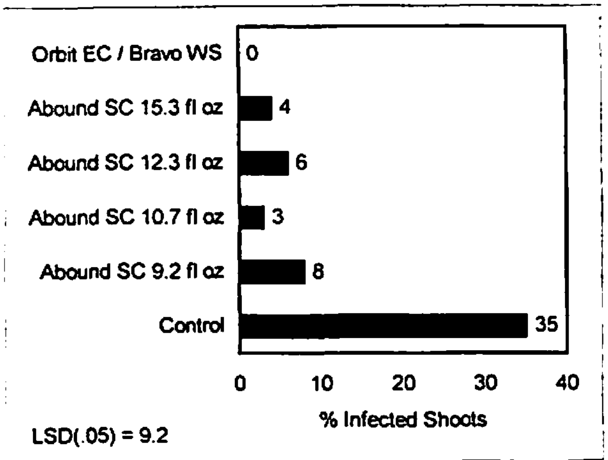

Fig. 1. Effect of azoxystrobin concentration (Abound SC) on incidence of blossom blight canker.

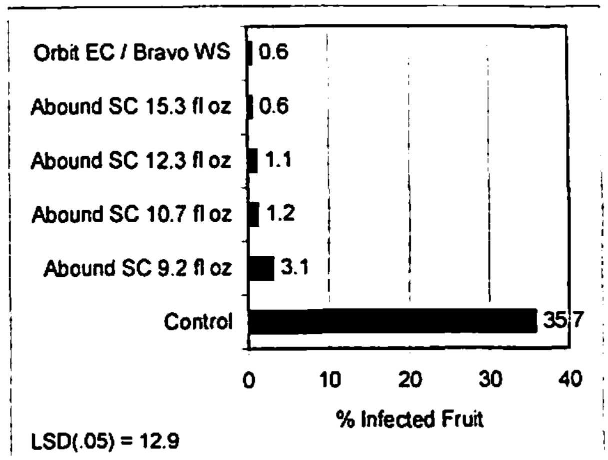

Fig. 2. Effect of azoxystrobin concentration (Abound SC) on incidence of preharvest brown rot.

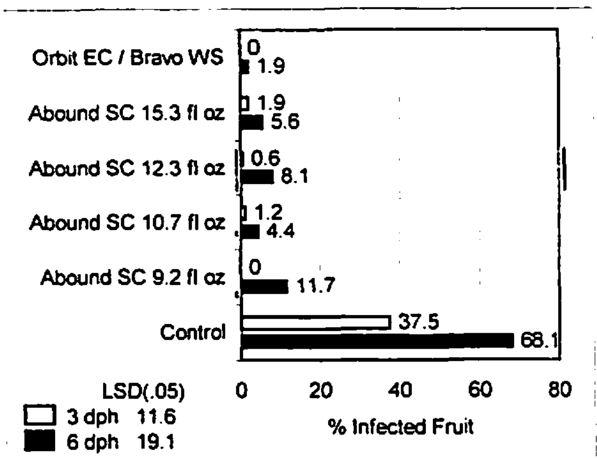

Fig. 3. Effect of azoxystrobin concentration (Abound SC) on incidence of postharvest brown rot.

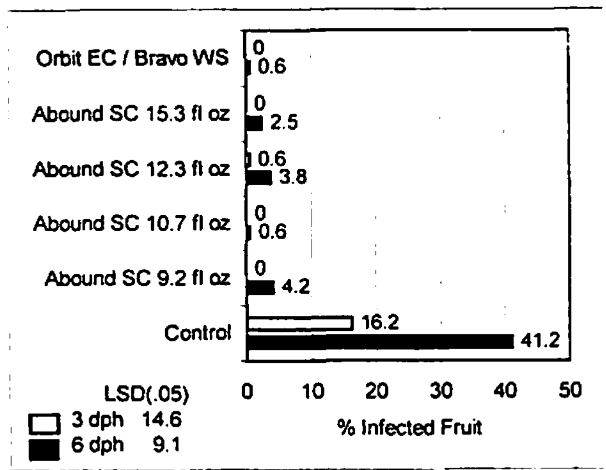

Fig. 4. Effect of azoxystrobin concentration (Abound SC) on incidence of postharvest Rhizopus rot.

Nectarine Scab. In contrast to the other diseases studied, fruit scab pressure was high and resulted in 75.9% of the fruit scabbed at harvest on the control (Table 2). Although all the Abound treatments had significantly less disease than the control, considerable scab developed (21-31%) and the rate of Abound had no effect on this level of disease. In comparison, the standard for scab control, Bravo, yielded only 3.5% fruit scabbed.

One possible explanation for the poor scab control was the occurrence of a rainfall approximately 1 hour after the shuck-split spray. Under these circumstances, it is postulated that the Abound / Latron combination provided less retentive capabilities than that exhibited by Bravo WeatherStik, even though the latter was applied last and therefore closest to the rainfall. This analysis also assumes that the Captan maintenance sprays, applied from 2C onward, had an equal effect across the Abound and standard treatments.

TABLE 2. Comparison of efficacy of azoxystrobin concentrations and standard fungicides against nectarine and peach scab in several field studies. * Zehr et al. 1995. ** Ritchie et al.

	Redgold Nectarine	Redhaven Peach*	Loring Peach**
Treatment - rate/A	SS & 1C	SF, 1C-4C	SS, 1-3 wk, 5 wk
Control	75.9 c	98.5 c	95.0 c
Azoxystrobin 0.8 oz ai		32.2 b	3.0 a
Azoxystrobin 1.2 oz ai		15.2 a	
Azoxystrobin 1.6 oz ai		18.8 a	0.0 a
Azoxystrobin 2.4 oz ai	21.5 ab	17.8 a	0.0 a
Azoxystrobin 2.8 oz ai	24.9 b		
Azoxystrobin 3.2 oz ai	31.5 b		
Azoxystrobin 4.0 oz ai	22.9 ab		
Bravo WS 4.125 pt	3.5 a		
Captan 50W 4lb SF, 1C-4C (4 trts)		13.8-26.2 a	
Bravo Ultrex 2.8 lb SS, 2 wk / Captec 4L 2 qt 8 wk (3 trts)			18.0-20.0 b

A second explanation for inadequate scab control may simply be lack of Abound activity on the causal pathogen. *Cladosporium carpophilum*. This same pathogen attacks peach. and in a recent experiment on Redhaven. Abound 80WG + Latron B-1956 was also found to exhibit poor control (Zehr et al., 1995; Table 2). However, in this same experiment, the standard Captan similarly did not provide adequate control. In contrast. Ritchie et al. (1996) recently obtained excellent disease control with Abound 80WG + Induce on Loring peach using similar spray timings. In this study, poor control for the standard Bravo Ultrex treatment was explained by an extended 6-wk interval between the second Bravo and first Captec applications.

In summary, the variable results obtained in this and previous studies indicates that additional field experimentation is needed to ascertain azoxystrobin's efficacy against *C. carpophilum*. In addition, the optimum spray timing for scab control appears to be in question. as well as the role of additives in relation to azoxystrobin's effectiveness.

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Acknowledgments

The authors wish to thank Mark Cantarella for his assistance in maintaining the test block.

APPLE (*Malus domestica* 'Golden Delicious')
Scab; *Venturia inaequalis*
Powdery mildew; *Podosphaera leucotricha*
Brooks spot; *Mycosphaerella pomi*

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POWDERY MILDEW AND SCAB CONTROL BY EXPERIMENTAL AND STANDARD FUNGICIDES ON GOLDEN DELICIOUS APPLE, 1997: Fourteen treatments involving experimental materials were compared to two registered treatments on 25-yr-old trees. The test was conducted in a randomized block design with four single-tree replicates separated by border trees in the row and by untreated border rows between treatment rows. Tree-row-volume was determined to require a 400 gal/A dilute base for adequate spray coverage. Treatments were applied to both sides of the tree on each application date with a Swanson Model DA-400 airblast sprayer at 100 gal/A as follows: App. 1: 4 Apr (TC, tight cluster - open cluster); App. 2: 15 Apr (Bl, 75% bloom); App. 3: 29 Apr (PF, petal fall); App. 4: 14 May; (1C, 1st cover); App. 5: 28 May (2C, 2nd cover); 3rd-6th covers (3C-6C): 12 Jun, 27 Jun, 10 Jul, and 30 Jul. Other applications applied to the entire test block with the same equipment included Supracide 2E, Guthion 3F, Lannate, Provado, Imidan and Penncap-M. Cedar-apple rust galls (1 May), bramble canes infected with the sooty blotch and fly speck fungi and bitter rot mummies were placed in baskets over each test tree (4 June). Foliar data represent averages of counts of all leaves on 10 terminal shoots from each of four replicate trees 26 Jun. A 25-fruit sample from each replicate tree was harvested 8 Oct and rated after three weeks' storage at ambient temperature 5-28 C.

The first fungicide application was applied eight days before the first infection period 12-13 Apr and the second application was two days later. Below average rainfall and relatively short wetting periods through late May reduced scab pressure but resulted in a build-up of powdery mildew on the moderately susceptible Golden Delicious trees. Excellent control of powdery mildew was provided by treatments involving the sterol-inhibiting compounds Nova, Maximum, and RH-7592 and by an alternated BAS 490- Nova schedule. RH-141647 and TM41201 gave good mildew control and Vangard and captan gave significant but moderate suppression. Under moderate scab test conditions, all treatments gave significant control of scab on leaves and fruit although there were some significant differences among treatments having less than two percent leaf scab incidence. Nova + Dithane, RH-7592, RH-141647, and one schedule involving BAS 490-Nova gave significantly better control of scab on foliage than the reduced rate of Vangard+Dithane, TM41201, and captan. The heaviest spring infection period occurred 1-4 June between the second and third cover applications. All treatments gave complete control of scab and Brooks spot on fruit. Sooty blotch, fly speck and rot incidence remained at less than 3% with no significance between treatments and non-treated trees. Fruit finish was likely somewhat impacted by an early spring freeze at bloom 9 Apr. However, finish was not significantly (p=0.05) affected by any treatment compared to "no fungicide" as indicated by russet ratings and combined USDA Extra Fancy and Fancy grades for russet.

Table 1. Concentrate applications of experimental fungicides on Golden Delicious apples, 1997

Treatment, rate/A and timing	Scab		Brooks	Powdery mildew	
	% leaves	% fruit	spot(%)	% leaves	% lf area
No fungicide	16.1 d	22 b	5 b	42.7 f	12.0 g
Nova 40W 4 oz + Dithane 75DF 3 lb (TC-2C) Captan 50W 3 lb + Ziram 76DF 3 lb (3C-6C)	0.0 a	0 a	0 a	1.9 ab	0.4 ab
Nova 40W 4 oz + Dithane 75DF 3 lb (TC-2C) RH-7592 75W 2 oz + Captan 50W 3 lb (3C-6C)	0.2 ab	0 a	0 a	1.0 a	0.3 a
RH-7592 75W 2 oz+Latron B-1956 4 fl oz/100 gal (TC-6C)	0.0 a	0 a	0 a	2.0 a	0.5 a
Maximum 62.25W 4 lb (TC-2C) RH-7592 75W 2 oz + Captan 50W 3 lb (3C-6C)	0.2 ab	0 a	0 a	1.4 a	0.3 a
Maximum 62.25W 8 lb (TC-BI) RH-7592 75W 2 oz + Captan 50W 3 lb (PF-6C)	0.3 abc	0 a	0 a	2.1 abc	0.6 abc
RH-141647 2.75F 17.5 fl oz (TC-6C)	0.0 a	0 a	0 a	1.2 a	0.4 a
RH-141647 2.75F 23.3 fl oz (TC-6C)	0.0 a	0 a	0 a	5.6 c	1.2 cde
Vangard 75WG 5.1 oz (TC) Vangard 75WG 3.0 oz+Dithane 75DF 3 lb(BI-2C) Captan 50W 3 lb + Ziram 76DF 3 lb (3C-6C)	0.7 bc	0 a	0 a	15.7 de	2.4 ef
Vangard 75WG 5.1 oz (TC) Vangard 75WG 5.1 oz + Dithane 75DF 3 lb(BI-2C) Captan 50W 3 lb + Ziram 76DF 3 lb (3C-6C)	0.2 ab	0 a	0 a	23.9 e	3.4 f
BAS 490 02F 50WG 3.2 oz (Apps. 1, 2 & 5) Nova 40W 5 oz (Apps. 3 & 4) Captan 50W 3 lb + Ziram 76DF 3 lb (App. 6-6C)	0.0 a	0 a	0 a	1.3 ab	0.4 abc
BAS 490 02F 50WG 3.2 oz (Apps. 1-3) Nova 40W 5 oz (Apps. 4 & 5) Captan 50W 3 lb + Ziram 76DF 3 lb (App. 6-6C)	0.2 ab	0 a	0 a	0.6 a	0.2 a
TM 41201 50W 21.4 oz (TC-6C)	1.2 bc	0 a	0 a	5.1 bc	1.1 bcd
Captan 50W 6 lb (TC-1C) Folpet 80WDG 60 oz (2C-6C)	0.7 bc	0 a	0 a	14.3 d	2.0 def
Captan 50W 6 lb (TC-6C)	1.2 c	0 a	0 a	19.2 de	3.1 f

Averages of ten shoots from each of four single-tree replications, 26 Jun or 25 fruit per rep after harvest. Mean separation by Waller-Duncan K-ratio t-test (p=0.05).

APPLE (*Malus domestica* 'Ginger Gold')

Powdery mildew; *Podosphaera leucotricha*

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EFFECT OF 2-YR TREATMENT REGIMES ON POWDERY MILDEW ON GINGER GOLD APPLE, 1997: Treatment regimes were established in 1996 as part of an intended 3-yr study of cumulative effect of powdery mildew on yield of the highly susceptible Ginger Gold apple cultivar. Test plots were established in a 4-yr-old commercial orchard in a randomized block design with five double-tree replicates separated by border trees in the treatment row and border rows between treatment rows. The registered fungicide rates per acre were adjusted to 40% tree-row-volume, and treatments were applied to both sides of the tree on each indicated application date with a Swanson Model DA-400 airblast sprayer at 100 gal/A as follows: 1996 Application 1: 22 Apr (P, pink to early bloom); App. 2: 26 Apr (Bl, bloom); App. 3: 2 May (PF, petal fall); App. 4: 10 May; App.5: 15 May (1C, 1st cover); App. 6: 30 May (2C, 2nd cover); App. 7: 13 Jun (3C, 3rd cover); App. 8: 26 Jun (4C, 4th cover). 1997: Application 1: 3 Apr (tight cluster-open cluster); App. 2: 16 Apr (Bl, bloom); App. 3: 30 Apr (PF, late bloom- petal fall); App. 4: 7 May (late petal fall); App. 5: 17 May (1C, 1st cover); App. 6: 29 May (2C, 2nd cover). Maintenance sprays applied to the entire block with the same equipment to provide broad spectrum disease and insect protection included: Syllit 65W; Ziram 76, Agri-Mycin 17, Supracide 2E, Dipel 2X, Lorsban 50W, Lannate, Guthion 50W, and Azinphos-M 50WSB. In addition, border rows were protected bi-weekly with dilute handgun treatments of Nova 40W 2 oz / 100 gal. All leaves on 10 terminal shoots were counted 12 Jun 96 and 11 Jun 97. Overwintering infection was rated 10 Jun 97 by recording primary infections observed near the periphery of tree up to 7 ft. Fruit yield was recorded at harvest 1 Aug 96 and 13 Aug 97 from each of five double-tree reps.

Although mildew inoculum was abundant in the test orchard, disease pressure in 1996 was somewhat reduced by frequent rains which occurred every day 30 Apr-11 May and 40 of 53 days 30 Apr-21 Jun. All treatments gave significant mildew suppression. Extending the early spray interval (omission of the 2nd & 4th apps.) significantly reduced control with sulfur to a level approaching the 20% action threshold level outlined in the *Mid-Atlantic Orchard Monitoring Guide.* Extending the early spray interval did not significantly reduce control by Nova followed by Bayleton. At the more extended early spray interval, Bayleton and Nova both gave significantly better control than sulfur. Bayleton also gave better control than sulfur, when compared in the 2nd-4th cover sprays, following early season Nova application at the extended interval. There was no significant difference where Nova and Bayleton were compared directly.

Overwintering of mildew inoculum for 1997 was closely related to mildew incidence in 1996. The most intense spray schedule, five applications of Nova followed by three of Bayleton, reduced the number of primary infections to 19% of those on trees not receiving a mildewcide in 1996. Drier weather during the 1997 growing season greatly increased mildew pressure in the test block as indicated by mildew incidence on the treatments in successive years. Per cent area affected was closely proportional to percent leaves with infection. Nova, five applications followed by Bayleton, was again the most effective treatment. However, the more extended schedule of three applications of Nova followed by Bayleton resulted in the highest yield. The schedule with three applications of Nova followed by sulfur was significantly less effective for mildew control, but resulted in the second highest yield in 1997. Trees receiving no mildewcide had the lowest yield although it was not significantly different than several more effective mildew treatments which yielded 138%, or more, higher than "no mildewcide".

The treatments resulted in distinct levels of mildew incidence both test years, which should provide insight into the economics of mildew management on the Ginger Gold cultivar. Disease pressure in 1997 was more what was expected of these treatments than the rain-suppressed levels in 1996. It is hoped that repeating these test regimes on the same trees a third consecutive year will again result in different levels of control and cumulative yield effects. This will allow comparison of yield-reduction effects of treatment-related mildew levels to the threshold level outlined in the *Mid-Atlantic Orchard Monitoring Guide.*

Table 2. Two-year effects of selected treatment regimes on powdery mildew and cumulative yield of Ginger Gold apple.
Virginia Ag. Council Project; 1996-1997, R&T Ginger Gold, Winchester, VA.

		Material applied (X) for indicated app. number and growth stage								1996 mildew infection		1996 Adjusted yield per tree (lb)	No. of primary infections 1996-97	Mildew inf. 1997		1997 yield per tree (lb)
	Mildewcide and rate / A	1 P	2 Bl	3 PF	4	5 1C	6 2C	7 3C	8 4C	% leaves	% leaf area			% leaves	% leaf area	
0	No mildewcide	--	--	--	--	--	--	--	--	41.5 d	11.9 d	5.9 b	32.5 c	72.4 e	40.4 d	81.8 b
1	Microfine Sulfur 4.8 lb	X		X		X				17.2 c	3.2 c	10.8 ab	17.0 abc	48.8 d	6.9 bc	121.7 ab
	Microfine Sulfur 4.0 lb						X	X	X							
2	Microfine Sulfur 4.8 lb	X	X	X	X	X				8.3 b	1.7 d	12.8 ab	19.4 bc	43.6 d	9.2 c	121.1 ab
	Microfine Sulfur 4.0 lb						X	X	X							
3	Nova 40W 1.6 oz	X	–	X	–	X				0.5 a	0.1 c	18.0 a	9.5 ab	5.7 ab	0.9 a	138.9 a
	Bayleton 50WDG 0.8 oz						X	X	X							
4	Nova 40W 1.6 oz	X	X	X	X	X				0.2 a	0.1 b	9.3 ab	6.1 a	2.5 a	0.6 a	112.9 ab
	Bayleton 50WDG 0.8 oz						X	X	X							
5	Bayleton 50WDG 0.8 oz	X	–	X	–	X				5.6 b	1.4 a	8.3 ab	15.4 abc	12.6 bc	1.9 ab	120.3 ab
	Microfine Sulfur 4.0 lb						X	X	X							
6	Nova 40W 1.6 oz	X	–	X	–	X				4.3 b	1.1 a	11.3 ab	14.0 ab	16.2 c	2.1 abc	127.6 a
	Microfine Sulfur 4.0 lb						X	X	X							

Data in columns followed by the same letter are not significantly different at the 95% confidence level.

Foliar infection based counts of all leaves on 10 terminal shoots 12 Jun 96 and 11 Jun 97. Overwintering infection rated 10 Jun 97 by recording primary infections observed near the periphery of tree up to 7 ft. Fruit yield recorded at harvest 1 Aug 96 and 13 Aug 97 from each of five double-tree reps.

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

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DISEASE CONTROL BY SI FUNGICIDES AND COMBINATIONS ON STAYMAN, IDARED AND GINGER GOLD APPLES, 1997: Ten treatments involving combinations with sterol-inhibiting fungicides designed for season-long disease management were compared on 11-yr-old trees. The test was conducted in a randomized block design with four three-cultivar replicate tree sets separated by untreated border rows. Treatment rows had been used as non-treated border rows in 1996 to stabilize mildew inoculum pressure for 1997. Tree-row-volume was determined to require a 400 gal/A dilute base for adequate coverage. Treatments were applied to both sides of the trees on each indicated application date with a Swanson Model DA-400 airblast sprayer at 100 gal/A as follows: 11 Apr (P, pink to early bloom); 29 Apr (Bl, bloom-petal fall); 1C-6C,1st-6th covers, respectively: 15 May, 28 May, 12 Jun, 27 Jun, 10 Jul, and 25 Jul. Insecticides, applied separately to the entire test block with the same equipment, included Supracide 2E, Guthion 3F, Lannate, Penncap-M, , and Provado. Bitter rot mummies and wild blackberry canes with the sooty blotch and fly speck fungi were placed over each Idared test tree 4 June. Other diseases developed from inoculum naturally present in the test area. Foliar data represent averages of counts of all leaves on 10 terminal shoots from each of four replicates 19 Jun (Idared) or 23 Jul (Stayman). Fruit samples were taken from each replicate tree 7 Aug (Ginger Gold) 6 Oct (Stayman), 27 Sep (Idared), and rated after 4-7 wks' storage at 1C. Percentage data were converted by the square root arcsin transformation for statistical analysis.

The relatively dry early season weather favored stronger test conditions for powdery mildew than for scab. All treatments gave acceptable commercial mildew control on Stayman. In combination with Dithane, Nova had significantly fewer Stayman leaves infected with mildew than did Procure 6 oz/A, and Elite. On Idared, Nova had significantly fewer leaves infected than Rubigan, Procure 6 and 8 oz/A, and Elite. Compared to non-treated trees, mildew suppression by Basic Copper "53" was stronger on Stayman than on Idared. Under relatively light pressure all treatments gave excellent control of scab on leaves and fruit compared to untreated trees. There was evidence of weakness for scab control under low levels on Idared by copper, Bayleton + Polyram + Ziram, and substitution of Thiram for Nova + Thiram during petal fall through 2nd cover. Scab and mildew control were not significantly affected where Dithane or Thiram was tank-mixed with Nova or whether Dithane or Polyram was tank-mixed with Elite. It is likely that much of the fruit scab infection occurred during a 76-hr wetting period 1-4 June. Few summer diseases were observed on treated trees with the exception of some light and variable rot incidence. Fruit finish ratings may have been partially affected by mildew infection and by a spring freeze 9 April. The strongest mildew treatment, Nova + Dithane also gave the best fruit finish on Stayman and Idared and did not signicantly affect the finish of Ginger Gold fruit. Basic Copper "53" significantly increased russet on all three cultivars. Compared to non-treated trees, russet was also significantly increased by Procure + Dithane and Bayleton + Polyram + Ziram. Rubigan + Dithane and Elite + Dithane significantly increased russetting of Idared fruit.

Table 3. Control of scab and mildew by concentrate fungicide applications on Stayman, and Idared apples, 1997

Treatment, rate/A and timing	Scab incidence (%)					Powdery mildew infection, %				
	Stayman		G. Gold	Idared		Stayman		Idared		
	leaves	fruit	fruit	leaves	fruit	% leaves	lf. area	leaves	lf. area	fruit
0 No fungicide	38.7 b	54 b	57 b	6.9 c	53 c	58.0 e	64.3 b	66.0 f	64.3 c	3 b
1 Nova 40W 4 oz + Dithane 75DF 3 lb (P-2C) Captan 50W 3 lb + Ziram 76DF 3 lb (3C-6C)	0.9 a	0 a	0 a	0.0 a	0 a	2.2 a	0.5 a	0.0 a	0.0 a	0 a
2 Nova 40W 4 oz + Thiram 75WDG 2.7 lb (P-2C) Captan 50W 3 lb + Ziram 76DF 3 lb (3C-6C)	0.3 a	0 a	0 a	0.2 ab	1 ab	4.0 ab	1.1 a	0.4 a	0.1 a	0 a
3 Nova 40W 4 oz + Thiram 75WDG 2.7 lb (thru Bl) Thiram 75WDG 5.3 lb (PF-2C) Captan 50W 3 lb + Ziram 76DF 3 lb (3C-6C)	1.4 a	0 a	0 a	0.3 ab	2 b	9.3 bcd	1.8 a	2.5 ab	0.7 ab	0 a
4 Rubigan 1E 9 fl oz + Dithane 75DF 3 lb (P-2C) Captan 50W 3 lb + Ziram 76DF 3 lb (3C-6C)	0.8 a	0 a	0 a	0.2 ab	0 a	4.9 abc	1.4 a	4.0 bc	1.0 ab	0 a
5 Procure 50WS 6 oz + Dithane 75DF 3 lb (P-2C) Captan 50W 3 lb + Ziram 76DF 3 lb (3C-6C)	1.8 a	0 a	1 a	0.0 a	0 a	11.4 d	2.3 a	10.8 cd	1.9 ab	0 a
6 Procure 50WS 8 oz + Dithane 75DF 3 lb (P-2C) Captan 50W 3 lb + Ziram 76DF 3 lb (3C-6C)	1.4 a	0 a	0 a	0.2 ab	0 a	6.0 a-d	1.6 a	5.9 bcd	1.1 ab	0 a
7 Elite 45DF 6 oz + Polyram 80DF 3 lb (P-2C) Captan 50W 3 lb + Ziram 76DF 3 lb (3C-6C)	0.4 a	0 a	0 a	0.0 a	0 a	9.8 bcd	2.0 a	11.2 cd	2.0 ab	0 a
8 Elite 45DF 6 oz + Dithane 75DF 3 lb (P-2C) Captan 50W 3 lb + Ziram 76DF 3 lb (3C-6C)	0.3 a	0 a	0 a	0.5 ab	0 a	9.4 cd	2.2 a	17.9 d	2.6 ab	0 a
9 Bayleton 50DF 2 oz + Polyram 80DF 3 lb+ Ziram 76DF 3 lb (P-2C) Captan 50W 3 lb + Ziram 76DF 3 lb (3C-6C)	1.9 a	0 a	0 a	1.4 b	0 a	6.7 bcd	1.6 a	7.5 bcd	1.6 ab	0 a
10 Basic Copper "53" 2 lb (P-PF) Basic Copper "53" 4 lb + Hydrated Lime 12 lb (1C-4C) Basic Copper "53" 4 lb + Hydrated Lime 8 lb (5C-6C)	2.4 a	0 a	1 a	0.8 b	1 ab	10.3 cd	2.4 a	29.5 e	6.2 b	0 a

Counts of ten terminal shoots from each of four single-tree replicates 19 Jun (Idared) or 23 Jul (Stayman) or harvest counts of 25 fruit / rep.
Mean separation by Waller-Duncan K-ratio t-test (p=0.05).

Table 4. Summer disease control and fruit finish effects by concentrate fungicide applications on Stayman and Idared, 1997

	Treatment, rate/A and timing	Fruit diseases, Idared (%)				Fruit finish rating (0-5)*				
		Sooty blotch	Fly speck	Brooks spot	Rots	Stayman russet	Stayman opalescence	Idared russet	Idared opalescence	G. Gold russet
0	No fungicide	6 b	5 b	2 b	3 b	0.8 ab	1.5 ab	1.0 a	0.6 c	1.6 a
1	Nova 40W 4 oz + Dithane 75DF 3 lb (P-2C) Captan 50W 3 lb + Ziram 76DF 3 lb (3C-6C)	0 a	0 a	0 a	0 a	0.4 a	1.3 a	0.9 a	0.3 ab	1.7 ab
2	Nova 40W 4 oz + Thiram 75WDG 2.7 lb (P-2C) Captan 50W 3 lb + Ziram 76DF 3 lb (3C-6C)	0 a	0 a	0 a	0 a	1.0 a-d	1.7 ab	1.1 abc	0.5 abc	1.5 a
3	Nova 40W 4 oz + Thiram 75WDG 2.7 lb (thru Bl) Thiram 75WDG 5.3 lb (PF-2C) Captan 50W 3 lb + Ziram 76DF 3 lb (3C-6C)	0 a	0 a	0 a	0 a	1.3 b-f	1.9 abc	1.5 c	0.6 c	1.5 a
4	Rubigan 1E 9 fl oz + Dithane 75DF 3 lb (P-2C) Captan 50W 3 lb + Ziram 76DF 3 lb (3C-6C)	0 a	0 a	0 a	0 a	1.2 b-f	1.7 ab	1.4 bc	0.5 abc	1.5 a
5	Procure 50WS 6 oz + Dithane 75DF 3 lb (P-2C) Captan 50W 3 lb + Ziram 76DF 3 lb (3C-6C)	0 a	0 a	0 a	3 b	1.7 ef	2.3 bc	1.0 a	0.6 bc	2.1 ab
6	Procure 50WS 8 oz + Dithane 75DF 3 lb (P-2C) Captan 50W 3 lb + Ziram 76DF 3 lb (3C-6C)	0 a	0 a	0 a	0 a	1.5 c-f	1.8 ab	1.1 ab	0.5 bc	1.5 a
7	Elite 45DF 6 oz + Polyram 80DF 3 lb (P-2C) Captan 50W 3 lb + Ziram 76DF 3 lb (3C-6C)	0 a	0 a	0 a	0 a	0.9 abc	1.5 ab	1.1 abc	0.3 a	2.0 ab
8	Elite 45DF 6 oz + Dithane 75DF 3 lb (P-2C) Captan 50W 3 lb + Ziram 76DF 3 lb (3C-6C)	0 a	0 a	0 a	0 a	1.1 a-e	1.5 ab	1.4 bc	1.0 d	1.7 ab
9	Bayleton 50DF 2 oz + Polyram 80DF 3 lb+ Ziram 76DF 3 lb (P-2C) Captan 50W 3 lb + Ziram 76DF 3 lb (3C-6C)	0 a	0 a	0 a	2 b	1.6 def	2.8 c	1.1 abc	0.5 abc	2.5 ab
10	Basic Copper "53" 2 lb (P-PF) Basic Copper "53" 4 lb + Hydrated Lime 12 lb (1C-4C) Basic Copper "53" 4 lb + Hydrated Lime 8 lb (5C-6C)	0 a	0 a	0 a	0 a	1.8 f	1.9 abc	2.3 d	1.2 d	2.7 b

Counts of 25 fruit from each of four single tree replicates harvested 6 Oct. Idared harvested 27 Sep. Both cultivars rated after 4 weeks' storage at 1C.

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

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

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

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SUPPRESSION OF POWDERY MILDEW AND OTHER DISEASES BY INTEGRATED FUNGICIDE SCHEDULES ON IDARED APPLES, 1997: Seven treatments involving combinations designed to incorporate the biofungicide AQ10 into a practical usage pattern with copper, dodine, sulfur, or Nova, and three involving a hydrophobic particle film, M-96-018 material, were compared on 16-yr-old trees in a test conducted in a randomized block design with four single-tree replicates separated by untreated border rows. The entire test block had been treated with a commercial spray program in 1996 and mildew inoculum was light to moderate. Tree-row-volume was determined to require a 400 gal/A dilute base for adequate coverage. AQ10-related treatments were applied to both sides of the trees on each indicated application date with a Swanson Model DA-400 airblast sprayer at 100 gal/A. M-96-018 was applied as dilute treatments to the point of runoff with a single-nozzle handgun at 400 psi. The treatment schedule was as follows: App. 1: 11 Apr (Bl, early bloom); App. 2: 16 Apr (FB, bloom); App. 3: 25 Apr (PF, petal fall); App. 4: 7 May (1C, 1st cover); App. 5: 20 May (2C, 2nd cover); App. 6: 28 May; App. 7: 6 Jun (3C, 3rd cover); App. 8: 12 Jun; App. 9: 20 Jun (4C, 4th cover); App. 10: 27 Jun; App. 11: 9 Jul (5C, 5th cover); App. 12: 18 Jul; App. 13: 25 Jul (6C, 6th cover); App. 14: 1 Aug; App. 15: 8 Aug (7C, 7th cover); App. 16: 15 Aug. Other materials, applied separately to the entire test block, included Agri-Mycin, Supracide 2E, Guthion 3F, Lannate, Penncap-M, and Provado. Bitter rot mummies and wild blackberry canes with the sooty blotch and fly speck fungi were placed over each Idared test tree 4 June. Other diseases developed from inoculum naturally present in the test area. Foliar data represent averages of counts of all leaves on 10 terminal shoots from each of four replicates 25 Jun. Fruit samples were taken from each replicate 29 Sep and rated after 4 wks' storage at 1 C. Percentage data were converted by the square root arcsin transformation for statistical analysis.

The relatively dry early season weather favored stronger test conditions for powdery mildew than for scab. Although there was considerable variation among treatments, all treatments except M-96-018, gave significant mildew control compared to untreated trees. Applying AQ10 on the second and third weeks of a 3-wk schedule alternated with Nova, gave mildew control comparable to Nova + Dithane on a 2-wk schedule. A well-integrated schedule for management of both scab and mildew rotated Nova + Dithane into the 3rd and 7th applications with AQ10 and AQ10 + Syllit alternated in other applications. A significantly weaker mildew treatment was one that began with a single application of copper, and was followed by alternating weekly applications of AQ10 with and without Syllit. The late-season schedules (applications 12 through 16) were designed to compare the efficacy of Basic Copper "53" and M-96-018 to captan + ziram for summer disease control. Summer disease pressure was light and treatments involving copper and captan + ziram gave good commercial control of sooty blotch, fly speck, and Brooks spot. M-96-018 gave significant suppression of fly speck, but not sooty blotch, and the higher rate on a 2-wk schedule resulted in a significant increase in Brooks spot incidence compare to non-treated trees. No treatment significantly increased russet or opalescence ratings compared to "no fungicide". However, a treatment involving sulfur alternated with AQ10 and ending with captan + ziram had significantly less russet than one which started and ended with copper, and less opalescence than the M-96-018 treatments.

Table 5. Mildew and scab suppression by integrated fungicide schedules on Idared apples, 1997

Treatment and rate per acre concentrate or per 100 gal dilute	Material(s) applied (X) for indicated application number and growth stage																Scab, %		Mildew, %		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16					
	BI	FB	PF	1C	2C		3C		4C		5C		6C		7C		leaves	fruit	leaves	lf. area	fruit
0 No fungicide	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	7.2 b	33 b	48 e	28 d	4 c
1 Nova 40W 4 oz + Dithane 75DF 3 lb/A	X	--	X	--	X	--	X	--	X	--	--		--		--		0.1 a	0 a	8 a	2 a	1 ab
Basic Copper "53" 4 lb + Lime 8 lb												X		X		X					
2 Microfine Sulfur 90W 6 lb/A	X		X		X		X		X												
AQ10 1 oz/A +ADDQ 38.4 fl oz/100 gal		X		X		X		X		X							1.1 a	3 a	8 ab	2 ab	1 ab
Captan 50W 3 lb + Ziram 76DF 3 lb											--	X	--	X	--	X					
3 Microfine Sulfur 90W 6 lb/A	X	--	X	--	X	--	X	--	X	--							0.8 a	1 a	13 ab	3 ab	0 a
Captan 50W 3 lb + Ziram 76DF 3 lb											--		--		--						
4 Nova 4 oz/A	X			X			X			X											
AQ10 1 oz/A + ADDQ 38.4 fl oz/100 gal		X	X		X	X		X	X								0.5 a	3 a	7 a	1 a	2 abc
Captan 50W 3 lb + Ziram 76DF 3 lb											--	X	--	X	--	X					
5 AQ10 1 oz/A + ADDQ 38.4 fl oz/100 gal +																					
Syllit 65W 1.5 lb/A	X		X		X		X		X								0.0 a	1 a	18 abc	3 ab	0 a
AQ10 1 oz/A + ADDQ 38.4 fl oz/100 gal		X		X		X		X		X											
Captan 50W 3 lb + Ziram 76DF 3 lb											--	X	--	X	--	X					
6 AQ10 1 oz/A + ADDQ 38.4 fl oz/100 gal +																					
Syllit 65W 1.5 lb/A	X				X				X												
AQ10 1 oz/A + ADDQ 38.4 fl oz/100 gal		X		X		X		X		X							0.0 a	0 a	9 ab	2 ab	1 ab
Nova 40W 4 oz + Dithane 75DF 3 lb/A			X				X														
Captan 50W 3 lb + Ziram 76DF 3 lb											--	X	--	X	--	X					
7 Basic Copper "53" 2 lb	X																				
AQ10 1 oz/A + ADDQ 38.4 fl oz/100 gal +																					
Syllit 65W 1.5 lb/A			X		X		X		X								0.0 a	1 a	22 bcd	4 abc	0 a
AQ10 1 oz/A + ADDQ 38.4 fl oz/100 gal		X		X		X		X		X											
Basic Copper "53" 4 lb + Lime 8 lb											--	X	--	X	--	X					
8 M-96-018 2X rate	X	--	X	--	X	--	X	--	X	--	--	X	--	X	--	X	6.0 b	25 b	31 cde	10 bc	4 bc
9 M-96-018 1X rate	X	--	X	--	X	--	X	--	X	--	--	X	--	X	--	X	5.8 b	17 b	39 de	14 cd	4 bc
10 M-96-018 1X rate	X	X	X	X	X	X	X	--	X	--	X	X	X	X	X	X	6.2 b	18 b	30 cde	7 abc	3 bc

Counts of 10 shoots from each of 4 single-tree replicates 25 Jun or 25 fruit / tree picked 29 Sep and rated after 4 wks' storage at 1 C.
Mean separation by Waller-Duncan K-ratio t-test (p=0.05).

Table 6. Summer disease suppression and fruit finish by integrated fungicide schedules on Idared apples, 1997

Treatment and rate per acre concentrate or per 100 gal dilute	Material(s) applied (X) for indicated application number and growth stage																Disease incidence (%)			Fruit finish rating (0-5)*	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Sooty	Fly	Brooks		
	BI	FB	PF	1C	2C		3C		4C		5C		6C		7C		blotch	speck	spot	russet	opalescence
0 No fungicide	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	4 b	9 c	4 b	1.1 ab	0.54 ab
1 Nova 40W 4 oz + Dithane 75DF 3 lb/A	X	--	X	--	X	--	X	--	X	--	--		--		--		0 a	0 a	0 a	1.3 ab	0.29 ab
Basic Copper "53" 4 lb + Lime 8 lb												X		X		X					
2 Microfine Sulfur 90W 6 lb/A	X		X		X		X		X												
AQ10 1 oz/A +ADDQ 38.4 fl oz/100 gal		X		X		X		X		X							0 a	0 a	0 a	0.9 a	0.23 a
Captan 50W 3 lb + Ziram 76DF 3 lb											--	X	--	X	--	X					
3 Microfine Sulfur 90W 6 lb/A	X	--	X	--	X	--	X	--	X	--							0 a	0 a	1 a	1.4 ab	0.38 ab
Captan 50W 3 lb + Ziram 76DF 3 lb											--		--		--						
4 Nova 4 oz/A	X			X			X			X											
AQ10 1 oz/A + ADDQ 38.4 fl oz/100 gal		X	X		X	X		X	X								1 ab	0 a	1 a	1.1 ab	0.40 ab
Captan 50W 3 lb + Ziram 76DF 3 lb											--	X	--	X	--	X					
5 AQ10 1 oz/A + ADDQ 38.4 fl oz/100 gal + Syllit 65W 1.5 lb/A	X		X		X		X		X								0 a	0 a	0 a	1.4 ab	0.43 ab
AQ10 1 oz/A + ADDQ 38.4 fl oz/100 gal		X		X		X		X		X											
Captan 50W 3 lb + Ziram 76DF 3 lb											--	X	--	X	--	X					
6 AQ10 1 oz/A + ADDQ 38.4 fl oz/100 gal + Syllit 65W 1.5 lb/A	X				X				X												
AQ10 1 oz/A + ADDQ 38.4 fl oz/100 gal		X		X		X		X		X							0 a	0 a	0 a	1.4 ab	0.54 ab
Nova 40W 4 oz + Dithane 75DF 3 lb/A			X				X														
Captan 50W 3 lb + Ziram 76DF 3 lb											--	X	--	X	--	X					
7 Basic Copper "53" 2 lb	X																				
AQ10 1 oz/A + ADDQ 38.4 fl oz/100 gal + Syllit 65W 1.5 lb/A			X		X		X		X								0 a	0 a	0 a	1.5 b	0.54 ab
AQ10 1 oz/A + ADDQ 38.4 fl oz/100 gal		X		X		X		X		X											
Basic Copper "53" 4 lb + Lime 8 lb											--	X	--	X	--	X					
8 M-96-018 2X rate	X	--	X	--	X	--	X	--	X	--	--	X	--	X	--	X	2 ab	2 b	8 c	1.3 ab	0.62 b
9 M-96-018 1X rate	X	--	X	--	X	--	X	--	X	--	--	X	--	X	--	X	2 ab	2 b	2 ab	1.3 ab	0.61 b
10 M-96-018 1X rate	X	X	X	X	X	X	X	--	X	--	X	X	X	X	X	X	2 ab	3 b	2 ab	1.4 ab	0.64 b

Counts of 25 fruit from each of 4 single-tree replicates picked 29 Sep and rated after 4 wks' storage at 1 C.
Mean separation by Waller-Duncan K-ratio t-test (p=0.05).

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

PEACH (*Prunus persica* 'Redhaven')
NECTARINE (*Prunus persica* 'Redgold')
Brown rot; *Monilinia fructicola*
Rhizopus rot; *Rhizopus* sp.
Scab; *Cladosporium carpophilum*

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EFFECTIVENESS OF REGISTERED AND EXPERIMENTAL FUNGICIDES FOR DISEASE CONTROL ON REDHAVEN PEACH AND REDGOLD NECTARINE, 1997: Several experimental and registered fungicides were compared for broad spectrum disease control on 5-yr-old trees. The planting is composed of 3-tree sets, each including Redhaven peach (which was not treated with fungicides in 1996 to allow the buildup of scab inoculum), Redgold nectarine in test in 1996 , and Loring peach which was not treated with fungicides in 1997. Brown rot inoculum was introduced into the orchard by placing three mummified fruit in each test tree before bloom. Dilute treatments were applied to the point of run-off (approximately 200 gal/A) with a single nozzle handgun at 300 psi in a randomized block design with four single-tree replicates as follows: Leaf curl applications treatments. #1-5 only: 13 Mar (BS, bud swell); all treatments: 28 Mar (P, pink); 3 Apr (bloom); 11 Apr (PF, petal fall); 1st-5th covers 7 May, 23 May, 6 June, 20 June and 9 July; 22 July (Redhaven 2PH, 2-wk pre-harvest; Redgold 6th C); 29 July (Redhaven only,1PH, 1-wk pre-harvest); 6 Aug (Redgold 2PH, 2-wk pre-harvest); 14 Aug (Redgold 1PH, 1-wk pre-harvest). Commercial insecticides were applied to the entire test block at 2-3 wk intervals with a commercial airblast sprayer. A sample of 40 apparently rot-free Redhaven fruit per replicate tree was harvested 5 Aug, rated for scab and split into 20-fruit subsamples. Fruit were selected for uniform ripeness and placed on fiber trays. One set was misted with de-ionized water and the other subsample was inoculated with a suspension containing 10,000 benzimidazole-sensitive *M. fructicola* conidia/ml. All were incubated in polyethylene bags at ambient temperature 19-29C (mean 24.2C) for the indicated interval before assessing rot development. Redgold fruit were harvested 26 Aug and handled as indicated for Redhaven. Ambient temperatures during Redgold incubation were 19-29C (mean 23.8C).

Weather conditions throughout the early cover spray period were favorable for scab infection. The full season Indar schedule provided the best control of scab under heavy inoculum conditions on Redhaven peach. On treatments covered with sulfur during the early cover spray period, there were significant differences based on the treatment applied at petal fall, and apparent differences based on peach compared to nectarine. On peach, the second most effective treatment was Benlate + Captan – sulfur. On nectarine Bravo - sulfur and TM 402 - sulfur also gave excellent scab control. Abound - sulfur schedules resulted in slightly more scab, but not significantly so (p=0.05) than the best treatments. Thiram – sulfur gave significantly poorer scab control than ziram – sulfur on nectarine, but equal suppression on peach. Latron B-1956 included with TM 402 significantly reduced effectiveness for scab control on nectarine. All treatments gave excellent brown rot control on the tree on both peaches and nectarines, but rot developed rapidly during incubation. Because brown rot pressure was moderate in the orchard, and inoculum stayed relatively low into the pre-harvest period, the postharvest inoculation gave opportunity to look at postharvest brown rot suppression under light and heavy inoculum conditions. Elite gave excellent brown rot control on non-inoculated and inoculated peach. Abound 2F showed a significant rate response on nectarines with the highest rate giving superior control. On non-inoculated nectarine fruit, all treatments gave good brown rot suppression after 6 days' incubation. However most treatments had become heavily infected by 9 days. Latron B-1956 did not improve brown rot control by TM 402 on peach or nectarine.

Table 7. Effects of pre-harvest treatments on postharvest brown rot development in Redhaven peach.

Treatment and rate/100 gal dilute	Timing	Scab % fruit	Scab les/ fruit	% of fruit with brown rot after indicated days incubation: non-inoculated fruit 4days	6days	7days	10days	inoculated fruit 4 days	6days	7days	10days
No fungicide	—	93 e	44 b	8 a	17 a	30 b	67 d	13 b	50 d	68 e	87 e
Ziram 76 DF 1.8 lb	BS-PF, 14 day PH	44 cd	7 a	0 a	3 a	12 ab	37 a-d	2 a	13 abc	27 abc	55 b-e
Microfine Sulfur 90W 3 lb	Covers										
Ferbam 76WDG 3.0 lb	BS	44 cd	3 a								
Indar 75W 1 oz +											
Latron B-1956 4 fl oz	P-PF, 2PH-1PH			0 a	0 a	2 a	29 a-d	2 a	12 ab	25 abc	42 a-d
Microfine Sulfur 90W 3 lb	Covers										
Thiram 75WDG 1.3 lb	BS-PF, 14&7 PHI	44 cd	5 a	0 a	0 a	8 ab	35 a-d	2 a	23 bc	40 bcd	72 de
Microfine Sulfur 90W 3 lb	Covers										
COCS 50WDG 4.0 lb	BS	13 ab	1 a								
Benlate 50W 4 oz+											
Captan 50W 1 lb	P-PF, 2PH-1PH			0 a	2 a	3 a	8 a	0 a	8 a	18 ab	47 bcd
Microfine Sulfur 90W 3 lb	Covers										
Bravo 720 20 fl oz	BS-PF	28 bcd	3 a								
Microfine Sulfur 90W 3 lb	Covers										
Rovral 4F 12 fl oz +											
Latron CS-7 1 pt	2PH-1PH			0 a	11 a	20 ab	48 bcd	4 ab	24 bc	55 de	73 de
TM 402 50WDG 12 oz	P-PF, 2PH-1PH	41 bcd	7 a	0 a	2 a	5 a	27 a-d	0 a	8 a	17 ab	50 bcd
Microfine Sulfur 90W 3 lb	Covers										
TM 402 50WDG 12 oz +	P-PF, 2PH-1PH	53 d	7 a								
Latron B-1956 4 fl oz				0 a	0 a	3 a	20 abc	0 a	13 abc	38 bcd	60 b-e
Microfine Sulfur 90W 3 lb	Covers										
Indar 75W 1 oz +	Full season	6 a	1 a								
Latron B-1956 4 fl oz	(P-1PH)			0 a	0 a	12 ab	48 bcd	0 a	0 a	12 a	33 ab
Elite 45DF 2.5 oz	P-PF, 2PH-1PH	29 bcd	3 a	0 a	0 a	3 a	3 a	0 a	2 a	3 a	13 a
Microfine Sulfur 90W 3 lb	Covers										
Vangard 75 WG 2.6 oz	P-PF	52 d	8 a								
Orbit 45W 2 oz	2PH-1PH			0 a	3 a	13 ab	55 cd	0 a	5 a	20 abc	56 b-e
Microfine Sulfur 90W 3 lb	Covers										
Abound 80WG 1.0 oz	P-PF, 2PH-1PH	36 bcd	4 a	0 a	0 a	2 a	15 abc	2 a	5 a	18 ab	38 abc
Microfine Sulfur 90W 3 lb	Covers										
Abound 80WG 1.5 oz	P-PF, 2PH-1PH	21 abc	1 a	0 a	2 a	10 ab	25 abc	0 a	7 a	25 abc	48 bcd
Microfine Sulfur 90W 3 lb	Covers										
Abound 80WG 2.0 oz	P-PF, 2PH-1PH	21 abc	2 a	0 a	3 a	8 ab	38 a-d	0 a	28 c	44 cde	68 cde
Microfine Sulfur 90W 3 lb	Covers										
Abound 80WG 2.5 oz	P-PF, 2PH-1PH	20 abc	2 a	0 a	0 a	0 a	3 a	0 a	0 a	7 a	38 abc
Microfine Sulfur 90W 3 lb	Covers										

Counts of 10-15 fruit from each of four replications 9-15 Aug. Mean separation by Waller-Duncan K-ratio t-test (p=0.05).

Table 8. Scab and postharvest brown rot development on Redgold nectarine.

Treatment and rate/100 gal dilute	Timing	Scab*		% of fruit with brown rot after indicated days of incubation**			
		% fruit	lesions / fruit	non-inoculated		inoculated fruit	
				6 days	9 days	6 days	9 days
0 No fungicide	---	50 cd	3.3 a	38 c	81 g	63 g	95 g
1 Ziram 76 DF 1.8 lb	BS-PF, 14 day PH			9 ab	52 fg	29 f	81 ef
Microfine Sulfur 90W 3 lb	Covers	11 ab	1.1 a				
2 Ferbam 76WDG 3.0 lb	BS						
Indar 75W 1 oz +							
Latron B-1956 4 fl oz	P-PF, 2PH-1PH	26 bc	1.6 a	2 ab	13 a-d	3 ab	17 a
Microfine Sulfur 90W 3 lb	Covers						
3 Thiram 75WDG 1.3 lb	BS-PF, 14 & 7 PHI			3 ab	38 def	19 def	62 de
Microfine Sulfur 90W 3 lb	Covers	60 d	13.1 b				
4 COCS 50WDG 4.0 lb	BS						
Benlate 50W 4 oz+							
Captan 50W 1 lb	P-PF, 2PH-1PH			0 a	24 a-e	5 a-d	43 cd
Microfine Sulfur 90W 3 lb	Covers	20 ab	1.6 a				
5 Bravo 720 20 fl oz	BS-PF						
Microfine Sulfur 90W 3 lb	Covers	3 a	0.03 a				
Rovral 4F 12 fl oz +							
Latron CS-7 1 pt	2PH-1PH			0 a	21 a-e	23 ef	70 ef
6 TM 402 50WDG 12 oz	P-PF, 2PH-1PH			5 ab	33 c-f	12 b-f	80 fg
Microfine Sulfur 90W 3 lb	Covers	3 a	0.1 a				
7 TM 402 50WDG 12 oz +	P-PF, 2PH-1PH						
Latron B-1956 4 fl oz				2 ab	43 ef	25 f	84 fg
Microfine Sulfur 90W 3 lb	Covers	24 bc	0.7 a				
8 Indar 75W 1 oz +	Full season						
Latron B-1956 4 fl oz	(P-1PH)	4 ab	0.2 a	8 b	33 c-f	12 b-f	59 de
9 Elite 45DF 2.5 oz	P-PF, 2PH-1PH			2 ab	32 c-f	14 c-f	62 de
Microfine Sulfur 90W 3 lb	Covers	23 ab	2.5 a				
10 Vangard 75 WG 2.6 oz	P-PF						
Orbit 45W 2 oz	2PH-1PH			0 a	31 b-f	8 a-f	47 cd
Microfine Sulfur 90W 3 lb	Covers	18 ab	1.1 a				
11 Abound 80WG 1.0 oz	P-PF						
Abound 2.08F 4.6 fl oz+	2PH-1PH			3 ab	14 abc	3 abc	40 bcd
Latron B1956 4 fl oz							
Microfine Sulfur 90W 3 lb	Covers	8 ab	0.1 a				
12 Abound 80WG 1.5 oz	P-PF,						
Abound 2.08F 5.4 fl oz+	2PH-1PH			3 ab	9 abc	9 a-e	35 bc
Latron B1956 4 fl oz							
Microfine Sulfur 90W 3 lb	Covers	8 ab	0.2 a				
13 Abound 80WG 2.0 oz	P-PF,						
Abound 2.08F 6.2 fl oz+	2PH-1PH			0 a	5 a	2 ab	21 ab
Latron B1956 4 fl oz							
Microfine Sulfur 90W 3 lb	Covers	10 ab	0.6 a				
14 Abound 80WG 2.5 oz	P-PF						
Abound 2.08F 7.7 fl oz+	2PH-1PH			0 a	7 ab	0 a	8 a
Latron B1956 4 fl oz							
Microfine Sulfur 90W 3 lb	Covers	10 ab	0.3 a				

* Scab based on harvest counts of 20-30 fruit from each of four replicate trees 26 Aug.
** Counts of 10-15 fruit per replicate unit from each of four replicate trees 1-4 Sept.
Mean separation by Waller-Duncan K-ratio t-test (p=0.05).

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

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EFFECTIVENESS OF REGISTERED FUNGICIDES FOR DISEASE CONTROL ON REDHAVEN AND LORING PEACH AND REDGOLD NECTARINE, 1997: Several registered fungicides were compared for broad spectrum disease control on 18-yr-old trees which had not been treated with a fungicide in 1996 to allow the buildup of leaf curl and scab inoculum. The planting is composed of 3-tree sets each including Loring peach, Redgold nectarine, and Redhaven peach. Brown rot inoculum was standardized by placing three mummified fruit in each test tree before bloom. Dilute treatments were applied to the point of run-off (approximately 200 gal/A) with a single nozzle handgun at 400 psi in a randomized block design with four single-tree replicates for peach and three single-tree nectarine replicates as follows: 28 Feb (dormant);.28 Mar (P, pink); 3 Apr (bloom); 11 Apr (PF, petal fall); 1st-5th covers 7 May, 23 May, 6 June, 20 June and 9 July; 22 July (Redhaven 2PH, 2 wk pre-harvest; Loring and Redgold 6th cover); 29 July (Redhaven only, 1PH, 1 wk pre-harvest); 6 Aug (Loring and Redgold 2PH, 2 wk pre-harvest); 14 Aug (Loring and Redgold 1PH, 1 wk pre-harvest). Commercial insecticides were applied to the entire test block at 2-3 wk intervals with a commercial airblast sprayer. Leaf curl infection was rated 19 May by counting the number of infections visible on two scaffold limbs of uniform size per tree. Scab incidence and severity were evaluated in harvest counts of 30-40 fruit from each of four replications 4 Aug (Redhaven), 40 fruit/tree, four replications 19 Aug (Loring); and 20 fruit/tree, three replications 21 Aug (Redgold). After harvest duplicate sets of 20 apparently rot-free fruit per replicate tree for Loring and Redhaven and 10 for Redgold were selected for uniform ripeness and placed on fiber trays. One set of fruit was misted with de-ionized water and another set was inoculated with a suspension containing 10,000 benzimidazole-sensitive *M. fructicola* conidia/ml. All fruit were incubated in polyethylene bags at ambient temperatures for the indicated interval before assessing rot development. Mean incubation temperatures, respectively, for Redhaven, Loring, and Redgold were 24.2 C, 23.3 C, and 23.5 C.

Weather conditions were most favorable for leaf curl infection 18-20 March and all treatments gave good control compared to untreated trees (Table 8). Although most scab infection was presumed to occur during the early cover spray period when most treatments were covered with sulfur, there were significant treatment differences based on the pink-petal fall sprays. The best treatment, Benlate + captan, gave only fair scab control on peach. On nectarine none of the treatment schedules adequately controlled scab. Because brown rot pressure was moderate in the orchard and inoculum stayed relatively low into the pre-harvest period, the postharvest inoculation gave opportunity to look at postharvest brown rot suppression under light and heavy inoculum conditions. Non-inoculated peach pre-harvest sprays of Indar, Benlate + captan, and Rovral provided longer residual protection than ziram which was applied only up to 2-wk PHI, or thiram. A similar trend was observed with non-inoculated peach fruit, however thiram was not significantly weaker than other treatments (p=0.05). Ziram was significantly weaker than other treatments on inoculated peach and nectarine fruit. It was probably handicapped under severe inoculum conditions created by the extended pre-harvest interval (2-wk) compared to the 1-wk pre-harvest interval for the other treatments.

Table 9. Control of leaf curl and scab by registered fungicides on Redhaven and Loring peach and Redgold nectarine.

Treatment and rate/100 gal dilute	Timing	Leaf curl infections*			Scab infection**					
					Redhaven		Loring		Redgold	
		Redhaven	Loring	Redgold	% fruit	les/fruit	% fruit	les/fruit	% fruit	les/fruit
0 No fungicide	---	10.5 a	38.0 b	22.3 b	100 e	35 e	93 c	21 b	98 c	27 d
1 Ziram 76 DF 1.8 lb	BS-PF, 14 day PH	0.5 a	0 a	0 a						
Microfine Sulfur 90W 3 lb	Covers				84 d	13 cd	24 a	2 a	95 c	13 c
2 Ferbam 76WDG 3.0 lb	BS	0 a	0.8 a	0 a						
Indar 75W 1 oz +										
Latron B-1956 4 fl oz	P-PF, 2PH-1PH									
Microfine Sulfur 90W 3 lb	Covers				51 b	5 ab	18 a	1 a	73 b	8 b
3 Thiram 75WDG 1.3 lb	BS-PF, 14 & 7 PHI	0 a	0.3 a	0.3 a						
Microfine Sulfur 90W 3 lb	Covers				78 d	18 d	53 b	8 a	100 c	29 d
4 COCS 50WDG 4.0 lb	BS	0.3 a	0 a	1.0 a						
Benlate 50W 4 oz+										
Captan 50W 1 lb	P-PF, 2PH-1PH									
Microfine Sulfur 90W 3lb	Covers				18 a	1 a	11 a	0.4 a	47 a	1 a
5 Bravo 720 20 fl oz	BS-PF	0 a	0.3 a	----						
Microfine Sulfur 90W 3lb	Covers				62 c	7 bc	20 a	2 a	----	----
Rovral 4F 12 fl oz +										
Latron CS-7 1 pt	2PH-1PH									

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

* Number of infections visible on two scaffold limbs per tree 19 May.

**Counts of 30-40 fruit from each of four replications 4 Aug (Redhaven), 40 fruit/tree, four replications 19 Aug (Loring); and 20 fruit/tree, three replications 21 Aug (Redgold).

Table 10. Effects of pre-harvest treatments on postharvest brown rot development in Redhaven peach.

Treatment and rate/100 gal dilute	Timing	% of fruit with brown rot after indicated days of incubation: non-inoculated fruit, 5 days	7 days	8 days	11 days	inoculated fruit, 5 days	7 days	8 days	11 days
0 No fungicide	---	13 a	34 b	48 c	88 c	40 b	64 b	86 b	100 c
1 Ziram 76 DF 1.8 lb	BS-PF, 14 day PH	2 a	14 ab	31 abc	78 c	39 b	65 b	83 b	98 c
Microfine Sulfur 90W 3 lb	Covers								
2 Ferbam 76WDG 3.0 lb	BS								
Indar 75W 1 oz +									
Latron B-1956 4 fl oz	P-PF, 2PH-1PH	2 a	4 ab	10 ab	51 b	10 a	13 a	40 a	56 a
Microfine Sulfur 90W 3 lb	Covers								
3 Thiram 75WDG 1.3 lb	BS-PF, 14 & 7 PHI	2 a	14 ab	40 bc	56 b	10 a	30 a	55 a	85 bc
Microfine Sulfur 90W 3 lb	Covers								
4 COCS 50WDG 4.0 lb	BS								
Benlate 50W 4 oz+									
Captan 50W 1 lb	P-PF, 2PH-1PH	0 a	0 a	5 a	27 a	2 a	10 a	28 a	68 ab
Microfine Sulfur 90W 3lb	Covers								
5 Bravo 720 20 fl oz	BS-PF								
Microfine Sulfur 90W 3lb	Covers								
Rovral 4F 12 fl oz +									
Latron CS-7 1 pt	2PH-1PH	3 a	8 ab	22 abc	50 b	12 a	18 a	32 a	58 ab

Counts of 20 fruit from each of four replications 9-15 Aug.
Mean separation by Waller-Duncan K-ratio t-test (p=0.05).

Table 11. Effects of pre-harvest treatments on postharvest brown rot development in Loring peach.

Treatment and rate/100 gal dilute	Timing	% of fruit with brown rot after indicated days of incubation: non-inoculated fruit, 4 days	6 days	8 days	10 days	inoculated fruit, 4 days	6 days	8 days	10 days
0 No fungicide	---	16 b	28 b	71 b	93 c	36 b	58 a	88 c	98 c
1 Ziram 76 DF 1.8 lb	BS-PF, 14 day PH	1 a	5 a	21 a	54 b	6 a	21 ab	49 b	79 bc
Microfine Sulfur 90W 3 lb	Covers								
2 Ferbam 76WDG 3.0 lb	BS								
Indar 75W 1 oz +									
Latron B-1956 4 fl oz	P-PF, 2PH-1PH	1 a	5 a	14 a	24 a	1 a	4 a	16 a	50 a
Microfine Sulfur 90W 3 lb	Covers								
3 Thiram 75WDG 1.3 lb	BS-PF, 14 & 7 PHI	3 a	6 a	16 a	46 b	3 a	9 ab	30 ab	69 ab
Microfine Sulfur 90W 3 lb	Covers								
4 COCS 50WDG 4.0 lb	BS								
Benlate 50W 4 oz+									
Captan 50W 1 lb	P-PF, 2PH-1PH	0 a	0 a	14 a	39 ab	5 a	19 b	39 ab	66 ab
Microfine Sulfur 90W 3lb	Covers								
5 Bravo 720 20 fl oz	BS-PF								
Microfine Sulfur 90W 3lb	Covers								
Rovral 4F 12 fl oz +									
Latron CS-7 1 pt	2PH-1PH	3 a	5 a	11 a	21 a	5 a	10 ab	23 ab	40 a

Counts of 20 fruit from each of four replications 23-29 Aug.
Mean separation by Waller-Duncan K-ratio t-test (p=0.05).

Table 12. Effects of pre-harvest treatments on brown rot development in Redgold nectarine.

			% of fruit with brown rot after indicated days of incubation					
			non-inoculated fruit			inoculated fruit		
	Treatment and rate/100 gal dilute	Timing	4 days	6 days	8 days	4 days	6 days	8 days
0	No fungicide	---	60 c	93 c	97 b	60 b	90 c	100 b
1	Ziram 76 DF 1.8 lb	BS-PF, 14 day PH	23 b	43 b	83 b	23 ab	47 b	90 b
	Microfine Sulfur 90W 3 lb	Covers						
2	Ferbam 76WDG 3.0 lb	BS						
	Indar 75W 1 oz +							
	Latron B-1956 4 fl oz	P-PF, 2PH-1PH	0 a	3 a	7 a	0 a	3 a	27 a
	Microfine Sulfur 90W 3 lb	Covers						
3	Thiram 75WDG 1.3 lb	BS-PF, 14 & 7 PHI	3 a	7 a	20 a	3 a	13 ab	37 a
	Microfine Sulfur 90W 3 lb	Covers						
4	COCS 50WDG 4.0 lb	BS						
	Benlate 50W 4 oz+							
	Captan 50W 1 lb	P-PF, 2PH-1PH	7 a	10 a	23 a	0 a	20 ab	43 a
	Microfine Sulfur 90W 3lb	Covers						

Counts of 20 fruit from each of four replications 25-29 Aug.
Mean separation by Waller-Duncan K-ratio t-test (p=0.05).

APPLE (*Malus domestica* 'Golden Delicious)

Fireblight; *Erwinia amylovora*

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SUPPRESSION OF FIREBLIGHT SHOOT BLIGHT BY BAS 125W ON APPLE, 1995-1997

Fireblight is an increasingly important disease in apple production throughout the mid-Atlantic region. Factors related to its increase in prominence include more plantings of highly susceptible scion/rootstock combinations and the use of crabapple pollinizers within high density orchards. Streptomycin resistance by the fireblight bacterium, *Erwinia amylovora*, has not yet not been proven in the mid-Atlantic region, but this concern and the increasing planting of highly susceptible scions and rootstocks heightens the need to avoid cultural practices which increase tree susceptibility. In addition to chemical control, a prudent program for overall management of fireblight should also include proper tree nutrition and practices that promote early cessation of growth (1,4).

General methods: Artificially inoculated fireblight research plots were established at Virginia Tech AREC, Winchester in 1995 and 1997 using four single-tree replications in a randomized block design. Vigorous, well-pruned Golden Delicious/M7 trees, 23 years old in 1995 and 25 in 1997, were used in these studies. BAS 125W treatments were also applied at Winchester in 1996, but trees were not artificially inoculated and natural infection did not develop. Streptomycin (Agri-Mycin 17) was included or applied separately as indicated. Regulaid was included with all BAS 125W treatments at 0.03 or 0.125% v/v as indicated. Treatments were applied dilute to runoff with a single nozzle handgun at 200 psi. Shoot tips were inoculated, as indicated, in the last leaf node with a No. 25 hypodermic syringe holding one droplet of a bacterial suspension solution containing approximately $1X10^8$ cells/ml. Inoculum was obtained by growing an *E. amylovora* culture on nutrient yeast dextrose agar one or two days at 25°C and harvesting and suspending the bacteria in a phosphate buffer.

1995 Test:. One set of trees was treated twice with BAS 125W 10DF 250 ppm + Regulaid, at early bloom 20 Apr and full bloom 25 Apr; other sets were treated once 28 Apr (petal fall) with BAS 125W 250 ppm + Regulaid, streptomycin 100 ppm, or BAS 125W 250 ppm + Regulaid + streptomycin 100 ppm. Twenty treated shoots per tree were selected and flagged on 4 May, 10 for inoculation 5 May and 10 for inoculation 12 May (1 week and 2 weeks after application to the single-application trees). Fireblight incidence and visible extent of canker progression into inoculated shoots were assessed on excised shoots, 20 Jun. Growth of shoots on non-inoculated trees was measured on 29 Jun. Non-inoculated strikes were counted and removed 20 Jun. Arcsine transformed means were analyzed with the Waller-Duncan K-ratio t-test (p=0.05).

BAS 125W treatment reduced shoot growth of non-inoculated shoots by approximately 50% (Table 13), and significantly suppressed incidence of infection of shoots inoculated two weeks after treatment (Table 2). Two applications during bloom significantly reduced canker length into first-year growth when shoots were inoculated ten days after the last treatment. When inoculated two weeks after treatment, all BAS 125W treatments significantly reduced canker length into first-year growth and significantly reduced total mean canker length. Streptomycin + Regulaid had no significant effect (p=0.05) on infection of shoots inoculated one week after application.

1997 Test. Potential synergistic effects of successive applications of BAS 125W 10DF and streptomycin were studied in 1997. BAS 125W 125 or 250 ppm was applied 21 May at 25-cm shoot growth; streptomycin 100 ppm was applied on 27 May as a 1-day pre-inoculation treatment for the first inoculation or an 8-day pre-inoculation treatment for the second inoculation. Twenty actively growing shoots per tree were selected and flagged on 19 May; ten were inoculated one week after the BAS 125W application 28 May and ten were inoculated two weeks after the BAS 125W treatment 4 June. Fireblight incidence and visible extent of canker progression were assessed on excised shoots 17 Jul. Arcsine transformed means were analyzed by Waller-Duncan K-ratio t-test (p=0.05).

Inoculations to non-treated trees 28 May resulted a higher incidence of fireblight than those on 4 June (Table 14). This was probably because of rains 1-3 June which increased shoot susceptibility by favoring renewed growth which may have been slowing due to earlier dry weather. Streptomycin alone or in combination with BAS 125W significantly suppressed fireblight incidence on inoculated shoots when applied the day before inoculation. The BAS 125W effect was greater two weeks after application than after one week. The most dramatic effect was with % shoots infected by inoculations 4 June. By two weeks after treatment the growth suppression had been initiated and the residual effect of streptomycin, now eight days after application, was reduced. However, BAS 125W followed six days later with streptomycin, appeared to give a synergistic effect: 97% control of shoot blight incidence compared to 83% control by BAS 125W and 33% control by streptomycin applied separately at the same time.. For inoculations 28 May, streptomycin gave an expected 1-day protective effect against % shoots infected and the BAS 125W had not yet really taken effect. No non-inoculated strikes were observed in the test trees.

DISCUSSION

In spite of long-term recognition that tree vigor is an important element in fireblight susceptibility (6), few reports have addressed the possibility that plant growth inhibitors could reduce susceptibility or suppress infection. Two reports discuss the potential effects of daminozide (5) and other plant growth regulators (6) on shoot growth, secondary bloom and fireblight risk in pear, but we are not aware of reports with experimental data that confirm a positive or negative effect of plant growth regulators on fireblight development.

Use of the beneficial growth suppressant effect of BAS 125W to reduce tree susceptibility would represent a logical but novel addition to the limited arsenal of fireblight management practices. Growth suppression in the post-bloom period could provide welcome relief in some high risk situations where the use of streptomycin is discouraged for shoot blight control after petal fall because of concern about development of resistance to streptomycin. The concern expressed by Deckers and Daemen (3), that some other plant growth regulators could cause an increase in fireblight risk on pear by increasing the amount of secondary bloom does not appear to be a concern with BAS 125W because it does not appear to increase bloom on apples.

Ideal rates and timing(s) for BAS 125W application for continued post-bloom fireblight suppression need to be determined. The late bloom to petal fall timing should allow opportunity for growth suppression to be initiated while streptomycin or other bactericides are residually active from bloom applications. It should be noted that the tests at Winchester were conducted on vigorously growing shoots selected before treatment to assure a strong challenge, then treated and inoculated. In practice season-long effectiveness of BAS 125W for shoot blight suppression would likely be proportional to the early setting and sustained suppression of terminal buds. Choice of one or two applications, rate, and timing may be determined as much by pomological and label considerations as by the ideal choice for effect on fireblight management but at present it appears that considerations for several uses may be quite compatible.

An abstract which included a portion of this work has been published (2).

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Table 13. Suppression of fireblight incidence and canker length by foliar applications of BAS 125W on 'Golden Delicious' apple, 1995.

Treatment and application timing*	% inoculated shoots infected 20 Jun		Mean canker length (cm), 20 Jun, all inoculated shoots				Mean canker length (cm) 20 Jun, infected inoculated shoots only				Non-inoculated strikes per tree 20 Jun	Mean shoot growth (cm) non-inoculated trees, 29 Jun
			in 1st-yr growth		total length		in 1st-yr growth		total length			
	inoc. 5 May	inoc. 12 May	inoc. 5 May	inoc. 12 May	inoc. 5 May	inoc. 12 May	inoc. 5 May	inoc. 12 May	inoc. 5 May	inoc. 2 May		
BAS 125W 250 ppm + Regulaid 0.03% v/v (20&25 Apr)	84 a	56 a	5.9 a	5.3 a	11.9 a	16.3 a	6.9 a	9.1 a	14.0 a	26.0 a	1.5 a	13.5 a
BAS 125W 250 ppm + Regulaid 0.03% v/v (28 Apr)	90 a	65 a	6.9 ab	7.5 a	15.3 a	18.7 a	7.6 ab	11.4 a	17.0 a	27.9 a	6.8 a	14.4 a
BAS 125W 250 ppm + Streptomycin 100 mg·L^{-1} + Regulaid 0.03% v/v (28 Apr)	86 a	46 a	7.0 ab	4.9 a	16.2 a	10.4 a	8.4 bc	11.1 a	19.4 a	28.4 a	3.5 a	14.1 a
Streptomycin 100 ppm + Regulaid 0.03% v/v (28 Apr)	90 a	93 b	8.0 ab	13.2 b	19.0 a	31.1 b	8.6 bc	14.2 b	21.3 a	33.7 a	11.0 a	—
No treatment	93 a	100 b	8.5 b	13.9 b	19.2 a	32.8 b	9.2 c	13.9 b	20.8 a	32.8 a	9.3 a	27.4 b

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

* Dilute treatments applied to the point of runoff with a single nozzle handgun at 200 psi as follows: two applications at early bloom 20 Apr and full bloom 25 Apr, or a single application at petal fall, 28 Apr.

NOT FOR PUBLICATION

Table 14. Effects of successive applications of BAS 125W and streptomycin on shoot blight incidence.
'Golden Delicious' apple, Winchester, VA, 1997

		% inoculated shoots infected 17 Jul		Mean total canker length (cm) 17 Jul			
				all inoculated shoots		infected shoots only	
Treatment*	Timing	inoc. 28 May	inoc. 4 Jun	inoc. 28 May	inoc. 4 Jun	inoc. 28 May	inoc. 4 Jun
BAS 125W 250 ppm + Regulaid 0.03% v/v..........	21 May	25 ab	13 b	1.3 a	0.4 a	6.8 a	2.4 a
BAS 125W 125 ppm + Regulaid 0.03% v/v	21 May	32 ab	20 b	2.2 a	2.2 a	7.4 a	11.6 a
BAS 125W 250 ppm + Regulaid 0.03% v/v	21 May						
Streptomycin 100 ppm..	27 May	16 a	2 a	1.1 a	0.7 a	5.6 a	6.7 a
Streptomycin 100 ppm.....	27 May	18 a	50 c	1.7 a	4.8 a	9.4 a	8.5 a
No treatment....................	---	48 b	75 d	3.7 a	12.1 b	7.1 a	15.9 a

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

Dilute treatments applied to the point of runoff with a single nozzle handgun at 200 psi as follows: BAS125 treatments applied 21 May. Agri-Mycin (1-day pre-inoculation for 1st inoculation; 8-day pre-inoculation for 2nd inoculation.) applied 27 May.

NOT FOR PUBLICATION

(Not for publication or distribution)

A Reduced Pesticide Program for the Control of Sooty Blotch and Flyspeck on Scab-Resistant Apple Cultivars

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Introduction

Sooty blotch and flyspeck are important pathogens affecting apples in Pennsylvania. The presence of sooty blotch and flyspeck on the fruit surface decreases fruit quality and marketability. Scab-resistant apple cultivars (SRCs) are immune to apple scab and vary in their resistance to cedar apple rust, powdery mildew and fire blight, however, they are not resistant to sooty blotch and flyspeck (3,5,7,8,9). These SRCs are as susceptible to sooty blotch and flyspeck as the scab-susceptible apple cultivars currently planted by commercial apple producers. Last year, a disease management program was implemented to control summer diseases. Various treatments were applied at different timings to minimize fungicide applications and control summer diseases. The 1996 growing season was atypical. Fruit set was low due to a frost that occurred on May 13 and 14. Treatments were applied to individuals trees, not blocks, as a result of scattered fruit production. The 1996 season was also extremely wet with above average precipitation occurring in June, July and August. Significant differences in treatment affects in the percent of sooty blotch and flyspeck on fruit were observed (9). Based on these results, treatments and application times were adjusted for the 1997 growing season. The research objective this year was to compare conventional and alternative management strategies for sooty blotch and flyspeck while minimizing fungicide use. The goal of this project was to produce high quality fruit and reduce disease to economic levels with a minimal amount of pesticide applications.

Materials and Methods

The experimental orchard, approximately one acre in size, was established at the Russell E. Larsen Research Farm at Rock Springs in the spring of 1992. Cultivars include Redfree, Jonafree, Liberty, and Freedom as well as Golden Delicious to serve as the standard. The orchard design is a randomized complete block with 50 trees per cultivar, 5 cultivars individually randomized within each block. All cultivars are planted on MARK rootstock. Each year the orchard receives a standard spray program for insects and weeds and is fertilized based on pH and leaf analyses results.

This year seven treatments were chosen to compare conventional and alternative management strategies for the control of sooty blotch and flyspeck. Treatments were randomized and assigned to individual blocks. Treatments were replicated four times. An unsprayed check was also included (treatment 8). Treatments were determined based on leaf wetness thresholds that would predict sooty blotch and flyspeck occurrence in the orchard. The basis of these leaf wetness thresholds were identified from a model designed specifically to control sooty blotch and flyspeck developed in North Carolina (1). The model is based on the correlation of the pathogen life cycle and accumulated leaf wetness hours. Hours of leaf wetness accumulated in this study included rainfall and dew. Scouting for the first visible symptom of sooty blotch and flyspeck on fruit began on July 30. Twenty fruit per tree of all cultivars (111 trees sampled) were observed weekly for symptoms.

All treatments included Captan at 1 lb plus 3 oz Benlate /100 gallon except the JMS Stylet Oil treatments (treatments 2 and 3). All hours of leaf wetness were based on the North Carolina model (1). JMS Stylet Oil was applied as a treatment this season. It has been as effective in controlling powdery mildew on grapes in Pennsylvania as our best material which is Nova (4). Specific treatment descriptions follow:

***Treatment* 1- Conventional Spray Program**
This treatment simulated a full fungicide spray program that would be applied in a commercial SRC apple orchard. Treatment applications began on June 9 and ended on September 5. A total of 7 applications were made.

***Treatment* 2 - JMS Stylet Oil, 225 Hours of Leaf Wetness**
Trees received applications of a 1.5% solution of JMS Stylet Oil when 225 hours of leaf wetness were reached as recorded by a hygrothermograph. A total of 5 applications were made. Treatment applications began on July 10 and ended on September 5.

***Treatment* 3 - JMS Stylet Oil, 275 Hours of Leaf Wetness**
Trees received applications of a 1.5% solution of JMS Stylet Oil when 275 hours of leaf wetness were reached as recorded by a hygrothermograph. A total of 4 applications were made. Treatment applications began on July 18 and ended on August 29.

***Treatment* 4 - Captan + Benlate/ 225 Hours of Leaf Wetness**
Treatments were applied when 225 hours of leaf wetness were reached as recorded by a hygrothermograph. A total of 5 applications were made. Treatment applications began on July 10 and ended on September 5.

***Treatment* 5 - Captan + Benlate/ 275 Hours of Leaf Wetness**
Treatments were applied when 275 hours of leaf wetness were reached as recorded by a hygrothermograph. A total of 4 applications were made. Treatment applications began on July 18 and ended on August 29.

***Treatment* 6 - SkyBit, 305 Hours of Leaf Wetness**
Treatments were applied when 305 hours of leaf wetness were reached as calculated by SkyBit. A total of 5 applications were made. Treatment applications began on July 10 and ended on September 5.

***Treatment* 7 - SkyBit, 605 Hours of Leaf Wetness**
Treatments were applied when 605 hours of leaf wetness were reached as calculated by SkyBit. A total of 2 applications were made. Treatment applications began on August 15 and ended on August 29. This treatment was applied before sooty blotch and flyspeck symptoms were observed on fruit in the orchard.
***Treatment* 8 - The Unsprayed Check,** No fungicide treatments were applied.

Following the North Carolina sooty blotch model, accumulation of leaf wetness hours were not begun until 10 days after petal fall and when rain or dew of 4 hours had occurred. Petal fall was on May 23 with the first 4-hour wetting period occurring on June 2. When threshold leaf wetness hours were reached, trees received treatment applications. Once initiated, fungicide treatments were applied at two week intervals until harvest.

All treatments were applied to individual blocks using a hand-held spray gun powered by a nitrogen bottle-cylinder, at 20 psi, until runoff. Treatment applications were terminated two weeks prior to anticipated harvest dates. When fruit of each SRC were mature, observations on the occurrence of sooty blotch and flyspeck were recorded. Fruit evaluation dates were August 18 for Redfree, September 22 for Freedom and Jonafree, and September 24 for Liberty and September 25 for Golden Delicious. At harvest, a sample of 50 fruit per cultivar per treatment was observed for symptoms. Each individual fruit was rated based on several categories. The fruit were rated according to the following criteria: 1.) clean which was defined as being "disease free", 2.) fruit with sooty blotch, 3.) fruit with flyspeck, 4.) fruit with both sooty blotch and flyspeck, 5.) fruit developing fruit rot symptoms, 6.) fruit with symptoms typical of powdery mildew infection, 7.) fruit with quince rust and 8.) fruit with Brooks Fruit spot. Incidence was determined for all categories and a severity rating was determined for sooty blotch and flyspeck. The following disease severity scale was utilized: **1** = 0 to 10% and **2** = 11 to 20% of the fruit surface affected.

Results

Analyses of Treatment Affects (all cultivars combined)

A summary of treatment description, application date, and total number of applications are presented in Table 1. There was no cultivar by treatment interaction. The four cultivars were combined (with the exception of Redfree) and the effects of all treatment applications on the combination of the four cultivars were evaluated. Redfree was analyzed separately since harvest occurred on August 18, one month prior to the other cultivars and sooty blotch and flyspeck were not observed on fruit of Redfree. A subsample of 10 to 20 fruit from all treatment applications was observed under laboratory conditions after harvest. Samples were placed in moisture chambers for 2 weeks, removed and observed for sooty blotch and flypeck.

Significant differences between treatments were observed when cultivars were combined (Table 2). The conventional spray program (treatment 1) yielded a significantly higher percentage of clean fruit (75.25%) when compared to all other treatments. Fruit receiving treatment 1 also had the lowest amount of sooty blotch and flyspeck (17.63%), sooty blotch alone (11.88%), and flyspeck alone (18.25%) when compared to the other treatments. Fruit receiving the conventional spray program were sprayed a total of 7 times during the season (Table 1) beginning on June 9 and ending on September 5 (2-week spray intervals). This is still about 25% less than non-scab resistant cultivars would receive.

Treatments 4, 5, and 6 (Captan + Benlate/ N.C. model) had the next significantly higher amounts of clean fruit when compared to the remaining treatments. These treatments were not significantly different from one another with percent clean fruit ranging from 61.63% (treatment 5, applied at 275 hours of leaf wetness), 63.13% (treatment 4, applied at 225 hours of leaf wetness), and 66.0% (treatment 6, SkyBit reading of 305 hours of leaf wetness). Fruit receiving JMS Oil applications at 225 or 275 hours of leaf wetness based on hygrothermograph readings (beginning on July 10 and July 18), were not significantly cleaner than the unsprayed check. JMS Oil applied at 225 hours of leaf wetness had 39.63% clean fruit and while JMS Oil applied at 275 hours of leaf wetness had 38.38% clean fruit. The upper limit SkyBit treatment (treatment 7), which was applied at 605 hours of leaf wetness on August 15, had 43.13% clean fruit.

Significant differences were observed in the amount of sooty blotch and flyspeck on the fruit surface. The least amount of sooty blotch and flyspeck colonies were observed on fruit receiving the conventional spray program (treatment 1) with 17.63% fruit affected. The highest amount of sooty blotch and flyspeck was observed on the unsprayed check (56.75%) followed by the JMS Oil treatments, 52.0 and 54.75% respectively, and 49.5% for treatment 7 (SkyBit, 605 hours). These four treatments (2,3,7,8) were not significantly different from one another.

Treatments 4, 5, and 6 (Captan + Benlate/ N.C. model) had significantly lower amounts of fruit with sooty blotch and flyspeck when compared to the JMS Oil treatments, the SkyBit 605 hour treatment and the unsprayed check (treatments 2,3,7,8). These treatments were not significantly different from one another with percent fruit with sooty blotch and flyspeck ranging from 31.13% (treatment 5, applied at 275 hours of leaf wetness), 31.38% (treatment 4, applied at 225 hours of leaf wetness), and 24.25% (treatment 6, SkyBit reading of 305 hours of leaf wetness). Only treatment 6 was not significantly different than the conventional spray program with a difference of 6.62% more fruit with sooty blotch and flyspeck.

When observing the amount of fruit with sooty blotch or flyspeck colonies occurring alone, the disease occurrence for the various treatments was the same when both diseases were observed together. The conventional program (treatment 1) in both cases had a lower percentage of fruit with sooty blotch (11.88%) and flyspeck (18.25%) when compared to all other treatments. Again, fruit receiving treatment 6 had 19.0% fruit with sooty blotch and 24.75% of fruit with flyspeck. These numbers were not significantly different than the conventional spray program. The percent sooty blotch and the percent flyspeck on fruit that received JMS Oil treatments were not significantly different than the unsprayed check or treatment 7. Approximately 40% of fruit receiving JMS Oil applications had sooty blotch compared to 45.38% for the check and 37.25% for fruit receiving treatment 7. An average of 55% of fruit receiving JMS Oil sprays had flyspeck colonies compared to 59.88% for the check and 50.63% for treatment 7. Severity rating for sooty blotch and flyspeck showed that treatments 4, 5, and 6 were not significantly different than the conventional SRC fungicide program. The cultivar Redfree, was analyzed separately. Significant differences in fruit disease were not observed between treatments.

Significant differences were not observed among treatment effects for the category "fruit rots" and data is not presented. Even though all trees had artificially inoculated black rot mummies placed within the tree canopy in the spring, fruit rot incidence was low. The season was relatively cool with an average temperature of 66 F., 69 F., and 66 F. for June, July and August and rainfall in June and July were below normal when compared to precipitation averages for 100 year norms. The lower temperatures may have delayed the development of fruit rots. Fruit suspected of fruit rot were taken into the laboratory and observed until either the rot progressed and/or until pycnidia formed on the fruit surface. Many of the fruit samples never developed rot. Fruit were observed for one month. When isolations were made on 9 fruit of Freedom that were rotting, *Botryosphaeria obtusa* was isolated from 5 fruit and *Botryosphaeria dothidea* was isolated from 4 fruit. *Botryosphaeria obtusa* was isolated from one Jonafree fruit. An *Alternaria* species was isolated from 7 fruit of Freedom and was considered a secondary saprophytic invader.

Analyses of Individual Cultivars (all treatments combined)

When considering fruit of each cultivar across all treatments, significant differences were observed (Table 3). Fruit of Liberty had the highest percentage of clean fruit (62.81%) when compared to Golden Delicious (56.0%), Freedom (49.8%), and Jonafree (42.0%). Fruit of Jonafree had significantly more colonies of both sooty blotch and flyspeck, as well as sooty blotch alone and flyspeck alone. This cultivar also had the highest severity rating (1.21) which was approximately 10-15% of the fruit surface covered with sooty blotch and flyspeck colonies. Jonafree also had more powdery mildew-like symptoms (9.2%) and more fruit with Brooks Fruit Spot (0.9%) than the other cultivars. Freedom was most susceptible to fruit rots with 4.7% of the fruit affected. Golden Delicious was most susceptible to quince rust with 32.8% of the fruit affected while 7.4% of Liberty fruit was infected with quince rust.

Discussion

Timing of the fungicide applications based on hours of leaf wetness as calculated from the North Carolina model was shown to be effective with a slight increase in diseased fruit. The 225 and 275 hour hygrothermograph leaf wetness treatments reduced the fungicide program from 7 applications required in the conventional SRC program to 5 and 4 applications respectively. The severity of sooty blotch and flyspeck on the fruit was not significantly different using the hygrothermograph data. The percent clean fruit for the 4 and 5 spray programs, however, was significantly less than the 7 spray program. To determine if this difference is significant to the growers one would have to determine if 10% more clean fruit is worth the cost of 2 additional fungicide applications.

The SkyBit threshold for leaf wetness was uncertain prior to this study. Since SkyBit calculates leaf wetness rather than recording it (2,6), the total leaf wetness hours vary from hygrothermograph leaf wetness hours. This study used 305 leaf wetness hours for the first SkyBit treatment application and 605 leaf wetness hours for the second. The 305 SkyBit treatment was applied on the same date as the 225 hygrothermograph treatment (July 10). The 605 SkyBit treatment was applied on August 15. No sooty blotch symptoms had been observed in the orchard by that date. The first date sooty blotch was observed in this orchard was August 18. The 305 hour SkyBit treatment was timed the same as the 225 hour hygrothermograph treatment and had similar results. The 605 SkyBit treatment resulted in significant sooty blotch levels on the fruit and was comparable to the unsprayed check.

It is clear that sooty blotch is a problem in the orchard before it is visible even when intensively scouted. This is the type of year one would assume that delaying fungicide applications based on leaf wetness would be most effective. It was dry in June and July and wet in August. However, the 7 spray full fungicide program began on June 9 and resulted in 10% more clean fruit than a 5 spray fungicide program which was initiated one month later on July 10.

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Table 1. Treatment descriptions, application dates and total number of applications[1] applied to scab-resistant apple cultivars during the 1997 season.

TRT	Description	Jun 9	Jun 23	Jul 10	Jul 18	Jul 25	Aug 1	Aug 8	Aug 15	Aug 22	Aug 29	Sep 5	Total # applic.
1	Conventional	x	x	x		x		x		x		x	7
2	JMS 225 hr			x		x		x		x		x	5
3	JMS 275 hr				x		x		x		x		4
4	225 hr hygro			x		x		x		x		x	5
5	275 hr hygro				x		x		x		x		4
6	SkyB 305 h			x		x		x		x		x	5
7	SkyB 605 h								x		x		2
8	check												0

[1] Treatments consisted of Captan 1 lb plus 3 oz Benlate, with the exception of oil applications.

Table 2. The effect of various treatment applications on the incidence and severity of sooty blotch and flyspeck over the 1997 growing season.

		Percent fruit affected				severity rating[1]
TRT	Description	Clean	Sooty Blotch & Flyspeck	Sooty Blotch	Flyspeck	Sooty Blotch & Flyspecks
1	Conventional	75.25[2] c[3]	17.63 a	11.88 a	18.25 a	0.97 a
2	JMS 225 hr	39.63 a	52.00 c	40.50 c	54.63 cd	1.19 cd
3	JMS 275 hr	38.38 a	54.75 c	40.63 c	57.25 cd	1.28 d
4	225 hr hygro	63.13 b	31.38 b	23.50 b	32.25 b	1.06 abc
5	275 hr hygro	61.63 b	31.13 b	25.75 b	31.63 b	1.05 ab
6	SkyB 305 h	66.00 b	24.25 ab	19.00 ab	24.75 ab	1.04 ab
7	SkyB 605 h	43.13 a	49.50 c	37.25 c	50.63 c	1.15 bcd
8	check	34.13 a	56.75 c	45.38 c	59.88 d	1.23 d

[1] Numbers represent a disese index where 1 = 0-10% and 2 = 11-21% of the fruit surface affected.
[2] Numbers represent the mean of 200 fruit/cultivar, 800 fruit/treatment and include 3 SRCs and a Golden Delicious control.
[3] Means in a column followed by the same letter do not differ significantly, DMRT ($P < 0.01$).

Table 3. Percent fruit affected by sooty blotch, flyspeck, fruit rot, Brooks fruit spot, powdery mildew and Quince rust during the 1997 growing season.

Cultivar	Clean	Sooty Blotch & Flyspeck	Sooty Blotch	Flyspeck	Fruit Rot	Brooks Fruit Spot	Powdery Mildew	Quince Rust	severity rating[1] Sooty Blotch & Flyspeck
Jonafree	42.0[2] a[3]	53.5 c	53.5 c	53.8 c	0.7 a	0.9 b	9.2 c	0.6 a	1.21 c
Freedom	49.8 b	41.1 b	4.4 a	42.4 b	4.7 b	0.0 a	2.7 b	0.1 a	1.15 bc
Golden	56.0 b	33.1 a	33.1 b	35.0 a	0.2 a	0.1 a	0.0 a	32.8 c	1.09 ab
Liberty	62.8 c	30.9 a	30.9 b	33.4 a	1.1 a	0.1 a	0.9 a	7.4 b	1.04 a

[1] Numbers represent the mean of all treatments applied (treatments 1-8).
[2] All numbers represent the mean of 1600 fruit per cultivar (8 treatments, 4 reps, 50 fruit sample/ cultivar).
[3] Means in a column followed by the same letter do not differ significantly, DMRT (P = 0.05).

One Consultant's Experience with the Delayed Scab Spray Program in New England

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Ezekiel Goodband, Alyson's Apple Orchard, Walpole, NH

Since the early 1990's, Dr. William MacHardy has been working with growers in New Hampshire to reduce fungicide use by employing a delayed spray strategy based on assessing the abundance of available inoculum of venturia inaequalis. However, the practice is very management-intensive and has not been well-adopted outside of the orchards where Dr. MacHardy was working along with the growers to make fungicide decisions. Thus, the cooperation of Alyson's Apple Orchard of Walpole, NH, a long-term client of Polaris Orchard Management, provided a unique opportunity to watch over Dr. MacHardy's shoulder and see how the program actually worked in a real-world situation.

Along with acknowledging the work that Drs. MacHardy, David Gadoury of Cornell University, Daniel Cooley of the University of Massachusetts, Lorraine Berkett of the University of Vermont, and others have done on developing and testing the delayed spray program, I should mention that this project was part of a "whole-farm" management project that Dr. MacHardy was doing with the USDA Consolidated Farm Service Agency. The overall results of that project have been presented elsewhere; what I would like to do here is to present what I saw as a "whole-farm" consultant observing the project.

Just to briefly review what is involved in using the delayed spray model, there are several steps, based on our knowledge of the biology of *Venturia inaequalis*, that are involved. First, a potential ascospore does, or PAD, assessment is done in the fall, so that the inoculum level of the orchard is known. Next, if the inoculum level is too high, measures may be taken to reduce it to an acceptable level: leaf chopping or removal, urea applications, etc. Finally, the inoculum level is used in combination with monitoring spring infection periods gives us the ability to know how long to hold off on the first fungicide application.

Recently the model has been simplified so that instead of having a continuum of possibilities for the first spray event, there is a specific threshold of 600 ascospores/m^2 that tells the grower that it is possible to delay until pink, or until the third infection period (but definitely before the fourth infection period) whichever comes first.

Having been trained (more or less) as an entomologist, I have been very interested in the notion that the PAD in combination with the percent of ascospores released gives us the equivalent of an economic threshold level for a pathogen. Lacking both qualifications in plant pathology and the wherewithal to test the program on my own, I have been an interested observer now for several years, so the chance to see the delayed spray "up close and personal," on a farm which I know well, was exciting to me.

Alyson's Apple Orchard is a 75-acre commercial orchard located in the Connecticut River Valley in southern New Hampshire. The orchard is somewhat unusual for New England in having essentially no trees older than 20 years, but the cultivar mix is fairly typical - McIntosh, Cortland, Macoun, Empire, Mutsu, and a smattering of minor varieties, here including some antique apples. The manager, Ezekiel Goodband, is well versed in the principles of IPM and we have had good success in reducing insecticide and miticide sprays. Because of the risk involved in reducing fungicide sprays, however, fungicide use has remained fairly constant over the years we've worked together.

A PAD assessment was done in the fall of 1995 by Dr. Donald K. Sutton of UNH which showed that the inoculum level in the orchard was a very low 40 ascospores/m² - another indication both of good management and a conservative fungicide program. There was no need to do any further inoculum reduction - a good thing, because as it turned out, with the heavy rains and substantial snowmelt in March and April, most growers in our area found it impossible to get any sort of equipment into the orchard before the end of April. In any case, the weather was closely monitored after green tip, and the first fungicide did go on after three infection periods, which coinciding with the early pink stage of development.

Figure 1 shows that it was indeed a very wet spring - a 2-day rainy period on April 29-30 was the first significant Mills infection in the region, followed by another major wetting on May 3-4. The first application was begun on the 5th and was finished on the 7th (the 6th was too cold to be a Mills period, but also too wet to allow a fungicide application). A fairly normal fungicide program ensued, with either Dithane alone or Dithane combined with Topsin used throughout the primary scab season (figure 2).

Fig 1

Wetting periods through 1996 primary scab season

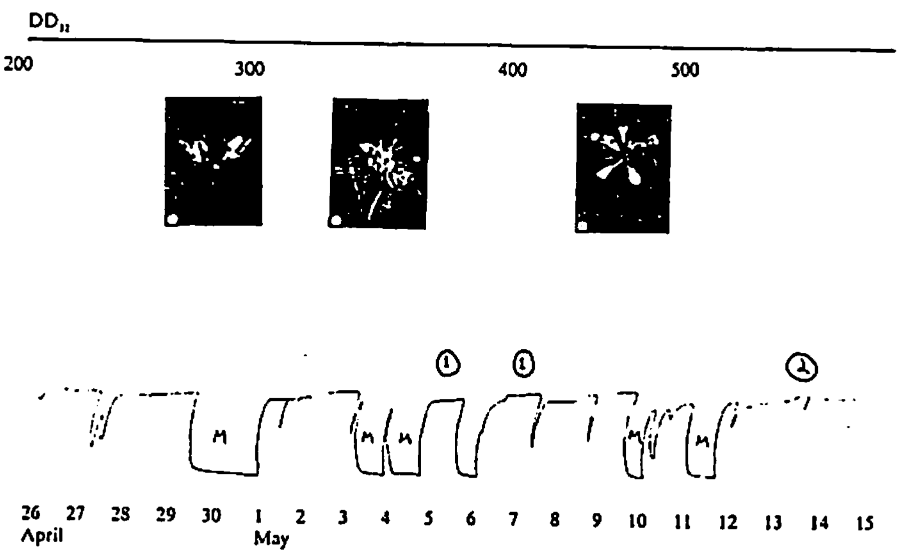


Fig. 2 Fungicide Usage in 1996
Alyson's Apple Orchard, Walpole, NH

Date	Material	Rate/acre	Dev Stage
5/5-7	Dithane DF	3 lb.	early pink
5/13-14	Dithane DF	3 lb.	late pink
5/23-25	Dithane DF	3 lb.	petal fall
	Topsin M70	5.3 oz	
5/31-6/1	Dithane DF	3 lb.	first cover
6/15	Dithane DF	3 lb.	
	Captan 80	2.25 lb	
7/8-11	Captan 80	1.25 lb	
	Topsin M70	5.3 oz	
7/28-29	Captan 80	2.5 lb	
8/13	Captan 80	1.25 lb	
	Topsin M70	5.3 oz	

On May 28th I found lesions from an infection that appeared to have occurred around tight cluster in some parts of the orchard. Lesions were not highly prevalent; in fact, Mr. Goodband had not noticed any lesions prior to my pointing them out. My assessment was that, although the number of lesions was not excessively high, it was too easy to find them, and I recommended a burnout spray. Mr. Goodband then contacted Dr. Sutton, who came out and did a more quantitative estimate, coming out with about 1% of susceptible leaves having been infected, and agreed that a burnout spray was in order. Topsin and Dithane together were applied on the 31; Topsin had also been used with the petal fall spray to control calyx end rot.

Although we were a little unnerved by the unexpected appearance of scab infections, however slight, in the orchard, Mr. Goodband continued to do only the minimum of fungicides needed until the end of primary scab, which in fact was only about a week after we had found the lesions. (The spray in mid-June was really aimed at summer disease control more than it was at controlling scab.) In the end, he did 4 fungicides aimed strictly at scab, 1 at both scab and summer diseases, and 2 or 3 at summer disease control. The amount of scab on fruit at harvest was not unacceptable - about 0.5% in the blocks where lesions had been noted. The PAD assessment of 727 in the fall of 1996 certainly showed the increase in lesion density, although that is still not a *very* alarming number. The summer of 1996 was unusually wet, so that any lesions that survived the spring would have had a good chance to reproduce.

Dr. MacHardy's project only lasted through 1996. In 1997, Mr. Goodband ran a slightly more conservative scab program, based on the higher inoculum level from the previous fall. Still, he maintained a protectant-only program and used only 5 fungicides in 1997 as compared with 4 in 1996 directed solely against scab. And the PAD at the end of 1997 was 60 - back down near the level that it was in 1995, before embarking on this "radical" spray program. Scab on fruit at harvest was negligible, owing to good management and helped by a very dry summer.

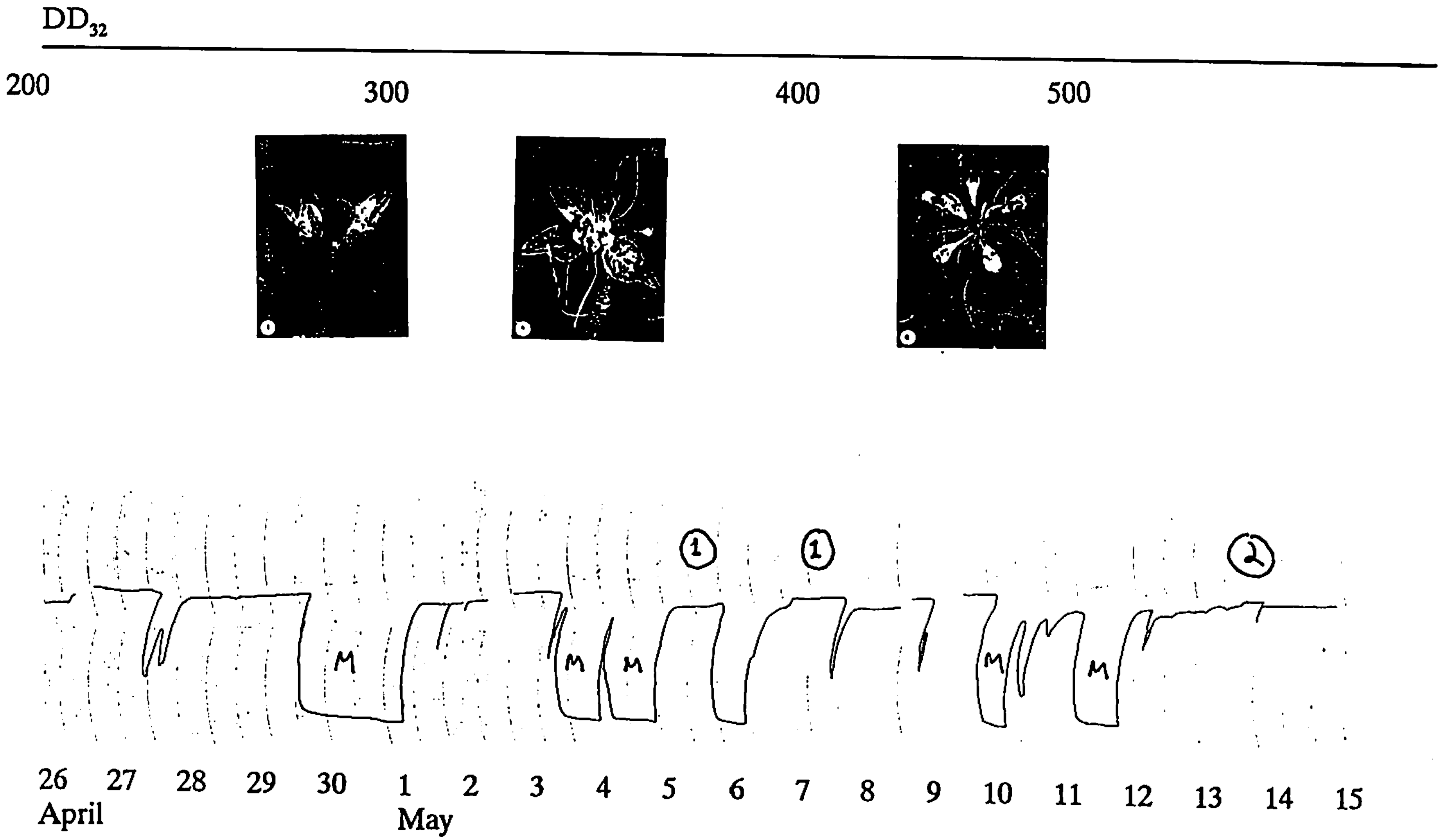
As a consultant, my initial reaction to the reduced spray program in 1996 was that I felt it was indeed too risky - to save only about 3 days on the fungicide program, we had delayed spraying to the point where we actually did get some scab lesions. However, looking at it from a two-year perspective, I would moderate my views somewhat. For one thing, the amount of scab in the orchard was really not very high. But more tellingly, the project occurred under what were just about the worst possibly conditions as far as what we experience in New England for apple scab pressure - extremely wet weather in both spring and summer, and several infection periods that were 48 hours or more in length as opposed to the more usual 10-24 hour infection periods. Furthermore, the scab occurred only in blocks that were not sprayed until the 7th, which may indicate that the spray on the 5th was sufficiently well timed. So, in an orchard with very low inoculum, a mild infection occurred under the delayed spray program under the worst possible conditions. Not so bad, perhaps.

Mr. Goodband was interested enough in the program to have me come out and do a PAD assessment this fall. He has no plans of moving to a sterol inhibitor program, and depending on what the weather does in the spring, we may do a moderated (more cowardly) version of the delayed spray program. Overall, I feel more comfortable with telling growers whose orchards are clean (a vital point!) that they can very likely get up to or through tight cluster without a protectant fungicide, and can possibly delay even longer if they are using a sterol inhibitor program. The question of when to start spraying in the spring has always been a difficult one, and this work seems to me to give us a somewhat better handle on making that decision. And to time the first spray at around tight cluster works out very well in our conditions, where we would be expecting to do the first oil spray at just about that time. In conclusion, I'm not ready yet to jump into the delayed fungicide program with both feet, but I'm willing to continue to work toward it. I will likely use the knowledge gained here to suggest to the rest of my growers that they might try the delayed program in part of their orchard in years to come - inoculum level and weather permitting, as always!

Fungicide Usage in 1996

	Date(s)	Material	Rate/acre	Dev. Stage
Scab	5/5 - 5/7	Dithane DF	3 lb.	early pink
	5/13 - 5/14	Dithane DF	3 lb.	late pink
	5/23 - 5/25	Dithane DF	3 lb.	petal fall
		Topsin M 70	5.3 oz	
	5/31 - 6/1	(Captan 80	2.5 lb.) OR	first cover
		Dithane DF	3 lb. PLUS	
		Topsin M 70	5.3 oz	
scab and summer diseases	6/15	Dithane DF	3 lb.	
		Captan 80	2.25 lb.	
summer diseases	7/8 - 7/11	Captan 80	1.25 lb.	
		Topsin M 70	5.3 oz	
	7/28 - 7/29	Captan 80	2.5 lb.	
	8/13	Captan 80	1.25 lb.	
		Topsin M 70	5.3 oz	

Wetting periods through 1996 primary scab season



SUPPRESSION OF APPLE BITTER ROT (*COLLETOTRICHUM* SPP.) BY CALCIUM SALTS.

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Calcium is used routinely in apple production as a nutritional supplement for the management of cork spot and bitter pit in York Imperial, Golden Delicious, and other cultivars that are sensitive to these disorders. The use of calcium sprays, as one part of the management plan to reduce calcium-related disorders, has some other reported benefits, including improved fruit quality. The studies presented below are part of our on-going program to characterize the sensitivity of plant pathogenic fungi to exogenous calcium. The effects of three calcium salts on conidial germination, germ tube elongation, growth in vitro, and infection were studied for the apple pathogens *Colletotrichum gloeosporioides* and *C. acutatum*.

Materials and Methods

Fungi and calcium treatments. All experiments were conducted with isolates of the bitter rot pathogens *C. acutatum* and *C. gloeosporioides* obtained from apple by Dr. K. S. Yoder. Fungi were maintained on potato dextrose agar in 9-cm-diam plastic Petri dishes in the dark at 22 C and were transferred weekly. The calcium salt treatments in these experiments included calcium chloride, calcium propionate, and calcium silicate. These three salts were selected based on preliminary tests on growth of *Colletotrichum* spp. in liquid culture (potato dextrose broth) with a range of calcium salts.

Conidial germination and germ tube elongation. Germination studies were conducted on water agar supplemented with calcium salts at 1,000 μg/ml calcium. Suspensions of 1 x 10^5 conidia/ml were prepared from 7-day-old cultures with standard methods. Drops of conidial suspension were placed on plain water agar medium or medium supplemented with one of the three salts. Germination was determined from 125 conidia (25 conidia from 5 replications per treatment). A conidium was considered germinated if the germ tube was longer than the width of the conidium. Germination was assessed after 6 hours at 22 C. The germ tube elongation experiments were conducted separately from the germination experiments. Drops of conidial suspension were prepared and placed as drops on the plain or supplemented water agar medium; however, the lengths of 50 tubes from 5 replications per treatment were measured at 100 X with a compound microscope. Germ tube lengths were determined after approximately 24 hours of incubation (6 hours at 22 C and 18 hours at 4 C). Both experiments were arranged in a completely randomized design and were conducted twice.

Fungal growth *in vitro*. Potato-dextrose broth, unamended and amended with calcium salts at 1,000 μg/ml calcium, was prepared and 50 ml was poured into sterile 250-ml Erlenmeyer flasks. Sixty μl of a 1 x 10^5 suspension of conidia from 7-day-old cultures of either *Colletotrichum* isolate were placed into each flask and the flasks were incubated at 22 C. After 7 days, mycelium was collected via filtration on to pre-weighed filter paper, dried at 60 C, and weighed. There were three replications for each treatment and the experiment was conducted four times.

Fruit infection. Laboratory studies. Laboratory studies were conducted with harvested fruit of the apple cultivar Nittany. Fruit were grown under commercial growing conditions that included a standard insecticide and fungicide program. To test for antagonistic effects of calcium salts against *Colletotrichum* spp., apples were first wounded with a 5-mm-diam cork borer to just below the epidermis, then the disk of epidermis was removed with a scalpel. The wound was then sprayed to the drip point with the calcium salt solutions (1,000 μg/ml calcium or nanopure water as the control), and then allowed to air dry. Each wound was then inoculated with 60 μl of a 1 x 10^5 conidia/ml suspension of either *Colletotrichum* isolate. Inoculated fruit were incubated at 22 C in plastic boxes with lids. Moistened paper towels were added to maintain high relative humidity. Moistened towels were removed after about 40 hours. Fruit were observed daily beginning two days after inoculation for up to 14 days and percent infection, lesion size, development of acervuli were determined. Each treatment consisted of 3 replicates of ten fruit each. The experiment was performed twice. In another experiment, fruit were prepared as described above, and were inoculated with conidial suspensions containing 1 x 10^3, 1 x 10^4, or 1 x 10^5 conidia/ml. The latter experiment has been conducted only once.

Field studies. Golden Delicious trees in an unsprayed research plot were selected for calcium treatments in June, 1997. Individual branches on three replicate trees received three weekly handgun treatments (to the drip point) of calcium solutions (1,000 μg/ml calcium from calcium propionate, calcium chloride, calcium silicate, or distilled, deionized water). On the day following the third calcium application, fruit were inoculated with a 2.5-cm-wide length of cheesecloth (4 layers thick) that had been immersed in a suspension of 1 x 10^5 condia/ml of either *Colletotrichum* spp. The cheesecloth containing the conidia was tied to the fruit, covered with plastic wrap, and then covered with aluminum foil. The inoculum and coverings were removed after 5 days. A control consisting of moistened cheesecloth without conidia was included, also. The experiment was conducted 3 times with inoculations on 1 July, 5 August, and 1 September. For evaluation of disease incidence, fruit were harvested at optimum maturity (9 September), placed in paper trays in open boxes, and allowed to senesce naturally. Fruit were rated weekly for incidence of bitter rot lesions within the 2.5-cm-wide strip on the fruit that was delimited by the cheesecloth inoculum carrier. Lesions outside of this region were excluded from the ratings. Final incidence values were adjusted to correct for the low level of bitter rot infection that was observed in the noninoculated control.

Results and Discussion

Conidial germination and germ tube elongation. Calcium chloride, calcium propionate, and calcium silicate had no effect on germination of conidia. For *C. acutatum*, calcium silicate and calcium chloride inhibited germ tube growth by about 50% relative to the control, while calcium propionate reduced germ tube growth by about 75%. For *C. gloeosporioides*, calcium silicate had no effect, while both calcium chloride and calcium chloride reduced germ tube growth by about 50%.

Fungal growth *in vitro*. All three calcium salts reduced fungal dry weight in liquid culture media. Significant growth reductions were apparent at concentrations of 600 μg/ml and higher for both calcium propionate and calcium chloride.

Fruit infection. Laboratory studies. Fruit treated with calcium chloride and calcium propionate exhibited 30% smaller lesions than those treated with calcium silicate or the control, which were similar. Fruit treated with calcium chloride and calcium propionate exhibited delayed formation of acervuli relative to the control and calcium silicate, which were similar. When fruit were inoculated with varying concentrations of conidia, fruit treated with calcium chloride exhibited reduced incidence of infection after inoculations with 10^3 conidia/ml. In all tests at 10^4 and 10^5 conidia/ml, the control and calcium salt treatments exhibited similar incidences of infection after inoculations of wounded fruit.

Field studies. In all three trials, fruit treated with calcium chloride or calcium propionate and then inoculated with either *C. gloeosporioides* or *C. acutatum* exhibited lower incidences of infection when compared to control fruit and fruit treated with calcium silicate. On control fruit, most infections became visible between the first and second weeks after harvest, reaching 83% incidence in trial 1 and 100% incidence in trials two and three. In comparison, for *C. acutatum*, mean incidences of infection at 2 weeks postharvest for fruit treated with calcium salts were 46%, 18%, and 8%, respectively for fruit treated with calcium silicate, calcium chloride, and calcium propionate. All three salt treatments were significantly different from the control ($P = 0.05$), and calcium chloride and calcium propionate were similar to each other and different from calcium silicate ($p = 0.05$).

For *C. gloeosporioides*, mean incidence of infection at two weeks postharvest in the control treatment was 85% compared to 31%, 8%, and 7% for calcium silicate, calcium chloride, and calcium propionate, respectively. All three salt treatments were significantly different from the control ($P = 0.05$), and calcium chloride and calcium propionate were similar to each other and different from calcium silicate ($p = 0.05$).

Upon sustained posthavest incubation, infections continued to emerge. For fruit inoculated with *C. acutatum*, mean incidence of fruit infection at 4 weeks posthavest was 100% in the calcium silicate treatment, and approached 100% in the calcium chloride treatment, both of which were not significantly different from the control; whereas the incidence of bitter rot in fruit treated with calcium propionate reached about 75% and was significantly different from the control and other treatments in two of three trials. Similarly, for *C. gloeosporioides*, after 4 weeks mean incidence of fruit infection was 100% in the calcium silicate treatment and approached 100% in the calcium chloride treatment, both of which were not significantly different from the control; whereas the incidence of bitter rot in fruit treated with calcium propionate reached about 53% and was significantly different from the control and other treatments in two of three trials.

Based on results of laboratory and field studies, calcium chloride and calcium propionate appear to have suppressive activity against the bitter rot pathogens. Although additional study is required, it can be concluded that applications of calcium chloride during the cover spray program on apples can have beneficial suppressive or, perhaps, inhibitory effects against the bitter rot pathogens.

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The Penn State Fruit Pathology Web Site

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Information on research, extension programs and fruit diseases is now available on the Fruit Pathology Web Site. The Web site is arranged in a frame design. The left frame provides the choices for all visitors. The major subject areas within this frame include:

Faculty, Staff and Students
Extension
Research
Disease Information
Teaching
Home (the major home page)
Related Links

The URL for the site is: http://www.cas.psu.edu/docs/CASDEPT/PLANT/fpath/fpath.html

Under the **Faculty, Staff and Students** page are general profiles for Dr.James Travis, research assistants Jo Rytter and Andy Muza, and Phillip Northover, a Ph. D. graduate student. By selecting the individual's name, a brief description of the persons work area and expertise is given.

Under the **Extension** page, there is an Extension Publication link which has the Fruit Times Newsletter on-line. Back issues and the most current issues are listed. Also included in this link are Fruit Disease Facts Sheets. Future links will include production guides. Other topics in Extensions Programs include New Technologies which focus on expert systems (VITIS and PSAOC) and information and publications on Automated Weather Retrieval Systems.

Under the **Research** page, the major research areas are highlighted. These include research projects and reports on apple fire blight, the reduced pesticide program (scab-resistant apple cultivars) and the grape research program. Publications on the evaluation of fungicide efficacies on grape are included (Fungicide and Nematicide Tests). These reports can be downloaded onto the users desktop and then printed for review.

Under the **Disease Information** page, Fruit Disease Fact Sheets and the Fruit Times Newsletter are again included. Production guides will be added in the future. Within the Fact Sheet link, information on the major diseases of tree fruit, stone fruit, small fruit, and grapes is presented. Individual fact sheets include symptom descriptions, disease cycle and disease management. Color pictures of disease symptoms enhance the fact sheet description.

Under the **Teaching** page, there is a brief description of the Plant Disease Management Course which is taught by Dr. Travis.

Home, takes you to the beginning of the Fruit Pathology Site.

Related Links include other interesting Web sites such as the Mid-Atlantic Fruit Loop, Expert System Development Group, Departments of Horticulture and Entomology, The College of Ag Science, etc.

The **Fruit Pathology Web Site** can also be accessed through The College of Ag Science Home Page within Extension/Research. The URL for the College of Ag Science is:
http://www.cas.psu.edu/

Throughout many areas within the **Fruit Pathology Web Site**, the Plant Pathology Department's home page can be viewed. The URL for the Plant Pathology Home Page is:
http://www.cas.psu.edu/docs/CASDEPT/PLANT/plant.html

Our **Fruit Pathology Web Site** is not complete. Many areas are currently being updated and new information is continually being added. Future goals for the site are to make it more interactive as well as educational. We welcome any comments you may have on improving the website. Please direct your comments to Jo Rytter at: jlr5@psu.edu.

THE WVU TREE FRUIT WEB SITE: ONE YEAR LATER

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Information on research and extension programs at the West Virginia University Experiment Farm in Kearneysville has been available on the Internet for one year. The purpose of this presentation is to review the first year of activity at the WVU Fruit Web Site, describe the additions to the site since it was published in November, 1996, and suggest some criteria for integration of fruit Web sites in the mid-Atlantic region. Integration of regional Web services should improve electronic information delivery to growers and consultants.

Background: The West Virginia University Experiment Farm at Kearneysville Web Site was published in November, 1996. Originally included at the site were: 1) the plant pathology information (text and photographs) from the *Mid-Atlantic Orchard Monitoring Guide*, 2) a diagnostic key to apple and peach diseases in the mid-Atlantic region, and 3) links to the Virginia Tech Fruit Page for entomological information.

At its inception, the Kearneysville Web site was laid out on eight pages as described in last year's presentation at this meeting. Briefly, those pages were (and still are, unless indicated):

1) wvufarm1.html (Home Page) presents the main menu of choices for visitors to the site.

2) wvufarm2.html (About Us) contains text and photographs on the location and description of the WVU Experiment Farm.

3) wvufarm3.html (Programs and Personnel) was the Faculty and Staff page with e-mail links to the WVU faculty located at Kearneysville. This page has been removed and replaced with specific discipline pages (see below).

4) wvufarm4.html (Publications) has links to issues of *The Orchard Monitor* Newsletter, and descriptions and purchasing information for the *Mid-Atlantic Orchard Monitoring Guide*, and *Virginia-West Virginia-Maryland Spray Bulletin for Commercial Tree Fruit Growers*.

5) wvufarm5.html (Key/Fruit Pests) is under development and not available at this time.

6) wvufarm6.html (Key/Fruit Diseases) is a Diagnostic Key to Apple and Peach

Diseases and disorders. The key is not exhaustive, rather it provides diagnostic guidance for some of the major pathological problems on these crops.

7) wvufarm7.html (Links) is a page of links to other fruit-related sites. This is not an exhaustive set of links. It is intended to get the visitor going to some of the other fruit sites currently available.

8) wvufarm8.html (Index of Fruit Disease Photos, Biology and Monitoring Information) contains a photographic index of images from the *Mid-Atlantic Orchard Monitoring Guide* and links to fact sheets that were developed from information contained in the Guide.

Additions and Modifications to the Web Site in 1997: All pages received a site identification tag to help users keep track of their location on the Web. All of the main pages received a navigation image map so that visitors can go almost anywhere in the site from almost any page. Site maintenance and design software was changed from Netscape Navigator Gold to Microsoft FrontPage97 and FrontPage98-beta.

1) wvufarm1.html (Home Page) was redesigned with a more graphical interface, user-friendly layout, animated images, and sound. Page structure and meta-tags were redesigned to improve detection of the site by the major Internet search engines. Links include University administrative units, local weather conditions/forecasts, and a link for Internet Explorer 4.0 users to subscribe to the WVU Fruit Web Channel.

2) wvufarm2.html (About Us) was given a navigation bar, scrolling java script, and a link to the Virginia Tech page on regional fruit workers.

3) wvufarm3.html (Programs and Personnel) was removed and replaced with three pages: entomology.html, pathology.html, and aglabor.html. These pages have links to other pages that display research summaries, program descriptions, and personal information. For plant pathologists, there is a searchable html database of fruit-related titles from Plant Disease Reporter, Plant Disease, and Phytopathology. For both pathology and entomology, there is an online reprint request form.

4) wvufarm4.html (Publications) received the general changes outlined above.

5) wvufarm5.html (Key/Fruit Pests) received the general changes outlined above.

6) wvufarm6.html (Key/Fruit Diseases) was improved with additional photos from A. L. Jones and T. B. Sutton, *Diseases of Tree Fruits in the East.*

7) wvufarm7.html (Links) received new links on an on-going basis.

8) wvufarm8.html (Index of Fruit Disease Photographs, Biology, and Monitoring Information) was improved with additional photos and disease cycle diagrams from A.

L. Jones and T. B. Sutton, *Diseases of Tree Fruits in the East.* Tables of cultivar susceptibility to diseases were added with the help of Dr. K. S. Yoder at Virginina Tech. There are a total of 49 disease descriptions, 156 disease images, 7 disease cycle diagrams, and 14 tables of cultivar susceptibility. Where appropriate, links to other online fact sheets are provided. Disease management sections have been added. Links to fungicide recommendations for home orchardists and commercial growers are provided when appropriate.

The pages listed below are new in 1997:

9) wvufarm9.html (Index of Pest and Natural Enemy Photos) lists and accesses all arthropod pest and natural enemy photos from the Monitoring Guide.

10) wvufarm10.html (Disease Management Guides) provides links to PDF versions of the Va. Home Orchard Management Guide and the Va./W.Va./Md. Spray Bulletin. Mike Ellis (Ohio State University) and I developed a web version of his "Spray Guidelines for Organic Apple Production" (organic-apple.html) that can be accessed from this page. A link to the North Carolina spray guide for home orchardists is available here, also.

11) wvufarm11.html (Visual Gallery of Disease Images) was added to facilitate disease diagnosis based on the layout of clickable thumbnail images from the major plant organs.

12) wvufarm12.html (Archive of Fruit Disease and Fruit Insect Focus) was added to allow past month's pages of Focus Pages to be accessed.

13) current.html (Current Conditions) was highly active in April through August when we posted current insect and disease observations at Kearneysville. This was done daily during bloom, with Maryblyt graphical images and interpretations, and as needed at other times. Insect observations and degree-day information were posted on alternate days, and pheromone trap data were posted weekly (pheromon.html) through August 31. Paul Steiner provided a frequently-asked-questions (FAQ) (with answers) page on Maryblyt.

14) reader.html (Reader Comments) is a page of feedback items and site awards.

15) whatsnew.html (What's New) provides the visitor with a quick summary of new items so that they can determine if anything of interest has been added since their last visit.

16) insectfocus.html (Fruit Insect Focus) is a monthly fact sheet on a particular insect pest or pest/natural enemy combination.

17) diseasefocus.html (Fruit Disease Focus) is similar to the above except focus is on a plant disease.

18) fruitloop.html (The Mid-Atlantic Regional Fruit Loop) is an umbrella page for all the participating fruit web sites in the region. Current participants include WVU, Virginia Tech, Rutgers, the University of Vermont, and the USDA/Appalachian Fruit Research Station.

19) wvufarm13.html (Va./W.Va./Md. Spray Bulletin for Commercial Tree Fruit Growers - Disease Management Section) is an access page for fungicide recommendations for commercial growers. Recommendations can be accessed by clicking on the proper stage of plant development under a crop heading.

Use Statistics for 1997: Precise statistics on the numbers of visits to each page are difficult to obtain because other web authors sometimes link directly to an internal page, thus by-passing the counter on the main page. The numbers listed in Table 1 are from the visible page counters and should be considered low estimates, since direct query of the server via Telnet provides numbers higher than those shown in Table 1 (for example, for the Home Page, the counter is 68% of the direct Unix query). The Home Page received about 500 visits per month in 1997, followed by the Mid-Atlantic Regional Fruit Loop Page at 235 visits per month. The high use rate of the "Loop" suggests that its intended use, to facilitate movement among the mid-Atlantic Web sites, is being fulfilled. The top five specific page visits within the WVU Web site in 1997 were: 1) Index of Fruit Disease Photos (186 visits per month), 2) Visual Fruit Disease Key (thumbnail images) (120 visits per month), 3) Current Conditions (109 visits per month), 4) Key/Diseases (106 visits per month), and 5) a tie between Links and Index of Fruit Insect Photos (64 visits per month). The least visited pages included some of the specific descriptions of research items (perhaps because the counters were added after these had been online for 6 months already) and the online reprint request form. Use patterns within the top five items, specifically the Disease Index (number 1), the Visual Disease Key (number 2), and the text-based Key/Diseases (number 4), suggests that visitors are using the site mainly to diagnose fruit diseases.

Current Conditions was posted as an experiment in 1997 to determine the level of interest in Web-based information exchange. Based on comments received, both verbally and via email from users, and numbers of site visits, we plan to continue this service in 1998. Current plans are to include disease information from the Winchester area and, perhaps, updates from a regional fruit horticulturist.

Integration of Fruit Web Sites in the Mid-Atlantic Region: The umbrella page fruitloop.html (The Mid-Atlantic Regional Fruit Loop) was created to provide a common page of regional fruit links for local Internet users. The reasons for creating this page included: 1) all the participating sites have something unique to offer the fruit growing community, 2) content at the various sites is complimentary to content at the other sites, 3) an umbrella page accompanied by return links on Home Pages provides easy surfing for those interested in fruit and increases the use of individual member sites. The only requirement for members of the "Loop" is to place a text link, with the optional apple tree logo, on the Home Page of the participating site. To date, participation in the Mid-Atlantic Regional Fruit Loop includes Virginia Tech, West Virginia University, Rutgers, the University of Vermont, and the USDA/Appalachian Fruit Research Station. Although this is a first step in regional Web integration, a concerted effort by the participants is required if more in depth integration is to occur. In-depth web integration could include extensive hyperlinking among sites to truly facilitate the integration of sites. Examples of more intensive Web integration can be seen locally at the Virginia Tech and WVU Fruit Sites, and on the west coast at the Washington State University TFREC plant pathology site.

Table 1. Estimates of page visits at The University Experiment Farm WWW Site during portions of 1997

Page Title	Total	Since	Visits/mo.
Home Page	4,677[z]	1/14/97	468
About Us	109	5/9/97	18
Map to Kearneysville	56	5/9/97	9
Plant Pathology	195	6/25/97	49
Alternative Orchard Project	38	5/9/97	6
Calcium/Monilinia Project	82	5/9/97	14
Peach Leaf Scar Project	36	5/9/97	6
Peach/Almond Hybrid Project	25	5/9/97	4
Calcium/Bitter Rot Project	88	5/28/97	18
Slide Show	107	3/25/97	15
Database	92	5/9/97	15
Biography	119	5/9/97	20
Reprint Request	44	5/9/97	7
Entomology	95	6/27/97	24
Ag Labor	56	6/27/97	14
Publications (Link to Newsletter)	308	5/9/97	51
Links	384	5/9/97	64
What's New	159	5/9/97	26
Key/Insect Pests	89	5/9/97	15
Key/Diseases	639	5/9/97	106
Current Conditions	761	4/17/97	109
Mid-Atlantic Regional Fruit Loop	939	7/5/97	235
Fruit Insect Focus	-	-	60
Fruit Disease Focus	-	-	60
Reader Comments	197	5/9/97	33
Index of Photos, etc./Diseases	1,113	5/9/97	186
Index of Photos/Insects	381	5/9/97	64
Orchard Pest Management Guides	159	7/17/97	45
Organic Guidelines for Apple Diseases	222	7/21/97	63
Visual Fruit Disease Key (thumbnail images)	359	7/30/97	120

[z] Values are from cgi-script page counters and should be considered as estimates only. Direct server query values are higher in all cases. Indented items are accessed only from the page listed above.

Peaches: To Wax or Not to Wax?

(Reprint from Tender Fruit and Grapevine Newsletter, November, 1997)

By Dr. Ting Zhou and Karin Schneider
Agriculture and Agri-Food Canada, Vineland Station
and Gerry Walker, OMAFA, Vineland Station

Waxes, such as Decco-282, are currently applied to peaches as a postharvest treatment to prevent moisture loss after defuzzing during storage and to improve the appearance of the fruit for the consumer. Waxes were originally developed to be combined with post harvest fungicides to control brown rot and other storage diseases. In Canada, the wax-fungicide treatment was never registered for peaches, and in the United States this procedure is no longer registered and will be phased out when existing fungicide supplies are used up.

In 1996, we observed that peaches which had been washed and waxed through a packing line seemed to have a higher incidence of brown rot than unwashed and unwaxed peaches. This led us to design a study to see what effect the washing and waxing process through a packing line has on the incidence of brown rot development.

Four growers, two from Niagara-on-the-Lake, one from Vineland and one from Beamsville agreed to participate in this study. For each grower, one hundred peaches were taken off the packing line at three stages. These were :

1. before being placed on the packing line (unwashed)
2. after washing with water (washed)
3. after waxing with Decco-282 (waxed)

The peaches were kept for five days at room temperature and under high humidity which would simulate a consumer's kitchen. This study was conducted twice, using Harrow Diamond and Redhaven peaches.

Weather conditions before the Harrow Diamond harvest were very dry resulting in moderate levels of brown rot infection, and very small fruit at harvest. There was a lower incidence of brown rot in the unwashed peaches (9.3%) than in the washed (27.5) and waxed (24.0) treatments after 5 days of storage (see Table #1). During the Redhaven harvest period weather conditions were much wetter which contributed to a dramatic increase in brown rot both in the field and during storage. However the same trend in disease severity as observed in the Harrow Diamonds was also found among treatments in the Redhavens. After 4 days storage, there was a significant increase in the percentage of rotted fruit from the washing (66.3%) and the waxing process (58.3%) as compared to unwashed peaches (35.5%). From these results it is clear that the washing process and movement through packing line does injure the peach skin enough to allow for new brown rot infections to occur during storage. This injury and increase in infection is not reduced by the application of the wax alone.

Early studies in California looked at the moisture retention of fruit that had been treated with wax, and found that waxed fruit consistently had a lower moisture loss than unwaxed fruit. Wax is also applied to improve the appearance of the peaches for the consumer. However, we observed that Harrow Diamond peaches which had been washed and waxed at the end of five days of storage looked decidedly more shriveled than those that were unwashed. These observations combined with growers being uncertain on how much wax to apply, indicate that more care needs to be taken on how much wax should be applied to ensure the reduction of water loss.

We found that the level of brown rot present in the peaches, particularly with the Redhavens, was quite high. After examining the growers' spray records we believe that the difference in the brown rot incidence among growers was primarily due to variations in their fungicide programs and application rates. The use of full fungicide rates and 3 blossom sprays proved to be very effective for the Virgil grower (19% brown rot) compared to the Niagara-on-the-Lake grower using no blossom and pre-pick fungicides below label rates resulted in poor brown rot control (98% infection). These scenarios illustrate the importance of full rates and the application at both critical times, bloom and preharvest.

From the grower's perspective, current application rates of wax may not provide protection against moisture loss during storage conditions. What seems to be the most important is that increased handling like washing/waxing may be actually making post-harvest brown rot more severe. This can be partially achieved with minimal handling of the fruit once it is harvested. More with less as the old saying goes.

Adopting wash/wax technology without having access to postharvest fungicides may sabotage the apparent advantage. Further investigations are required to tackle post-harvest brown rot problems.

Table 1: Effects of washing/waxing on the incidence of Brown Rot.

Treatment	Harrow Diamond*	Redhaven**
Unwashed	9.3	35.5
Washed	27.5	66.3
Waxed	24.0	58.3
Significance	sig*	n.s.

* - 5 days incubation
**- 4 days incubation

Zhou, Schneider, and Walker (unpublished, 1997)

Table 2: Incidence of Brown Rot after 5 day incubation of washed peach fruit

Grower	Harrow Diamond		Redhaven	
	BR Inf.	# of Fung.	BR Inf.	# of Fung.
NOTL	29	1 (60%)[a]	98	2 (70%)
Virgil	31	5 (100%)	19	6 (100%)
Vineland	11	4 (70%)	97	5 (70%)
Beamsville	39	3 (80%)	96	5 (80%)

a - (%) percent of full label rate used

Zhou, Schneider & Walker (unpublished, 1997)

Apple: (*Malus domestica* ' ('Rome Beauty', 'Golden Delicious', 'Delicious', 'Stayman')
Apple scab; *Venturia inaequalis*
Powdery mildew; *Podosphaera leucotricha*

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APPLE SCAB AND POWDERY MILDEW INCIDENCE ON APPLE TREATED WITH CONCENTRATE FUNGICIDE SPRAYS IN 1997: Fungicide spray programs were evaluated for disease control on apple when applied seasonally as concentrate sprays. The 12-year old semi-dwarf test orchard used was five acres in size and consisted of five rows, three of which contained the research plots. Research plots were arranged in a randomized complete block design and consisted of one tree each of four cultivars planted 10' apart along the rows and separated by a 50' space between plots. Adjacent rows to the sprayed trees which were nontreated served as buffers against spray drift. Fungicide treatments were applied as complete sprays with a Metters Model 36 airblast sprayer operated at 2.5 mph and a manifold pressure of 200 psi. Application dates and growth stages were: 16 Apr (1/2"-green - tight-cluster), 22 Apr (open-cluster), 28 Apr (pink), 5 May (bloom), 12 May (petal-fall), first through seventh cover sprays on 23 May, 6, 20 Jun, 5, 17, 31 Jul, and 12 Aug, respectively. Environmental monitoring and apple scab infection periods were recorded with a Neogen Envirocaster which utilized the Mills Modified apple scab model for determining scab infection periods. Favorable conditions for apple scab infection occurred during the primary scab infection period with seven primary infections recorded between 12 Apr (tight-cluster) and 1 Jun (first/second cover). Infrequent rain periods during the summer were unfavorable for secondary spread of scab and development of the summer disease complex (sooty blotch, flyspeck, and fruit rots). Apple powdery mildew inoculum was light and spring temperatures generally too low for mildew development. Disease incidence was determined on leaves and fruit on the four cultivars. Scab incidence during the pre-bloom period was determined on cluster leaves on 'Golden Delicious' by observing all leaves on 20 nonfruiting spurs (clusters) per tree on 4-5 Jun. Scab incidence on terminal leaves was recorded by observing all leaves on 10 vegetative terminals per single tree on each of the cultivars on 30 Jun ('Stayman'), 29-30 Jul ('Rome Beauty'), 4-5 Aug ('Golden Delicious'), and 5-6 Aug ('Delicious'). On 'Rome Beauty', terminals were flagged and the youngest unfolded leaf marked on 10 Jun to distinguish the periods up to and after first cover. Both scab and mildew were recorded on this cultivar on 29-30 Jul. Observations for scab on fruit of each cultivar were made on 15 Sep ('Golden Delicious', 34 days between last spray and harvest), 16 Sep ('Delicious'), 6-7 Oct ('Stayman'), and 13 Oct ('Rome Beauty'). Fruit russeting on 'Golden Delicious' was determined by the Horsfall-Barratt rating scale on 20 fruit/replicate. The data obtained on both leaves and fruit were analyzed by analysis of variance using appropriate transformations and significance between means was determined by the Tukey-Kramer HSD test ($P \leq 0.05$).

A cool spring and relatively dry summer were not highly favorable for fungal disease development on leaves and fruit. Percent apple scab infection on terminal leaves on nontreated leaves were 31.5 ('Delicious'), 36.3 ('Golden Delicious'), 44.8 ('Rome Beauty'), and 50.0 ('Stayman') (Table 1). Cluster-leaf infection on 'Golden Delicious' during the pre-petal-fall period was 29.3%. Terminal leave infection was 58% on nontreated 'Rome Beauty' trees from tight-cluster (12 Apr) to first cover spray (25 May) (five infection periods). Scab incidence on terminal leaves from first cover to second cover (3 Jun) (two infection periods) was 25%. Excellent scab control was provided by all treatments. Only the treatments of Procure on 'Rome Beauty' leaves showed a significantly lower scab control. Scab infection on nontreated fruit ranged from 32% ('Delicious') to 70% ('Stayman'). Incidence on treated fruit was very low and differences among fungicide treatments were not significant. Powdery mildew incidence on nontreated 'Rome Beauty' leaves was only 7.3%, but the relatively ineffective treatments of Vangard were statistically separated from other treatments. Summer diseases such as sooty blotch and flyspeck occurred at 2.3 and 6.5% fruit infection on nontreated 'Golden Delicious' and were not observed on any of the treated fruit. Fruit finish among treatments on 'Golden Delicious' was excellent and no differences among treatments were evident.

Table 1 . Apple Scab and Powdery Mildew Incidence on Apple Cultivars Treated Seasonally with Fungicides Applied Airblast at 50GPA in 1997. Penn State Fruit Research and Extension Center, Biglerville, PA. K.D. Hickey.

			Percent Apple Scab							Percent P. mildew
			'Rome'		'Delicious'	'Stayman'		'G. Delicious'		'Rome'
	Fungicide and Rate/A	Application Timing	Lvs	Fruit	Lvs	Lvs	Fruit	Lvs	Fruit	Lvs
1.	Elite 90DF 3.0 oz + Captan 50W 3.0 lb Benlate 50W 12.0 oz	1/2"-G, OC, P, B, PF, 1C, 2C 1/2"-G thru 7C 6C, 7C	0.7 a*	0.0 a	0.6 ab	0.8 a	0.0 a	0.5 abc	0.0 a	1.0 ab
2.	Elite 45DF 6.0 oz + Captan 50W 3.0 lb Benlate 50W 12.0 oz	1/2"-G, OC, P, B, PF, 1C, 2C 1/2"-G thru 7C 6C, 7C	0.8 a	0.0 a	0.6 ab	1.2 a	0.0 a	0.3 ab	0.0 a	4.5 a-d
3.	Elite 45DF 6.0 oz + Polyram 80W 3.0 lb Captan 50W 3.0 lb Benlate 50W 12.0 oz	 1/2"-G, OC, P, B, PF, 1C, 2C 3C thru 7C 6C, 7C	2.2 abc	0.0 a	0.6 ab	2.3 a	0.0 a	1.7 bc	0.0 a	5.1 bcd
4.	Vangard 75WG 5.1 oz Vangard 75WG 2.56 oz + Dithane 75DF 3.0 lb Captan 50W 3.0 lb	1/2"-G, OC P, B, PF, 1C, 2C 3C thru 7C	1.8 ab	0.0 a	0.5 a	0.7 a	0.0 a	0.1 a	0.0 a	10.0 de
5.	Vangard 75WG 5.1 oz Vangard 75WG 5.1 oz + Dithane 75DF 3.0 lb Captan 50W 3.0 lb	1/2"-G, OC P, B, PF, 1C, 2C 3C thru 7C	0.6 a	0.0 a	0.1 a	0.1 a	0.0 a	0.2 ab	0.0 a	12.1 e
6.	Procure 50W 6.0 oz + Dithane 75DF 3.0 lb Ziram 75DF 4.0 lb Ziram 75DF 3.0 lb + Topsin-M 85WDG 12.0 oz	 1/2"-G, OC, P, B, PF, 1C, 2C 3C, 4C, 5C 6C, 7C	10.2 d	1.5 a	2.0 ab	2.9 a	0.8 a	1.6 abc	0.0 a	0.9 a
7.	Procure 50W 8.0 oz + Dithane 75DF 3.0 lb Ziram 75DF 4.0 lb Ziram 75DF 3.0 lb + Topsin-M 85WDG 12.0 oz	 1/2"-G, OC, P, B, PF, 1C, 2C	5.6 cd	0.3 a	2.0 ab	1.7 a	0.9 a	0.9 abc	0.0 a	2.9 abc
8.	Nova 40W 3.0 oz + Dithane 75DF 3.0 lb Captan 50W 4.0 lb Topsin-M 85WDG 12.0 oz	 1/2"-G, OC, P, B, PF, 1C, 2C 3C thru 7C 6C, 7C	4.6 bc	0.0 a	2.0 ab	1.6 a	0.8 a	2.4 c	0.0 a	2.1 abc

Table 1 . Apple Scab and Powdery Mildew Incidence on Apple Cultivars Treated Seasonally with Fungicides Applied Airblast at 50GPA in 1997. Penn State Fruit Research and Extension Center, Biglerville, PA. K.D. Hickey. (continued)

			Percent Apple Scab							Percent P. mildew
			'Rome'		'Delicious'	'Stayman'		'G. Delicious'		'Rome'
	Fungicide and Rate/A	Application Timing	Lvs	Fruit	Lvs	Lvs	Fruit	Lvs	Fruit	Lvs
9.	Maximum 62W 4.0 lb Captan 50W 6.0 lb	1/2"-G, OC, P, B, PF, 1C, 2C 3C thru 7C	4.1 bc	0.3 a	0.8 ab	0.8 a	0.0 a	1.2 abc	0.0 a	1.1 a
10.	Maximum 62W 8.0 lb Nova 40W 3.0 oz Captan 50W 6.0 lb	1/2"-G, OC, P, B, PF, 1C, 2C 1C, 2C 3C thru 7C	0.9 a	0.0 a	0.3 a	0.7 a	0.3 a	0.2 ab	0.0 a	1.3 ab
11.	Maximum 62W 8.0 lb Nova 40W 3.0 oz Indar 75WSP 2.0 oz	1/2"-G, OC, P, B, PF, 1C, 2C 1C, 2C 3C thru 7C	0.7 a	0.0 a	0.5 a	0.8 a	0.0 a	0.0 a	0.0 a	0.7 a
12.	Nontreated	....	44.8 e	63.0 b	31.5 c	50.0 b	70.3 b	36.3 d	60.0 b	7.3 cde

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

Apple: (*Malus domestica* '('Golden Delicious', 'Red Delicious', 'Rome Beauty')
Apple scab; *Venturia inaequalis*
Cedar-Apple Rust; *Gymnosporangium juniperi-virginianae*
Powdery mildew; *Podosphaera leucotricha*

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EFFICACY OF EXPERIMENTAL FUNGICIDES APPLIED AS DILUTE SPRAYS FOR APPLE DISEASE CONTROL, 1997: Efficacy of two experimental fungicides was determined in a mature semi-dwarf orchard planted 30 X 35 ft and pruned to 12 ft high. Treatments were arranged in a randomized complete block design with four replicates. Plots consisted of three trees, one of each cultivar planted in a group at each tree site. Apple scab inoculum was high and environmental conditions were moderately favorable during the primary infection period, but drought conditions during the summer were unfavorable for secondary spread. There were seven primary scab infection periods (two severe and five low) between tight-cluster (12 Apr) and first/second cover (1 Jun) recorded with a Neogen Disease Predictor (Mills Modified Model). Apple powdery mildew and cedar-apple rust inocula were light. Temperatures from pink to first cover were generally too low for mildew development and only one rust infection period occurred at first cover (25 May). Wetting periods during the summer were infrequent and inadequate for significant development of sooty blotch and flyspeck. The fungicide treatments were applied as dilute sprays timed at 7-10 da intervals from tight-cluster through petal-fall and at approximately 14-day intervals during the cover sprays. Applications were made with a high pressure orchard sprayer operated at 400 psi and equipped with a 9-nozzle boom which delivered 2.8 gallons/tree (280 gallons/A). Application dates and growth stages were: 11 Apr (tight-cluster), 21 Apr (open-cluster), 28 Apr (pink), 5 May (bloom), 12 May (petal-fall), first through seventh cover sprays on 23 May, 6, 20 Jun, 5, 17, 31 Jul, and 14 Aug, respectively. The percent infection of vegetative leaves with scab, mildew, and rust was determined by observing all leaves on 15 nonfruiting terminals/replicate on 2-3 Jul ('Delicious'), 20-24 Jul ('Rome'), and 31 Jul ('Golden Delicious'). Disease incidence on fruit was recorded at harvest (23 Sep, 'Golden Delicious'; 24 Sep, 'Delicious'; and 9 Oct, 'Rome Beauty') on 100 fruits/replicate. Scab severity was measured by counting total lesions on up to 10 of the most severely infected fruits/replicate. Fruit russeting on 'Golden Delicious' was determined by the Horsfall-Barratt rating scale using 20 fruits/replicate. All data obtained were analyzed by the analysis of variance using appropriate transformations and significance between means was determined by the Tukey-Kramer HSD Test ($P \leq 0.05$).

Apple scab incidence on nontreated terminal leaves was moderate with 32.0, 32.9, and 16.0% infection on 'Rome Beauty', 'Delicious', and 'Golden Delicious', respectively (Table 1). Scab on nontreated fruit at harvest was appreciably higher with 55.3, 53.3%, and 26.3% infection on the same cultivars. Scab severity on nontreated trees was moderately severe with a mean 20.7, 16.8, and 1.6 lesions per fruit on 'Rome Beauty', 'Delicious', and 'Golden Delicious', respectively. On treatments showing some fruit infections, lesion count ranged from 0.2 to 1.1 per fruit. Incidence of cedar-apple rust on leaves was low to moderate and mildew infections were only 4.5% on the nontreated trees. Differences in scab control among the fungicide treatments were generally not significant and all provided very good control. Differences in scab control among the BAS 490F programs were not significant, but better rust control was obtained when Nova 40W was used in the program. RH-1647 2.75F provided excellent control of scab, but was ineffective against rust and was not different from the nontreated for mildew. The new experimental formulation of dodine was not significantly different from the Syllit 65W commercial formulation. Rust control was inadequate with dodine and infections occurred before Ziram 76DF was included in the spray program. Sooty blotch incidence on nontreated 'Golden Delicious' at harvest was 1.8% and not present on any of the treatments when observed 40 days after the last application. Flyspeck incidence was 29.5% on nontreated fruit and ranged between 0.3 and 2.8% among the treatments which were not significantly different. Fruit russet on 'Golden Delicious' fruit was low on all treatments ranging from 1.0 to 1.6% of the fruit surface affected with no significant differences among treatments. Fruit russeting was the highest on the nontreated fruit which showed 1.6%.

Table 1 . Disease Incidence on Apple Sprayed Seasonally with Fungicides Applied Dilute in 1997. Penn State Fruit Research and Extension Center, Biglerville, PA. K. D. Hickey.

			Percent Disease on Cultivars							
			'Rome Beauty'				'Delicious'		'Golden Delicious'	
		Application	Apple Scab		A. rust	P. mildew	Apple Scab		Apple Scab	
	Fungicide and Rate/100 gal	Timing	Leaves	Fruit	Leaves	Leaves	Leaves	Fruit	Leaves	Fruit
1.	BAS 490F 50W 1.1 oz Nova 40W 1.67 oz Captan 50W 2.0 lb	TC, OC, PF, 1C P, B, 2C 3C thru 7C..............	1.8 a*	0.0 a	0.1 a	0.7 a	0.5 a	0.3 a	0.4 a	0.0 a
2.	BAS 490F 50W 1.1 oz Polyram 80W 2.0 lb (1.0 lb) Captan 50W 2.0 lb	TC, OC, PF, 1C P, B, (2C) 3C thru 7C..............	2.6 ab	0.0 a	7.2 b	2.4 abc	0.9 a	0.0 a	0.2 a	0.8 a
3.	Nova 40W 1.67 oz BAS 490F 50W 1.1 oz Captan 50W 2.0 lb	TC, OC, PF, 1C P, B, 2C 3C thru 7C..............	1.9 a	0.5 a	0.7 a	0.5 a	0.6 a	0.0 a	0.4 a	0.0 a
4.	BAS 490F 50W 1.1 oz Nova 40W 1.67 oz Captan 50W 2.0 lb	TC, OC, P, 1C B, PF, 2C 3C thru 7C..............	1.2 a	0.0 a	0.2 a	0.8 ab	0.2 a	0.0 a	0.2 a	0.0 a
5.	RH-1647 2.75F 3.9 fl oz	TC thru 7C..............	3.1 abc	0.5 a	10.6 c	3.4 bcd	0.9 ab	2.8 b	0.7 ab	0.5 a
6.	RH-1647 2.75F 7.8 fl oz	TC thru 7C..............	2.4 ab	1.3 a	21.7 de	0.8 ab	0.4 a	1.8 ab	0.3 a	0.0 a
7.	Nova 40W 1.0 oz + Dithane 75DF 1.0 lb Captan 50W 1.5 lb Topsin-M 85WDG 4.0 oz	 TC, OC,P,B,PF,1C,2C 3C thru 7C 6C, 7C...................	2.6 ab	0.0 a	0.3 a	0.6 ab	0.3 a	0.0 a	0.6 a	0.0 a
8.	Syllit 65W 6.0 oz Ziram 76DF 1.5 lb Topsin-M 85WDG 4.0 oz	TC thru 2C 3C thru 7C 6C, 7C...................	5.0 bc	0.8 a	6.8 b	5.6 d	1.3 ab	0.0 a	2.2 bc	0.5 a
9.	Dodine 65W (Exp.) 6.0 oz Ziram 76DF 1.5 lb Topsin-M 85WDG 4.0 oz	TC thru 2C 3C thru 7C 6C, 7C...................	6.8 c	0.5 a	16.7 d	2.7 cd	2.7 b	1.8 ab	3.7 c	1.3 a
10.	Nontreated	....	32.0 d	55.3 b	26.3 e	4.5 cd	32.9 c	53.3 c	16.0 d	26.3 b

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

Apple: (*Malus domestica* "Golden Delicious', 'Red Delicious', ' Rome Beauty', 'York Imperial')
Apple scab; *Venturia inaequalis*
Cedar-Apple rust; *Gymnosporangium juniper-virginianae*

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APPLE SCAB AND RUST INCIDENCE ON FOUR APPLE CULTIVARS SPRAYED CONCENTRATE FROM ALTERNATE MIDDLES WITH VANGARD FUNGICIDE PROGRAMS IN 1997: The efficacy of Vangard, an experimental fungicide, applied to apple in two spray programs was determined in an experimental orchard planted to eight cultivars (four used in this evaluation). The test orchard consisted of 16-year-old trees grown on MM 106 rootstock and planted at 20 ft between trees in rows 22 ft wide. Each row contained six trees each of two cultivars and each four row section planted to the eight cultivars was replicated four times. The trees were of moderate density and pruned to a height of 12 ft. The apple scab inoculum level was light to moderate and environmental conditions favored disease development during the pre-bloom through the first cover period (11 Apr - 4 Jun). There were seven primary apple scab infection periods between tight-cluster (12 Apr) and first/second cover (1 Jun). Apple rust infections from natural inoculum occurred only during one wetting period on 25 May (first cover). The fungicide sprays were applied at 50 gallons/A from alternate middles with a Metters 36 airblast orchard sprayer operated at 2.5 mph with a manifold pressure of 200 psi. Tree growth stages and tree side (A or B) to which the spray was directed and application dates follows: 1/2"-green - tight-cluster, side A on 11 Apr and side B on 14 Apr; open-cluster, side A on 21 Apr and side B on 25 Apr; bloom, side A on 30 Apr and side B on 7 May; petal-fall, side A only on 13 May; first cover, side B only on 21 May; second cover, side A only on 4 Jun; third cover, side B only on 17 Jun; third/fourth cover, side A only on 27 Jun; fourth cover, side B only 7 Jul; fifth cover, side A only on 16 Jul; sixth cover, side B on 25 Jul and side A on 4 Aug; seventh cover, side B on 14 Aug and side A on 21 Aug. Incidence of apple scab on vegetative terminal leaves was recorded by observing all leaves on each of 15 terminals/tree (6 trees/treatment for each cultivar) on 9-10 Jul ('Delicious'), 10 Jul ('Golden Delicious'), 1 Aug ('Rome Beauty'), and 8 Aug ('York Imperial'). Incidence of rust on 'Rome Beauty' leaves was recorded on 1 Aug. Scab incidence on fruit was obtained by observing 100 fruits/tree (6 trees/treatment). Data obtained were analyzed by analysis of variance using appropriate transformations and significance between means was determined by the Tukey-Kramer HSD test ($P \leq 0.05$).

Apple scab incidence on nontreated leaves was low, ranging from 15.9% on 'York Imperial' to 29.6% on 'Rome Beauty' (Table 1). Fruit scab on nontreated was moderate in severity, ranging from 42.0% on 'Delicious' to 75.3% on 'Rome Beauty'. A severe drought in July and Aug prevented secondary spread of scab except for one rain period on 23-24 Jul which was favorable for disease development (accumulated wetness of 41 hours at 62^{o} F). Both Vangard 75WG spray programs provided good protection against scab during the early season and the captan plus ziram applications during the cover spray period allowed less than 1% scab infection. Only minor differences in scab incidence between the Vangard programs and the Nova plus Dithane standard treatment was found. Cedar-apple rust control was provided by the mancozeb and ziram used in the treatments, since infection did not occur until 25 May (first cover). There was no evidence of fruit phytotoxicity to leaves or fruit among the cultivars.

Table 1 . Disease Incidence on Apple Sprayed Seasonally with Fungicide Treatments Applied Concentrate (Airblast at 50 GPA) from Alternate Middles in 1997. Penn State Fruit Research and Extension Center, Biglerville, PA. K. D. Hickey.

Fungicide and Rate/A	Application Timing	Percent Apple Scab 'Rome' Lvs	'Rome' Fruit	'Delicious' Lvs	'Delicious' Fruit	'York' Lvs	'York' Fruit	'G. Delicious' Lvs	'G. Delicious' Fruit	Percent A. rust 'Rome' Lvs
1. Nontreated	....	29.6 c*	75.3 b	20.7 c	42.0 b	15.9 c	57.3 b	19.5 b	48.0 b	10.4 c
2. Vangard 75WG 5.0 oz	TC									
Vangard 75WG 3.0 oz + Dithane 75DF 3.0 lb	OC, P, B, PF									
Captan 50W 2.0 lb + Ziram 76DF 2.0 lb	1C thru 7C									
Topsin-M 85WDG 12.0 oz	6C, 7C	2.1 b	0.0 a	2.0 b	0.2 a	1.6 b	0.3 a	0.4 a	0.0 a	1.5 b
3. Vangard 75WG 5.0 oz	TC, OC									
Vangard 75WG 3.0 oz + Dithane 75DF 3.0 lb	P, B, PF									
Captan 50W 2.0 lb + Ziram 76DF 2.0 lb	2C thru 7C									
Topsin-M 85WDG 12.0 oz	6C, 7C.............	2.3 b	0.5 a	0.7 ab	0.3 a	0.2 a	0.0 a	0.7 a	1.2 a	1.1 b
4. Nova 40W 5.0 oz + Dithane 75DF 3.0 lb	TC									
Nova 40W 3.0 oz + Dithane 75DF 3.0 lb	OC,P,B,PF,1C,2C									
Captan 50W 4.0 lb	3C,4C,5C,6C,7C									
Topsin-M 85WDG 12.0 oz	6C,7C..............	0.1 a	0.0 a	0.3 a	0.0 a	0.1 a	0.0 a	0.3 a	0.0 a	0.0 a

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

Apple: (*Malus domestica* 'Golden Delicious', 'Red Delicious', 'Rome Beauty', 'York Imperial')
Apple scab; *Venturia inaequalis*
Cedar-Apple rust; *Gymnosporangium juniper-virginianae*
Powdery mildew; *Podosphaera leucotricha*

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EFFICACY OF EXPERIMENTAL COMPOUND M-96-018 FOR DISEASE CONTROL ON APPLE IN 1997: The efficacy of a new experimental compound from the Engelhard Corporation for apple disease control was determined in an 18-year-old semi-dwarf orchard. The trees were planted in rows 22 ft wide the pruned to a height of 12 ft. The treatments were arranged in a randomized complete block design with four replicates. Experimental plots consisted of one tree each of six cultivars (four used in this experiment) planted 15 ft apart along the rows and separated by a 50 ft space between plots. Inoculum of the apple scab fungus was high and environmental conditions were moderately favorable during the primary infection period, but drought conditions during the summer were unfavorable for secondary spread. There were seven primary scab infection periods (two severe and five low) between tight-cluster (12 Apr) and first/second cover (1 Jun) recorded with a Neogen Disease Predictor (Mill's Modified Model). Both apple powdery mildew and cedar-apple rust were light in this test block. Temperatures from pink to first cover were generally too low for mildew development and only one rust infection period occurred at first cover (25 May). Wetting periods during the summer were infrequent and inadequate for significant development of sooty blotch and fly speck or fruit rots. The experimental compound M-96-018 was evaluated in two spray programs applied as dilute sprays with a high-pressure orchard sprayer operated at 400 psi and equipped with a 9-nozzle boom which delivered 2.8 gallons/tree (280 gallons/A). In one program the compound was used alone for the entire season and was compared to a second program in which its use was limited to the post-bloom period. The programs were compared to a standard fungicide program used in commercial orchards. The treatments were applied at 5-8 day intervals during the pre-petal-fall period and at 10-15 day intervals during the post-bloom and summer sprays as follows: 16 Apr (tight-cluster), 21 Apr (open-cluster), 22 Apr (pink), 30 Apr (early-bloom), 7 May (late-bloom), 14 May (petal-fall), first through the eighth cover sprays on 23 May, 6, 19 Jun, 5,15,30 Jul, 11 and 26 Aug, respectively. Scab incidence on cluster leaves of 'Delicious' was determined on 18 Jun by examining all leaves on 25 non-blossoming clusters/tree. Scab incidence on 'Delicious' and 'Golden Delicious' terminal leaves was recorded on 3 Jul and on 18 Jul for 'Stayman' by observing all leaves on 15 vegetative terminals/tree. Similarly, scab, rust, and powdery mildew on 'Rome Beauty's' vegetative terminals was determined on 17-18 Jul. The percent fruit infected with apple scab was obtained by observing 100 fruits/replicate on 25 Sep ('Delicious', 'Golden Delicious') and 16 Oct ('Stayman', 'Rome Beauty'). Fruit russet on 'Golden Delicious' was determined by the Horsfall-Barratt rating scale using 20 fruit/replicate. All data obtained were analyzed by the analysis of variance using appropriate transformations and significance between means was determined by the Tukey-Kramer HSD test ($P \leq 0.05$).

Apple scab incidence on nontreated terminal leaves of the four apple cultivars ranged between 22.7% ('Rome Beauty') and 36.3% ('Delicious') and occurred primarily during the infection periods prior to the second cover spray period (Table 1). Scab on nontreated fruit was moderately severe ranging from 63.8% ('Delicious') to 82.7% ('Rome Beauty') infected (Table 2). The Nova plus Dithane standard fungicide program provided near complete control (range 0.0 to 1.4% leaf infection). Experimental Compound M-96-018 was not effective in protecting leaves or fruit against scab. When used seasonally in this evaluation the scab level was not significantly different from the nontreated trees. When the standard fungicide program was used during the pre-bloom period followed by M-96-018, scab control was only fair on leaves (range 3.1% to 1.9%) but poor on fruit (range 0.5% to 31.0%). Apple rust and powdery mildew incidence was very low on the nontreated trees, and the data obtained strongly suggest that M-96-018 was ineffective. There was no significant effect on fruit finish of 'Golden Delicious' which had less than 3.0% fruit russet on fruit treated with the experimental compound. Observations of disease development during the primary scab period suggests that failure to control scab, rust, and mildew on leaves was attributable to poor redistribution from sprayed tissue to new developing leaves. Poor retention of spray residues on fruit during limited rainfall conditions or degradation from solar radiation may account for the failure on fruit.

Table 1 . Incidence of Disease on Apple Leaves Treated with Experimental Compound M-96-018. Fruit Research and Extension Center, Biglerville, PA. K. D. Hickey.

Fungicide and Amt/100 gal	Application Timing	Percent Apple Scab on Leaves					Percent Disease 'Rome Beauty'	
		Cluster	Terminal					
		'Del'	'Stayman'	'Rome'	'Del'	'G. Del'	A. rust	P. mildew
1. Nontreated	- -	27.3 c*	27.7 d	22.7 c	36.3 d	32.0 c	4.8 b	2.0 b
2. Nova 40W 1.67 oz + Dithane 75DF 1.0 lb	TC, P, B							
M-96-018 25.0 lb	PF, 1C-7C.............	0.5 a	3.1 b	6.7 b	4.9 b	7.9 b	5.8 b	0.3 a
3. Nova 40W 1.67 oz + Dithane 75DF 1.0 lb	TC, P, B, PF, 1C, 2C							
Ziram 76DF 1.5 lb	3C, 4C, 5C							
Ziram 76DF 1.0 lb + Topsin-M 85WDG 4.0 oz	6C, 7C....................	0.3 a	0.3 a	1.4 a	0.0 a	1.4 a	0.3 a	0.2 a
4. M-96-018 25.0 lb	OC thru 7C............	18.5 b	22.0 c	23.4 c	28.7 c	28.8 c	9.6 c	0.9 a

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

Not for Publication

Table 2. Incidence of Scab on Apple Fruit Treated with Experimental Compound M-96-018. Fruit Research and Extension Center, Biglerville, PA. K. D. Hickey.

Fungicide and Amt/100 gal	Application Timing	Percent Apple Scab on Fruit 'Stayman'	'Rome'	'Delicious'	'G. Del'	Fruit Russet % surface affected 'G. Del'
1. Nontreated	- -	69.7 bc	82.7 c	63.8 c	64.0 b	4.2 a
2. Nova 40W 1.67 oz + Dithane 75DF 1.0 lb	TC, P, B					
M-96-018 25.0 lb	PF, 1C-7C..............	31.0 ab	12.0 b	5.8 b	0.5 a	2.3 a
3. Nova 40W 1.67 oz + Dithane 75DF 1.0 lb	TC, P, B, PF, 1C, 2C					
Ziram 76DF 1.5 lb	3C, 4C, 5C					
Ziram 76DF 1.0 lb + Topsin-M 85WDG 4.0 oz	6C, 7C....................	0.0 a	0.3 a	0.0 a	0.0 a	2.6 a
4. M-96-018 25.0 lb	OC thru 7C............	92.8 c	90.0 c	82.0 c	89.0 b	2.1 a

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

** Not for Publication **

Apple: (*Malus domestica* 'Rome Beauty')
Flyspeck; *Zygophiala jamaicensis*
Bot rot; *Botryosphaeria dothidea*

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INCIDENCE OF FLYSPECK AND BOT ROT ON APPLE SPRAYED WITH SUMMER FUNGICIDE TREATMENTS IN 1997: Fungicide treatments were applied during July and August for control of the apple summer disease complex which includes sooty blotch, flyspeck, bot rot, and black rot. The test orchard was a block of mature trees planted 30 ft X 36 ft and well-pruned to a height of 15 ft. The test trees were grafted to each of three cultivars which composed approximately one-third of the tree. Treatments were arranged in a randomized complete block design with four single-tree replicates (each with the three cultivars). The treatments were applied as dilute sprays to the point of "complete wetness" with a high pressure sprayer operated at 400 psi and equipped with a 9-nozzle boom which delivered 2.8 gallons per tree (280 gal/A). Folpet, Topsin-M, and a combination of ziram or captan (half rates) with Topsin-M were applied during the summer on: 2 Jul (fourth cover), 16 Jul (fifth cover), 30 Jul (sixth cover), and 12 Aug (seventh cover). The combinations of ziram or captan (full rates) with Topsin-M were also evaluated when applied in three applications at three week intervals on: 2, 25 Jul, and 14 Aug. Fungicides commonly used during the late cover sprays (sixth cover through eighth cover) such as captan, ziram, folpet, and Topsin-M were applied to separate plots in a single application on 21 Aug (eighth cover). This application was delayed because of low rainfall during the summer and was applied when 196 hours of accumulated wetness had been reached, starting 10 days after petal-fall (16 May). The hours of accumulated wetness was determined by a Neogen Disease Predictor which did not detect wetness caused by dew. One treatment of Topsin-M 70W 8.0 oz/100 gallons was applied first at 300 hours of accumulated wetness (16 Jul), as determined by a deWit Wetness Meter that was sensitive to wetness produced by dew formation. Two additional applications of this treatment were applied on 30 Jul (sixth cover) and 12 Aug (seventh cover). Fruit from all treatments were observed for sooty blotch and flyspeck development on 1 Oct (49 days after the seventh cover spray and 40 days after the eighth cover spray) by observing 100 fruit harvested from each replicated tree. After disease counts were completed a 25 fruit sub-sample was selected which had no disease symptoms. The sub-samples were placed on fruit packing trays, and incubated for 22 days at 73-76^{o} F and relative humidity of 90-100%. Observations for development of fruit decay and symptoms of sooty blotch and flyspeck were made after 16 and 22 days of incubation. The data obtained were analyzed by the analysis of variance using appropriate transformations and significance between means was determined by the Tukey-Kramer HSD test ($P \leq 0.05$).

Infrequent rain periods during the summer were unfavorable for fungal disease development. Accumulated wetness initiated 10-days after petal-fall (16 May) reached 196 hours on 21 Aug. During this period measurable rainfall occurred only during 25 periods with accumulated rainfall of 1.75 inches during six wetting periods in May, 2.57 inches during eight periods in Jun, 2.9 inches during eight periods in Jul, and 2.6 inches in nine periods in Aug. Sooty blotch symptoms were not observed on any treated or nontreated 'Golden Delicious' fruit at harvest and was found on only three fruit after 22 days high humidity incubation. Flyspeck incidence on the nontreated was 2.8% at harvest and was found on an additional four fruit after incubation. Differences among treatment means generally were not significant, except those showing no symptoms. Bot rot and black rot (*Botryosphaeria obtusa*) were not detectable at harvest, but bot rot incidence was 23% and 31% on nontreated trees after 16 and 22 days incubation, respectively. Variability in incidence among replicates prevented separation of treatment means except for one treatment. The combination of Ziram 76W 1.0 lb plus Topsin-M 8.0 oz was significantly different from the nontreated. The results obtained showed that infrequent rain periods have a very adverse effect on incidence of sooty blotch and flyspeck. Under these conditions sooty blotch failed to develop after more than 225 hours accumulated wetness (dew not included) or after more than 400 hours of wetness including dew.

Table 1 . Flyspeck and Bot Rot Incidence on 'Golden Delicious' Apple Sprayed with Post-bloom Fungicide Treatments in 1997. Penn State Fruit Research and Extension Center, Biglerville, PA K. D. Hickey.

	Fungicide and Amt/100 gal	Application Timing	Percent Disease: Flyspeck	Bot Rot After Incubation (days): 16	22
1.	Folpet 80WDG 20.0 oz	4C-7C[1]	0.3 ab[5]	5.0 ab	7.0 ab
2.	Folpet 80WDG 20.0 oz + Topsin-M 70W 4.0 oz	4C-7C[1]	0.0 a	3.0 ab	7.0 ab
3.	Topsin-M 70W 8.0 oz	4C-7C[1]	0.0 a	9.0 ab	12.0 ab
4.	Ziram 76W 1.0 lb + Topsin-M 70W 8.0 oz	4C-7C[1]	0.3 ab	1.0 a	4.0 a
5.	Captan 50W 1.0 lb + Topsin-M 70W 8.0 oz	4C-7C[1]	0.0 a	8.0 ab	9.0 ab
6.	Ziram 76W 2.0 lb + Topsin-M 70W 8.0 oz	4C-7C[2]	0.0 a	15.0 ab	19.0 ab
7.	Captan 50W 2.0 lb + Topsin-M 70W 8.0 oz	4C-7C[2]	0.0 a	7.0 ab	10.0 ab
8.	Ziram 76W 1.0 lb + Topsin-M 70W 8.0 oz	8C[3] (196 hr wet)	0.5 ab	11.0 ab	16.0 ab
9.	Topsin-M 70W 8.0 oz	8C[3] (196 hr wet).......	0.5 ab	14.0 ab	16.0 ab
10.	Ziram 76W 2.0 lb	8C[3] (196 hr wet).......	1.8 ab	18.0 ab	21.0 ab
11.	Folpet 80WDG 12.0 oz	8C[3] (196 hr wet).......	1.3 ab	15.0 ab	19.0 ab
12.	Topsin-M 70W 8.0 oz	5C,6C,7C[4]	0.0 a	15.0 ab	19.0 ab
13.	Captan 50W 2.0 lb	8C[3] (196 hr wet).......	1.3 ab	10.0 ab	15.0 ab
14.	Nontreated	--	2.8 b	23.0 b	31.0 b

1 Applied on 2, 16, and 30 Jul and 12 Aug at 14 day intervals
2 Applied on 2 and 25 Jul and 14 Aug at 21 day intervals.
3 Applied on 21 Aug after 196 hr accumulative wetness from 16 May (Neogen Predictor)
4 Applied on 25 Jul (after 300 hr accumulative wetness from 16 May as determined by a deWit Wetness Meter including dew) and on 17 and 21 Aug.
5 Means followed by the same letter(s) are not significantly different (Tukey-Kramer HSD Test, $P \leq 0.05$).

Apple: (*Malus domestica* "Rome Beauty')
Fire Blight; *Erwinia amylovora*
Phytotoxicity on leaves and fruit

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FIREBLIGHT INCIDENCE AND PHYTOTOXICITY TO LEAVES AND FRUIT ON 'ROME BEAUTY' TREES SPRAYED WITH ANTIBIOTICS AND COPPER COMPOUNDS IN 1997: Three antibiotic and four copper fungicides/bactericides were evaluated for control of fire blight, blossom blight, and shoot blight in a mature 'Rome Beauty'/ seeding rootstock orchard which had moderate levels of fire blight in 1996. The 35 year-old trees were planted at 25 ft in rows 30 ft wide and pruned to 12 ft high. Experimental plots consisted of three trees arranged in a randomized complete block design with four replicates. Treated trees were bordered on each side by nontreated buffer rows. Treatments were applied with a Metters 36 airblast orchard sprayer operated under still air and low evaporation conditions at 2.5 mph with a manifold pressure of 200 psi. Sprays were applied from both sides from early bloom through the third cover spray at 50 gpa. Application dates and tree growth stages were: 30 Apr (early bloom), 2 May (90% bloom), 9 May (petal-fall with 15% late bloom, 4 Jun (first cover with 5-10% late bloom), 16 Jun (second cover), and 30 Jun (third cover). Environmental conditions during the blossoming period were highly unfavorable for blossom infection and consisted of a mean temperature of 50^{o} F (30 Apr - 9 May) with accumulated leaf wetness of 25 hours for the period. The most favorable period for blossom infection was on 19-20 May when infections were recorded (MaryBlyt predictive model). Environmental conditions were not highly favorable for significant secondary spread to vegetative shoots, but the most favorable period for shoot blight infection was on 1 Jun when the mean temperature was 68^{o} F with relative humidity of 84% (range 66-93%). Incidence of blossom and shoot blight infections was recorded on 8-9 Jul by counting the number of infections (blossom and shoot) on each tree (3-4 tree plots). Incidence and severity of necrotic spotting, marginal necrosis, and chlorosis on leaves was determined by observing on 28 Aug 15 basal leaves on each of 10 vegetative terminals per tree (three trees per replicate). Leaf spotting severity was determined using the Barratt-Horsfall Rating Scale of 0-11, then converting to percentages using the Elanco Conversion Tables. Similarly, fruit russeting severity was determined on 20 fruit per replicate collected at harvest from the center tree of each three-tree plot on 22 Oct. The data obtained were analyzed by analysis of variance using appropriate transformations and significance between means was determined by the Tukey-Kramer HSD test ($P \leq 0.05$).

Incidence of fire blight on blossoms and shoots was highly variable among the treatments with four treatments showing higher blossom blight incidence than on nontreated trees. There were no significant differences among treatments because of high variability among the trees (Table 1). The data strongly suggests that the new antibiotic GWN-9100 had no activity against the fire blight pathogen. Although not as effective as Agri-mycin 17W, Mycroshield 17W, Cuprofix-M 27DG, and Kocide 2000 35W appeared to have activity in protecting blossoms and shoots from infection. Phytotoxicity to leaves and fruit russeting was evident on all trees treated with the copper compounds. No injury was found on antibiotic treatments. Incidence of leaf spotting was significantly higher on all copper treatments compared to the nontreated check. Cuprofix-M and Kocide 2000 produced significantly less injury than Copper Count-N or Champ Formula 2F. Fruit russet on copper treated trees was significantly high enough to downgrade the fruit from fresh market to a processing grade.

Table 1 . Fire Blight Incidence, Terminal Leaf Phytotoxicity, and Fruit Russeting on 'Rome Beauty' Apple Sprayed Concentrate (Airblast at 50 GPA) with Antibiotics and Copper Compounds in 1997. Penn State FREC, Biglerville, PA. K. D. Hickey.

		No. Fire blight Infections/tree				Terminal Leaf Injury		Fruit
		Blossom		Shoot		Incidence	% Surface	Russet
Bactericide and Rate/A	Application Timing	Mean	St. Dev.	Mean	St. Dev.	Percent	Affected[3]	Percent[3]
1. GWN-9100 1.0W 4.2 lb + LI-700 1.0 pt	EB, FB, PF, 1C, 2C, 3C	24.3 a[4]	49.4	9.9 a	23.3	--	--	--
2. Agri-mycin 17W 1.5 lb + LI-700 1.0 pt	EB, FB, PF, 1C, 2C, 3C	1.5 a	2.3	0.6 a	1.4	--	--	--
3. Mycoshield 17W 3.0 lb + LI-700 1.0 pt	EB, FB, PF, 1C, 2C, 3C	7.4 a	9.4	1.6 a	3.0	--	--	--
4. Cuprofix-M 27DG 3.56 lb	EB, FB, PF, 1C[1], 3C[2]	2.6 a	3.2	0.1 a	0.3	45.0 b	3.7	33.3 a
5. Copper Count-N 8%L 1.5 qt	EB, FB, PF, 1C, 2C, 3C....	13.7 a	40.6	2.3 a	7.2	64.9 c	8.2	33.3 a
6. Kocide 2000 35W 13.0 oz	EB, FB, PF, 1C, 2C, 3C....	9.1 a	16.6	1.1 a	1.6	54.3 bc	4.7	27.0 a
7. Champ Formula 2F 8.0 fl oz	EB, FB, PF, 1C, 2C, 3C....	15.3 a	28.9	2.2 a	4.8	49.0 b	3.7	33.3 a
8. Nontreated	....	8.1 a	9.8	3.7 a	8.8	5.0 a	0.5	11.4 a

1 Used at 2.5 lb/A at First Cover (1C).
2 Changed to C-O-C-S 75WDG 12.0 oz plus Dithane 75DF 3.0 lb/A.
3 Barratt-Horsfall rating scale (0-11) and Elanco Conversion Tables
4 Means followed by the same letter(s) are not significantly different, Tukey-Kramer HSD Test ($P \leq 0.05$).

EFFICACY OF FOUR POST-BLOOM APPLICATIONS OF COPPER COMPOUNDS FOR CONTROL OF FIREBLIGHT ON APPLE IN 1997

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The control of fireblight during the post-bloom period with copper compounds is hampered by low efficacy and relatively high phytotoxicity levels to leaves and fruit. The level of injury varies with type of formulation, rate, and specific application timing. Copper formulations that rapidly release copper (copper sulfate) used during the early post-bloom period causes higher rates of leaf necrosis and chlorosis and fruit russet. Chelated and fixed copper formulations often produce less leaf and fruit injury, but also are often not as effective. In a search for less injurious compounds a number of copper formulations have been evaluated in the past and the plant nutritive compound Nitro Plus 9 (9% nitrogen, 7% calcium, and 1.5% magnesium) was tested in 1996. Nitro Plus 9 manufactured by Stoller Chemical Company reportedly has been used effectively for fireblight control by a number of apple growers in Michigan during the mid-1990's. Our results in 1996 showed no significant improvement when it was used in one, two, three, or four post-bloom applications on 'Rome Beauty' apple, but variability in fireblight incidence prevented statistical separation of treatment means.

Further evaluation of Nitro Plus 9 used alone and in combination with Keylate, a chelated copper compound, was evaluated in comparison to Copper Count-N, a copper ammonium complex, manufactured by Mineral Research and Development Corporation. This compound has been used with varied success and phytotoxicity levels varies with rate used. The test site was a mature semi-dwarf orchard planted 30 ft X 35 ft and pruned to 12 ft high. Many of the test trees were previously infected with fireblight in 1995 and 1996 and most of the 'Rome Beauty' trees had one or more overwintering cankers which provided ample inoculum for shoot blight infection in 1997. No blossom sprays for fireblight blossom blight were applied. Environmental conditions were not favorable for blossom blight, but a few blossom blight and shoot blight infections were apparent at the time of the first applications. Treatment plots contained three trees, one of each cultivar ('Delicious', 'Golden Delicious', and 'Rome Beauty') planted in a group at each tree site. Treatment plots were arranged in a randomized complete block design across four rows and included four double-plot replicates. Treatments were applied as dilute sprays with a high pressure sprayer operated at 400 psi and equipped with a 9-nozzle boom which delivered 2.8 gallons per tree (280 gals/A). Treatments were applied in four applications beginning between second and third cover spray on 17 Jun and repeated on: 26 Jun (third cover), 10 Jul (fourth cover), and 21 Jul (fifth cover). Fireblight incidence was determined on 20 Oct by observing all infections on each tree. Observations for phytotoxicity to leaves and fruit were made throughout the summer, and russet ratings on 'Golden Delicious' was made at harvest. Leaf samples for nitrogen and copper analyses were collected on 7 Aug and after being oven dried were analyzed by the Penn State University Soil and Leaf Analysis Laboratory. Data for fireblight incidence were statistically analyzed by analysis of variance using appropriate transformation and significance between means was determined by the Tukey-Kramer HSD Test ($P \leq 0.05$).

Results

The first fireblight infections were observed on 17 Jun on the day of the first application. Secondary spread was generally light but continued through Jul. The nontreated trees showed a mean 10.6 strikes per tree on 20 Oct (Table 1). The number of strikes per tree ranged from a mean 3.6 to 23.5 and differences among treatment means were not significant because of high variation in incidence per tree. The Nitro Plus 9 treatment used alone had 23.5 strikes per tree while the combination with Keylate 32.0 fl oz/100 gal had 3.6 strikes. The Copper Count-N treatments were no more effective than those treated with Keylate. Leaf nitrogen levels on two of the treatments sprayed with Nitro Plus 9 48 fl oz/100 gal (4.2 qt/A) were 2.04 and 2.05 percent which was lower than the nontreated trees (2.10%). The incidence of fire blight on these treatments was not related to nitrogen level. The amount of copper in the leaf tissue samples was closely correlated with treatment rate, but not to incidence of fire blight. Leaf injury was minimal on all three cultivars and the level not determined. Fruit russet on 'Golden Delicious' was light among the treatments and only the level on the Copper Count-N 20 fl oz rate was significantly higher.

Table 1 . Incidence of Fireblight on 'Rome Beauty' Apple and Fruit Russet on 'Golden Delicious' Treated with Copper Compounds in Four Post-bloom Dilute Applications in 1997. Penn State Fruit Research and Extension Center, Biglerville, PA. K. D. Hickey.

Treatment and Rate/100 gal	Applic. Timing	Fire blight strikes/tree 'Rome Beauty'	% Surface russeted 'G. Del'	Leaf Analyses Nitrogen Percent	copper ug/gm
1. Nitro Plus 9 48.0 fl oz	2/3C,3C,4C,5C....	23.5 a*	4.7 a	2.04	--
2. Nitro Plus 9 48.0 fl oz + Keylate 5% CU 16.0 fl oz	2/3C,3C,4C,5C ...	11.5 a	7.6 ab	2.05	18
3. Nitro Plus 9 48.0 fl oz + Keylate 5% CU 32.0 fl oz	2/3C,3C, 4C, 5C ..	7.8 a	7.0 a	--	32
4. Nitro Plus 9 48.0 fl oz + Keylate 5% CU 32.0 fl oz Nitro Plus 9 48.0 fl oz	2/3C,3C,4C,5C ...	3.6 a	5.4 a	--	16
5. Copper Count-N 8% CU 20.0 fl oz	2/3C,3C,4C,5C..	15.9 a	17.7 b	--	--
6. Copper Count-N 8% CU 10.0 fl oz + Dithane 75DF 1.0 lb	2/3C,3C,4C,5C...	21.0 a	4.4 a	--	--
7. Water Check	2/3C,3C,4C,5C...	10.6 a	4.2 a	2.10	7

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

PHYTOTOXICITY TO LEAVES AND FRUIT OF APPLE PRODUCED BY COPPER COMPOUNDS APPLIED IN THREE APPLICATIONS

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An experimental copper compound (GX-270) and Kocide 2000 (cupric hydorxide) developed by Griffin Corporation was evaluated for level of phytotoxicity to apple leaves and fruit when applied as dilute sprays during the early post-bloom period. Applications were made with a high pressure orchard sprayer operated at 400 psi and equipped with a 9-nozzle boom which delivered 2.8 gallons/tree (280 gal/A). The test was conducted in a mature semi-dwarf orchard planted 30 X 35 ft and pruned to 12 ft high. Treatments were arranged in a randomized complete block design with three replicates. Replicated plots consisted of three trees, one each of the cultivars Delicious, Golden Delicious, and Rome Beauty, planted in a group at each tree site. Applications were made during the early cover spray period on: 19 May (first cover), 3 Jun (second cover), and 16 Jun (third cover). Necrotic leaf spotting and marginal necrosis was determined on 'Rome Beauty' leaves on 28 Aug by observing the 10 basal leaves on each of 10 vegetative terminals per replicated tree. Phytotoxicity severity was determined by estimating the percent of leaf area affected using the Barratt-Horsfall rating scale of 0-11 then converting to percentages using the Elanco Conversion Tables. Fruit russeting on 'Golden Delicious' fruit at harvest (26 Sep) was similarly estimated on 20 fruits per replicate. All data obtained were analyzed by the analysis of variance using appropriate transformations and significance between means was determined by the Tukey-Kramer HSD test ($P \leq 0.05$).

Data presented in Table 1 show that incidence of necrotic spotting and marginal necrosis with limited chlorosis on leaves sprayed with the copper compounds varied from 36% to 49%. Differences among treatment means were not significant. The level of injury was low with a range 1.4% to 2.7% of the leaf surface affected. Only the Kocide 2000 4.3 oz/100 gal rate was significantly higher than the nontreated. All of the treatments produced fruit russet on 'Golden Delicious' significantly higher than the nontreated. Differences among treatments were generally not significant.

Table 1. Apple Leaf and Fruit Phytotoxicity Produced by Copper Compounds Applied in Three Dilute Applications in 1997. Penn State Fruit Research and Extension Center, Biglerville, PA. K. D. Hickey.

Product and Rate/100 gal			'Rome Beauty' Percent Leaf Phytotoxicity		'Golden Delicious' Fruit Russet
			Incidence	Surface Affected	% Surface Affected
1.	Kocide 2000	4.3 oz	49.0 b*	2.1 b	23.7 bc
2.	Kocide 2000	3.2 oz	42.0 ab	1.6 ab	10.2 ab
3.	GX-270	7.6 oz	41.0 ab	1.6 ab	33.3 c
4.	GX-270	5.7 oz	33.3 ab	1.4 a	27.0 bc
5.	GX-270	3.8 oz	36.3 ab	1.6 ab	27.0 bc
6.	Water Check		28.3 a	1.2 a	7.0 a

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

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

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DISEASE INCIDENCE ON MONTMORENCY CHERRY SPRAYED SEASONALLY WITH FUNGICIDES IN 1997: The efficacy of seasonal fungicide sprays was determined in a 18 year-old orchard planted at 30 X 30 ft and well-pruned to a height of 12 ft. Low temperatures during the blossoming season were unfavorable for brown rot blossom blight infection. Although the inoculum levels for leafspot and brown rot were high, low rainfall during the immediate post-bloom period was unfavorable for leafspot and brown rot development. The accumulated rainfall amount for June was 2.44 inches with an accumulation of 47 hours of leaf wetness. Fungicide treatments were arranged in a randomized complete block design with four single-tree replicates and applied seasonally as protective dilute sprays. Trees were sprayed to "complete wetness" with a high-pressure (400 psi) sprayer equipped with a 9-nozzle boom which delivered 3.0 gallons per tree (300 gallons/A). Sprays were applied on: 25 Apr (bloom), 14 May (shuck-fall), 29 May (first cover), 9 Jun (second cover), 30 Jun (7-days pre-harvest), 7 Jul (harvest), and 22 Jul (post-harvest). A random sample of 100 fruits from each single-tree replicate was harvested one hour after the harvest application was applied on 7 Jul. Fruits were placed stem-end down on styrofoam plates and inoculated by atomizing with conidia of *Monilinia fructicola* at 1 X 10^5 conidia/ml. Incubation was for 7 and 9 days at 73-75° F and 100% relative humidity under a polyethylene tarp. Soluble solids were determined at harvest with a Atago PR-1 refractometer from a 50-fruit composite sample from each tree. The effect of fungicide treatments on fruit size was determined by counting the number of fruit/kg. Incidence of cherry leafspot and powdery mildew on leaves was determined on 12 Aug and 12 Sep by observing all leaves on 10 vegetative terminals/single tree replicate. The data obtained were subjected to an analysis of variance using appropriate transformations and the significance between treatment means was determined by the Tukey-Kramer HSD test ($P \leq 0.05$).

At harvest on 7 Jul brown rot incidence on nontreated fruit was less than 0.01%. All fungicide treatments provided excellent control of brown rot after 7- and 10-day incubation periods on inoculated fruit (Table 1). Incidence of anthracnose rot was commonly found at harvest with 5-10% infection on nontreated and treated fruit. RH-1647 2.75F, Indar 75W, and TM-402 50WDG were not effective against anthracnose. Both RH-1647 and Indar provided significantly better control of powdery mildew than Elite or TM-402, which were not significantly different from the nontreated. Leaf spot incidence was very low with only 15.4 and 23.2% of leaves infected on 12 Aug and 12 Sep, respectively. Elite, Indar, and the 6.2 fl oz rate of RH-1647 provided significantly better control of leaf spot than other treatments. There were no significant adverse effects on fruit size or soluble solids levels, caused by any of the treatments (data not shown).

Table 1. Disease Incidence on 'Montmorency' Cherry Sprayed Seasonally with Dilute Fungicide Treatments in 1997. Penn State Fruit Research and Extension Center, Biglerville, PA. K. D. Hickey.

Fungicide and Rate/100 gal	Application Timing	Percent Brown rot* Incubation days 7	10	Percent Anthracnose 10 days	Percent Disease P. mildew 12 Aug	Leaf spot 12 Aug	12 Sep
1. RH-1647 2.75F 3.1 fl oz	B, SF, 1C, 2C, 7 da, 0 da PHI, PH	0.8 a**	3.8 ab	53.3 b	13.5 ab	12.7 bc	24.4 b
2. RH-1647 2.75F 6.2 fl oz	B, SF, 1C, 2C, 7 da, 0 da PHI, PH	0.8 a	4.5 ab	41.8 ab	4.2 a	1.8 a	5.8 a
3. Indar 75W 0.67 oz	B, SF, 1C, 2C, 7 da, 0 da PHI, PH	1.3 a	4.5 ab	58.8 b	17.9 b	1.2 a	4.7 a
4. Elite 45DF 2.0 oz Captan 50W 2.0 lb Elite 45DF 1.5 oz + Captan 50W 1.0 lb Elite 45DF 2.0 oz	B, SF 1C, 2C 7 da, 0 da PHI Post-harvest	0.0 a	0.3 a	10.0 a	30.7 c	1.4 a	4.0 a
5. TM-402 50WDG 8.0 oz	B, SF, 1C, 2C, 7 da, 0 da, PHI, PH	2.0 a	7.0 b	51.0 b	32.0 c	4.1 ab	9.2 ab
6. Nontreated	....	14.0 b	29.8 c	47.5 ab	36.9 c	15.4 c	23.2 b

* Brown rot from inoculations with *Monilinia fructicola* at harvest.

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

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

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BROWN ROT INCIDENCE ON PEACH FRUIT TREATED WITH FUNGICIDES WHEN APPLIED AS DILUTE SPRAYS AT BLOOM AND PRE-HARVEST, 1997: Fungicide treatments applied dilute during the blossoming and pre-harvest periods were evaluated for efficacy against brown rot. The treatments were applied in a seven year-old experimental orchard with trees planted at 10 feet in rows 30 feet wide. Experimental plots consisted of three trees, one each of 'Loring' peach, 'Redskin' peach, and 'Sunglo' nectarine which were arranged in a randomized complete block design with four replicates. Because of low temperature injury to blossoms the nectarine trees had insufficient fruit numbers for adequate evaluations. The fungicide sprays were applied with a high pressure orchard sprayer equipped with a 6-nozzle boom and operated at 400 psi. Sprays were applied to "complete wetness" using two gallons per tree (200 gallons/A) and were timed to protect blossom infections and fruit near harvest. Generally fungicides were not applied during the developmental stages between petal-fall and six days before harvest except for three treatments that received three additional applications at shuck-fall, second and fourth covers. The blossom sprays were applied on 11 Apr (early-bloom) and 17 Apr (full-bloom). Timing of the mid-season sprays for the three treatments on both cultivars was 13 May (shuck-fall), 9 Jun (second cover), and 8 Jul (fourth cover). The near-harvest applications were made as follows: 'Loring' on 19 Aug (6-day PHI) and 25 Aug (day of harvest or 0 day PHI); 'Redskin' on 2 Sep (6-day PHI) and 8 Sep (day of harvest). Brown rot incidence on fruit was determined by observing 20 uniformly selected fruit per replicate collected 1-2 hours after final spray. Fruits were harvested at a "firm-ripe" stage which showed slight yellowing of the "green" ground-color. Fruits were placed stem-end down on fruit packing trays and inoculated by uniformly atomizing with a 1 X 10^5 conidia per ml suspension of the pathogen. Conidia were from an isolate obtained in 1996 from the same test orchard, produced on canned peach halves, and stored at -20° F until used. The germination rate on PDA plates was 95%. Fruits were incubated for 5, 7, 9, and 11 days at 77° F ('Loring') and 74-75° F ('Redskin') and 95-100% RH under a polyethylene tarp before disease incidence was determined. The data were subjected to analysis of variance using appropriate transformations and significant differences among means determined by the Tukey-Kramer HSD test ($P \leq 0.05$).

Low temperatures during the blossoming season were unfavorable for blossom infections throughout the region and no blossom blight was found in the test orchard. Brown rot incidence in the orchard was not evident on the nontreated or treated trees at harvest. Brown rot development on 'Loring' from the post-harvest inoculation was 17.5% after a 5-day incubation which progressed to 65% infection after 11 days incubation (Table 1). Differences among the treatments were not significant until the 11th day. At this observation time Abound 2.1SC 6.1 fl oz showed significantly better control than the nontreated control but not significantly different from other treatments. Although not significantly different, brown rot levels were appreciably lower on many of the treatments with the exception of TM-402 and Rovral which were closer to the nontreated level. The 'Redskin' nontreated fruit showed 21.3% infection after five days and 62.5% after 11 days incubation. Brown rot levels after a 5-day incubation were significantly different from the nontreated on fruit treated with Orbit 45W, Indar 75WSP plus Captan 50W (mid-season only), and Abound 2.1SC 4.3 fl oz. As on 'Loring', differences among means of other treatments and the nontreated on 'Redskin' were not significant because of variability in brown rot development on harvested fruit. This may have been influenced by the extreme shortage of rainfall during the summer months which extended through Oct. Brown rot levels on 'Redskin' was lower than on 'Loring' fruit treated with TM-402 50WDG. Disease levels were similar on both cultivars treated with Abound 2.1SC and no rate response was evident.

Table 1 . Brown Rot Incidence on 'Loring' and 'Redskin' Peach Sprayed with Dilute Fungicide Treatments in 1997. Penn State Fruit Research and Extension Center, Biglerville, PA. K. D. Hickey.

	Fungicide and Rate/100 gal	Application Timing	Incubation Days 'Loring' 5	7	9	11	'Redskin' 5	7	9	11
1.	Vangard 75WG 1.2 oz Orbit 45W 1.6 oz	EB, FB 6 da, 0 da PHI	11.3 a*	21.3 a	36.3 a	46.3 ab	0.0 a	2.5 a	17.5 ab	35.0 ab
2.	Elite 45DF 2.0 oz	EB, FB, 6 da, 0 da PHI..	6.3 a	16.3 a	32.5 a	50.0 ab	5.0 ab	12.5 ab	28.8 ab	40.0 ab
3.	Indar 75WSP 0.8 oz + Latron B-1956 8.0 fl oz	EB, FB, 6 da, 0 da PHI	10.0 a	20.0 a	32.5 a	51.3 ab	6.3 ab	13.8 ab	33.8 ab	51.3 ab
4.	Indar 75WSP 0.8 oz + Latron B-1956 8.0 fl oz Captan 50W 1.0 lb	EB, FB, 6 da, 0 da PHI SF, 2C, 4C..................	8.8 a	18.8 a	32.5 a	42.5 ab	0.0 a	2.5 a	11.3 a	21.3 a
5.	TM-402 50WDG 9.6 oz Captan 50W 1.0 lb	EB, FB, 6 da, 0 da PHI SF, 2C, 4C..................	17.5 a	31.3 a	41.3 a	55.0 ab	3.8 ab	8.8 a	18.8 ab	28.8 ab
6.	Abound 2.1SC 3.7 fl oz + Latron B-1956 8.0 fl oz	EB, FB, 6 da, 0 da PHI..	8.8 a	16.3 a	28.8 a	46.3 ab	5.0 ab	10.0 ab	25.0 ab	47.5 ab
7.	Abound 2.1SC 4.3 fl oz + Latron B-1956 8.0 fl oz	EB, FB, 6 da, 0 da PHI..	10.0 a	17.5 a	35.0 a	48.8 ab	1.3 a	5.0 a	13.8 a	23.8 ab
8.	Abound 2.1SC 4.9 fl oz + Latron B-1956 8.0 fl oz	EB, FB, 6 da, 0 da PHI..	7.5 a	12.5 a	23.8 a	37.5 ab	2.5 ab	7.5 ab	13.8 a	23.8 ab
9.	Abound 2.1SC 6.1 fl oz + Latron B-1956 8.0 fl oz	EB, FB, 6 da, 0 da PHI..	6.3 a	13.8 a	25.0 a	31.3 a	5.0 ab	16.3 ab	33.8 ab	46.3 ab
10.	Rovral 4F 12.8 fl oz + Latron B-1956 8.0 fl oz Captan 50W 1.0 lb	EB, FB, 6 da, 0 da PHI SF, 2C, 4C..................	16.3 a	25.0 a	37.5 a	51.3 ab	2.5 ab	11.3 ab	21.3 ab	42.5 ab
11.	Nontreated	....	17.5 a	38.8 a	53.8 a	65.0 b	21.3 b	28.8 b	52.5 b	62.5 b

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

EVALUATION OF SKYBIT VERSUS ON-SITE WEATHER INSTRUMENTATION FOR PEST PHENOLOGY PREDICTION

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Introduction

A relatively recent development in IPM programs is the use of degree day models to improve the timing of pesticide application to better coincide with the most susceptible insect stage (Hogmire 1995). Degree day models are driven by temperature data, and were developed using data acquired primarily with site-specific weather instrumentation. Grower use of these models in the past has involved the purchase, installation, and maintenance of weather instrumentation. This can be prohibitive because of the cost and time required to take data, especially with multiple orchard sites. By subscribing to an electronic weather service, such as SkyBit, Inc. (Boalsburg, Pa), growers can receive daily site-specific weather data via fax or e-mail for a monthly fee. Although some validation of electronic weather service data has been conducted (Felland et al. 1997), more extensive work is needed to compare this method with on-site instrumentation for pest phenology prediction.

Methods and Materials

On-Site Weather Instrumentation. Weather instrumentation was set up at two sites at the West Virginia University Experiment Farm in Kearneysville. Site one consisted of a standard National Weather Service shelter located within a 24 x 45 ft fenced lawn area. The weather shelter housed a hygrothermograph (Belfort Instrument Co., Baltimore, Md) and a model TA51-P biophenometer with temperature sensor (Omnidata International, Logan, Ut). Site two consisted of an identical weather shelter located in a 12 acre dwarf apple orchard of somewhat lower elevation, 1500 feet from site one. This weather shelter housed a TA51-PF biophenometer (Dataloggers, Inc., Logan, Ut), with temperature sensor located within a radiation shield positioned in a nearby apple tree. The hygrothermograph was calibrated in an environmental chamber with a factory certified liquid-in-glass thermometer. Biophenometers were checked against the liquid-in-glass thermometer and found to average +0.3°F for the TA51-P, and -0.9°F for the TA51-PF.

The above weather instrumentation was operated from April 1 to August 31, 1997. A 7-day weather chart was changed every Monday morning on the hygrothermograph. Daily maximum and minimum temperatures were recorded from the weather charts, and daily and accumulated degree days from biofix (first trap catch) were determined for Oriental fruit moth, codling moth, and tufted apple bud moth using tables in the Mid-Atlantic Orchard Monitoring Guide (Hogmire 1995). Biophenometers were programmed with lower and upper developmental base temperatures for Oriental fruit moth, codling moth, and tufted apple bud moth, and accumulated degree day values were recorded every Monday morning.

SkyBit. Daily and accumulated degree day values from biofix for Oriental fruit moth, codling moth, and tufted apple bud moth were obtained by fax from April 1 to August 31, 1997, from SkyBit, Inc. in Boalsburg, Pa.

Results and Discussion

The highest accumulation of degree days for Oriental fruit moth, codling moth, and tufted apple bud moth occurred with the hygrothermograph, followed by the biophenometer (lawn), SkyBit, and biophenometer (orchard) (Fig. 1). SkyBit values were quite close to those recorded with the biophenometer located in the lawn area, especially for codling moth (average difference of only 24 degree days). The lower accumulation of degree days with the biophenometer (orchard) than with the biophenometer (lawn) (134-226 less) is due to a combination of temperature differences between recorders (lawn biophenometer records slightly higher and orchard biophenometer records slightly lower than actual temperature) and lower temperatures in the orchard than in the lawn environment.

Differences in days of degree day predictions with the weather instrumentation as compared to SkyBit are presented in Fig. 2. Accumulated degree days from biofix to first and 50 percent egg hatch of first and second generation codling moth and tufted apple bud moth, and first and third generation Oriental fruit moth were used for these comparisons. SkyBit predictions differed by 0-2 days from the biophenometer in the lawn, 1-5 days from the hygrothermograph, and 0-10 days from the biophenometer in the orchard. Egg hatch events were predicted to occur earlier with the hygrothermograph than with SkyBit, but later with the biophenometer located in the orchard. Most insect degree day models have been developed using daily maximum and minimum temperatures as determined with a max-min thermometer or hygrothermograph. When compared to a hygrothermograph, SkyBit delayed prediction of phenological events by 1-5 days for Oriental fruit moth, 1-2 days for codling moth, and 1-4 days for tufted apple bud moth. When considering the flexibility of current pest management programs, SkyBit would appear to be a suitable substitute for on-site weather instrumentation for predicting pest phenology events.

References Cited

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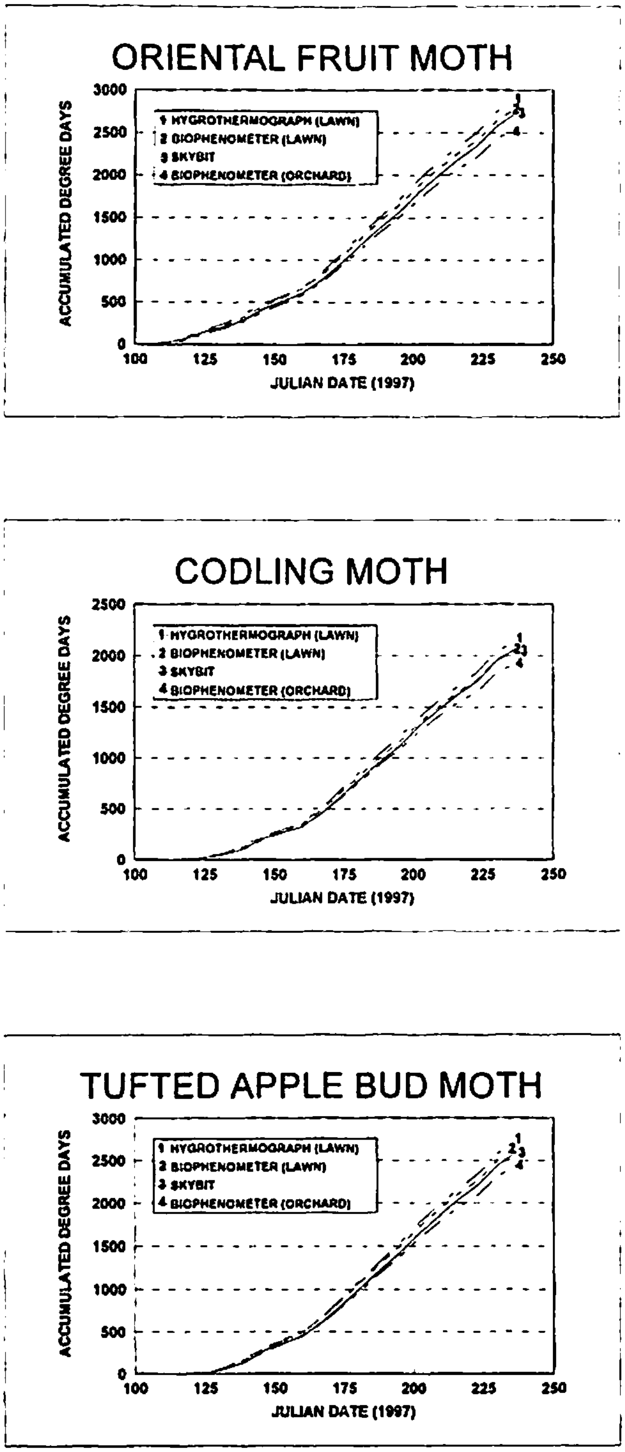

Fig. 1. Accumulated degree days for Oriental fruit moth, codling moth, and tufted apple bud moth as determined by SkyBit and on-site weather instrumentation.

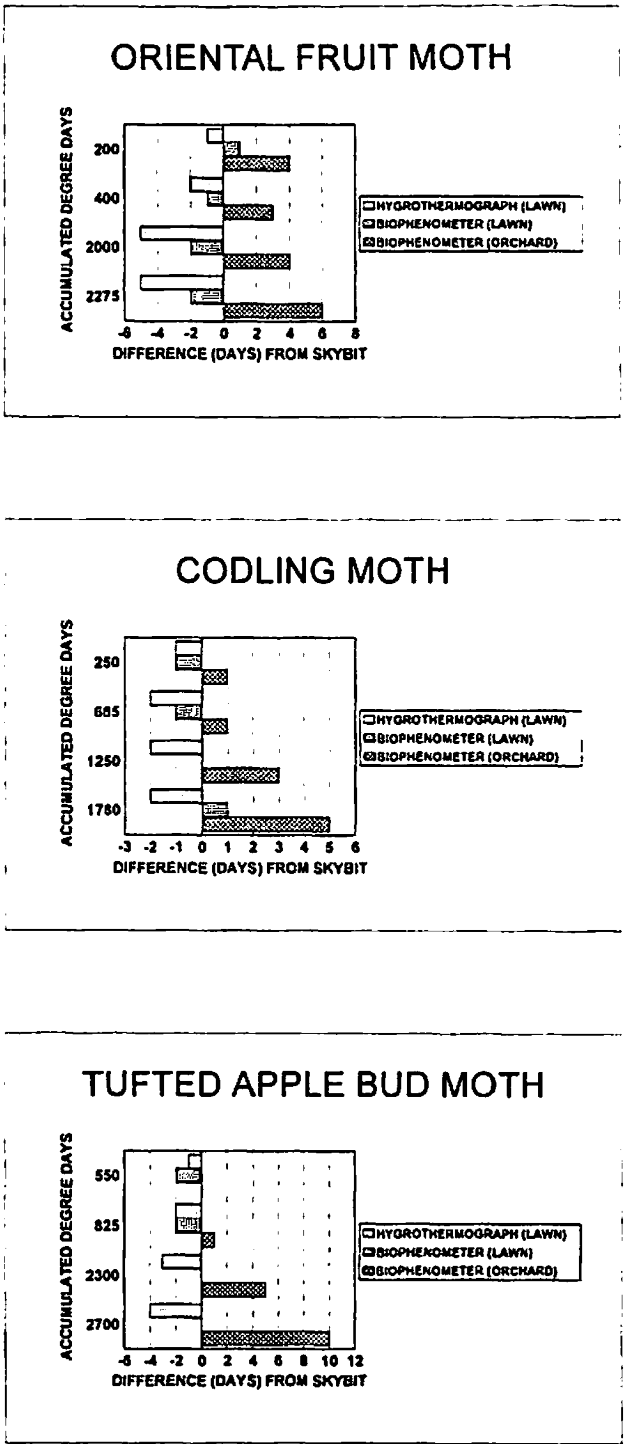

Fig. 2. Difference between SkyBit and on-site weather instrumentation in prediction of phenological events for Oriental fruit moth, codling moth, and tufted apple bud moth.

Site-Specific Apple Insect Forecasting

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We report here on the second of a three year pilot program called the Apple Orchard IPM Project. This Project is being conducted cooperatively between Penn State Research and Extension personnel and SkyBit, Inc. (Boalsburg, PA). The goal of the Project is to encourage orchardists to use new information technology products as a part of their IPM programs. To this goal we are demonstrating the use of electronic-weather (E-Weather) products for scouting and control timing for diseases and insect pests. In this report we will give an update of this Project and discuss the entomology component during the past season.

Project Background

The Project got underway in 1996 with funding from various sources. The Pennsylvania Department of Agriculture covered the full cost for twenty-five grower cooperators in 1996 and provided a 50/50 cost share split in 1997. The growers picked up their half of the cost split in 1997 and will cover the full cost of the Project in 1998. Funding from the State Horticultural Society of Pennsylvania supported a summer assistant to maintain contact with the growers. Additional start-up support can through the US Apple Association (formerly the International Apple Institute).

The growers were selected from eleven counties throughout the state. Several additional growers joined the Project on their own expense. Twenty-two of the growers elected to receive SkyBit E-Weather products by fax and the remaining seven received them by e-mail. Four of sixteen fax users indicated interest in receiving the E-Weather products by e-mail in the future. Growers reported that faxes were quicker and easier to use than e-mail and that everyone can see the faxed product.

The growers received daily forecasts and weekly pest sheets from April through August in 1996. The insects modeled were apple maggot, codling moth, Oriental fruit moth, plum curculio, and tufted apple bud moth. The sources for the insect models were the PETE model for codling moth and Oriental fruit moth egg hatch periods, Cornell for the apple maggot biofix and the plum curculio treatment period, and Penn State for the tufted apple bud moth egg hatch periods. Growers desiring to supply local biofixes for tufted apple bud moth were given traps and lures. Otherwise, biofix dates were estimated by extrapolating between sites based on degree-day accumulation and/or tree phenology.

The Project includes validation of the E-Weather data by on-site temperature data. Three growers in the southcentral counties ran hygrothermographs loaned from PSU researchers.

Additional growers provided temperature and rainfall data to PSU personnel. Weather and pest validations were also made at the Biglerville and Arendtsville farms of the Penn State FREC.

Tracking of accumulated degree-days was accurate enough to use in grower decision-making. The E-Weather and the on-site accumulated degree-days were within 2 and 5 days of predicting when the second brood of tufted apple bud moth hatch period occurred in August and September following a biofix in May. Most growers (14 out of 20) felt that their insecticide applications were better timed for tufted apple bud moth and seven applied less insecticide. Growers using the E-Weather data were able to delay the first insecticide application for each brood, and in some cases use three instead of four alternate row middle applications for this key pest because the models showed that hatch was delayed by about two weeks across the state in the cool growing season. In addition, the amount of insecticide used was reduced with 1996 being the first year that Confirm® was available for control of tufted apple bud moth on a Section 18 label. This long-residual insect growth regulator was often used in place of multiple conventional insecticides. The E-Weather data was especially pertinent because the label specifies an accumulated degree-day target for application of this product to give maximum efficacy.

Project Description 1997

The insect product was modified in 1997 based on grower feedback in 1996. In particular, a new format was introduced to provide a month's data on a single page and it was sent daily to growers and their Cooperative Extension Agents. The pests chosen were altered by the substitution of spotted tentiform leafminer for plum curculio. A new Pest Wait/Watch/Warning system, symbolized on the product by -/+/++, respectively, was introduced to alert growers to critical timings of pest appearance.

The IPM Apple Insect Product from Arendtsville on June 24, 1997 is included as an example (Fig. 1). Data from June 1 to 23 is historical and data from June 24 to 30 is forecast. The pest name is at the top of the column, under which are the lower and upper temperature thresholds, and the biofix date (B). For Oriental fruit moth (OFM) the first capture was recorded on April 6. The columns include degree-days (DD) for the individual day and the accumulated degree-days (ADD), followed by the Pest Wait/Watch/Warning. For OFM the watch is activated when moth flight began (+) and the warning of possible damage (++) occurs during the period the eggs are hatching. Note that tufted apple bud moth hatch began on June 15, which is about two weeks later than normal. For spotted tentiform leafminer the biofix is the first flight of the second generation and the warning occurs at the optimum timing to scout for sap-feeding larvae. On June 24 the 1350 ADD, 43°F from January 1 for first capture of apple maggot has not yet been forecast to occur and no adults have been captured in the region to call for the adjustment of the biofix.

Product accuracy in the temperatures that drive the insect models remains high. The ADD beginning in mid-May when the first moth was caught predicted hatch within one day for the first brood and three days for the second brood of tufted apple bud moth based on modeled hatch for various locations in southcentral Pennsylvania (Table 1). At Arendtsville the E-Weather tracked ground weather almost perfectly, although the actual hatch deviated somewhat from the model. The hatch model was very close to actual hatch during the first brood, while it was 2 or 3 days early for the final two-thirds of the second brood hatch period based on field observations. For the first brood OFM in Biglerville, hatch was also closely tracked according to field observations with the first and last hatch E-Weather dates within one day of the dates those hatch events occurred in the field. No observations were made of the hatch of the subsequent broods of OFM.

Growers found the various pest models of differing degrees of usefulness (Table 2). The greatest impact on the grower insecticide schedule was again the key pest tufted apple bud moth. Five of the twenty growers who responded changed their spray schedule for this species on the basis of the E-Weather using the local egg hatch model. Hatch was delayed and Confirm available as in 1996. Growers followed with some interest the spotted tentiform leafminer modeling and affirmed that their treatments were timed correctly for codling moth.

Plans for 1998

A positive response over the first two years has directed some additional changes for 1998. Growers have indicated additional pests they would like to be included and we plan to add white apple leafhopper and obliquebanded leafroller models. Some growers have also found degree-days cumbersome, so we plan to replace them with the percent of individuals in the targeted stage. We will retain the popular Pest Wait/Watch/Warning system. In addition the products will include degree-days from January 1 base 43°F as a standard to compare across sites and for correlation with various events in life cycles of various additional pests. Finally, we are prepared to provide more specialist comments on the products.

Summary

This Project, with its demonstration of information-technology products, has helped several groups involved in orchard management. For example, growers were able to receive daily on a single e-mailed or faxed sheet, weather data, insect model output, and pest warnings. Through this insect product, they gained confidence in their ability to refine pesticide applications. The research and extension personnel benefited by keeping track of pest development across the state and determining if models accurately portrayed insect activity in the orchards. The Project also demonstrated the potential use of alternate IPM strategies as pesticides are lost through regulation and resistance.

Acknowledgments: We thank the State Horticultural Association of Pennsylvania Research and Extension Advisory Committees, the US Apple Association (formerly the International Apple Institute), and the Pennsylvania Department of Agriculture for funding this project. Special appreciation is extended to the participating growers. We also wish to thank SkyBit, Inc. (1-800-454-2266) for its support of electronic communication among growers and researchers and for its reduced rate for the products used in this project.

Table 1. Prediction of hatch of tufted apple bud moth larvae based on E-Weather historical data and hygrothermographs in four Pennsylvania orchards, 1997.

Site (County)	First moth	Brood	E-Weather First hatch	E-Weather Last hatch	Hygrothermograph First hatch	Hygrothermograph Last hatch
Biglerville	5/12	1	6/12	7/2	6/13	7/3
(Adams)		2	8/13	9/11	8/13	9/11
Cherry Hill	5/8	1	6/10	6/29	6/10	6/29
(Lancaster)		2	8/9	9/5	8/10	9/7
Five Forks	5/14	1	6/13	7/3	6/13	7/2
(Franklin)		2	8/14	NA	8/14	NA
Shatzer's	5/9	1	6/13	7/2	6/11	7/1
(Franklin)		2	8/15	NA	8/12	NA

Table 2. Response of Pennsylvania growers to E-Weather IPM Apple Insect Products, 1997

Response	Number of growers responding for each pest				
	AM	CM	OFM	STLM	TABM
Not concerned with this pest in apple	4	1	5	0	0
Concerned, but do not have confidence in E-weather models	2	2	2	4	0
Looked at pest warnings and am beginning to feel that they may be useful	7	8	7	6	2
Pest warnings definitely seem like they will be useful	3	3	2	5	6
The pest warnings gave me confidence that what I was doing was correct	3	5	3	4	7
I changed my spray schedule based on E- weather	1	1	1	1	5

Key to acronyms: AM, apple maggot; CM, codling moth; OFM, Oriental fruit moth; STLM, spotted tentiform leafminer; TABM, tufted apple bud moth

SkyBit Inc. (518) 283-5357 06/24/97 05:19:30 Page 1 of 1

E-WEATHER SERVICE
For: PA-ARENDTSVILLE

AGWEATHER IPM APPLE INSECT PRODUCT
Date: TUE Jun 24, 1997

WEATHER				OFM 45/90 970406			TABM 45/91 970518			CM 50/88 970518			STLM 43/NA 970605			AM 43/NA ------		
Date	TMX F	TMN F	PREC in	DD	ADD	PW	DD	ADD	PW	DD	ADD	PW	DD	ADD	PW	DD	ADD	PW
BASED ON OBSERVATIONS																		
0601	73	60	0.60	22	545	++	22	232	+	17	166	+	-	-	-	-	-	-
0602	64	53	1.50	16	561	++	16	248	+	11	177	+	-	-	-	-	-	-
0603	54	48	0.49	9	570	++	9	257	+	4	181	+	-	-	-	-	-	-
0604	71	48	0.00	10	580	++	10	267	+	6	187	+	-	-	-	-	-	-
0605	73	46	0.00	14	594	++	14	281	+	10	197	+	17	17	B	-	-	-
0606	70	49	0.00	15	609	++	15	296	+	10	207	++	17	34	+	-	-	-
0607	61	51	0.00	13	622	++	13	309	+	15	215	++	15	49	+	-	-	-
0608	71	47	0.00	12	634	++	12	321	+	7	222	++	14	63	+	-	-	-
0609	79	47	0.00	16	650	++	16	337	+	11	233	++	18	81	+	-	-	-
0610	85	55	0.00	24	674	++	24	361	+	19	252	++	26	107	+	-	-	-
0611	83	57	0.00	26	700	++	26	387	+	21	273	++	28	135	+	-	-	-
0612	79	63	0.29	27	727	+	27	414	+	22	295	++	29	164	+	-	-	-
0613	79	65	0.33	27	754	+	27	441	+	22	317	++	29	193	+	-	-	-
0614	77	59	0.00	24	778	+	24	465	+	19	336	++	26	219	+	-	-	-
0615	77	55	0.00	21	799	+	21	486	++	16	352	++	23	242	+	-	-	-
0616	79	56	0.00	22	821	+	22	508	++	17	369	++	24	266	+	-	-	-
0617	79	62	0.00	26	847	+	26	534	++	21	390	++	28	294	+	-	-	-
0618	79	65	0.68	27	874	+	27	561	++	22	412	++	29	323	+	-	-	-
0619	83	63	0.00	27	901	+	27	588	++	22	434	++	29	352	+	-	-	-
0620	88	61	0.00	28	929	+	28	616	++	23	457	++	30	382	+	-	-	-
0621	91	68	0.00	34	963	+	34	650	++	29	486	++	36	419	+	-	-	-
0622	88	69	0.00	34	997	+	34	684	++	29	515	++	36	454	+	-	-	-
0623	89	60	0.00	29	1026	+	29	713	++	24	539	++	31	485	+	-	-	-
BASED ON FORECASTS																		
0624	88	67	0.00	33	1059	+	33	746	++	28	567	++	35	520	+	-	-	-
0625	92	73	0.00	36	1095	+	36	782	++	31	598	++	39	559	+	-	-	-
0626	86	73	----	36	1131	++	36	818	++	31	629	++	38	597	+	-	-	-
0627	83	65	----	30	1161	++	30	848	++	25	654	++	32	629	+	-	-	-
0628	84	62	----	28	1189	++	28	876	++	23	677	++	30	659	+	-	-	-
0629	86	64	----	30	1219	++	30	906	++	25	702	++	32	691	++	-	-	-
0630	84	64	----	30	1249	++	30	936	++	25	727	++	32	723	++	-	-	-

** IN THE FUTURE, THIS SPACE WILL HAVE MESSAGES FROM EXTENSION SPECIALISTS. **

GLOSSARY:

- DD = Degree-days for the day.
- ADD = Degree-days accumulated from the biofix date.
- PW = Pest Wait/Watch/Warning: - = not active; + = active; B = biofix day & active; ++ = active with possible damage
- OFM = Oriental Fruit Moth; TABM = Tufted Apple Bud Moth; CM = Codling Moth;
- STLM = Spotted Tentiform Leafminer; AM = Apple Maggot

** The biofix or catch date for each insect is given at the top of each column.
Call us or your local representative if you have observed a different date.

Fig. 1. Example of IPM Insect Product for Arendtsville, PA on 24 June 1997

Novel and Conventional Acaricides for European Red Mite in Apple

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I. Introduction:

European Red Mite (ERM), *Panonychus ulmi* (Koch), has proven to be an infamous pest in apple orchards, and often difficult to regulate. With increasing resistance to conventional acaricides, growers are searching for newer, more effective acaricides to assist in ERM management. In May 1997, BASF's product, pyridaben, known as Pyramite™ 60WP, received federal registration. As a mitochondrial electron transport inhibitor, pyridaben blocks cellular respiration, causing the pest to lose motile coordination and collapse. Cyhexatin (TD 2383-01 2F, Elf Atochem) is being reintroduced to the apple system after an absence of approximately 10 years; there was documented resistance to cyhexatin in Virginia at the time of its withdrawal (Pfeiffer and Pfeiffer et al. 1986). This trial compares the effectiveness of pyridaben and cyhexatin with an acaricide in current use, dicofol (Kelthane™ 50W).

II. Methods and Materials:

The efficacy of the three acaricides was compared with an untreated control. The test block consisted of one row of 32 Red Delicious, Redchief (Mercier) apple trees on Kentland Research Farm in Montgomery County (an orchard previously untreated with cyhexatin). The treatments were randomly allocated among the 32 trees, leaving one buffer tree between each experimental tree. A total of four trees was used per treatment. On 14 July an initial mite count was made. The acaricides were then applied by handgun to drip on 16 July. The amount of formulated product used per 100 gallons is as follows: cyhexatin 946 ml, pyridaben 8.5 g, dicofol 59.5 g. Samples of 20 leaves were collected from each of four trees per treatment. The leaves were then run through a mite brushing machine, and the numbers of ERM eggs, immature stages, and adults were recorded. Data were transformed, and an ANOVA, followed by Duncan's multiple range test, was performed to compare differences between treatments.

III. Results and Discussion:

The average number of motile European red mites (ERM) and eggs (RME) is presented in Table 1 and Figures 1-2. All three acaricides significantly reduced ERM densities at the first date after pretreatment count. Cyhexatin provided the most dramatic control, with pyridaben an intermediate between cyhexatin and dicofol. Overall, cyhexatin established the best control, however differences with pyridaben were never significant. Following the first date, dicofol was not significantly different from the control.

Egg density seldom reduced, in fact was often higher than the control. This may be due to the failure of eggs to hatch on treated trees, compounded by initial differences between trees (Fig. 2).

Results suggest that both cyhexatin and pyridaben provided effective control of ERM motile stages. Dicofol, however, was unable to provide sufficient control of populations; possibly due to overuse and resistance development. Pyridaben, with its unique mode of action, is a promising acaricide, especially for control of mites resistant to traditional compounds. Current control by cyhexatin supports data by Pree that cyhexatin resistance may subside after 4-6 generations and beyond (Pree et al. 1987), although resistance was never shown in this young orchard. Due to the unavailability of cyhexatin in recent years, resistance has subsided, and growers may now use the product to its full potential. Although both cyhexatin and pyridaben exhibit effective control, growers must display caution and incorporate biological control methods, as well as acaricide rotation, with all acaricide use.

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Table 1. Average numbers[1] of motile European red mites (ERM) and eggs (RME) on apple leaves (20 leaves/sample, 4 reps/treatment) at Kentland Farm, Montgomery County, VA. July 14 = pretreatment count - 1997

Treatment	7/14		7/22		7/29		8/5		8/11		8/18		8/25	
	ERM	RME	ERM	RME	ERM	RME	ERM	RME	ERM	RME	ERM	RME	ERM	RME
Dicofol	872.3a	2470.5a	663.8b	1547.3a	685.5a	1911.8b	343.5a	2049.0ab	524.3a	2511.0a	267.8a	438.0b	269.3a	674.3ab
Pyridaben	1076.3a	3566.3a	245.3bc	1784.3a	91.5b	2083.5b	40.5b	1883.3ab	61.5b	2348.3a	84.0ab	751.5b	69.8b	510.0b
Cyhexatin	1322.3a	3892.5a	84.8c	2150.3a	26.3b	2235.0b	12.0b	2922.8a	13.5b	2949.8a	23.3b	2018.3a	29.3b	1122.0a
Control	783.0a	1854.0a	1786.5a	953.3a	1153.5a	478.5a	650.3a	1032.0b	312.8a	41.3b	212.3ab	530.3b	176.3ab	575.3b

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

KENTLAND: ACARICIDE TRIAL, ERM MOTILE STAGES

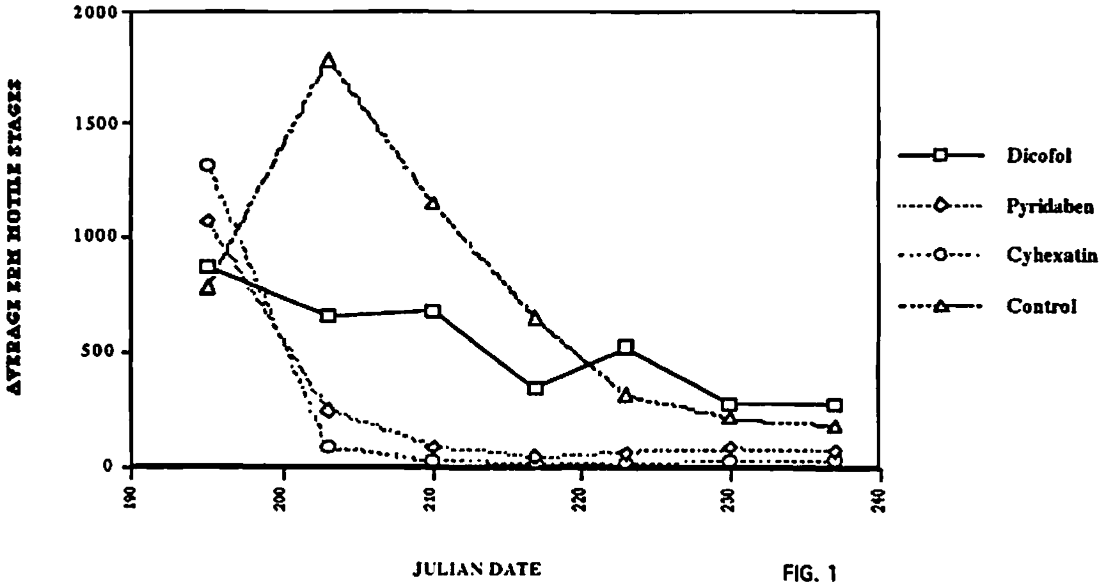

FIG. 1

KENTLAND: ACARICIDE TRIAL, ERM EGGS

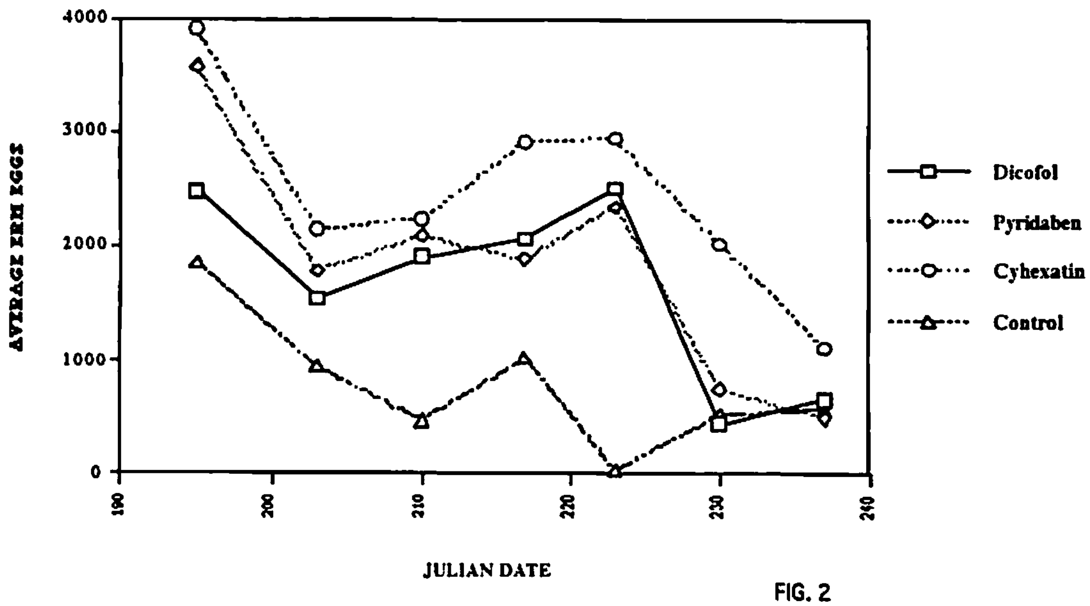

FIG. 2

EFFICACY OF EARLY SEASON ACARICIDES TO CONTROL MITES IN APPLE, 1997

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Tests were set up to compare the effectiveness of different spring treatments using Sunspray 6E Oil, Apollo, and Savey in the control of European red mite (ERM), *Panonychus ulmi* (Koch), in two commercial orchards in Wayne Co. Treatment plots were arranged in a randomized block design, and were applied in plots three rows by 6–12 trees in size. Treatments were applied with a truck-mounted airblast sprayer calibrated to deliver 100 gpa, and were replicated twice in each of two semi-dwarf orchards — Wells farm in Fairville ('McIntosh' and 'Macoun') and Smith farm in Sodus ('McIntosh' and 'Empire'). Treatments and rates applied (formulation per 100 gal) were: oil (2 gal) at Half-Inch Green, on 23 April; Apollo (4 oz) at Tight Cluster, on 5 May; Savey (3 oz) at Tight Cluster; Oil (1 gal) plus Apollo (4 oz) at Tight Cluster; Apollo (4 oz) at Pink, on 14 May; and Apollo (4 oz) at Petal Fall, on 5 June. One set of plots was left untreated to serve as an absolute Check. Leaf counts were taken on a 1–2-week schedule in all plots to track the development of ERM eggs and motile forms. Samples of 25 intermediate-age leaves were taken from each of 4 trees per replicate plot per treatment, brushed in the laboratory with a mite-brushing machine and counted to determine the average numbers of ERM eggs, immatures, and adults per leaf. The data were log transformed and analyzed using a repeated measures ANOVA; treatment means were separated with Fisher's Protected LSD at the $P = 0.05$ level.

Despite what appeared to be an adequate number of overwintered eggs on the spurs, the ERM pressure at the Smith site did not reach economic levels at any time during the season, even in the untreated plots. The counts were highest in the Half-Inch Green oil-only plots and the untreated Check, approaching 5 motiles per leaf by the first week in August; aside from this trend, nothing further is noteworthy from this site. Spring and early summer weather was generally cool and rainy, but mite numbers at the Wells site did eventually attain and surpass threshold levels. The Half-Inch Green oil-only treatment kept mite populations below threshold until the first week in July, eventually peaking at about 25/leaf in mid-July; this pattern mirrored the population growth in the Check plots. Numbers began to head down somewhat by the end of July, but a rescue treatment of Pyramite was applied in the oil plots anyway (31 July), to minimize bronzing damage to the trees.

Among the earlier Apollo treatments, the Tight Cluster timing maintained the mites below threshold until the middle of July, but the Apollo+Oil (at TC) combination consistently gave counts 60–70% lower than Apollo alone for the entire season, providing below-threshold control through mid-August (Table 1). Savey at TC, Apollo at Pink and Apollo at Petal Fall all gave results similar to the Apollo+Oil treatment, and although some differences with regard to threshold levels can be seen on individual sample dates, none of these five treatments differ statistically when averaged over the entire season; however, all had significantly lower ERM motile counts than did the Oil-only and Check plots.

When the mite counts were broken into the three periods of the summer — Early (June sample dates), Mid (July sample dates), and Late (August sample dates) — that were then analyzed separately, a few more distinctive trends could be seen (Table 2). Analyses of the Early and Mid season counts yielded little variation in the treatment rankings, but when the August sample dates are examined separately, the Apollo+Oil TC plots show significantly lower counts than those in the Apollo TC treatment.

In general, it appears that under conditions of moderate ERM pressure such as that seen in the Wells orchard in 1997, any of the Apollo or Savey treatments tested would provide acceptable mite control for the majority of the season. However, Apollo at Tight Cluster might be expected to break threshold to some degree before the end of summer, and as evidenced for the second year, the addition of a 1% rate of oil tank-mixed with this product applied at Tight Cluster would probably improve its residual efficacy.

Table 1. European red mite counts, Wells Orchard, Fairville (Wayne Co.), NY 1997.

	Mean number of ERM motiles per leaf Sample Date						
Treatment	16 Jun	23 Jun	1 Jul	14 Jul	28 Jul	4 Aug	11 Aug
Apollo PF	0.04	0.17	1.10	1.41	2.05	0.93	1.40
Apollo Pink	0.06	0.09	0.62	1.66	8.35	5.30	2.72
Apollo+Oil TC	0.04	0.05	0.16	1.92	2.52	2.69	1.58
Apollo TC	0.01	0.20	0.72	6.82	6.78	8.83	9.10
Savey TC	0.01	0.04	0.06	0.28	0.69	2.16	1.89
Oil HIG	0.15	0.48	7.24	24.64	21.31	10.71	2.12
Check	0.16	0.59	7.55	37.85	18.47	15.14	7.28

Table 2. Treatment rankings (lowest counts to highest) of Wells ERM samples analyzed by month.

Early (June counts)	Mid (July counts)	Late (August counts)
a Savey TC	a Savey TC	a Apollo PF
a Apollo+Oil TC	a Apollo PF	ab Savey TC
a Apollo PK	a Apollo+Oil TC	ab Apollo+Oil TC
a Apollo PF	a Apollo PK	ab Apollo PK
a Apollo TC	a Apollo TC	bc Oil HIG (w/ Pyramite rescue)
b Oil HIG	b Oil HIG	cd Apollo TC
b Check	b Check	d Check

Treatments in each column preceded by the same letter not significantly different ($P = 0.05$, lsd test).

Acknowledgments

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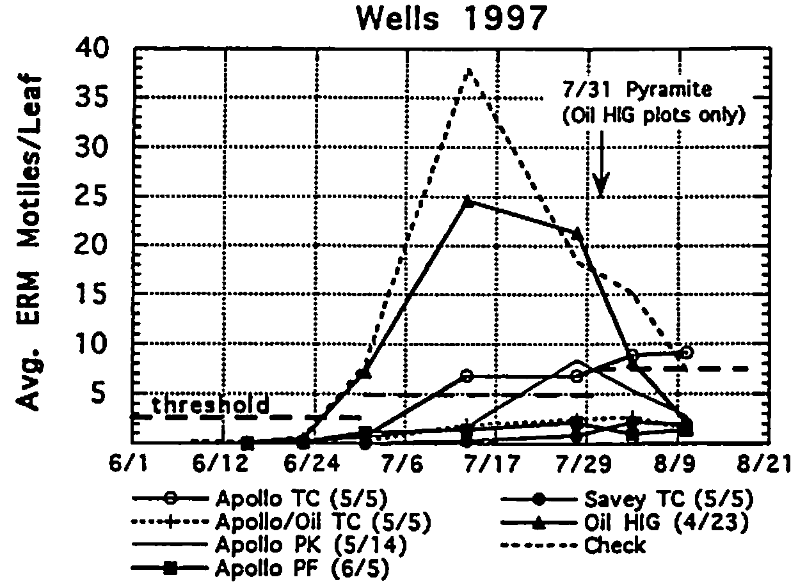
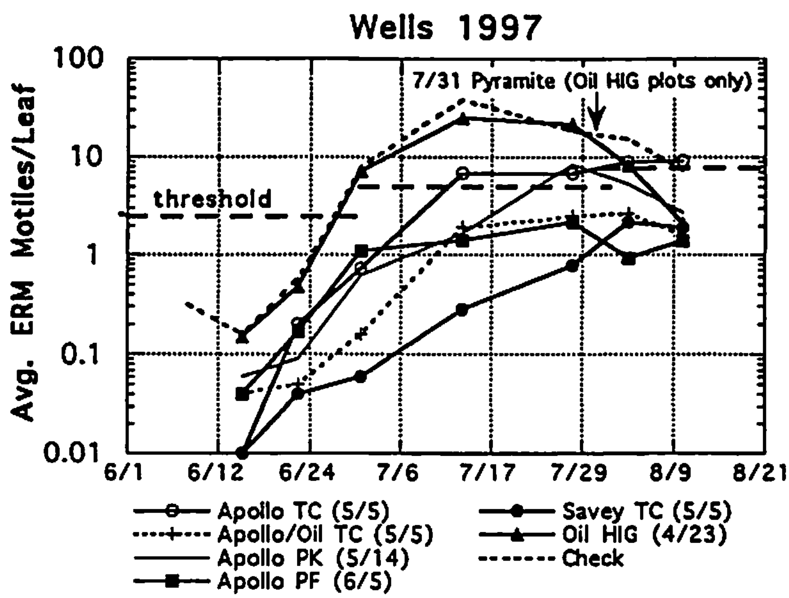
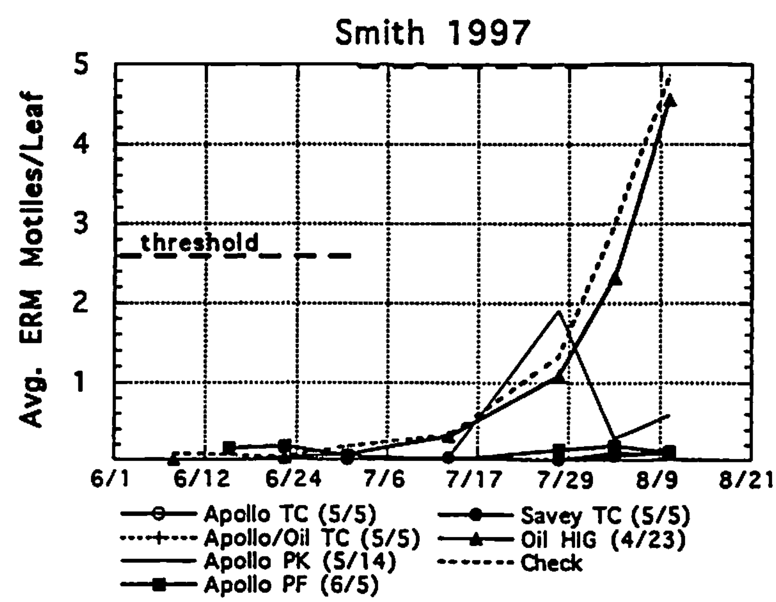

Wells 1997
Avg. ERM Motiles/Leaf
40
35
30
25
20
15
10
5
threshold
7/31 Pyramite
(Oil HIG plots only)
6/1
6/12
6/24
7/6
7/17
7/29
8/9
8/21
Apollo TC (5/5)
Apollo/Oil TC (5/5)
Apollo PK (5/14)
Apollo PF (6/5)
Savey TC (5/5)
Oil HIG (4/23)
Check


Wells 1997
Avg. ERM Motiles/Leaf
100
10
1
0.1
0.01
threshold
7/31 Pyramite (Oil HIG plots only)
6/1
6/12
6/24
7/6
7/17
7/29
8/9
8/21
Apollo TC (5/5)
Apollo/Oil TC (5/5)
Apollo PK (5/14)
Apollo PF (6/5)
Savey TC (5/5)
Oil HIG (4/23)
Check


Smith 1997
Avg. ERM Motiles/Leaf
5
4
3
2
1
threshold
6/1
6/12
6/24
7/6
7/17
7/29
8/9
8/21
Apollo TC (5/5)
Apollo/Oil TC (5/5)
Apollo PK (5/14)
Apollo PF (6/5)
Savey TC (5/5)
Oil HIG (4/23)
Check

Control of European red mite in 'Mourvedre' grapes - 1997

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

GRAPE, ACARICIDE TRIAL, 1997: A comparison of acaricide efficacy against European red mite (ERM) was conducted at Horton Vineyard, Orange Co. Cyhexatin (TD 2383-01 2F) and dicofol (Kelthane 50W) were each applied to four grapevines, on 31 July, at the rates of 946 ml and 59.5 g per 100 gal, respectively. Four vines sprayed with water were used as a control. Applications were made with a backpack sprayer. Pre- and post-treatment counts were made on four leaves per vine. Pre-treatment counts were made on 10, 18 and 26 July (not shown) and 31 July; post-treatment counts were made on 7, 15, 22, and 29 August, and on 5, 12, and 19 September. For two weeks the two acaricides provided statistically equivalent control. On the third week post-treatment, cyhexatin was significantly superior to dicofol. On the following week, the two pesticides were not significantly different; thereafter, significance of all differences declined.

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

Material, AI/100L	ERM per Leaf							
	31 Jul	7 Aug	15 Aug	22 Aug	29 Aug	5 Sep	12 Sep	19 Sep
cyhexatin	26.8a	1.1a	1.3a	0.7a	2.5a	1.6a	2.1a	4.9a
dicofol 50W 150.6 g	28.6a	2.9a	8.7a	5.4b	6.9a	7.7ab	8.7a	13.2a
Control	33.2b	21.6b	41.7b	23.9c	28.6b	16.8b	13.5a	15.2a

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

Validation of Pheromone Traps Catches for Predicting Tufted Apple Bud Moth, *Platynota idaeusalis* (Walker), Fruit Infestation

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Abstract: During 1997 season we attempted to establish a relationship between TABM trap capture and potential fruit injury at harvest. The study was conducted in commercially managed apple orchards with the use of six various trap designs and five doses of sex pheromone. The correlation coefficients for all analyzed doses were significant for 'Yorking' apples during the flight of first brood TABM. There were significant differences among various doses of pheromones in the cumulative numbers of captured moths for the entire season. Among various trap designs baited with standard dose of pheromone, the significant correlation between cumulative trap capture and fruit infestation was observed only for three trap designs. During the mark - recapture experiment the standard 10.0 mg dose captured the highest percentage of marked moths among all pheromone doses at each distance. With one additional year of research, we are hopeful that growers will have an affordable and easy tool for making pest management decisions for TABM.

Introduction

In Pennsylvania, the tufted apple bud moth (TABM), *Platynota idaeusalis* (Walker), is the major direct pest for many fruit growers (Knight & Hull 1988). Due to the extreme difficulty in sampling for eggs, larvae, or larval shelters, growers are not able to actively assess population levels within their orchards in order to determine the need to spray; therefore, the most common control practice for TABM still relies on a selectively timed, but routine insecticide program.

The use of male moth catches in sex pheromones traps to predict pest population density has been investigated for several fruit pest species (Riedl & Croft 1974, Knight & Hull 1989). In Pennsylvania, Knight and Hull (1989) found that cumulative capture of first generation TABM males through the 3-4th week after initial trap catch was a significant predictor of total-season fruit injury, but only for some apple varieties.

The mobility of TABM, its numerous alternate hosts, both within and outside the orchard and the varying levels of insecticide resistance found in TABM populations probably play a major role in our inability to establish a useful relationship between sex pheromone trap catch and late season fruit infestation. Pheromone load rates presently used in traps may attract male moths not only from the orchard, but from surrounding areas outside the orchard as well. Thus, actual moth capture may overrepresent the densities of local moth populations (McNeil 1991).

Besides the dose of the pheromone, the trap design may also have a strong effect on the strength and shape of the pheromone plume, thus impacting the efficiency of the trap (Lewis & Macaulay 1976). For example, Krawczyk (1996) reported that various trap designs baited with the same pheromone dose highly influenced the capture of lesser appleworm, *Grapholita prunivora* (Walsh), males in the Michigan apple system.

The main objective of our research was to attempt to establish a relationship between TABM trap capture and potential fruit injury at harvest as influenced by various trap designs and doses of pheromone. If we are successful, growers will have an affordable and easy tool for making pest management decisions.

Materials and Methods

All experiments were conducted in commercial apple orchards located in Adams Co., Pa. Each orchard consisted of 'Yorking' trees, mixed with other varieties. During the entire season each orchard was sprayed with the grower's choice of insecticide programs. In each orchard, fruit injuries were evaluated twice, August and October. For each replicate within the orchard, 50 fruit from the upper and lower parts of the tree (100 apples per tree) on 10 trees were evaluated for TABM injury. During the fall evaluation an additional 25 fruit were sampled from the ground under each tree.

Pheromone traps were hung at a height of 1.5-1.8 m in each orchard, at least 50 m apart, except in the mark-recapture experiment. Traps bottoms were exchanged every four weeks or when more than 50 moths were captured in any one week. Pheromone lures were exchanged every four weeks. Traps within each replicate were rotated weekly.

Evaluation of different pheromone doses: This study was conducted in four orchards. Five different pheromone doses: 10.0, 2.5, 1.0, 0.1, and 0.05 mg were evaluated for their effectiveness in attracting male TABM. Unbaited Pherocon I traps (with no septa) and Pherocon I traps with unbaited septa were used as controls. Traps were placed in a completely randomized design with four replications in every orchard. Average cumulative number of moths captured with each pheromone dose at various weeks of the season were regressed against total TABM fruit injury at harvest (SuperANOVA, Abacus Concepts 1989).

Evaluation of pheromone trap designs: This study was also conducted in four orchards. Six different trap designs were evaluated for their effectiveness in collecting adult male: Pherocon I CP (IPM Technologies Inc.), Pherocon II (Trece Inc.), Intercept A (IPM Technologies Inc.), Intercept C (IPM Technologies Inc.), Delta (Scenturion Inc.), and Multi-Pher I (Bio-Controle Services). Traps were set up in a completely randomized design and replicated 3 times within each orchard. Each trap was baited with a standard TABM 10.0 mg pheromone lure. Average cumulative number of moths captured in various trap designs at various weeks were regressed against total TABM fruit injury at harvest (SuperANOVA, Abacus Concepts 1989).

Mark-recapture experiment: A mark-recapture study for TABM was conducted in three separate apple orchards using Pherocon I traps baited with three sex pheromone doses (10.0, 1.0, and 0.05 mg) and caged TABM virgin females. During each moth release, four traps baited with a different sex pheromone dose or virgin females, were hung at the same distance while two additional traps were placed at the other two distances from the moth release point (50, 100, or 200 m). During each release, these two additional traps were baited with the same pheromone dose in all orchards. Within various dose-distance combinations, male TABM were marked with different colors using magic markers and released at the eastern edge of the rows. Moths were released four times in each orchard: 17 July, 21 July, 25 July, and 30 July. Within each single release date, the same number of moths was released at every dose-distance combination, but the number of moths released was different at each release date (10, 30, 20, and 15 moths, respectively). The placement of treatments within the orchard was randomly assigned before each release. Traps were checked daily and all captured moths removed. For testing the strength of various sex pheromone doses in attracting male moths toward traps, the percentage of recaptured moths was statistically analyzed using *arcsin x* transformation and an ANOVA (Fisher's Protected LSD test ($P \leq 0.05$)).

Results

During our testing of various pheromone doses the highest average number of moths per trap was observed in traps with 10.0 and 2.5 mg of pheromone, while the traps with 0.05 mg of pheromone captured the lowest number of moths (Fig. 1). Despite the differences in the number of collected moths, all pheromone doses were able to show changes in population trends during the season. There were significant differences among the various doses of pheromones ($P \leq 0.05$) in the cumulative numbers of captured moths for the entire season (Fig. 1). The three lowest doses (0.05, 0.1, and 1.0 mg) captured lower numbers of moths than the two highest doses. The cumulative trap capture of the 10.0 mg dose was almost identical to the cumulative trap capture of the 2.5 mg dose (average of 731.3 vs. 749.0 moths per trap/per season, respectively); similarly the 1.0 and 0.1 mg doses had almost identical cumulative moth capture. They collected 76.9 and 77.3 percent, respectively, of the moths captured by the 10.0 mg dose.

The correlation analysis of total TABM fruit injury at harvest against weekly cumulative moth catches throughout the first brood flight of TABM was conducted for all orchards. The correlation coefficients for all analyzed pairs were significant ($P \leq 0.01$; df = 14) for 'Yorking' apples (Fig. 2). The highest *r* values were observed for the 10.0 mg pheromone dose during weeks 2 and 3 of the first brood flight ($r = 0.973$ and $r = 0.912$ respectively) and again during weeks 7 and 8 ($r = 0.936$ and $r = 0.944$ respectively). The most consistent correlation coefficients between cumulative moth capture and total fruit injury were observed during weeks 5, 6, 7, and 8 for traps containing the 1.0 mg dose (*r*'s of 0.921, 0.921, 0.912, and 0.922, respectively). When all correlation coefficients within a single week for the various doses were analyzed together, the highest average correlation coefficient was observed for week 4 after the beginning of the flight (mean $r = 0.891$; $P = 0.05$) followed by the correlation coefficients during weeks 7 and 8 (mean *r*'s = 0.884 and 0.876, respectively).

All trap designs were good indicators of moth flight seasonality throughout the entire sampling period (Fig. 3). The Pherocon I trap captured the highest cumulative number of males while Intercept A and Pherocon II captured the lowest number of moths. The Intercept C trap design was similar in cumulative moth capture to Intercept A and Pherocon II traps during the first brood flight, but it captured more TABM during the second brood flight than either trap.

The correlation analysis for the cumulative number of males collected in the various trap designs and total TABM fruit injury at harvest (Fig. 4) showed that cumulative moth capture by the Scenturion trap during every week except week 7 after the beginning of the flight was significantly correlated ($P \leq 0.05$; df = 10) with the level of fruit injury. Among other trap designs only Pherocon I during week 1 and Intercept C trap during week 4 had a significant correlation ($P \leq 0.05$) between the number of collected moths and fruit injury.

During the mark - recapture experiment the 10.0 mg dose captured the highest percentage of marked moths among all pheromone doses at each distance (Table 1). No significant differences ($P \leq 0.05$) were detected in recapture activity between the 1.0 mg and 0.05 mg doses at any distance. The traps with caged virgin females were the least attractive for marked moths. No marked moths were recaptured when traps with virgin females were placed 200 m from the release point. At each distance the traps with various doses of synthetic sex pheromone were more attractive for marked males than traps with caged females.

Discussion

During our study with various doses of TABM pheromone, we found significant correlation between cumulative moth capture by traps containing various doses of sex pheromone and fruit injury at harvest during the entire flight of first brood TABM. Although the highest dose (10.0 mg) provided the best correlation during the beginning and the end of the flight, lower doses of pheromone were also good indicators for predicting total fruit injury at harvest. A 200 fold reduction in the amount of pheromone (10.0 vs. 0.05 mg) resulted only in an approximate 50 percent reduction in cumulative trap capture. Knight and Hull (1989), using a 10.0 mg dose of pheromone, also reported that cumulative capture of first generation TABM males during the first three weeks of the season was a significant predictor of total-season fruit injury on 'Yorking' and 'Delicious' but not for 'Golden Delicious'. More work will be necessary to determine if the 10.0 mg dose continues to be the most effective and accurate dose for predicting potential TABM fruit injury at harvest.

In our second experiment with various trap designs, differences exist in the ability of certain types of traps to capture TABM males. The standard Pherocon I trap design captured the highest number of TABM moths. The surprising part of this study was the low correlation between trap capture and fruit injury for a majority of the trap designs, even though we used the 10.0 mg lure in each trap design. We are still in the process of trying to understand why this relationship failed across trap designs, given our success in the experiment with various pheromone doses. The insecticide programs for controlling first and second brood TABM varied in each orchard. The growers used various combinations of the methomyl, organophosphate insecticides, or the insect growth regulator tebufenozide (Confirm®) during the season. The physical differences among orchards (i.e., tree size, orchard density) and management practices employed by the growers in these sites may also have an effect on the results of our experiments. Additionally, in two of the orchards, we observed high populations of the obliquebanded leafroller, *Choristoneura rosaceana* (Harris), which may have a bias effect on our fruit injury observations, since the type of injury caused by both species is somewhat difficult to separate (Table 2).

The mark-recapture experiment showed that the standard pheromone dose of 10.0 mg as well as lower doses are much stronger attractants than caged virgin females. The three pheromone doses attracted a higher percentage of male moths at each distance, possibly indicating that all three pheromone doses are capable of attracting moths from outside the orchard. This conclusion is in agreement with review data presented by McNeil (1991). The relationship among the size of an orchard, its surroundings, and trap placement needs to be studied in greater detail, so a grower will be able to determine not only 'when' to spray, but also 'if' he/she should spray.

Additional studies with even lower pheromone doses are necessary for better understanding the effective range of traps within the orchard and their attractiveness to male TABM.

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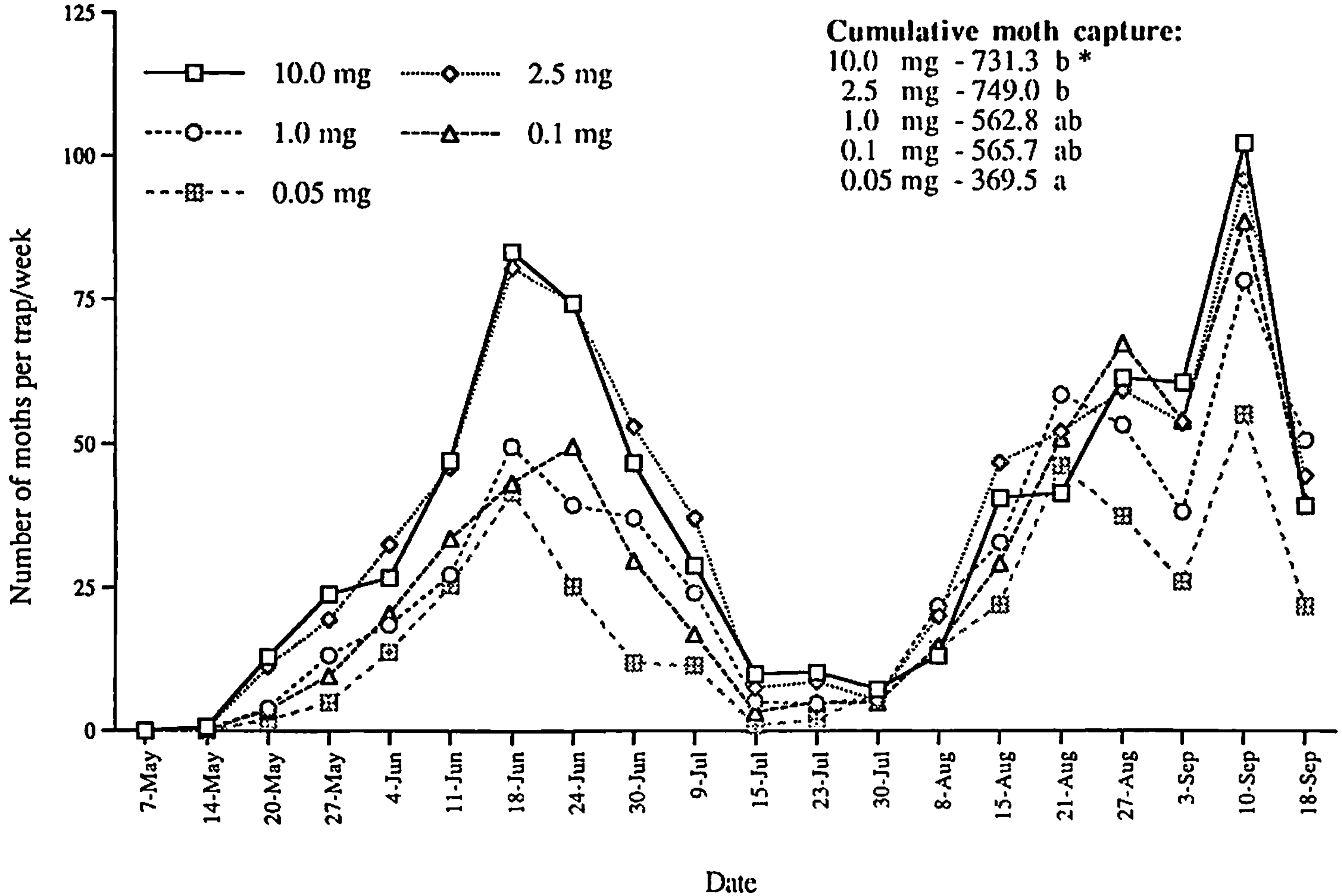


* - sqr x transformation, Fisher's Protected LSD (P=0.05)

Figure 1. TABM flight seasonality and cumulative moth capture observed with Pherocon I traps baited with five different doses of TABM sex pheromone. Data collected from four commercial apple orchards. Adams Co., PA 1997.

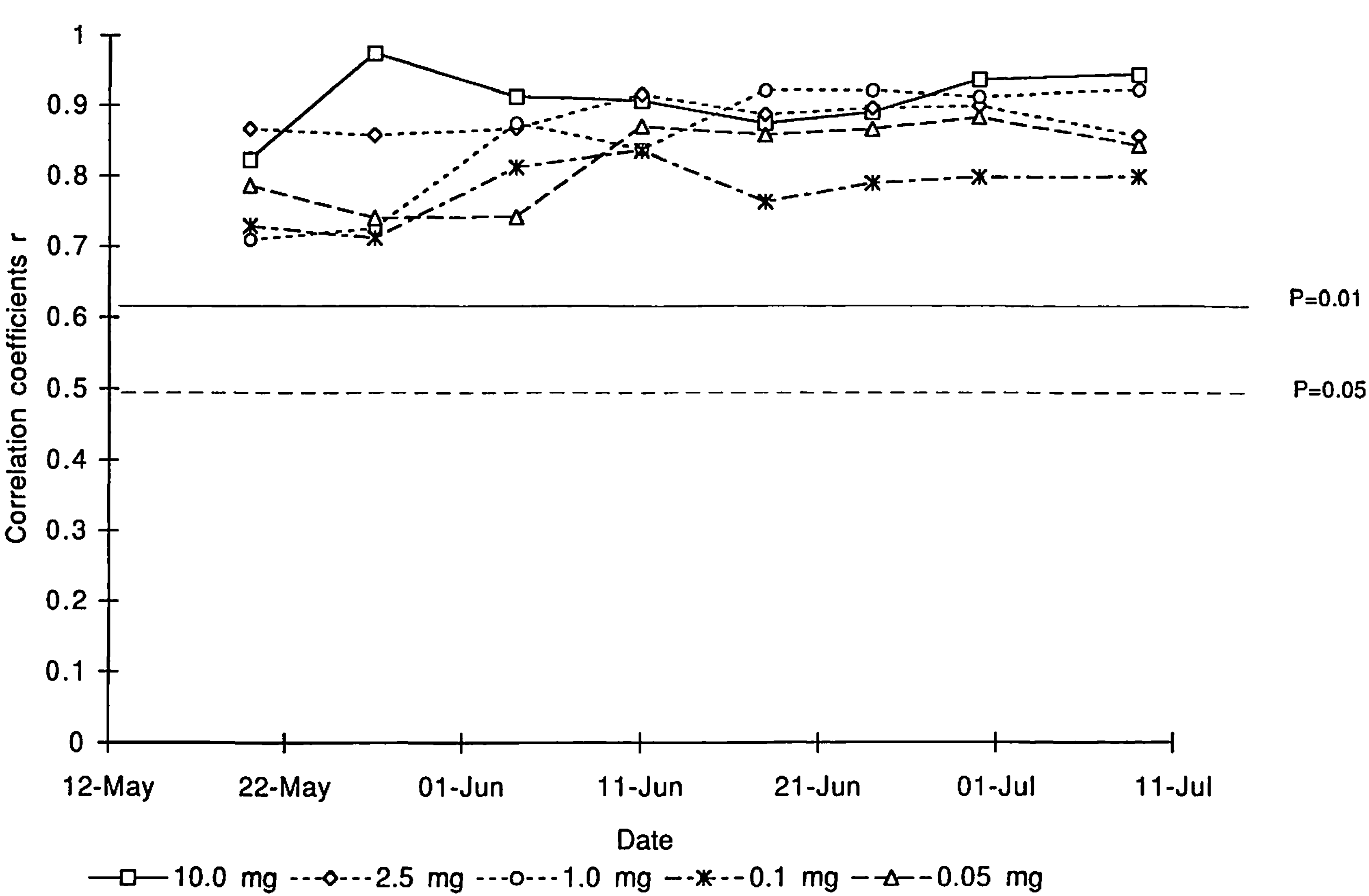
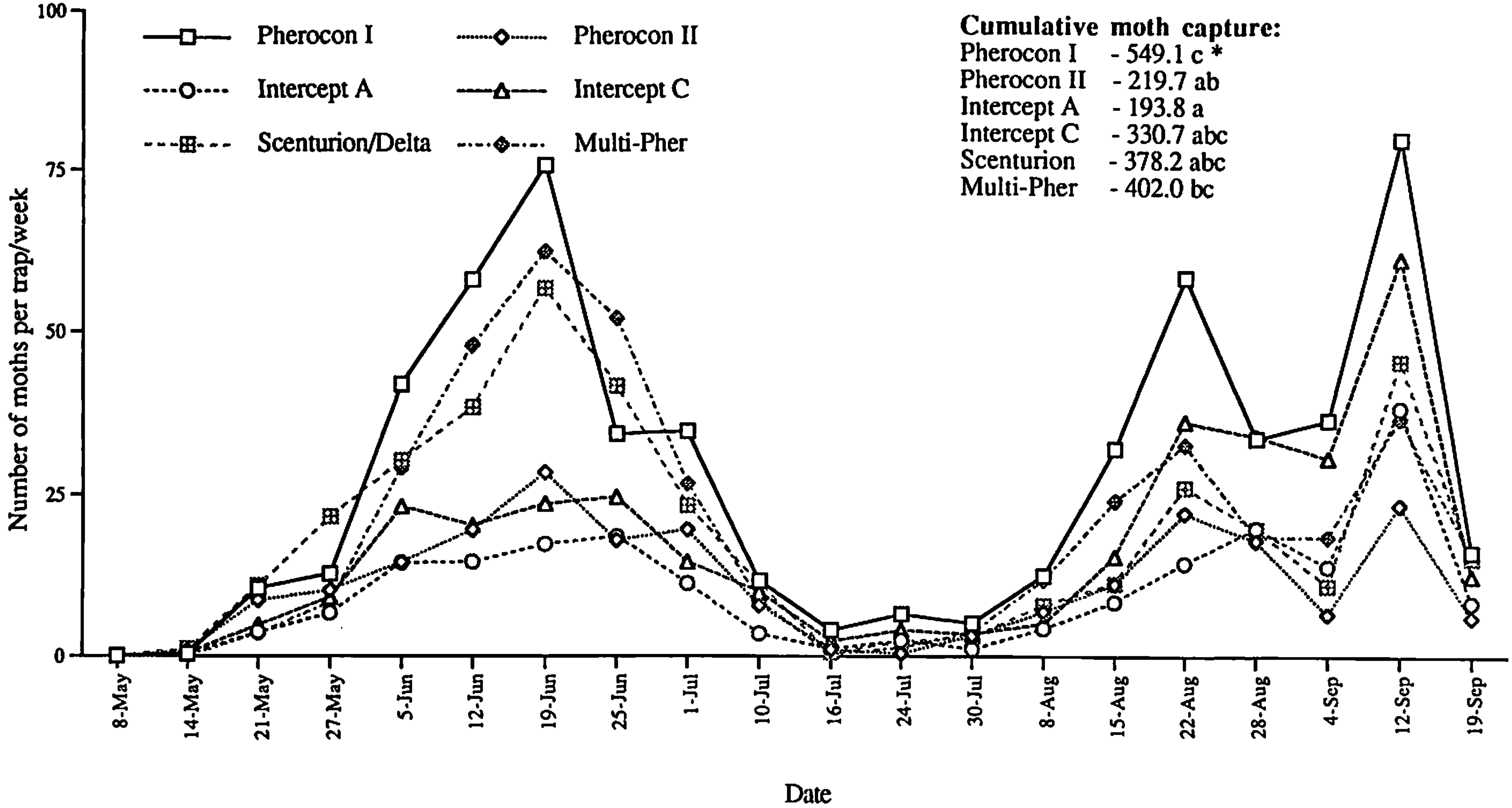


Figure 2. The correlation between the cumulative trap capture using various doses of sex pheromone during the flight of the first brood TABM and fruit injury during harvest fruit evaluation. The correlation coefficient *r* is significant at P= 0.05 (df=14) when *r* value is higher than 0.497 and at P=0.01(df=14) when *r* value is higher than 0.623. Data collected from four commercial apple orchards. Adams Co., PA 1997.



* - sqr *x* transformation, Fisher's Protected LSD (P=0.05)

Figure 3. TABM flight seasonality and season cumulative moth capture observed with six different trap designs baited with a standard sex pheromone dose of 10.0 mg. Data collected from four commercial apple orchards. Adams Co., PA 1997.

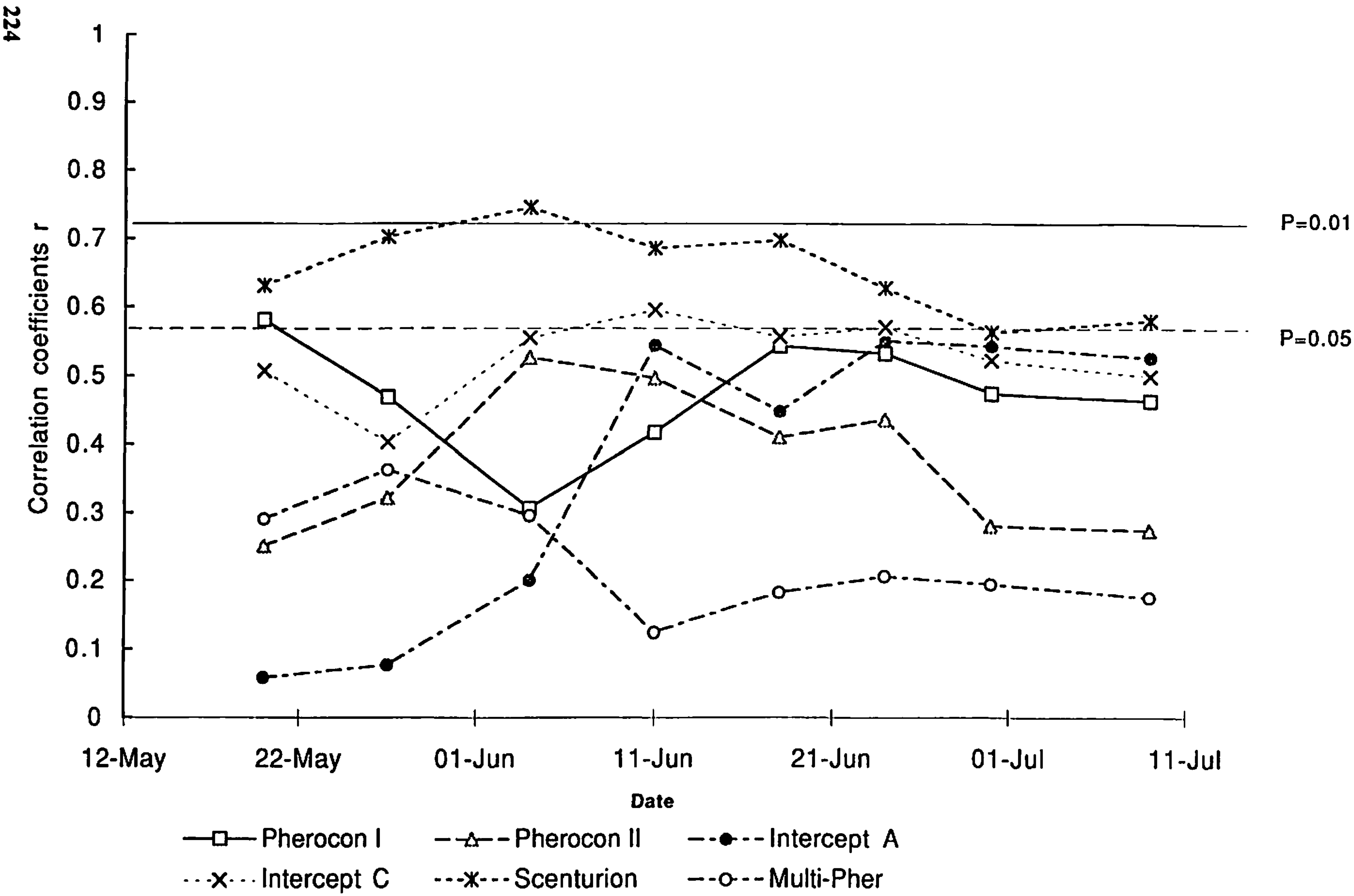


Figure 4. The correlations between cumulative pheromone trap capture of various trap designs baited with 10.0 mg sex pheromone dose during the flight of the first brood TABM and total fruit injury at harvest evaluation. The correlation coefficient *r* is significant at P= 0.05 (df=10) when *r* value is higher than 0.567 and at P=0.01 (df=10) when *r* value is higher than 0.708. Data collected from four commercial apple orchards. Adams Co., PA 1997.

Table 1. Percentages of recaptured TABM moths at three distances from the moth release point using Pherocon I traps baited with various sex pheromone doses and caged TABM females. Data collected from three orchards during four moth releases. Adams Co., PA 1997.

Pheromone dose	Distance from moth release point		
	50 m	100 m	200 m
10.0 mg	45.3 ± 9.9 b*	24.4 ± 8.4 b	12.5 ± 4.3 b
1.0 mg	17.5 ± 6.0 a	22.8 ± 7.8 b	5.6 ± 3.3 ab
0.05 mg	7.5 ± 5.1 a	17.5 ± 7.8 ab	9.2 ± 2.9 ab
Female TABM	3.3 ± 3.3 a	1.1 ± 1.1 a	0.0 a

*- percentage of recaptured moths within the columns followed by the same letter are not significantly different (sqrt *x* transformation, Fisher's Protected LSD ($P \leq 0.05$)).

Table 2. The leafrollers: tufted apple bud moth (TABM) and obliquebanded leafroller (OBLR) fruit injury in orchards with various pheromone dose and trap designs experiments. Data collected from 'Yorking'. October 1997. Adams Co., PA.

Site	Percentage of injured fruit during fall fruit evaluation *									
	OBLR top	OBLR bottom	OBLR drops	TABM 1 top	TABM 1 bottom	TABM 1 drops	TABM 2 top	TABM 2 bottom	TABM 2 drops	**Clean fruit**
	Orchards with pheromone dose comparison experiment									
I	0.4 ± 0.1 a	0.2 ± 0.1 a	0.6 ± 0.2 a	1.4 ± 0.3 a	1.4 ± 0.2 a	0.6 ± 0.2 a	2.2 ± 0.4 b	3.3 ± 0.5 b	1.7 ± 0.4 b	**96.0 b**
II	1.9 ± 0.4 b	0.7 ± 0.2 ab	5.3 ± 0.7 b	12.5 ± 1.1 b	8.8 ± 0.8 b	37.6 ± 2.2 b	11.4 ± 0.9 c	9.7 ± 1.5 c	3.3 ± 0.7 c	**70.6 a**
III	0.0 ± 0.0 a	0.3 ± 0.2 a	0.1 ± 0.1 a	0.8 ± 0.3 a	1.2 ± 0.2 a	1.0 ± 0.3 a	0.4 ± 0.2 a	0.8 ± 0.2 a	0.2 ± 0.1 a	**98.4 c**
IV	0.4 ± 0.2 a	1.2 ± 0.3 b	1.0 ± 0.3 a	1.3 ± 0.3 a	2.1 ± 0.3 a	0.9 ± 0.3 a	0.7 ± 0.2 a	2.5 ± 0.5 ab	2.4 ± 0.6 bc	**95.8 b**
	Orchards with trap designs comparison experiment									
V	0.9 ± 0.3 a	0.5 ± 0.2 a	2.0 ± 0.7 a	4.9 ± 0.7 a	2.0 ± 0.4 a	3.7 ± 0.7 a	4.1 ± 0.7 b	1.9 ± 0.4 a	5.3 ± 0.9 b	**91.8 c**
VI	0.3 ± 0.1 a	0.0 ± 0.0 a	1.1 ± 0.4 a	1.7 ± 0.4 a	0.2 ± 0.4 a	2.9 ± 0.6 a	0.1 ± 0.1 a	0.3 ± 0.2 a	0.1 ± 0.1 a	**97.2 d**
VII	3.0 ± 0.5 b	1.0 ± 0.3 a	12.3 ± 1.2 b	19.8 ± 1.6 b	9.8 ± 1.1 b	25.2 ± 2.2 b	7.2 ± 0.9 c	6.5 ± 0.6 b	14.4 ± 1.6 c	**68.5 b**
VIII	7.3 ± 1.0 c	5.6 ± 0.8 b	29.1 ± 1.4 c	16.9 ± 1.6 b	11.7 ± 1.5 b	2.5 ± 0.6 a	7.2 ± 0.9 c	12.5 ± 1.2 c	21.6 ± 1.7 d	**63.0 a**

*- Means followed by the same letter(s) are not significantly different (Fisher Protected LSD, P≤0.5)

Tufted Apple Bud Moth Egg Hatch Model in North Carolina

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Insecticide sprays for tufted apple bud moth are timed so that a residue of toxin is present on leaves during the period of first and second generation egg hatch, which generally occurs in June and August/September, respectively. The timing of these applications is critical to ensure that insecticides are applied when larvae are small, because TABM larvae become increasingly tolerant to most insecticides as they increase in size. In North Carolina, the timing of these sprays have been based solely on pheromone trap catches. Previous studies have shown that first generation egg hatch starts about 7 days after the peak catch of pheromone trap catches and continues for about one month. Second generation egg hatch generally begins shortly after second generation flight starts (late July to early August) and continues for 4 to 6 weeks.

In Pennsylvania, Hull et al. (1996) have developed a degree-day model which accurately predicts cumulative egg hatch of first and second generation TABM, and which is also a more accurate method for timing sprays compared to using pheromone trap catches. This model predicts that 10, 50 and 95% egg hatch of the first generation occurs at approximately 530, 750 and 965 degree days (DD), respectively, after biofix (first capture of moths in pheromone traps in the spring). For the second generation, 10, 50 and 90% egg hatch occurs at approximately 2280, 2585 and 2890 DD after biofix. However, this model does not appear to be relevant to NC TABM populations, because 530 and 2280 DD (10% hatch of first and second generations) occurs well before egg hatch is initiated in NC.

However, geographic populations of TABM are known to vary in their temperature-dependent developmental requirements. For instance, Rock et al. (1993) reported that the average interval between the start of first and second generation TABM flight (as measured by pheromone trap catches) was 100 days in North Carolina compared to only 72 days in Pennsylvania and Michigan. This represented a difference of 165 DD between NC and PA populations. When comparing the interval between peak pheromone trap catches of the first and second generation, NC populations completed an additional 213 DD (31 days) compared to PA populations.

Considering the above-mentioned developmental differences between NC and PA TABM populations, it is likely that the PA egg hatch model will need to be modified for NC populations. Hence, the objective of this project was to correlate cumulative egg hatch of first and second generation TABM populations in NC with degree-day accumulations from biofix, and to use this information as the basis for a NC TABM egg hatch model.

Materials and Methods

Two commercial apple orchards were used to monitor TABM egg hatch in 1997. In mid March, TABM pheromone traps a recording hygrothermograph were placed in the Hend-B orchard, while only pheromone traps were placed in the Hend-MR orchard. The orchards were approximately 2 miles apart. The orchard (Hend-B) was a mixed block of 'Delicious' and 'Gold Delicious' trees planted at a density of 120 trees/acre, and trees were 12-15' tall. The Hend-MR orchard was a solid block of 'Rome' apples planted at a density of 100 trees/acres and trees were 15-18 ft tall. Pheromone traps were checked twice per week until the first sustained catch of moths occurred, and at weekly intervals thereafter. Recording sheets in the hygrothermograph were replaced at weekly intervals, and daily maximum and minimum temperatures were used to calculated TABM degree days (45°F low base temperature and 91°F high base temperature) using the sine-wave method.

Twenty-four trees uniformly dispersed within a 10-acre section of the Hend-B orchard and 28 trees in the Hend-MR orchard were marked and served as sample trees. A 5-minute search/tree for TABM egg masses was conducted on each sample date, and the number of hatched egg masses observed during the search was recorded. All hatched eggs were removed, while fresh eggs were left on the tree until they hatched. During the first generation, trees were sample 3 times per week (Monday, Wednesday, Friday) from 19 May to 23 July in the Hend-B orchard, but only once per week in the Hend-MR orchard. During the second generation, trees were sampled once per week in the Hend-B orchard from 6 August to 9 October. Egg mass searches were not conducted in the Hend-MR orchard during the second generation.

Results

Biofix occurred on 16 and 22 April in the Hend-B and Hend-M orchards, respectively. Although these biofix dates were consistent with past years, below normal temperatures from late April through May resulted in subsequent population development being delayed by 10 to 14 days compared to previous years. However, relatively high populations occurred in these orchards, with a first generation peak pheromone catch of 132 and 90 moths/trap/week occurring in the Hend-B and Hend-MR orchards, respectively. Second generation pheromone trap catches peaked at 132 and 128 moths/trap/week in the Hend-B and Hend-MR orchards respectively.

Cumulative egg hatch trends were similar in both orchards during the first generation (n = 21 in Hend-B and 34 in Hend-MR), with 10 and 90% egg hatch occurring at approximately 800 and 1650 DD after biofix, respectively (Fig. 1). The interval between 10 and 90% hatch was approximately 850 DD, or 30 days. This is in contrast to populations in Pennsylvania, where 10 and 90% egg occurs at 530 and 965 DD after biofix. Hence, the initiation of first generation egg hatch by NC populations occurs approximately 270 DD later than PA populations, and the time period over which 10 and 90% hatch occurs is about 415 DD longer in NC populations.

A total of 90 hatched eggs were detected during the second generation in Hend-B, with the first hatch detected on 13 August, or about 2450 DD after biofix (Fig. 2). During the second generation, 10 and 90% egg hatch occurred at 2700 and 3600 DD after biofix, respectively. Hence, the time period over which 10 and 90% egg hatch occurred (900 DD) was similar to that observed in the first generation. Again, second generation egg hatch of NC populations occurred approximately 400 DD later than that observed in PA, and the interval between 10 and 90% hatch of the second generation required about 300 more DD than the second generation in PA.

Although this work will be repeated in 1998, these results should provide NC apple growers with a more accurate method of timing insecticide applications for the TABM. In NC, two to three insecticide applications at 14-day intervals are typically made against the first generation, and results from 1997 indicate that the first application should be made at about 800 DD after biofix (10% egg hatch). One or two insecticide applications are usually made against the second generation, depending on the variety. These results suggest that the first application should be made at about 2700 DD after biofix.

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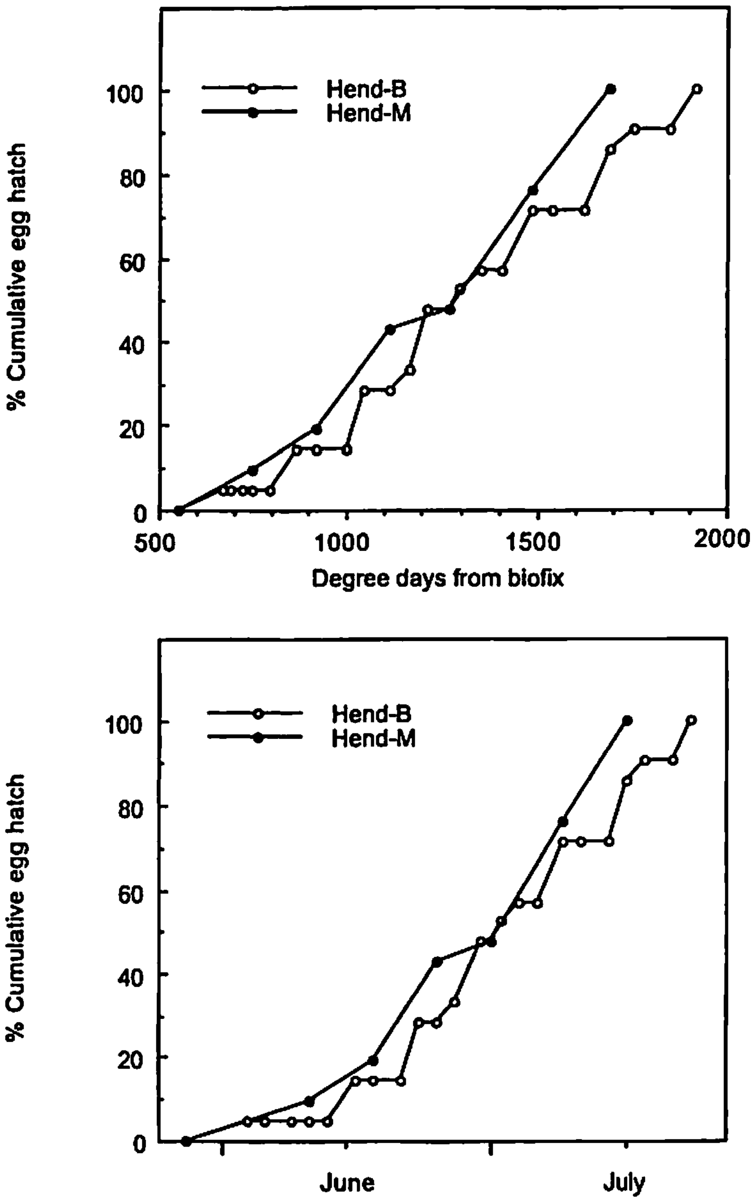

Fig. 1. First generation TABM egg hatch in relation to cumulative degree days from biofix and by date . Henderson Co., NC. 1997.

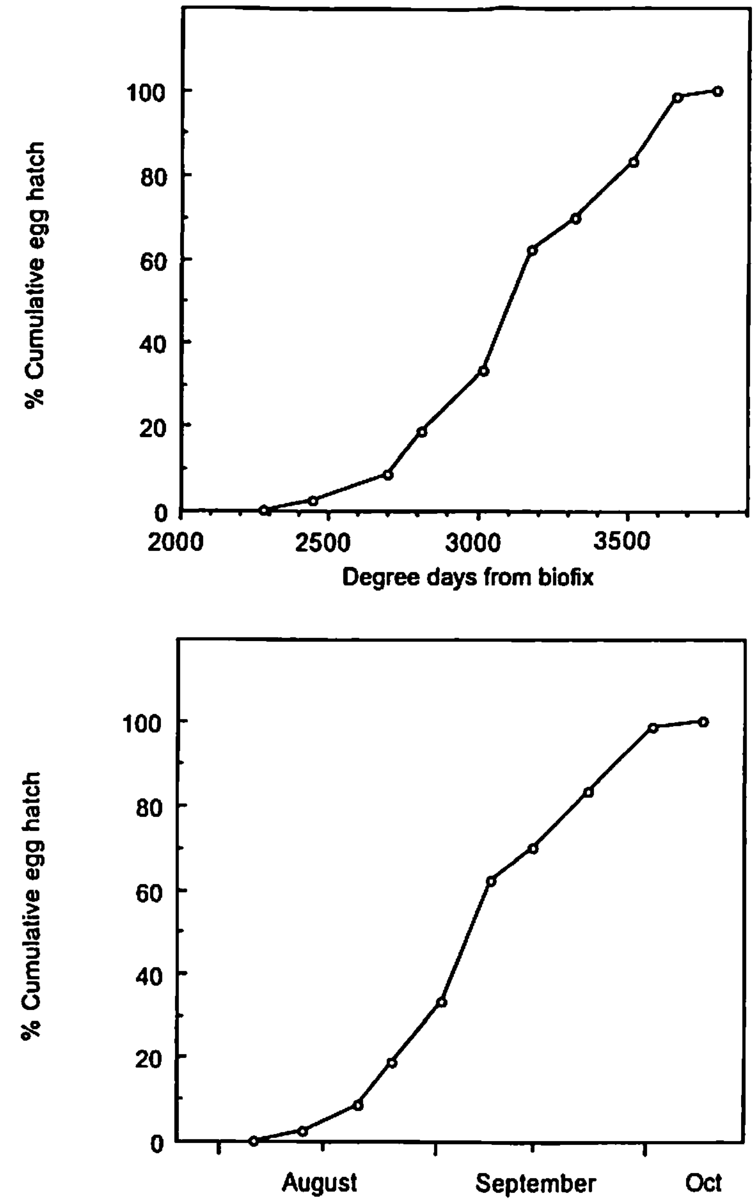

Fig. 2. Second generation TABM egg hatch in relation to cumulative degree days from biofix and by date. Hend-B orchard, Henderson Co., NC. 1997.

Comparison of Confirm, Bt's and Mating Disruption with Organophosphate Programs in Large Block Trials

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The tufted apple bud moth (TABM) and codling moth are the key direct pests of apple in North Carolina, and hence the target of most, if not all, post bloom insecticide applications. For almost 30 years these pests have been managed almost exclusively with organophosphate (OP) insecticides. The availability of effective OPs has been an important component of the Apple IPM program, because many of the predators and parasites of common secondary pests (i.e., European red mite, spotted tentiform leafminer, apple/spirea aphid, etc.) have developed a high level of tolerance to this group of insecticides. On average, 5 to 6 OP insecticide applications are targeted specifically for TABM and/or codling moth in NC.

In recent years a number of factors have evolved which threaten to remove OPs as an apple pest management option, including the development of TABM populations resistant to these insecticides and the potential loss of these materials with implementation of the Food Quality Protection Act. Furthermore, public concern over the potential adverse health effects of pesticide residues in food products has placed increased pressure on certain segments of the processing industry to produce products free of pesticide residues.

The use of pheromone-mediated mating disruption for control of codling moth has proven to be a reliable strategy under conditions of low to moderate moth densities. However, the need to apply insecticides for control of TABM has precluded the use of codling moth mating disruption in NC. Hence, in recent years we have placed emphasis on the development of non-organophosphate control tactics for managing TABM. The two most promising tactics have been the use of *Bacillus thuringiensis* products and mating disruption. In addition, the insect growth regulator tebufenozide (Confirm) has shown excellent activity against both the TABM and codling moth. The objective of this project was to compare the efficacy and economics of mating disruption and Bts) to OP insecticides for control of the apple insect complex, and to compare the efficacy of Confirm to OPs for control of both TABM and codling moth.

Materials and Methods

Large plot trials were used to minimize the effects of interplot movement of both pest and beneficial insects, and to compare the efficacy of the various programs on an orchard basis. Within each of six commercial orchards, one or two reduced-risk management programs was compared to an OP management program. All treatments were sprayed with the same insecticides through petal fall, and with the same season-long fungicide program. The only OP used in the non-OP blocks was at petal fall for control of plum curculio. In addition, all insecticide applications at both locations were made with an airblast sprayer.

Tial 1: Comparison of Mating Disruption/Bt to OP Program

Treatments evaluated in this trial included:

MD/Bt - A single application of Isomate C Plus pheromone dispensers (400/acre) at bloom was used for codling moth, and either Biobit, Dipel or Xentari (all at 1 lb/acre) was used for control of TABM. At all locations, 3 applications of Bt at 14-day intervals were made against the first TABM generation (the initial application at about 10% egg hatch), and either one or two applications, depending on harvest date, against the second generation (the first applications at about 10% egg hatch).

MD/MD - A single application of Isomate C Plus as described above was used for mating disruption of codling moth, and a single application of NoMate TABM pheromone dispensers (600 spirals/acre) applied at bloom were used for mating disruption of TABM. Previous work has shown that when NoMate TABM spirals are applied prior to the first TABM generation, they do not release sufficient pheromone for disruption of the second generation. Thus, one or two applications of Dipel DX (1 lb/acre) were made against the second TABM generation in these blocks.

OP/MD - An OP (Imidan 70W at 2.4 lb/acre) was applied for control of the codling moth at first cover and when pheromone trap catches exceeded 7 moths/trap/week. NoMate TABM and was used for control of the first TABM generation and Bts for the second generation, as described above.

OP/OP - Both codling moth and TABM were controlled with organophosphate insecticides. Guthion (2 lb/acre) and/or Imidan (2.4 lb/acre) were used for codling moth sprays, and applications were made at approximately 350 and 1350 degree days after biofix for the first and second generations, respectively. For TABM, two applications of Lorsban 50W (3 lb/acre) were applied for the first generation (first application at approximately 10% egg hatch) and one or two applications (depending on harvest date) of Penncap-M 2F (4 pt/acre) for the second generation (first application at approximately 10% egg hatch).

Trial B: Comparison of Confirm to OP Program

In each of two commercial orchards in Henderson County, a mixed block of 'Delicious' and 'Golden Delicious' apples were separated into two 5-acre treatments. Both treatments received the same insecticide program through petal fall. In the Confirm treatment at both locations, Confirm 2F (0.28 lb[AI]/A) was applied for control of both codling moth and tufted apple bud moth; in the organophosphate treatment at both locations, Guthion 50WP (1.0 lb[AI]/A) was applied for codling moth, Lorsban 50W 1.0 to 1.5 lb[AI]/A) for first generation TABM, and Penncap-M 2F (1.0 lb[AI]/A) for second generation TABM. The timing of all insecticide applications was based on egg hatch degree-day models and the number of applications was based on the intensity of pest populations as measured by pheromone trap catches.

For both trials, 10 sample trees/treatment (block) were marked and used to monitor the density of secondary pest populations and beneficial arthropods. Arthropods monitored included

European red mite (10 leaves/tree observed with a 12X visor lens), potato leafhopper (10 youngest leaves on 10 shoots/tree), white apple leafhopper (10 mature leaves/tree), spotted tentiform leafminer (no. mines observed during a 5-minute search per tree), and apple aphid/spirea aphid infestations (number of infested leaves on 10 shoots/tree). Generalist predators (lady beetles, syrphid fly larvae, lacewing larvae, predaceous midge larvae, and insidious flower bugs) were monitored on 10 aphid-infested shoots per tree. Mites, potato leafhoppers, aphids and generalist predators were monitored at two-week intervals from late May to early August. White apple leafhopper and spotted tentiform leafminer were monitored on a single date in early to mid August. In addition, STLM parasitism was estimated on 21 August by collecting 100 leafminer-infested leaves per treatment, returning them to the laboratory, and opening all mines and recording number parasitized. At harvest, 100 fruit from each of 10 sites per treatment (1,000 fruit/treatment) were harvested and examined for insect damage. Data from treatments were compared within sites by a paired *t*-test.

Results

Trial A: Mating Disruption/Bt vs. OP

The use of codling moth mating disruption and Bts for management of TABM eliminated an average of 5 post bloom insecticide applications compared to the OP program (Table 1). Populations of secondary pests did not differ between the reduced-risk and organophosphate insecticide management programs (Table 2). However, populations of generalist predators, which prey primarily summer aphids (i.e., apple aphids and spirea aphids), were higher in the non-OP compared to OP blocks and appeared to contribute to control of these aphid populations. Similar levels codling moth control were obtained in the mating disruption and OP blocks, although higher levels of damage did occur in the OP treatment in the Hend-H orchard (Table 3). In addition, TABM control was similar in the Bt and OP treatments. However, at Hend-H, where TABM has high levels of OP resistance, Bts provided superior control. Under the high TABM population pressure at Hend-M, TABM mating disruption did not provide effective control. The mating disruption/Bt program was the most economical of the reduced risk strategies evaluated, but this approach cost approximately $92/acre more than the conventional OP program (Table 4). In the absence of a premium price for fruit grown in this manner, this increased production cost will present a significant barrier to the widespread adoption of this technology.

Trial B: Confirm vs. OP

Tufted apple bud moth populations were of high intensity at both locations, with first generation peak pheromone trap catches peaking at approximately 130 moths/trap/week in the two orchards. Second generation pheromone trap catches were similar to those of the first generation in Hend-B, but in the Hend-MC orchard second generation trap catches peaked at about 190/trap/week. In Hend-B, the OP block received a total of 6 post petal fall OP applications, while only 3 Confirm applications were made (Table 5). In Hend-MC, the OP block received 7 OP applications compared to only 4 Confirm applications.

Populations of spotted tentiform leafminer and European red mite were lower in Confirm compared to organophosphate blocks, while potato leafhopper populations were lower in the organophosphate blocks (Table 6). Summer aphid populations (apple aphid/spirea aphid complex) were slightly lower in the Confirm block, but this was not related to differences in generalist predator populations. In general, both Stethorus punctum and generalist predators populations were slightly higher in the organophosphate than Confirm treatment in the Hend-B orchard, but this was because of higher prey populations (mites and aphids, respectively) rather than toxic effects of Confirm. The use of Confirm for post petal fall applications resulted in lower levels of codling moth and tufted apple bud moth damage and higher levels of clean fruit compared to organophosphate managed blocks in both orchards (Table 7). This higher level of control was achieved with three fewer applications of Confirm compared to organophosphates.

Table 1. Pesticides and pheromone dispensers applied to various blocks for management of codling moth and tufted apple bud moth. Henderson County, NC. 1997

Orchard	Date	OP	MD-Bt	MD-MD
Hend-S	3/11 (GT)	Oil + Ambush	Oil + Ambush	
	4/23		Isomate C+	
	5/5 (PF)	Guthion 50W	Guthion 50W	
	6/2	Imidan 70W		
	6/10	Lorsban 50W	Dipel WD	
	6/28	Lorsban 50W	Dipel WD	
	7/14	Guthion 50W	Dipel WD	
	8/15	Penncap-M	Dipel WD	
Hend-H	3/19 (GT)	Oil	Oil	
	3/27 (TC)	Asana	Asana	
	4/25		Isomate C+	
	5/5 (PF)	Imidan	Imidan	
	6/2	Guthion		
	6/16	Lorsban	Xentari	
	6/30	Lorsban	Xentari	
	7/15		Xentari	
	8/14	Penncap-M	Xentari	
Hend-M	3/24 (½" GT)	Oil	Oil	Oil
	4/2 (PNK)	Asana	Asana	Asana
	4/24		Isomate C+	Isomate C+ NoMate TABM
	6/3	Guthion		
	6/16	Penncap-M	Biobit	
	7/2	Penncap-M	Biobit	
	7/15		Biobit	
	8/19	Penncap-M	Biobit	
	9/1	Penncap-M	Biobit	Biobit
Hend-N	3/19 (GT)	Oil	Oil	
	3/27 (TC)	Thiodan	Thiodan	
	4/28		NoMate TABM	
	5/6 (PF)	Thiodan	Thiodan	
	5/20	Imidan	Imidan	
	6/2	Guthion		
	6/16	Lorsban		
	6/30	Lorsban		
	7/16	Imidan	Imidan	
	8/15	Penncap-M	Xentari	

Table 2. Secondary pest and beneficial arthropod populations in blocks managed with either mating disruption (MD), *Bacillus thuringinensis* (Bt) or ogranophosphate insecticides for codling moth (CM) and tufted apple bud moth (TABM). Henderson County, NC. 1997.

Orchard	Treatment CM	Treatment TABM	Cumul. mite days	Cumul. PLH days	WALH[1]	STLM[2]	% STLM parasitism	AA/SA[3] Aphid	Total[4] predators
Hend-S	MD	Bt	4.9a	76.3b	9.3a	23.1a	3.5a	115.4a	11.1a
	OP	OP	9.8a	7.3a	14.4a	26.9a	4.0a	134.4a	10.2a
Hend-H	MD	Bt	0.0a	0.8a	7.2a	26.1b	12.3a	130.1b	19.5b
	OP	OP	5.6a	1.2a	2.4a	11.6a	1.3b	57.2a	1.3a
Hend-M	MD	Bt	23.8a	43.2ab	13.0a	9.3a	5.6a	48.9a	8.3a
	MD	MD	2.8a	49.1b	16.7a	7.0a	6.2a	51.6a	8.6a
	OP	OP	0.0a	32.1a	19.4a	17.7b	4.3a	87.2a	6.1a
Hend-N	OP	MD	6.4a	15.4a	2.4a	37.2a	27.5a	53.1a	15.8b
	OP	OP	4.3a	11.9a	3.4a	32.0a	26.9a	58.7a	7.3a

Means within the same column and orchard followed by the same letter are not significantly differenty by paired *t*-test ($P = 0.05$).

[1]WALH populations expressed as number per 10 leaves on 6 August.

[2]STLM represented as number per 5-min search on 21 August.

[3]Apple aphid/spirea aphid complex populations expressed as season total number of leaves infested per 10 shoots.

[4]Generalist predator populations expressed as season total predators per 10 shoots.

Table 3. Insect-damaged fruit harvested from blocks managed with either mating disruption (MD), *Bacillus thuringinensis* (Bt) or ogranophosphate insecticides for codling moth (CM) and tufted apple bud moth (TABM). Henderson County, NC. 1997.

Orchard	Treatment		Codling moth			TABM			Plum	Plant	%
(harvest)	CM	TABM	stings	entries	total	gen I	gen II	total	curculio	bug	clean
Hend-S	MD	Bt	0.0a	0.3a	0.3a	2.0a	0.0a	2.0a	0.0a	0.0a	97.7a
(9/8)	OP	OP	0.2a	0.1a	0.3a	1.2a	0.1a	1.3a	0.0a	0.1a	98.3a
Hend-H	MD	Bt	0.3a	0.1a	0.4a	1.8a	0.0a	1.8a	0.1a	0.0a	97.7a
(9/12)	OP	OP	1.5b	1.6b	3.1b	7.5b	0.4a	7.9b	0.0a	0.0a	89.0b
Hend-M	MD	Bt	3.1a	0.1a	3.2b	4.5a	3.3b	7.8a	0.0a	0.3a	88.7b
(10/7)	MD	MD	1.0b	0.0a	1.0a	10.0b	7.8c	17.8b	0.6a	0.0a	80.6a
	OP	OP	1.4b	0.7a	2.1ab	6.3a	1.8a	8.1a	0.4a	0.4a	89.0b
Hend-N	OP	Bt	0.0a	0.0a	0.0a	1.0a	0.0a	1.0a	0.0a	0.0a	99.0a
(8/22)	OP	OP	0.0a	0.2a	0.2a	1.2a	0.0a	1.2a	0.0a	0.0a	98.6a

Means within the same column and orchard followed by the same letter are not significantly differenty by paired *t*-test (P = 0.05).

Table 4. Cost[1] ($/acre) of various insect management programs using organophosphates (OP), mating disruption (MD) and *Bacillus thuringiensis* (Bt) products. Henderson Co., NC. 1997

	Codling Moth/TABM Mangement Program			
Orchard	OP/OP	MD/Bt	MD/MD	OP/MD
Hend-S	97.86	193.60		
Hend-H	109.97	196.57		
Hend-M	71.52	205.92	273.27	
Hend-N	120.90			206.05
Average	100.06	198.97	273.27	206.05

[1]Costs of insecticides were based on a survey of local pesticide dealers. Isomate C Plus pheromone dispensers and labor for application were charged at $116.50/acre, and NoMate TABM dispensers and labor for application were charged at $130.25/acre.

Table 5. Insecticides applied to the Confirm and Organophosphate treatments in the Hend-B and Hend-MC orchards. Henderson Co., NC. 1997

		DD from biofix[1]		Treatment (amount/acre)	
Orchard	Date	CM	TABM	Confirm	Organophosphate
Hend-B	3/18	--	--	Oil (6 gal)	Oil (6 gal)
	5/2	134	155	Thiodan 50W (4 lb)	Thiodan 50W (4 lb)
	5/16	342	440	Guthion 50W (2 lb)	Confirm 2F (20 oz)
	6/2	486	640	Guthion 50W (2 lb)	
	6/18	692	921	Lorsban 50W (2 lb)	Confirm 2F (20 oz)
	7/3	1020	1324	Lorsban 50W (2 lb)	
	8/6	1811	2280	Guthion 50W (2 lb)	
	8/25	2219	2780	Penncap-M 2F (4 pt)	Confirm 2F (20 oz)
Hend-MC	3/17	--	--	Oil (3 gal)	Oil (3 gal)
	4/3	--	--	Thiodan 3EC (1.3 qt)	Thiodan 3EC (1.3 qt)
	5/6	172	222	Lorsban 50W (2 lb)	Lorsban 50W (2 lb)
	5/22	352	454	Guthion 50W (2 lb)	Confirm 2F (20 oz)
	6/5	510	679	Lorsban 50W (3 lb)	
	6/19	725	950	Lorsban 50W (3 lb)	Confirm 2F (20 oz)
	7/4	1043	1350	Lorsban 50W (3 lb)	
	7/17	1350	1720	Guthion 50W (2 lb)	Confirm 2F (20 oz)
	8/15	1997	2514	Penncap-M 2F (4 pt)	Confirm 2F (20 oz)
	8/28	2295	2870	Penncap-M 2F (4 pt)	

[1]Codling moth (CM) biofix dates: 4/9 in Hend-B and Hend-MC.
Tufted apple bud moth (TABM) biofix dates: 4/16 in Hend-B and 4/20 in Hend-MC.

Table 6. Secondary pest populations on apples treated with a mating Confirm vs. an organophosphate program.

Orchard	Treatment	Cumulative mite days	PLH days	WALH	STLM[2]	% STLM parasitiz.	AA/SA[3] Aphid	Total[4] predators
Barnwell	Confirm	49.0a	13.3b	--	6.1a	25.7a	136.9a	12.4a
	OP	285.8b	4.1a	--	50.4b	19.4a	165.8b	14.6a
McConnell	Confirm	81.1a	4.0a	3.6a	3.5a	0.0	--	--
	OP	95.4a	3.3a	5.1a	17.3b	0.0	--	-- --

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

[1]WALH populations expressed as number per 10 leaves on 6 August.

[2]STLM represented as number per 10 shoots and % parasitization on 25 September.

[3]Apple aphid/spirea aphid complex populations expressed as season total number of leaves infested per 10 shoots.

[4]Generalist predator populations expressed as season total predators per 10 shoots

Table 7. Percent fruit damage on 'Delicious'(RD) and 'Golden Delicious' (GD) apples treated with a Confirm and Conventional insecticide program. Hendercon County, NC. 1997

Orchard (harvest)	Management program	Codling moth			TABM			Plum curculio	Plant bug	Apple maggot	% clean
		stings	entries	total	gen I	gen II	total				
Barnwell-RD	Confirm	0.4a	0.7a	1.1a	0.5a	0.0a	0.5a	0.9a	0.8a	0.0a	96.7b
(9/9)	Conventional	2.8b	0.8a	3.6b	3.4b	0.1a	3.5b	0.8a	2.5a	0.0a	89.6a
Barnwell-GD	Confirm	1.1a	0.3a	1.4a	1.1a	0.1a	1.2a	0.0a	8.0a	0.0a	89.4a
(9/16)	Conventional	1.6a	0.9a	2.5a	4.2b	0.8a	5.0b	0.0a	3.3a	0.2a	89.0a
McConnell-RD	Confirm	0.4a	0.4a	0.8a	0.1a	0.0a	0.1a	0.0a	0.0a	0.0a	99.1b
(9/18)	Conventional	0.9a	2.5b	3.4b	3.9b	0.3a	4.2b	0.5a	0.1a	0.0a	90.8a
McConnell-GD	Confirm	0.5a	0.6a	1.1a	0.9a	0.1a	1.0a	0.1a	0.2a	0.1a	97.4a
(9/15)	Conventional	1.4b	2.5a	3.9b	3.2b	0.3a	3.5b	0.0a	0.8a	0.1a	91.6b

Means within the same column, orchard and cultivar followed by the sames letter are not significantly different by paired *t*-test ($P = 0.05$).

Trials of Tebufenozide, Spinosad and Hydrophobic Clay in Apple

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APPLE: 'Delicious' and 'Golden Delicious'
Codling moth (CM): *Cydia pomonella* (L.)
Redbanded leafroller (RBL): *Argyrotaenia velutinana* (Walker)
Plum curculio (PC): *Conotrachelus nenuphar* (Herbst)

APPLE, INSECTICIDE TRIAL, 1997: An orchard block located at Shenandoah Valley Agricultural Research & Extension Center (Steeles Tavern) was used to compare several pesticide programs. The treatments were (1) Confirm (tebufenozide), (2) Spintor (spinosad), (3) diazinon AG600 (2 lb ai/A), (4) Dupont program, (5) hydrophobic clay (M-96-018 kaolin), and (6) the untreated control. The Dupont program consisted of Asana at green tip, Vydate at 10-20 mm fruit, Guthion at PF and 1C, Lannate/Penncap at 2C and 3C, Guthion at 4C and 5C, and Lannate/Penncap at 6C. Each treatment was applied to 0.25 acre plot using a truck-mounted Durand-Wayland airblast sprayer (except that 5 and 6 were applied to a half acre each). The petal fall in mid May was somewhat late because of a cool spring and protracted bloom. A dilute rate of 180 gallons per acre was used. The clay treatment was applied weekly, as per manufacturer's recommendation. Other sprays were applied every two weeks.

Control of CM provided by all treatments except clay. Treatments 3 and 4 provided control of PC. Most leafroller damage was caused by RBL; almost no injury was seen except for the control. Neither spinosad nor tebufenozide provided any control of PC.

Table 1. Average numbers[1] of injured fruit on apple trees five alternative control programs (Steeles Tavern, Virginia)

Material, product/A	Injured fruit per 50 fruit		
	CM	RBL	PC
Confirm	0.0a	0.0a	5.5a
spinosad	0.0a	0.2a	4.5ab
diazinon	0.0a	0.0a	0.2c
Dupont	0.0a	0.0a	0.0c
kaolin	3.8b	0.0a	1.0c
Control	3.5b	1.2b	2.5bc

[1]Data were transformed for analysis $[(x+0.5)^{0.5}]$. Numbers in a column followed by the same letter are not significantly different.

Residual Toxicity of Several Insecticides Against Neonate Tufted Apple Bud Moth, *Platynota idaeusalis* (Walker), on Apples

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Introduction

The development of various levels of resistance to organophosphate and methomyl insecticides by populations of the tufted apple bud moth (TABM), *Platynota idaeusalis* (Walker), in Pennsylvania has forced growers to seek new tools for controlling this pest (Hull et al. 1997). New, more selective, IPM compatible chemistries are being tested for their effectiveness in controlling TABM.

Tebufenozide, an insect growth regulator known as an ecdysone agonist is one of those new chemistries. Both methoxyfenozide, another compound with similar mode of action, and tebufenozide are very effective compounds in Pennsylvania apple orchards for controlling leafrollers (Hull & Krawczyk 1997). During 1996 and 1997, tebufenozide was registered under an emergency exemption (Section 18) for use on apples in Pennsylvania.

Spinosad, another new chemistry, is a member of a Naturalyte class of insecticides. Its activity is based on natural metabolites derived from the actinomycetes bacterium, *Saccharopolyspora spinosa*. In contrast to other biologically derived insecticides, spinosad is active through ingestion and contact. With its new mode of action, different from all other insecticides, spinosad is not cross-resistant with any other group of insecticides (Bret et al. 1997).

While the changes in residual activity of an insecticide over time are not sufficient enough to totally assess the field effectiveness of a compound, they can provide important information for a better understanding of an insecticide's properties. The knowledge of an insecticide's persistence on foliage under field conditions can help in choosing the best timing for applications, especially when the compound is going to be used more than once during the same season.

Materials and Methods

Treatments. All treatments were applied to four replicated 12-15 tree plots in a randomized block design. Each plot consisted of alternating trees of 'Yorking' and 'Golden Delicious'. Trees were planted to a spacing of 18 x 25 ft and were 18 years old.

During the 1996 and 1997 seasons we tested the residual activity of tebufenozide (Confirm 70W, Rohm & Haas Company, Philadelphia, PA, 0.22 lb AI/A); methoxyfenozide (RH-2485 80W, Rohm & Haas Company, Philadelphia, PA, 0.125 lb AI/A); micro-encapsulated methyl parathion (Penncap M 2F, Atochem North America, Tifton, GA, 0.75 lb AI/A, in 1997 the rate was 0.5 lb AI/A); *Bacillus thuringiensis* (Dipel DF, Abbott Laboratories, N. Chicago, IL, 1 lb/A); spinosad (SpinTor 2SC, DowElanco, Indianapolis, IN, 0.078 lb AI/A); and methomyl (Lannate 90SP, DuPont, E. I. de Nemours & Inc. Wilmington, DE, 0.45 lb AI/A).

Pesticide applications. Experimental sprays were applied with a Friend Airmaster '309' calibrated to deliver 100 GPA at 2.4 mph. Date of the insecticide applications during 1996 and 1997 was 24 June and 19 June, respectively. Each treatment during 1996 and 1997 was applied as a complete spray, except for Confirm 70W during 1997, which was applied using the alternate row middle (ARM) application method on 19 (south side of the tree) and 26 June (north side). Dipel DF and the combination of Penncap M 2F plus Lannate 90SP were additionally applied on 30 June during 1997. A routine schedule of fungicides was maintained throughout the experiment.

Bioassay procedures. At 1, 2 (1996 only), 4 (1997 only), 7, 14, 21, 28, 35, and 42 days after the initial insecticide applications, 40 leaves were collected from each center 'Yorking' tree at height of 4-6 ft around the periphery of the tree and returned to laboratory. In the treatment with an ARM application of Confirm, 40 leaves were collected separately from each side of the tree. Temperature and rainfall within the area was recorded in a nearby weather station. Two small disks (22 mm in diameter) were cut from each leaf with a cork borer. For each year of the studies, the TABM populations were collected from various apple orchards in Adams County, PA during the preceeding year. The F4 and F6 generations of TABM larvae were used for laboratory bioassays during 1996 and 1997, respectively. Ten dishes with 4 leaf disks per petri dish were used for each tree, while leaves collected from untreated trees were used as controls. Bioassays were conducted by exposing newly hatched neonates (less than 24 h old) to the treated foliage. Five neonates were transferred to the surface of treated disks in each petri dish (10 dishes per tree x 5 larvae per dish = 50 larvae per replicate). Larvae were maintained in a growth chamber at 21.1°C with a photoperiod of 16:8 (L:D). Larval mortality was assessed after 7 and 14 days.

Statistical Analysis. Corrected mortality was calculated using Abbott's formula (Abbott, 1925). Percentage of corrected mortality was analyzed by analysis of variance (ANOVA). Mean larval mortality at 7 and 14 days was analyzed separately using Fisher protected LSD test ($P \leq 0.05$) after using *arcsin sqrt x* transformation (SuperAnova, Abacus Concepts 1989).

Results and Discussion

During both years of the study the residual activity of RH-2485 remained highly effective against neonate TABM larvae for 28 days after the application, with only a slight decrease in activity on leaves collected 35 and 42 days after treatment (Figs. 1 and 2). The ARM application of Confirm to the south side of the trees provided very high larval mortality for up to 21 days after application (Fig. 2). During the first week after the south side ARM application, the residual activity of Confirm on the unsprayed side (North) of the tree remained lower than on the sprayed side. Mortality levels remained similar on both sides of the tree after the second Confirm ARM spray. When Confirm was applied as a complete spray during 1996, it remained highly active until 14 days after application, with a significant drop in activity after 21 days (Fig. 1). The mortality readings were higher at 14 days than at 7 days for both the RH-2485 and Confirm treatments.

The differences in residual activity between different sides of the tree during ARM applications of Confirm are similar to data collected by Knight & Hull (1992) for methomyl and organophosphate insecticides. The above authors, during chemical analysis of treated leaves from both sides of the tree, showed a lower deposition of insecticide residue on the unsprayed side of the tree after a single ARM application. When the alternate row middle application technique was used during the entire season, the significantly higher levels of pesticide residues were observed on the side of the tree, that was most recently sprayed (Knight & Hull 1992a).

The SpinTor treatment showed very high neonate mortality up to 7 days after application, but the residual activity dropped sharply thereafter (Fig. 3). Dipel DF provided the lowest level of mortality 1 day after treatment with mortality quickly declining to 50% after 6 days. When Penncap M was applied as a single complete spray during 1996, its residual activity remained high for only 2 days after application. Unexpectedly, the two complete applications of Lannate plus Penncap M mixture during 1997 provided very high residual activity against TABM neonate larvae for almost 35 days after the first spray, lasting longer than any other treatment except RH-2485.

It is possible, that a significant bias effect on the data collected during 1996 and 1997 was caused by the total amount and intensity of the rainfall (Fig. 4). In 1996, almost 2.5 times higher rainfall was observed than during 1997. Additionally, during 1996 the first rainfall was observed within a few hours after the application of insecticides.

During our study we tested the residual activity of various insecticides only on neonate TABM larvae. No data was collected on the effect of the compounds on other stages of the insect. The effectiveness and residual activity of these compounds may be greatly different if older larval stages were bioassayed.

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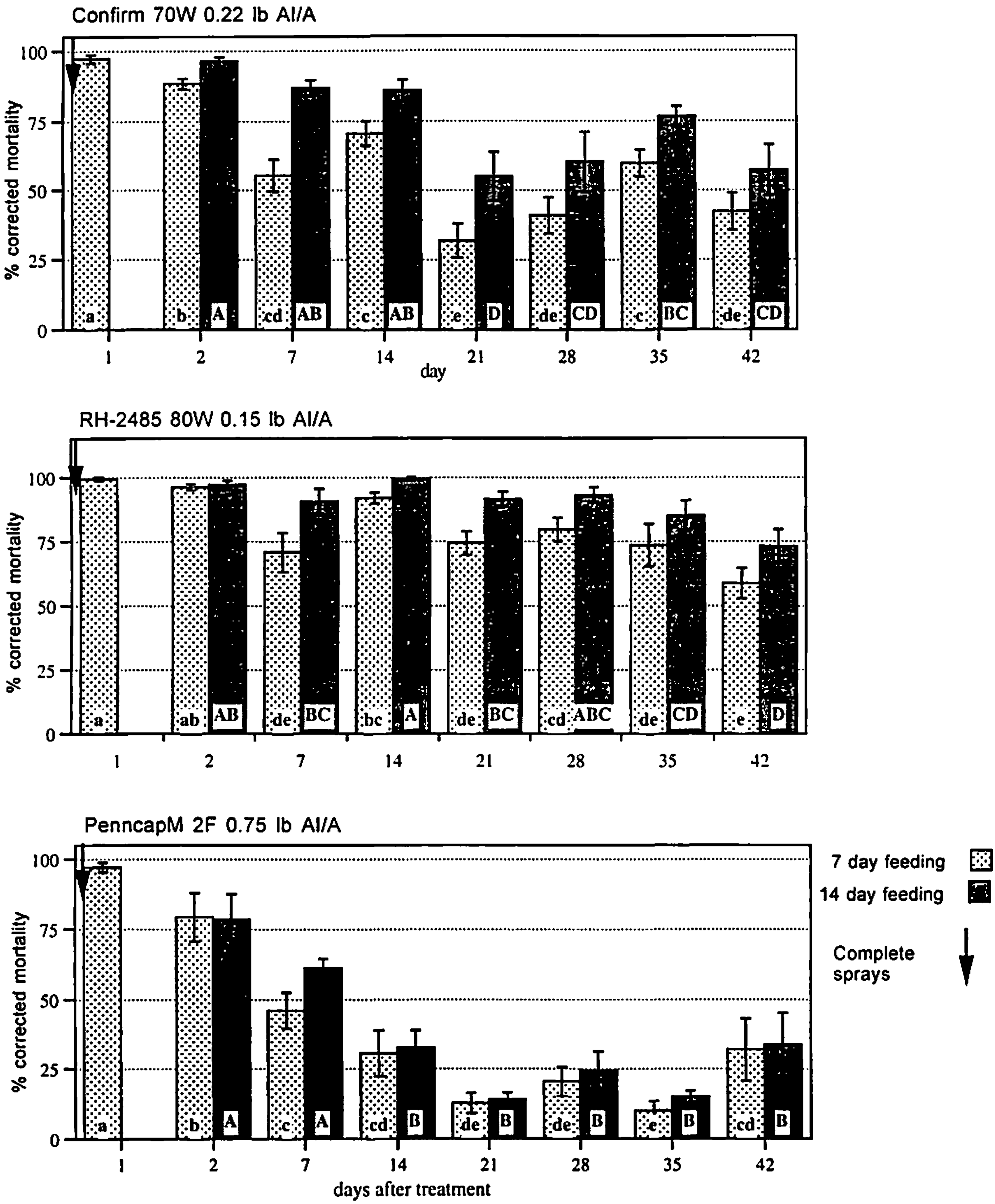

Figure 1. Residual activity of insecticides against neonate TABM. Larvae were allowed to feed on treated leaves for 14 days after collection from orchard. Mortality readings were made at 7 and 14 days. Biglerville, PA 1996.

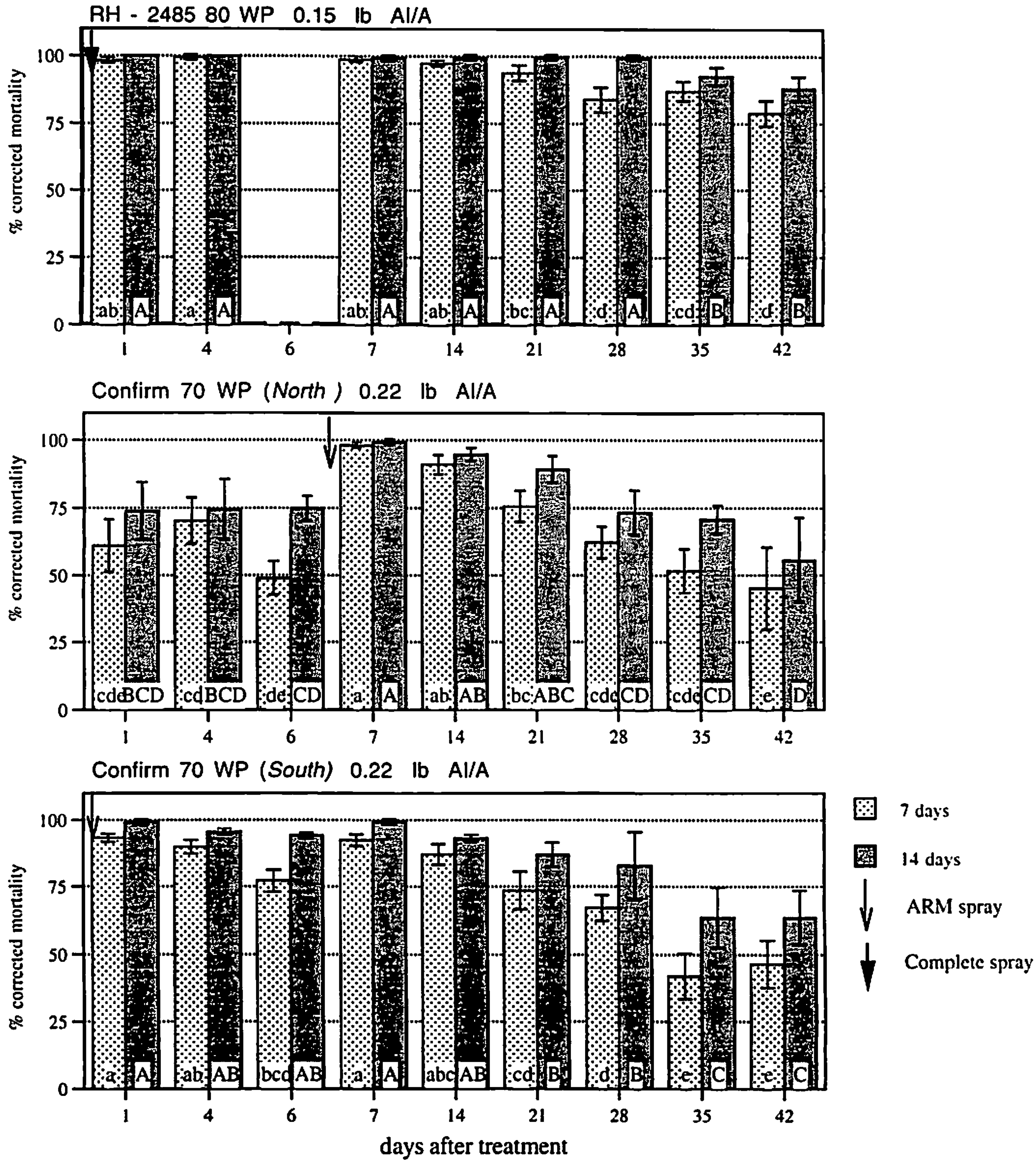

Figure 2. Residual activity of insecticides against neonate TABM. Larvae were allowed to feed on treated leaves for 14 days after collection from orchard. Mortality readings were made at 7 and 14 days. Biglerville, PA 1997.

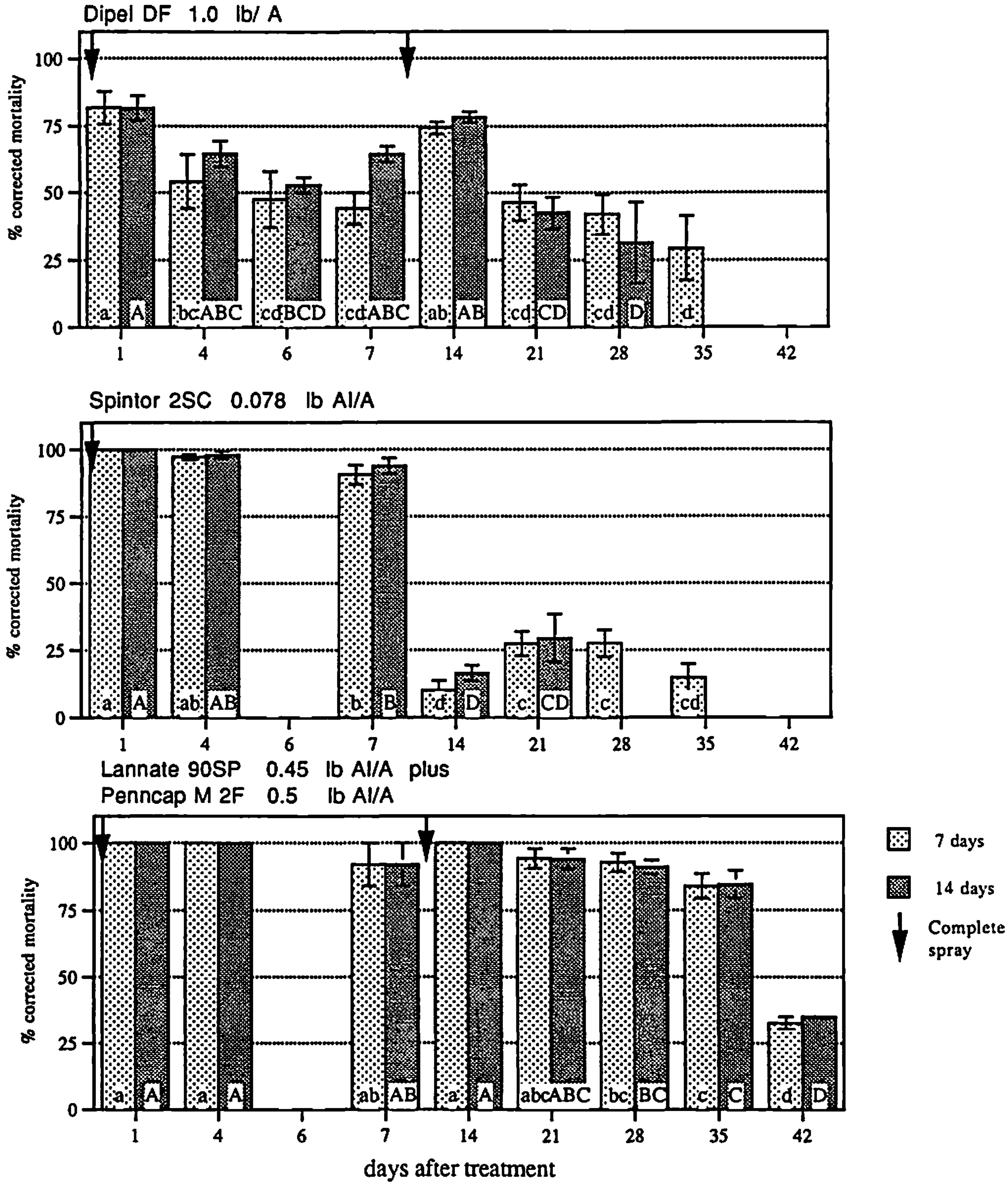

Figure 3. Residual activity of insecticides against neonate TABM. Larvae were allowed to feed on treated leaves for 14 days after collection from orchard. Mortality readings were made at 7 and 14 days. Biglerville, PA 1997.

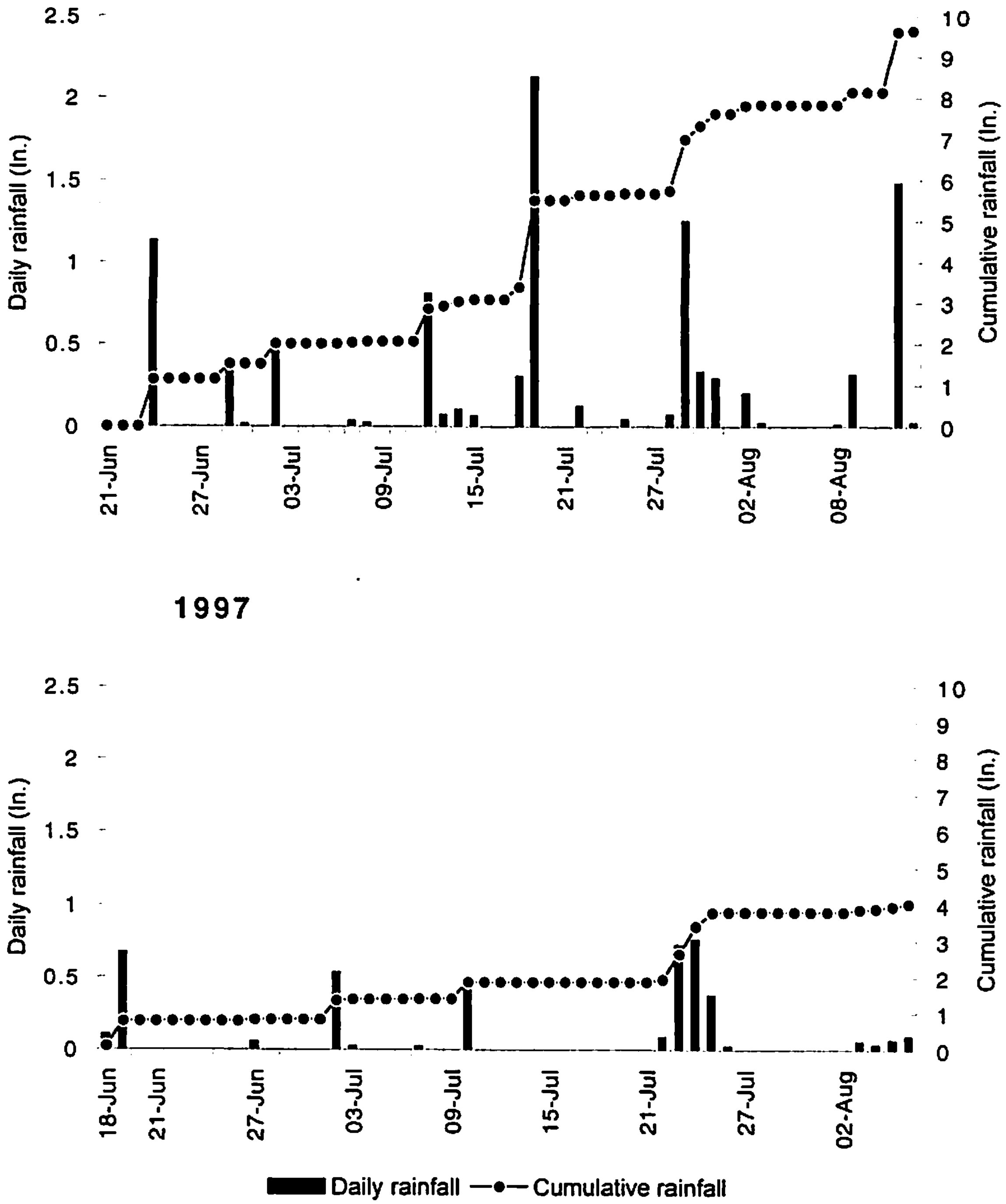

Figure 4. Daily and cumulative rainfall in Biglerville, PA during 1996 and 1997.

Economic Performance of Tebufenozide, Mating Disruption, and Conventional Spray Programs for Tufted Apple Bud Moth and Leafroller Management in Processing Apples

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Introduction. In the past, management of lepidopteran pests in processing apples has required numerous applications of organophosphates and carbamates. The continued use of these types of pesticides is being questioned for various reasons including: 1) the impact of broad-spectrum pesticides on environment, 2) concern about the health and safety of consumers and farm workers, and 3) increasing evidence of tufted apple bud moth (TABM) and leafroller resistance to a number of insecticides in these two classes. Two promising alternatives to current pesticides are tebufenozide and mating disruption. A comparison of the cost and quality of fruit is important information for any grower considering changing from a conventional spray program to either tebufenozide or mating disruption.

Materials and Methods. The use of tebufenozide and mating-disruption have been extensively studied in experimental plots (Hull and Felland 1993, 1994; Hull 1996). In 1995, field experiments were initiated in commercial orchard blocks in Adams County, Pennsylvania to compare the efficacy of tebufenozide and mating disruption with a conventional spray program. In 1996, four treatments were evaluated for their effect on apple quality and profitability: 1) two early-season applications (June 5 and June 22) of tebufenozide (Confirm 2F) at 0.2 lb ai/A for first brood coddling moth control and TABM, followed by two applications of methyl parathion (total of 2.0 lb ai/A) for second brood TABM control, 2) three applications of tebufenozide (2 applications of Confirm 2F as in 1), followed by one application of Confirm 2F at 0.2 lb ai/A on August 20) to provide all-season control, 3) two applications (on May 23 and July 23) of NoMate™ pheromone spirals at the rate of 5-6 spirals/tree or approximately 400 spirals/A, and 4) 12 alternate row-middle applications of methyl-parathion (total of 3.625 lb ai/A). All treatments received applications of Sniper 50 WP and Provado 1.6F on May 14 and 23 for control of early season pests. In addition, the mating disruption block received an additional application of Sniper 50W on August 6 to control an outbreak of Oriental fruit moth.

The commercial blocks used in the study are owned and operated by the same grower. Other than the four insect management programs, the disease, fertility, and weed management programs were similar (Table 1). All blocks contained the same two cultivars: 'Yorking' with Golden Delicious as the pollenizer. The percent of trees which are 'Yorking' varied from 64% in the mating disruption block to a high of 77% in the early-season tebufenozide block (average of 69% 'Yorking'). Block sizes varied from 4.8 acres (for the two tebufenozide treatments) to 6.3 acres for mating disruption. The conventional block used for comparison was 9.8 acres. Tree densities were similar for the four blocks varying from 64 to 82 trees per acre (average of 75 trees/A). Yields averaged 10.2 bu/tree for 'Yorking' and 11.5 bu/tree for Golden Delicious. Average apple sizes for US #1 fruit was 30% 2 ¾" and up, 45% 2 ½"-2 ¾", and 25% less than 2 ½". All the trees in these blocks are over 20 years old; the trees in the tebufenozide treatments are somewhat older than the others.

In order to isolate the economic impact of the control program for TABM and leafrollers, averages were used for tree densities, yields, and apple sizes. Important comparative information is the resulting grades of the apples and the cost of the control programs. Estimated gross returns were calculated for each treatment based on average yields and fruit sizes and 1996 Knouse Foods prices[1]. Net returns were calculated by subtracting the adjusted costs from a low-density processing apple enterprise budget (Harper 1996) by actual grower costs for the insecticide, fungicide, herbicide, and fertility programs. Grower costs for insecticides, fungicides, herbicides, and fertilizer are given in Table 1. The conventional spray program had the lowest insecticide cost at $64/acre, while mating disruption had the highest cost at $228/acre. The early-season tebufenozide treatment cost $96/acre, with the all-season treatment costing only $3 more (difference between one application of Confirm and several applications of PennCap-M).

Results. Overall, all the treatments produced a high proportion of apples which graded out as U.S. #1; all treatments were over 95% US #1 and the tebufenozide treatments were 100% (Table 2). However, based on these slight quality differences, the tebufenozide treatments generated net returns which were $49/A higher for the early season tebufenozide treatment and $57/A higher for the all-season tebufenozide treatment (Table 3). The mating disruption treatment produced higher quality apples than the conventional spray program treatment, but the high cost of the pheromone spirals resulted in net returns which were $167 lower.

At the present time, processors pay growers on the basis of size and U.S. #1 grading standards (which allows up to 5% trim waste). There is considerable evidence, however, that apples with TABM damage lose weight and often have problems with rot when put into conventional storage. Estimates of lost weight are in the 5-6% range with occurrence of fruit rot in the 3-10% range (Hull and Rajotte 1988). If processors continue to pay growers on the basis of USDA grade standards, then there is less incentive for growers to adopt new pest management methods like tebufenozide and mating disruption. It could be argued that it is in the best interest of the processor to encourage growers to use methods which dramatically increase the percentage of fruit free from TABM damage. If processors used either a combination of premiums and discounts for TABM damage or just discounts, this would provide additional incentive for growers to adopt new control practices. Modest premiums and discounts in the 5-15% range could be used to encourage adoption and could save approximately 8-16% of the weight of apples in

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[1] 1996 Knouse Foods prices for premium quality fruit ($/cwt.):

	York	Golden Delicious
U.S. #1 2 ¾" and up	$13.00	$12.00
U.S. #1 2 ½"-2 ¾"	$10.00	$9.00
juice apples	$7.00	$7.00

Note: The apples in these orchard blocks would have been eligible for premium prices in 1996.

conventional storage. Examples of the net returns under a 5, 10, and 15 percent premium for damage-free apples and/or a 5, 10, and 15 discount for TABM damaged apples are given in Table 2. Under these types of grade incentives, the net return advantage of tebufenozide becomes even more pronounced. Each 5% change in the premium/discount increases net returns by approximately $109-112/A for the tebufenozide treatments. Each 5% increase in a discount only scheme increases net returns over conventional spraying by $52-53/A. A 15% premium/discount structure is needed before mating disruption compares favorably with the conventional spray program.

Conclusions. When compared to a conventional spray program in 1996, orchard blocks protected with either tebufenozide or mating disruption had a higher percentage of damage-free fruit. Tebufenozide appears to be an economical alternative to a conventional spray program because its 50% higher cost is more than offset by the value of higher quality fruit. Although it results in a higher percentage of damage-free fruit, the high cost of mating disruption makes it unlikely that this IPM tactic will be selected as a primary source of control for TABM and leafrollers.

Current application of USDA grade standards allows for considerable TABM damage in processing apples. Research suggests that TABM-damaged fruit put into conventional storage will have losses of 8-16%. By providing incentives to growers to produce fruit free of TABM damage, processors could speed up adoption of alternatives to conventional spray programs and also reduce their storage losses.

This experiment was repeated in 1997 in the same orchard blocks and will also be conducted in 1998. Although processing apple prices were high in 1996, it is expected that tebufenozide will continue to be an economical option to conventional spray programs.

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Table 1. Insecticide, fungicide, herbicide, and fertilizer costs for the alternative TABM and leafroller control treatments.

Input Costs	All-season Confirm ($/acre)	Early-season Confirm ($/acre)	Mating disruption ($/acre)	Conventional OP sprays ($/acre)
Fungicides				
Polyram	45.22	45.22	46.57	45.90
Rubigan	34.79	34.79	34.79	34.79
Captan	19.80	26.40	13.20	23.10
Ziram	8.80	13.20	8.80	15.40
Insecticides				
Provado	13.30	13.30	13.30	13.30
Sniper	6.97	6.97	12.20	6.97
Penncap	2.73	24.58	2.73	43.70
Confirm + Latron	75.99	50.66		
NoMate™			200.00	
Herbicides	13.34	13.34	17.15	12.69
Fertilizers	16.86	16.86	16.86	16.86
Total cost	$237.80	$245.32	$365.60	$212.71

Table 2. Proportion of fruit graded as U.S. #1 and fruit totally damage-free.

Cultivar	All-season tebefunozide	Early-season tebufenozide	Mating disruption	Conventional OP sprays
'Yorking':				
% U.S. #1	100.0	100.0	98.0	97.4
% damage-free	98.4	97.3	77.5	61.4
Golden delicious:				
% U.S. #1	100.0	100.0	95.5	97.4
% damage-free	98.8	98.9	88.6	83.0

Table 3 . Differences in net returns compared to a conventional organophosphate spray program.

Processing apple pricing structure	All-season Confirm ($/acre)	Early-season Confirm ($/acre)	Mating disruption ($/acre)
current USDA standards	57	49	-167
5% premium/5% discount	169	158	-117
5% discount	110	101	-142
10% premium/10% discount	281	268	-67
10% discount only	164	153	-117
15% premium/15% discount	393	377	-17
15% discount only	217	206	-92

FIELD TEST OF INSECTICIDES AGAINST THE OBLIQUEBANDED LEAFROLLER

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Treatments were applied with a truck-mounted airblast sprayer calibrated to deliver 100 gallons of water/acre to 0.25 acre plots of apple trees in two orchards: (1) 'Idared' trees (Nesbitt orchard), which were 10 ft high, 12 ft wide and with rows 20 ft apart, (2) 'Delicious' trees (Buhr orchard), which were 10 ft high, 9 ft wide and with rows 20 ft apart. Treatments were arranged in a RCB design once in each orchard. Six schedules of a mixture of Confirm 2F (4.5 oz AI/acre) and Latron B-1956 (16 oz/acre) were compared: (1) An initial spray was applied at the first catch of moths (20 Jun) followed by sprays on 1 Jul, 16 Jul and 30 Jul; (2) An initial spray was applied at the first catch of moths (20 Jun), followed by a spray at first hatch (1 Jul); (3) An initial spray was applied at first catch (20 Jun) followed by another spray on 16 Jul; (4) The initial spray was applied at the estimated mid-point of cumulative egg hatch (16 Jul), followed by a spray on 30 Jul; (5) The initial spay was applied at first hatch (1 Jul) followed by another spray at the estimated mid-point of cumulative egg hatch (16 Jul); (6) A spray was applied at first hatch (1 Jul), followed by sprays on 16 Jul and 30 Jul. Also, Confirm 2F (4.5 oz AI/acre) + summer oil, Confirm 2F (4.5 oz AI/acre) and Confirm 2F (3.0 oz AI/acre) + Latron B-1956 (16 oz/acre) were applied on 1 Jul, 16 Jul and 30 Jul. Three treatments of Spinosad 2SC were compared: (1) Spinosad 2SC (1.0 oz AI/acre) applied at first hatch on (1 Jul), followed by additional sprays on 16 Jul and 30 Jul; (2) Spinosad 2SC (1.25 oz AI/acre) applied at first hatch (1 Jul), and on 16 Jul and 30 Jul; (3) Spinosad 2SC (1.0 oz AI/acre) plus Confirm 2F (3.0 oz AI/acre) applied at first hatch (1 Jul), 16 Jul and 30 Jul. Lorsban 50 W (24 oz AI/acre) was applied as a standard treatment at first hatch (1 Jul), 16 Jul and 30 Jul. Check plots were not sprayed with insecticides during the test. Summer populations of larvae were compared by examining 20-50 growing terminals from each of five randomly selected trees/plot for live larvae on 29 Jul. Fruit damage from the first summer generation of larvae was estimated initially on 11, 12 Aug by sampling 100-200 apples from each of 4 randomly selected trees/plot. At harvest (30 Sep Buhr orchard and 3 Oct Nesbitt orchard), 200 apples were picked from each plot and OBLR damaged fruit was classified according to USDA grading standards into the categories of "Fancy", #1 and culls.

OBLR infestation in the Buhr orchard was considerably lighter than that on the Nesbitt orchard, and the relative effectiveness of the different treatments tested varied considerably at the two locations. Most of the treatments set up in the Buhr orchard, including the standard materials Dipel, Lorsban, and Asana, were quite effective in preventing fruit injury at harvest. The most effective treatments in preventing fruit damage at harvest in the Nesbitt orchard were: the Lorsban standard program, Danitol, and the 4-spray program of Confirm. Levels of fruit damage were generally quite similar in all of the programs set up to compare different schedules of Confirm. The addition of Latron-B or oil did not appear to improve fruit protection in the Confirm treatments. The treatments of RH-2485 provided similar levels of control to the best treatments of Confirm. Diazinon was less effective than the Lorsban standard, but it is difficult to compare the two materials directly because only two sprays of Diazinon were applied, compared to the three sprays of Lorsban.

Buhr Orchard

Treatment and rate	form/acre	# Sprays	% inf term 29 Jul	% Fruit Damage 11 Aug	Harvest Fruit Rating (30 Sep) % Fruit Damage (USDA Cat) Fancy	#1	cull	% clean
RH-2485 80 W[a]	2.0 oz	3[b]	1.9	1.5	2.5	1.5	0.0	96.0
RH-2485 80 W[a]	4.0 oz	3[b]	2.9	0.5	2.0	0.0	1.0	97.0
RH-2485 80 W[a]	6.0 oz	3[b]	2.6	0.2	0.5	1.5	0.5	97.5
Confirm 2F[a]	18.0 oz	3[b]	2.9	0.8	0.0	0.5	1.0	98.5
Confirm 2F +	18.0 oz	3[b]	6.1	0.9	1.5	0.5	1.0	97.0
summer oil	128 oz	3[b]						
Confirm 2F	18.0 oz	3[b]	2.8	0.0	1.0	1.0	0.0	98.0
Confirm 2F[a]	12.0 oz	3[b]	10.3	0.5	0.5	0.5	0.5	98.5
Confirm 2F[a] +	12.0 oz	3[b]	2.6	0.8	2.0	1.0	1.0	96.0
Spinosad 2SC	2.5 oz	3[b]						
Spinosad 2SC	2.5 oz	3[b]	4.0	1.5	4.5	2.5	0.0	93.0
Spinosad 2SC	5.0 oz	3[b]	11.4	1.5	2.5	1.5	0.5	95.5
Confirm 2F[a]	18.0 oz	4[c]	3.8	1.3	2.0	0.0	0.5	97.5
Confirm 2F[a]	18.0 oz	2[d]	3.6	1.3	0.0	1.5	1.5	97.0
Confirm 2F[a]	18.0 oz	2[e]	7.8	1.4	2.0	1.5	0.5	96.0
Confirm 2F[a]	18.0 oz	2[f]	14.3	1.3	2.0	0.5	0.0	97.5
Confirm 2F[a]	18.0 oz	2[g]	16.7	3.2	0.5	0.5	1.0	98.0
Diazinon AG600	54.0 oz	2[e]	2.4	1.8	2.0	0.5	1.0	96.5
Danitol 2.4 EC	10.7 oz	3[b]	3.4	0.2	0.0	1.5	0.0	98.5
Warrior 1 EC	0.5 oz	3[b]	10.0	0.9	1.0	0.5	0.5	98.0
MYX 837	6.0 qts	3[b]	10.5	2.1	1.0	4.5	1.0	93.5
Dipel DF	32.0 oz	3[b]	0.0	0.9	1.0	0.0	1.5	97.5
Asana XL	12.0 oz	3[b]	2.7	0.3	0.0	0.0	0.0	100.0
Lorsban 50W	48.0 oz	3[b]	6.8	2.7	0.5	0.0	0.5	99.0
Check			13.3	2.8	3.5	3.0	2.5	91.0

[a] Applied with Latron B-1956 (16 oz/100 gal)
[b] Sprays applied 30 Jun (1st hatch), 15 Jul (mid-hatch), and 29 Jul (cover).
[c] Sprays applied 20 Jun (1st catch), 30 Jun (1st hatch), 15 Jul (mid-hatch), and 29 Jul (cover).
[d] Sprays applied 20 Jun (1st catch) and 30 Jun (1st hatch).
[e] Sprays applied 20 Jun (1st catch) and 15 Jul (mid-hatch),
[f] Sprays applied 30 Jun (1st hatch) and 15 Jul (mid-hatch).
[g] Sprays applied 15 Jul (mid-hatch) and 29 Jul (cover).

Nesbitt Orchard

Treatment and rate	form/acre	# Sprays	% inf term 29 Jul	% Fruit Damage 12 Aug	Harvest Fruit Rating (3 Oct) % Fruit Damage (USDA Cat) Fancy	# 1	cull	% clean
RH-2485 80 W[a]	2.0 oz	3[b]	16.2	4.4	5.0	1.5	2.5	91.0
RH-2485 80 W[a]	4.0 oz	3[b]	10.2	3.1	2.5	0.5	1.5	95.5
RH-2485 80 W[a]	6.0 oz	3[b]	18.5	3.8	3.5	2.5	0.5	93.5
Confirm 2F[a]	18.0 oz	3[b]	14.0	9.7	4.0	4.5	4.0	87.5
Confirm 2F +	18.0 oz	3[b]	13.3	3.6	4.5	3.0	2.0	90.5
summer oil	128 oz	3[b]						
Confirm 2F	18.0 oz	3[b]	9.3	9.7	1.5	3.0	4.5	91.0
Confirm 2F[a]	12.0 oz	3[b]	6.9	4.3	4.5	2.5	1.0	92.0
Confirm 2F[a] +	12.0 oz	3[b]	10.6	2.5	2.5	2.0	0.5	95.0
Spinosad 2SC	2.5 oz	3[b]						
Spinosad 2SC	2.5 oz	3[b]	12.3	5.6	3.0	0.5	2.5	94.0
Spinosad 2SC	5.0 oz	3[b]	5.1	2.7	2.0	1.5	1.5	95.0
Confirm 2F[a]	18.0 oz	4[c]	13.9	4.4	3.0	0.5	0.5	96.0
Confirm 2F[a]	18.0 oz	2[d]	19.1	3.8	3.5	2.5	4.5	89.5
Confirm 2F[a]	18.0 oz	2[e]	15.3	5.0	5.5	3.5	3.0	88.0
Confirm 2F[a]	18.0 oz	2[f]	4.0	5.3	4.5	0.5	2.0	93.0
Confirm 2F[a]	18.0 oz	2[g]	15.2	3.8	2.0	2.5	1.0	94.5
Diazinon AG600	54.0 oz	2[e]	18.2	9.8	7.0	8.0	13.5	71.5
Danitol 2.4 EC	10.7 oz	3[b]	4.7	2.0	0.0	1.0	2.5	96.5
Warrior 1 EC	0.5 oz	3[b]	7.3	1.0	2.5	4.0	0.5	93.0
MYX 837	6.0 qts	3[b]	25.4	9.7	1.0	4.0	9.0	86.0
Dipel DF	32.0 oz	3[b]	24.7	8.4	2.5	4.0	10.0	83.5
Asana XL	12.0 oz	3[b]	8.8	4.8	0.0	1.0	4.5	94.5
Lorsban 50W	48.0 oz	3[b]	0.0	0.4	2.5	0.0	1.0	96.5
Check			41.2	18.7	6.0	10.5	15.0	68.5

[a] Applied with Latron B-1956 (16 oz/100 gal)
[b] Sprays applied 30 Jun (1st hatch), 15 Jul (mid-hatch), and 29 Jul (cover).
[c] Sprays applied 20 Jun (1st catch), 30 Jun (1st hatch), 15 Jul (mid-hatch), and 29 Jul (cover).
[d] Sprays applied 20 Jun (1st catch) and 30 Jun (1st hatch).
[e] Sprays applied 20 Jun (1st catch) and 15 Jul (mid-hatch).
[f] Sprays applied 30 Jun (1st hatch) and 15 Jul (mid-hatch).
[g] Sprays applied 15 Jul (mid-hatch) and 29 Jul (cover).

Combined

			% inf	% Fruit	Harvest Fruit Rating (30 Sep, 3 Oct) % Fruit Damage (USDA Cat)			%
Treatment and rate	form/acre	# Sprays	term 29 Jul	Damage 11, 12 Aug	Fancy	# 1	cull	clean
RH-2485 80 W[a]	2.0 oz	3[b]	9.1ab	2.9a	3.8b	1.5abcde	1.3ab	93.5abc
RH-2485 80 W[a]	4.0 oz	3[b]	6.5ab	1.8a	2.3b	0.3ab	1.3ab	96.3bc
RH-2485 80 W[a]	6.0 oz	3[b]	10.5ab	2.0a	2.0b	2.0abcde	0.5a	95.5bc
Confirm 2F[a]	18.0 oz	3[b]	8.4ab	5.2a	2.0ab	2.5abcde	2.5ab	93.0abc
Confirm 2F +	18.0 oz	3[b]	9.7ab	2.3a	3.0b	1.8abcde	1.5ab	93.8abc
summer oil	128.0oz	3[b]						
Confirm 2F	18.0 oz	3[b]	6.0ab	4.8a	1.3ab	2.0abcde	2.3ab	94.5abc
Confirm 2F[a]	12.0 oz	3[b]	8.6ab	2.4a	2.5b	1.5abcde	0.8ab	95.3bc
Confirm 2F[a] +	12.0 oz	3[b]	6.6ab	1.6a	2.3b	1.5abcde	0.8ab	95.5abc
Spinosad 2SC	2.5 oz	3[b]						
Spinosad 2SC	2.5 oz	3[b]	8.2ab	3.5a	3.8b	1.5abcde	1.3ab	93.5abc
Spinosad 2SC	5.0 oz	3[b]	8.3ab	2.1a	2.3b	1.5abcde	1.0ab	95.3abc
Confirm 2F[a]	18.0 oz	4[c]	8.8ab	2.8a	2.5b	0.3ab	0.5a	96.8bc
Confirm 2F[a]	18.0 oz	2[d]	11.3ab	2.6a	1.8ab	2.0abcde	3.0ab	93.3abc
Confirm 2F[a]	18.0 oz	2[e]	11.5ab	3.2a	3.8b	2.5bcde	1.8ab	92.0abc
Confirm 2F[a]	18.0 oz	2[f]	9.1ab	3.3a	3.3b	0.5abcd	1.0a	95.3abc
Confirm 2F[a]	18.0 oz	2[g]	15.9ab	3.5a	1.3ab	1.5abcde	1.0ab	96.3bc
Diazinon AG600	54.0 oz	2[e]	10.3ab	5.8a	4.5b	4.3cde	7.3ab	84.0ab
Danitol 2.4 EC	10.7 oz	3[b]	4.0a	1.1a	0.0a	1.3abcde	1.3ab	97.5bc
Warrior 1 EC	0.5 oz	3[b]	8.7ab	0.9a	1.8b	2.3abcde	0.5a	95.5bc
MYX 837	6.0 qts	3[b]	18.0ab	5.9a	1.0ab	4.3de	5.0ab	89.8abc
Dipel DF	32.0 oz	3[b]	12.3ab	4.7a	1.8b	2.0abcd	5.8ab	90.5abc
Asana XL	12.0 oz	3[b]	5.7ab	2.5a	0.0a	0.5abc	2.3ab	97.3c
Lorsban 50W	48.0 oz	3[b]	3.4a	1.5a	1.5ab	0.0a	0.8ab	97.8bc
Check			27.2b	10.7a	4.8b	6.8e	8.8b	79.8a

Means within a column followed by the same letter are not significantly different (Fisher's Protected LSD Test, $P<0.05$).

Counts transfored $Log_n(x+1)$, and percentages of damaged and clean fruit transformed Arcsin(Sqrt X) prior to analysis

[a] Applied with Latron B-1956 (16 oz/100 gal)
[b] Sprays applied 30 Jun (1st hatch), 15 Jul (mid-hatch), and 29 Jul (cover).
[c] Sprays applied 20 Jun (1st catch), 30 Jun (1st hatch), 15 Jul (mid-hatch), and 29 Jul (cover).
[d] Sprays applied 20 Jun (1st catch) and 30 Jun (1st hatch).
[e] Sprays applied 20 Jun (1st catch) and 15 Jul (mid-hatch),
[f] Sprays applied 30 Jun (1st hatch) and 15 Jul (mid-hatch).
[g] Sprays applied 15 Jul (mid-hatch) and 29 Jul (cover).

Movement of the Obliquebanded Leafroller, *Choristoneura rosaceana* (Harris) and its Relationship to Confirm® Field Efficacy

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Due to the unique behavior of the obliquebanded leafroller (OBLR), *Choristoneura rosaceana* (Harris), labelling of the larval habitation site rather than the organism itself was feasible in order to study its local migration behavior. This technique was employed in order to ascertain the frequency of movement into new habitation sites. This is of particular concern since during the spray season larvae have the potential to move to newly developed untreated terminals and escape insecticide exposure. This movement into internal refugia has been implicated as a possible contributing factor in the difficulty of controlling this orchard pest. This may be particularly important with slower acting compounds such as biorationals (e.g., Bt compounds) and IGR's (e.g., Confirm) that need longer exposure durations to be maximally effective. Once residency times of OBLR are determined it is important to relate this to both concentration and exposure regimes of insecticides intended for control of this pest in order to determine if and to what extent this phenomenon is occurring.

Materials and Methods

Field Ecology and Behavior. Obliquebanded leafroller (OBLR), *Choristoneura rosaceana* (Harris) larvae were monitored to determine duration of residency in habitation sites. The second half of the overwintering (3rd-5th instars, June 10-23) as well as the entire summer (1st-5th instars, July 9-Sept. 4) generations were monitored. Sites were marked by tying colored flagging tape to branches proximal to the site and tying string to the petiole of the leaf or leaves where the larvae resided. Flagging tape was numbered to distinguish between sites. Sites were checked every one to seven days and new sites were added with different colored flagging tape. The location of the overwintering portion of the study was the Trickler experimental orchard containing Red Delicious and MacIntosh varieties of apples. The Station Creek experimental orchard containing Cortlands was used for the summer portion of the study. Both orchards are located in or near Geneva, NY. For each OBLR habitation site maximum residency duration time was calculated. Due to the presence of a small percentage of pupae at the end of the study, pupae were counted as vacated sites. For the summer generation, larvae that were dead or parasitized were not included in the count of residency duration time. For the winter generation, dead larvae were included in the residency duration determinations since they accounted for a very small portion (0.33%) of the total. No parasitized larvae were included in the residency duration data set from the winter or summer generation. Sites from the overwintering generation that were not vacated at the end of the study (June 23) were not included in the residency duration determinations. All sites from the summer generation were monitored until vacancies occurred. No new sites were added after August 19 in the summer generation portion of the study since egg masses began to hatch larvae for the next overwintering generation. For the summer generation monitoring, each start date when new sites were flagged was compared independently to observe trends over the entire generation. In addition to these, comparisons were made between the first half of the summer generation (1st-3rd instars) and the second half of the summer generation (3rd-5th instars). Each of these groups from the summer generation was also compared to the overwintering generation (3rd-5th instars) of OBLR.

The summer generation was split into two groups so that both developmental and generational (i.e., overwintering vs. summer) differences could be compared. To determine if varietal differences influenced residency duration, data from McIntosh was compared to Red Delicious, both from the overwintering generation. Data of cumulative percent vacancy based on maximum residency duration were plotted with respect to time for each of the above comparisons except varietal differences which was placed into a table. In addition to these comparisons with live larvae, comparisons of incidence of dead and parasitized (considered separately) larvae within and between groups were made.

Studies of overwintering and summer generations were synchronized based on moth flights so accurate comparisons between the generations could be made. The first flight of the overwintering generation of OBLR was on June 17 and peak flight occurred on June 23. For the summer generation, first flight occurred on August 4 and two major peak flights occurred on August 24 and on September 4 (A. Agnello, personal communication).

Larval Exposure Duration Bioassay. Larvae for the bioassay came from the Brown colony which was started by larvae collected in May 1997 from a commercial apple orchard in Orleans county New York. Once collected, larvae were placed individually into 8 dram clear plastic jelly cups containing a pinto bean, *Phaseolus vulgaris* L., diet modified from Shorey and Hale (1965). When pupae had developed they were placed into plastic bags with damp cotton. The resulting adults mated and laid egg masses. Egg masses were placed into vials and hatched larvae were put onto fava bean, *Vicia faba* L., plants and used for the continuation of the colony. For the bioassay, fava bean leaves were treated by dipping in an aqueous solution of tebufenozide (Confirm®) (RH5992 70WP®, Rohm and Haas, Philadelphia, PA) for five seconds and allowed to air dry. Leaf discs were then cut out of the leaves with a cork borer. Each larva was placed into a 30 ml polystyrene cup along with two 14 mm diameter treated fava bean leaf discs. Larvae from the F3 generation were tested at three concentrations including 12.22 ug/ml, 36.75 ug/ml and 122.5 ug/ml. These concentrations were based on the LC50, 90, and 99+ from a probit analysis on the F2 generation. Three replications of approximately 40-60 larvae were tested at each concentration in addition to an untreated control in which leaves were dipped in distilled water (≈200-300 total larvae/concentration). One fourth of the total for each concentration was divided into four different exposure durations including one, two, four and ten days. After exposure to treated discs larvae were transferred to non-treated fava bean leaf discs for nine, eight, six, and zero days, respectively for a total exposure duration to treated and non-treated foliage of ten days. Percent mortality adjusted for control mortality was determined at ten days. Larvae were maintained during the ten days at 23° C, 16:8 (L:D) photoperiod, and 50% relative humidity.

Results and Discussion

Field Ecology and Behavior. Comparisons between summer and overwintering generations of obliquebanded leafrollers showed substantial differences. These differences were most dramatic between the first half of the summer generation (1st-3rd instars) and the winter generation (see Figure 1). Differences were also seen upon comparison of the early and late portions of the summer generation (see Figure 3). Differences between the overwintering generation and the second half of the summer generation were not as extreme (see Figure 2). This indicates the major influence on OBLR movement to new sites is behavioral differences among instars. A progression from decreased movement into new sites of early instars to rapid movement into new sites of late instars is evident in the summer generation (see Figure 4). Percent cumulative vacancy after ten days ranged from about 50% in the early instars to near 100% in the late instars at the end of the study. The major reason for late instars moving more often than early instars is differences in the amount of foliage required to meet feeding demands. The same size leaf can satisfy these requirements for longer if the larval biomass is smaller. It is not necessary for larvae to move as frequently as their larger counterparts to other sources to meet these demands. In addition to feeding requirements, movement may be governed by intra and interspecific interactions. Competition among leafrollers for feeding sites is likely to be greater as larvae become larger. Movement to avoid predators may also increase as larvae become larger and are more visible.

Developmental differences were not the only factor influencing larval movement from habitation sites. This is shown by the comparison between the overwintering and summer generations (see Figure 1). This may be explained by differences in foliage quality available for each generation. Poorer foliage quality during the overwintering generation may lead to increased movement in search of suitable host foliage. Another possibility influencing behavior is the differences in daylength between the two generations. During the overwintering generation monitoring, the light to dark ratio was at or near its maximum of 16:8. During the later portion of the summer generation monitoring, however, it was near 14:10. This increased daylength during the overwintering generation may have lead to increased activity and more movement to new habitation sites.

Although differences between both instars and generations were shown to occur, differences between varieties of apples (i.e., Red Delicious vs. McIntosh) did not have any influence on residency times of OBLR during the overwintering generation (see Table 2).

Larval mortality was substantially greater in the summer generation (i.e., 14.91%) than the overwintering generation (i.e., 1.02 %) (see Table 1). This may be due to increased activity and numbers of parasites present during the summer generation. It may also be in part related to variations in the orchards in which studies were conducted. In both the overwintering and summer generations a majority of larval mortality from parasitism occurred in the late stages of monitoring (i.e., 6/20-23, and 8/7-19, respectively). This may be due to dependence on the life cycle of the parasitoid. Another factor may be the increased probability of parastism as larvae become larger and easier to locate or more suitable hosts. In addition to the major limitation of sensitivity to orchard insecticides parasitism as a type of biocontrol for OBLR may have decreased efficacy since fruit damage from early instars may be considerable before larvae die.

Larval Exposure Duration Bioassay. The most dramatic differences in mortality occurred among one, two, and four day exposures at the LC50 and LC90. A substantial difference in mortality occurred between four and ten day exposures at the LC50, however, these exposures showed similar mortality rates for the LC90 and LC99+. A two day exposure to tebufenozide at a concentration greater than the LC99 also differed little from a ten day exposure (see Figure 5).

These results indicate tebufenozide efficacy may decrease as larvae increase in size throughout the season. When OBLR larvae are in the late instars a majority of the larvae are vacating sites after three to four days (see Figure 4 and Table 2). Only at high concentrations (i.e., >LC90) is tebufenozide mortality at four day exposures near its maximum. These findings suggest spray programs involving the use of Confirm should target early instars and less emphasis should be placed on use during the latter portion of the life cycle of the obliquebanded leafroller.

Although tebufenozide was used as the model compound to examine the interplay between toxicity-exposure durations and OBLR movement behavior, it is important to note how this could easily be applied to other orchard insecticides used in controlling this pest. It is likely other IGR's and some typically slow acting biorationals (e.g., fenoxycarb and Bt's) would be affected in a manner similar to tebufenozide. However, fast acting neurotoxins such as organophosphates (e.g., Lorsban) and pyrethroids (e.g., Asana) are likely to have less of a problem than these compounds. In efforts to manage insecticide resistance for the OBLR it may be prudent to not only rotate compounds with different toxicological modes of actions, but to include slow acting compounds during early instars and rapid acting compounds during late instars to maximize the efficacy of the spray program. Factors such as cross resistance between compounds with distinct modes of action may confound such efforts and should be further investigated in order to better manage control of the obliquebanded leafroller.

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We wish to thank Shana Henderson, Sara Meyer, Laura Dunham, and Melanie Happ for their data collection efforts throughout the study. We also thank Rohm & Haas (Philadelphia, PA) for providing the tebufenozide sample.

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Figure 1. OBLR % Vacancy Overwintering vs. Early Summer Generation (different developmental stages)

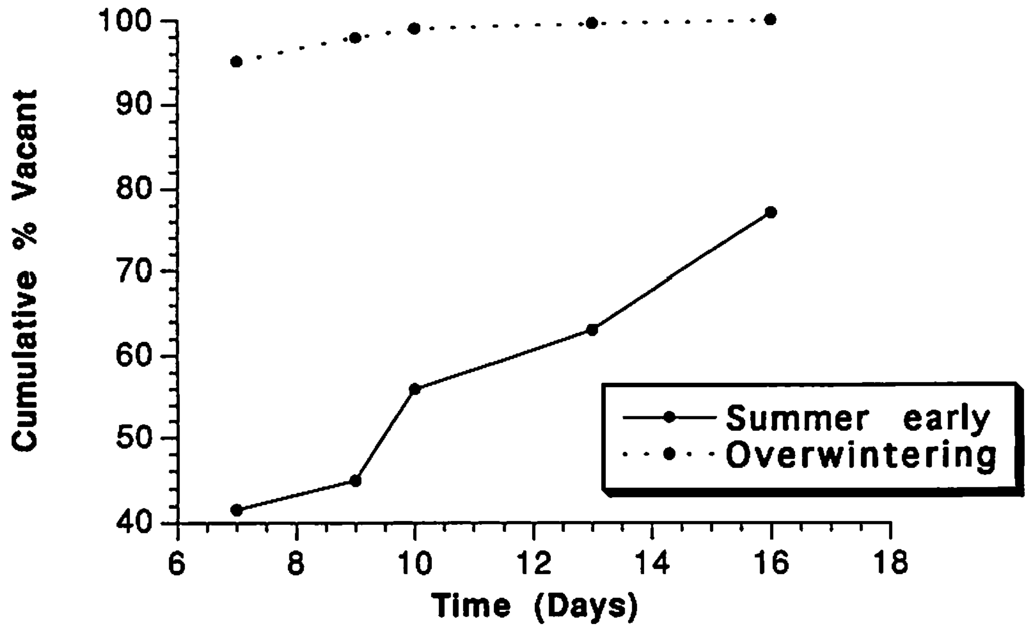

Figure 2. OBLR % Vacancy Overwintering vs. Late Summer Generation (same developmental stages)

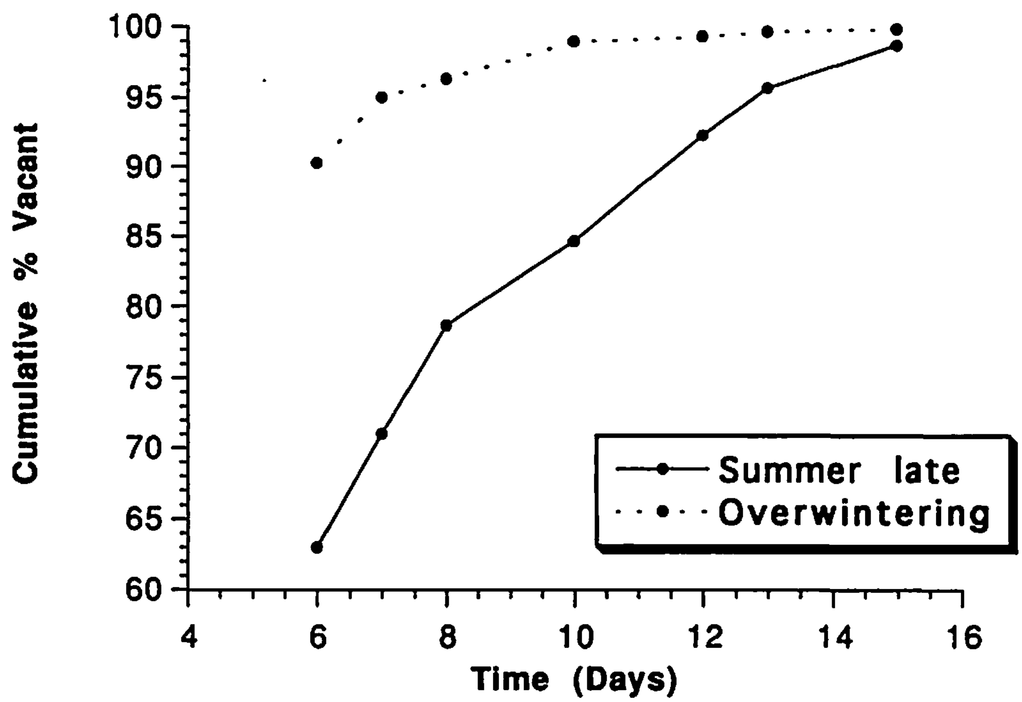

Figure 3. OBLR % Vacancy Early (1st-3rd instars) vs. Late (3rd-5th instars) Summer Generation

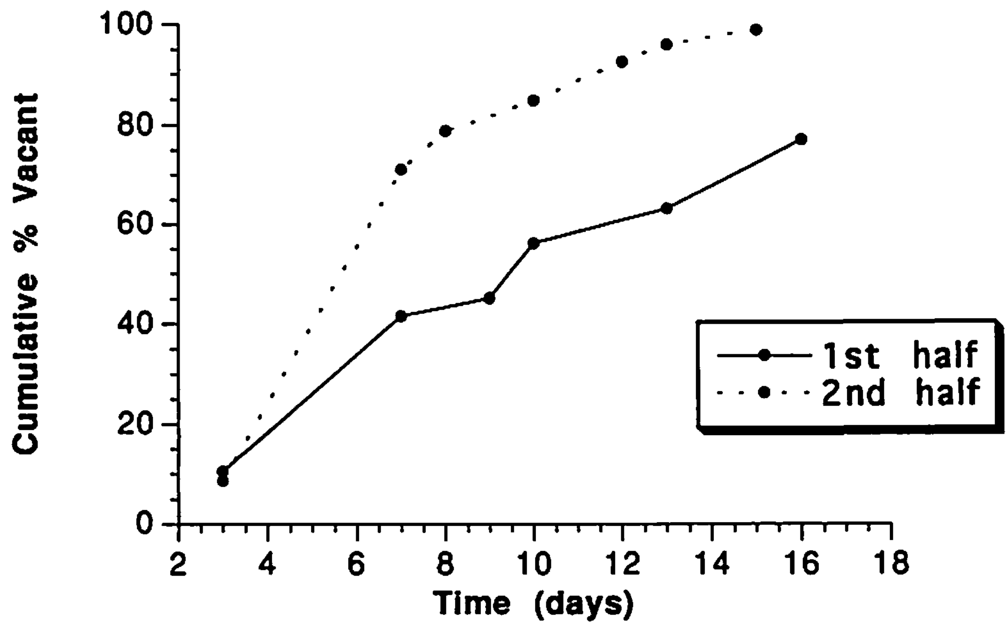

Figure 4. Comparison of Summer Generation OBLR Cumulative % Vacancy from Various Dates of New Sites

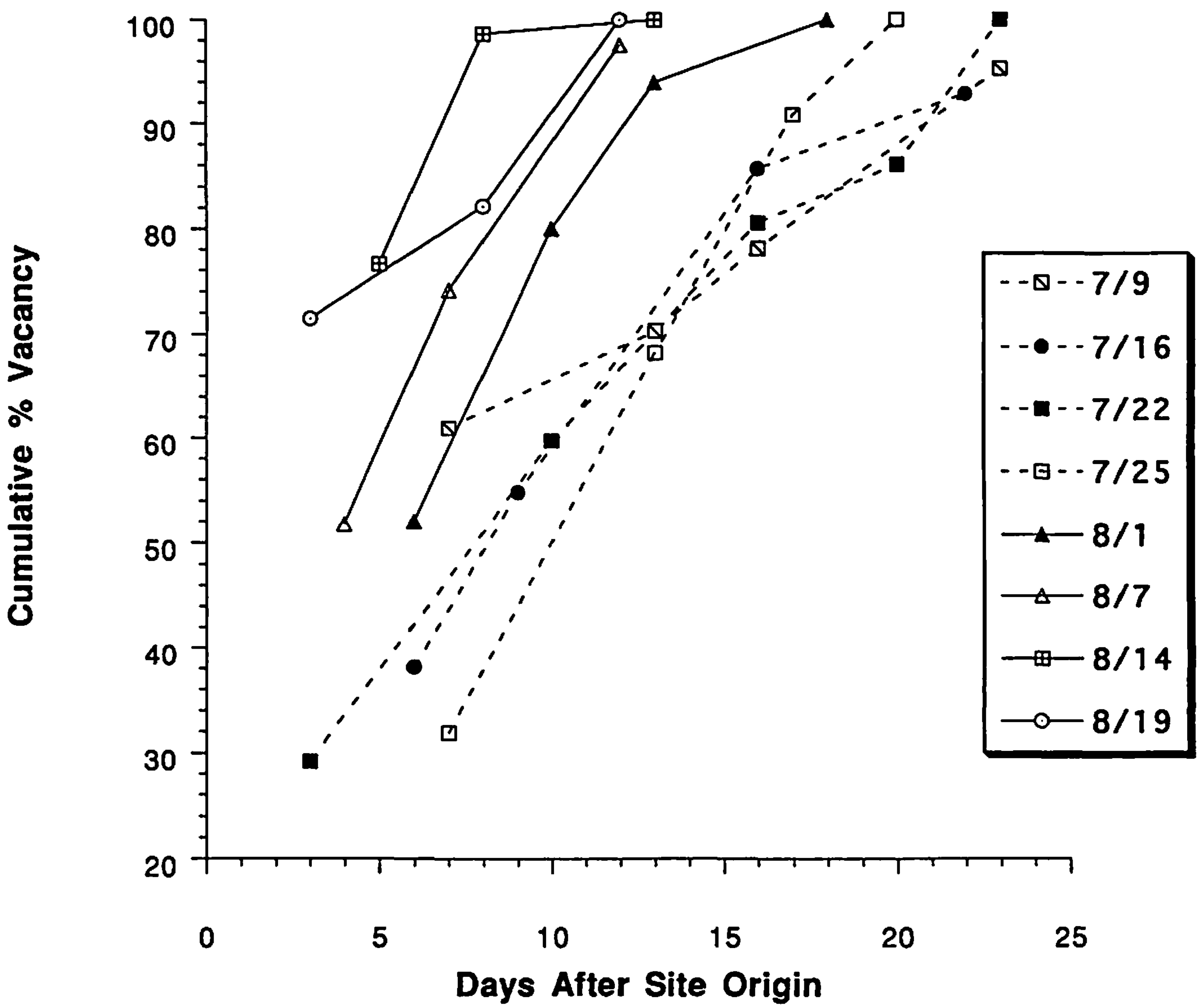

Figure 5. Confirm Effect on OBLR Neonate Mortality After Various Exposure Durations Brown 97 Colony

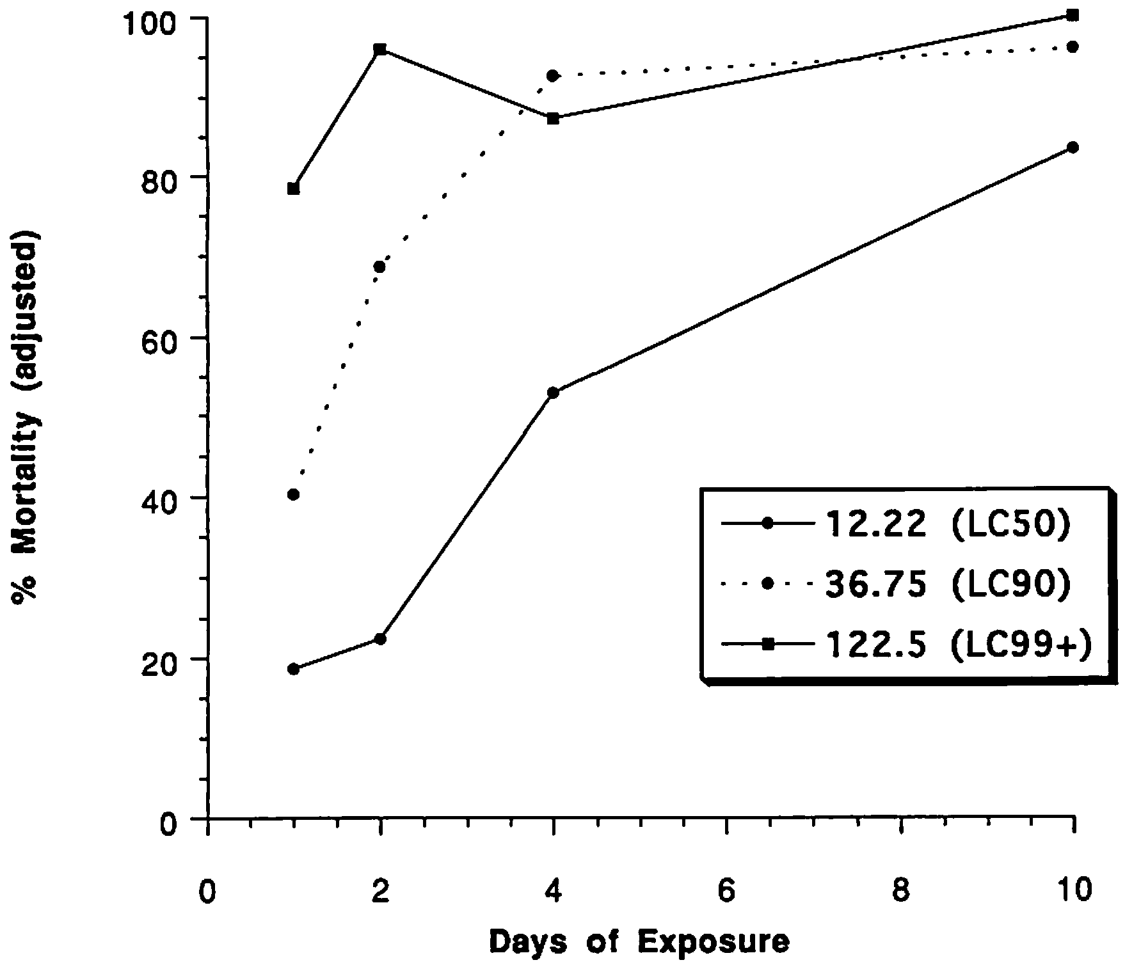

Table 1. OBLR total larval mortality and from parasitism alone in both overwintering and summer generations. Comparison between dates when new sites were added.

Date (site origin)	% larvae dead (from parasitism)	Total number of new sites
OVERWINTERING GENERATION		
6/10	0.0	25
6/11	0.89 (0.30)	338
6/12	0.0	72
6/13	0.0	99
6/16	(1.32)	76
6/18	0.0	32
6/20	(9.10)	22
6/23	(4.17)	24
Totals	1.02 (0.73)	688
SUMMER GENERATION		
7/9	22.89 (1.20)	83
7/16	16.00 (0.0)	50
7/22	12.20 (0.0)	82
7/25	4.35 (0.0)	23
8/1	9.09 (0.0)	55
8/7	14.00 (2.00)	100
8/14	14.71 (5.88)	102
8/19	20.00 (17.14)	35
Totals	14.91 (2.83)	530

Table 2. Comparison of McIntosh and Red Delicious OBLR percent cumulative vacancy at various days after site origin in overwintering generation.

Variety	Days after site origin	% Cumulative Vacancy
McIntosh	2	42.36
Red Delicious	2	47.20
McIntosh	3	58.26
Red Delicious	3	55.24
McIntosh	4	67.60
Red Delicious	4	61.12
McIntosh	5	86.29
Red Delicious	5	89.16
McIntosh	6	89.72
Red Delicious	6	90.91
McIntosh	7	94.70
Red Delicious	7	95.45
McIntosh	8	95.33
Red Delicious	8	97.55
McIntosh	9	97.20
Red Delicious	9	98.60
McIntosh	10	98.75
Red Delicious	10	99.30
McIntosh	16	100.0
Red Delicious	16	100.0

Apple Maggot Phenology in Southcentral Pennsylvania

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Apple maggot is not a commercial problem in southcentral Pennsylvania with the present organophosphate based insecticide program. However, this species was found above thresholds, given absence of insecticide, in one third of the commercial orchards throughout the state in 1996 trapping survey. Apple maggot was abundant in abandoned orchards, of which there are nearly 1000 acres in Adams County alone, and was relatively common in orchards under alternate IPM programs.

Three factors point to the increasing importance of this pest in this region. The first is the increasing use of new IPM tactics that reduce organophosphate use including Bts, insect growth regulators, and mating disruption. Second, apple maggot is included in phytosanitary regulations associated with the Brazilian export market, which in itself added six million dollars to Pennsylvania economy in 1995. And third, the Food Quality Protection Act is bringing the use of organophosphate insecticides under increased scrutiny.

Apple maggot phenology is not as well known in the mid-Atlantic region as in more northern regions of the country. The effects of the more southern latitude, warmer growing seasons, and differing apple cultivars and alternative hosts may impact when and how control measures should be used in changing systems of IPM. This study was conducted to begin to look at the phenology of apple maggot in abandoned, home owner, and commercial orchards in southcentral Pennsylvania.

Methods and Materials

Emergence cage and trap capture were monitored in three orchards. These included a thirty acre abandoned block in southern Adams County (Site 1), two backyard trees with unmanaged trees nearby in northern Adams County (Site 2), and two backyard trees in Perry County (Site 3). The abandoned orchard and the Perry County sites were also monitored with traps in 1996. Emergence cages were pyramid shaped with a glycol-filled reservoir that covered 0.21 sq-m. These were placed under the trees in June without apples having been added. Nine cages were placed in the abandoned orchard and two each in the home owner orchards. Both yellow panels baited with ammonia carbonate and red spheres baited with apple essence were monitored in all the orchards. Capture was reported in number per trap per day.

Infestation of fruit was monitored by weekly sampling in the abandoned orchard. 'Yorking' and 'Golden Delicious' were sampled from three locations. Each week from 10 to 15 fruit were collected at each site. A subsample was examined for oviposition sites and for larvae. The remainder of the fruit was held over vermiculite in an insectory for emergence of the larvae. Pupae were removed periodically until emergence from the fruit was complete. Emergence timing was modeled by a logistic growth equation and related to temperature and rainfall periods.

Traps were also monitored in three commercial apple orchards in Adams County at sites where capture was relatively high in 1996. At each site of 'Yorking' and 'Golden Delicious' a yellow panel and red sphere trap were paired both on the edge of the orchard and in adjoining woodland. No woodland traps had been monitored in 1996.

Results and Discussion

Apple maggot flies were captured in cages at the two Adams County sites and in the yellow and red traps at all sites (Fig. 1). Flies were first captured on the yellow panel traps during the period of 30 June to 3 July, 2-3 July, and 5-6 July at sites 1-3, respectively. Capture in these traps was highest at site 1, where flies were recorded through mid-October when trapping was discontinued. First capture on red spheres was at the same time as the yellow panels at site 2 and delayed in the other two sites. Capture at site 1 was lower in 1996 than 1997. Higher capture on the yellow panels than the red spheres at the abandoned orchard was also observed in 1996. A total of 13, 18 and 0 flies were recovered in cages at sites 1-3, respectively.

Measurable rain during the period through early August and total inches occurred on 19 June (0.5), 1 July (0.6), 9-10 July (0.1), 22-24 July (1.6), and 4-5 August (0.2). Most flies emerged before 22 July during drought conditions.

Cumulative emergence and trap capture showed some similar trends across the three sites (Fig. 2). Capture was delayed in the red spheres relative to the yellow panels at all the sites. At site 3 capture in the yellow panels occurred earlier than the other two sites.

Emergence curves overlapped closely for the two sites in Adams County, and the site 1 data allowed a good model fit (Fig. 3). One fly recovered on 27 August was considered an outlier and not included in the data set because of a note that it was probably missed on earlier sample dates. The logistic function shows 1% emergence at 1451 ADD base 43°F from 1 January or about 29 June, just prior to the sampling period during which the first flies were captured on the yellow panels. This accumulation falls within the range of first capture published in the Scaffolds Newsletter of 1351±171 ADD 43°F, from 1 January.

The relationship between oviposition punctures and emergence of larvae from the fruit in the individual sample trees shows that punctures tended to be missed during some sampling periods, especially in the 'Yorking' (Fig. 4). The increase of stings at the end of the season may have been attributed in part to their becoming more visible as fruit broke down. Infested fruit was first observed within two weeks of capture on yellow panels and clearly increased through the end of August for both varieties, and may have continued to increase in some trees through mid-September. Infestation levels were about 60% of those in 1996.

Flies were captured in commercial orchards and adjoining woodland sites in 1997 (Fig. 5). Fewer flies were captured in 1997 than in 1996. Capture in the woods was similar to that in apple except at orchard 3 where all the flies were recorded on the yellow traps in the woods. These flies are being held to confirm identification.

These results along with other observations in the mid-Atlantic region show that apple maggot should not be ignored in mid- to late-season cultivars as IPM programs change. This work will help define application timing. Further work is planned in investigating the role of the abandoned orchards and other alternate hosts on fruit infestation in commercial orchards.

I acknowledge K. Valley, J. Witmer, and J. Martin for assistance with trapping and B. Felland for helping out with the fruit evaluations.

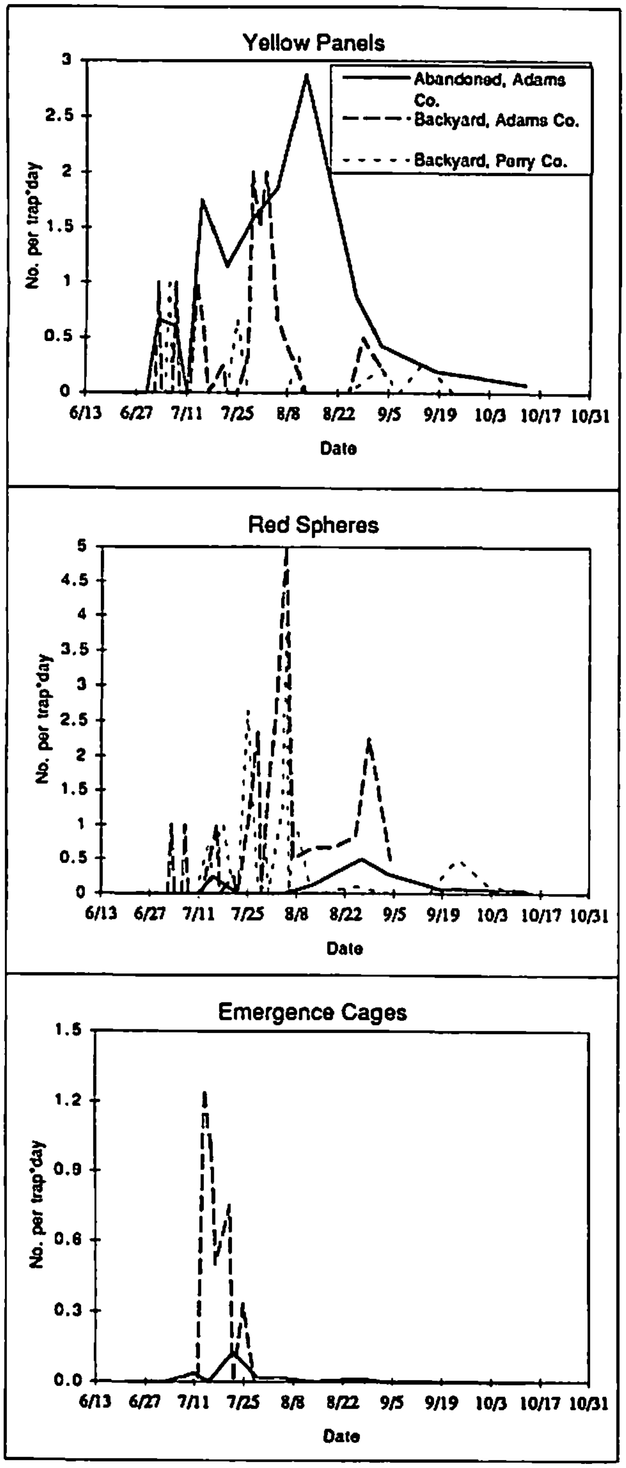

Fig. 1. Capture of apple maggot flies in three types of traps in three sites in southcentral Pennsylvania, 1997

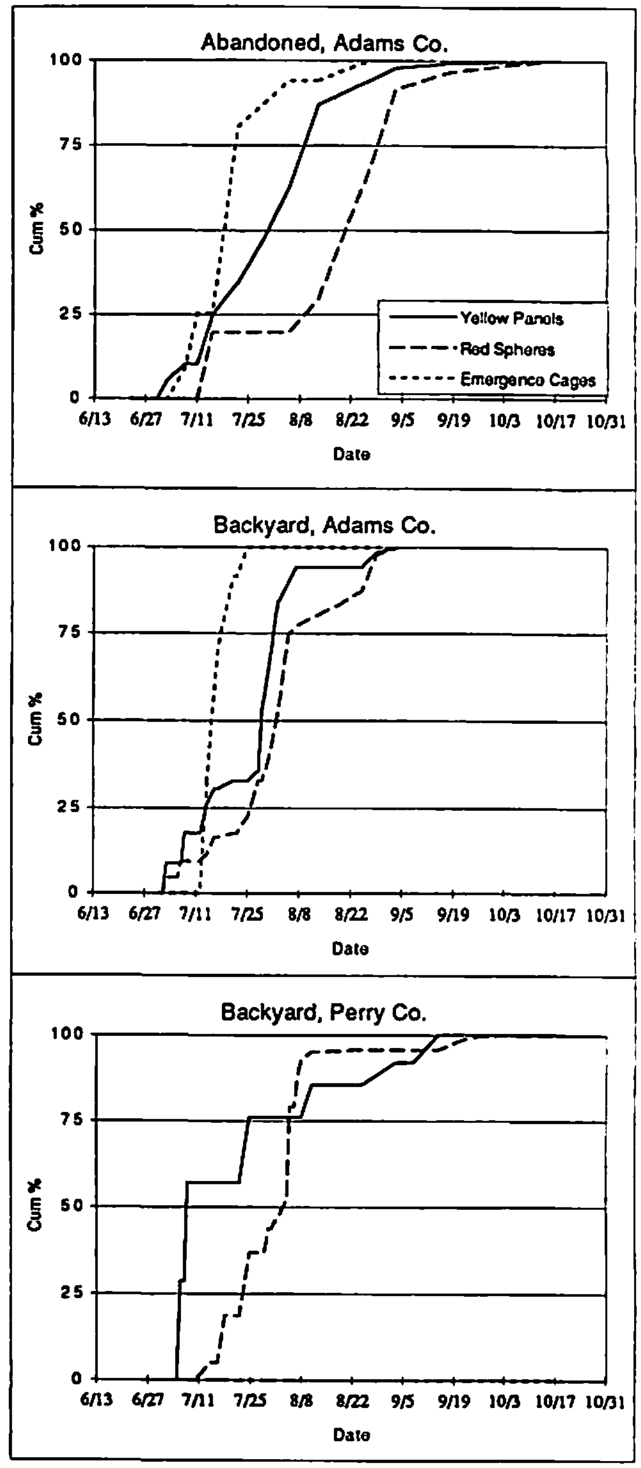

Fig. 2. Cumulative capture of apple maggot flies at three sites in southcentral Pennsylvania using different traps, 1997

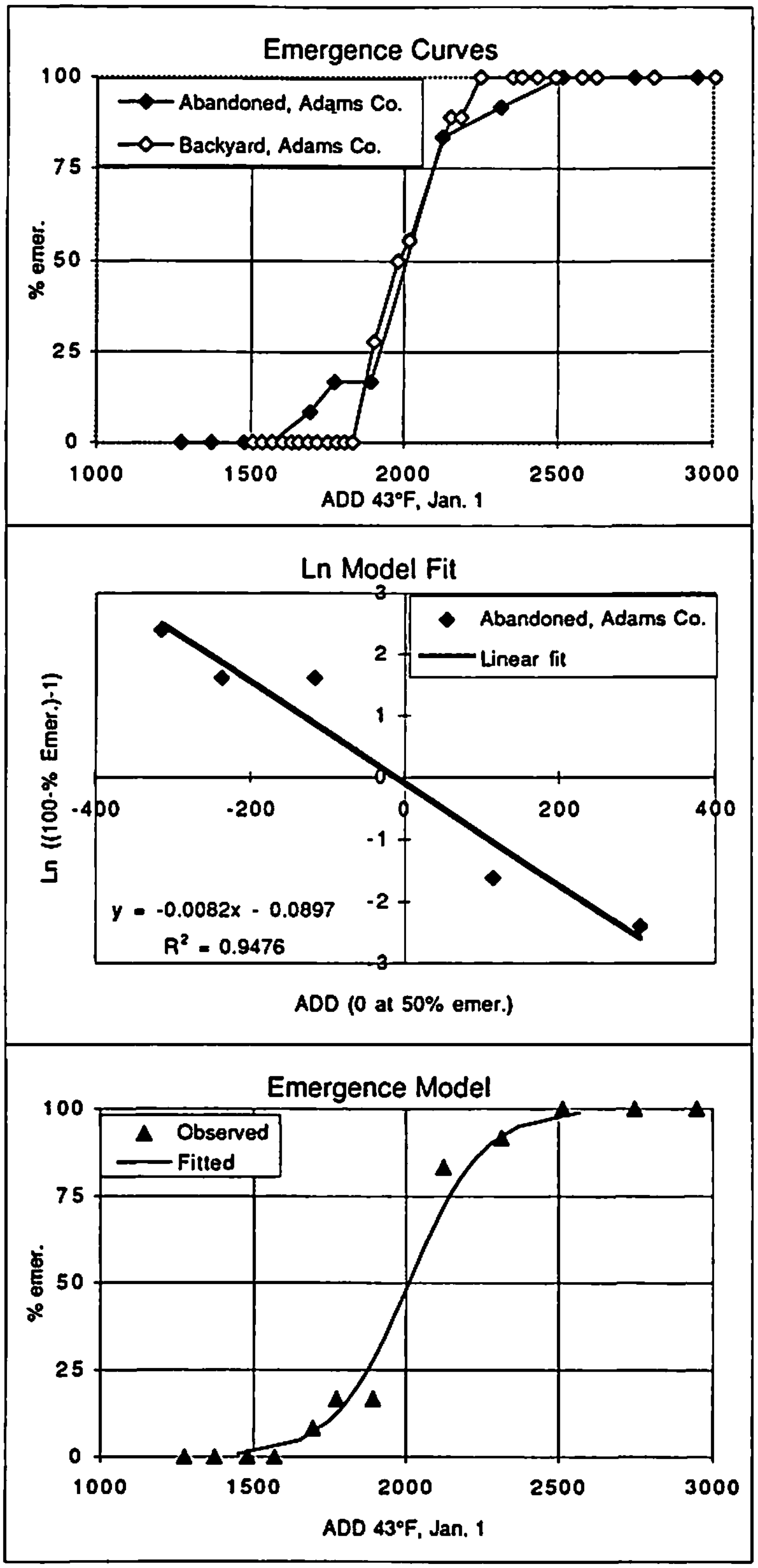

Fig. 3. Apple maggot emergence cage data and modeled emergence, 1997

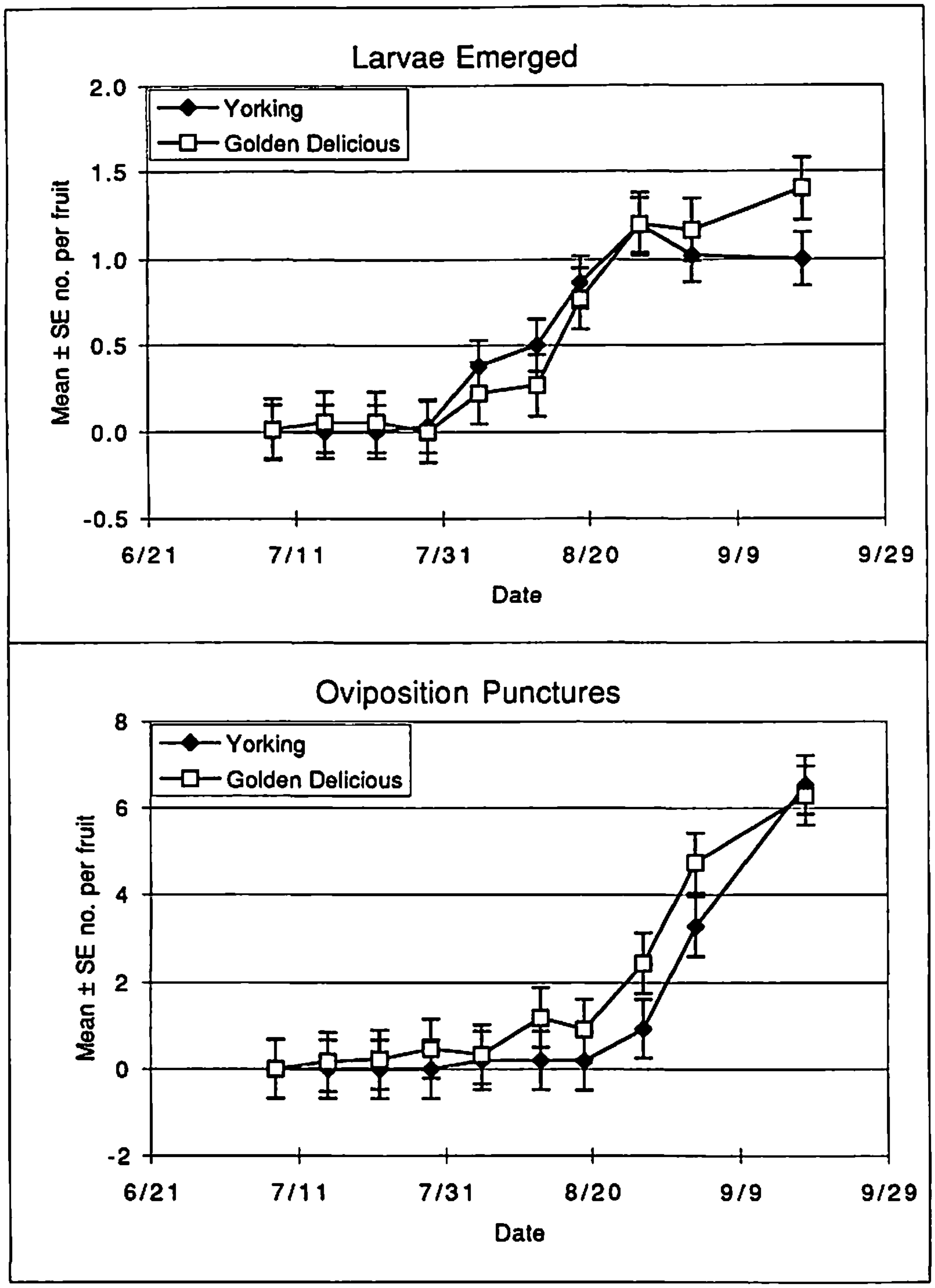

Fig. 4. Apple maggot larvae emerged and oviposition punctures observed in two cultivars in abandoned orchard in Adams Co., Pennsylvania, 1997

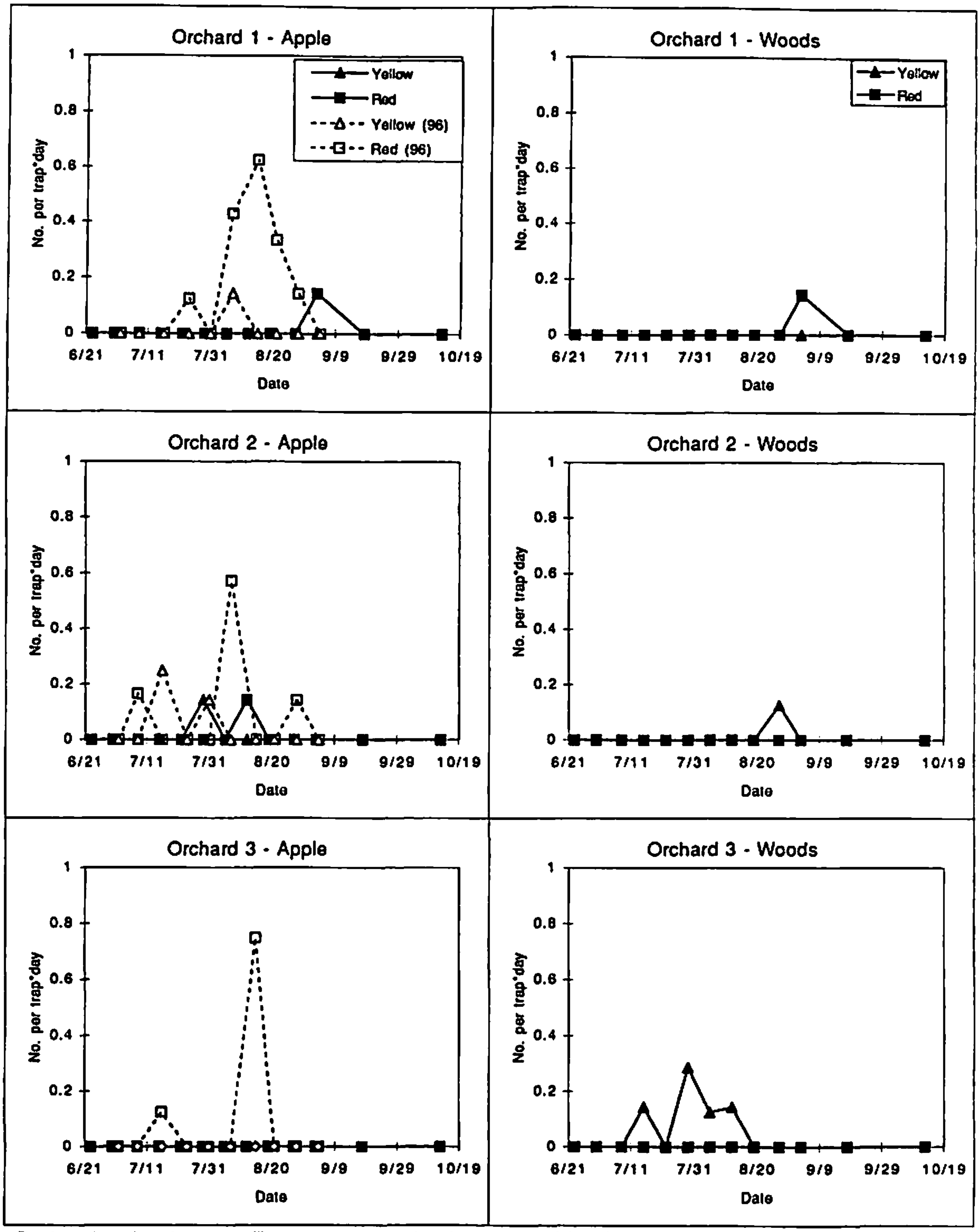

Fig. 5. Total number of apple maggot flies per trap captured at three commercial apple orchards (1996 and 1997) and adjoining woodlands (1997 only) in Adams County, Pennsylvania

ORCHARD GROUND COVER MANAGEMENT AFFECTS PEACH INSECT DAMAGE

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Penn State University

Objective 1. Demonstrate suitability of selected ground covers for use in integrated crop production strategies for peaches.

We established 8 different ground covers in a 4.5 acre, 1-year old peach orchard. This study, replicated 5 times, included 3 types of sod (a hard fescue, a tall turf-type fescue, and a commonly used orchard fescue), naturalized weedy ground covers with and without broadleaf weeds, a predominately white clover sod, and 2 types of bare soil orchard floors maintained as such by either disking or applications of herbicides. Individual plots were 60 X 100 ft and were established in the drive rows on each side of 3 row of trees planted at 20 X 25 ft spacing. Ten foot wide weed-free strips were maintained in the tree row with herbicides.

The different ground cover treatments were sampled about every other week using a sweep net to determine the presence of tarnished plant bugs and stink bugs. Sweep net samples were taken from the centers of each replicate and consisted of 2 sets of 10 sweeps per replicate. Seasonal average tarnished plant bug adults and nymphs were analyzed with SAS then plotted.

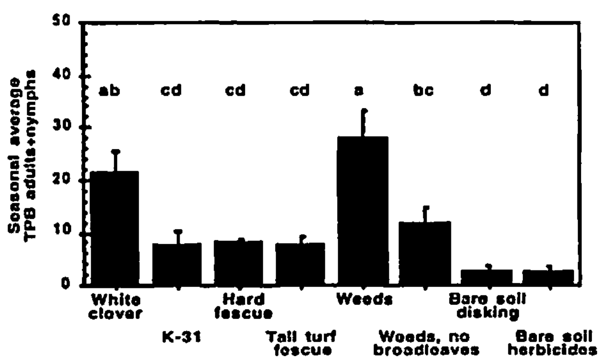

Figure 1. Seasonal average tarnished plant bug levels collected with sweep nets from various ground covers.

Results demonstrate that more tarnished plant bugs are found on orchard floors that are weedy or have white clover than orchard floors that are kept clean or in sod (Figure 1). Removing broadleaf weeds reduces tarnished plant bug levels. Some tarnished plant bugs were observed in both the bare soil treatments because of volunteer weeds.

Objective 2. Demonstrate how ground cover management affects arthropod abundance and damage to peaches.

Four commercial peach blocks were used in this study. Each block was at least 12 acres and all blocks were divided into 3 plots. Each block had 3 treatments assigned to it; 1 treatment per plot. The 3 treatments consisted of 1) hard fescue sod established in the drive rows, 2) naturalized vegetation (weeds) maintained in the drive rows, and 3) disked drive rows. The sod and weedy drive rows were periodically mowed. Each of the 3 treatments at a grower site were sprayed with the same arthropod and disease sprays so that any differences in observed arthropod levels or damage could be attributed to the ground cover treatment. Harvest samples were collected at 2 of the 4 sites; the other 2 sites had limited fruit numbers due to a localized freeze. Levels of tarnished plant bug damage were determined then plotted.

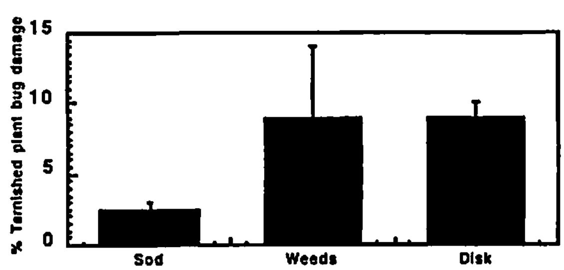

Figure 2. Tarnished plant bug damage to peaches from commercial orchards with different ground covers.

Results demonstrate that there was about 2/3 less tarnished plant bug damaged fruit collected from the sod treatments than from the weedy or disked treatments (Fig. 2). Damage from the disked areas was attributed to the length of time between diskings and subsequent growth and development of weeds which attracted tarnished plant bugs.

Results of this study clearly demonstrates that properly managed peach orchard ground cover reduces certain insect pest pressure and subsequent damage to the crop.

Acknowledgment: This project was funded in part by a NE Region Sustainable Agriculture Research & Education Program (SARE) grant.

PARASIZATION OF PUPAE AND PREPUPAE OF *COCCINELLA SEPTEMPUNCTATA* L. AND *HARMONIA AXYRIDIS* PALLAS (COLEOPTERA: COCCINELLIDAE) IN VIRGINIA

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Introduction

Coccinella septempunctata L. is an important biological control agent in both field crops and orchards. It was the most commonly collected species of lady beetle in alfalfa in southwestern Virginia until recently, when *Harmonia axyridis* Pallas rose to prominence. It is equally abundant in apple orchards. Recent sampling in four orchards in central and southwestern Virginia indicated *H. axyridis* was captured most often, followed by *C. septempunctata* (Knowles 1997).

One factor that has not been given much consideration in North America in assessments of the role of lady beetles as predators is parasitization. A 1992 compilation of world parasites of *C. septempunctata* (Schaefer and Semyanov 1992) listed 16 species of insects and two species of mites, but had few records from North America. *Dinocampus coccinellae* (Schrank) (Braconidae), an adult coccinellid parasite, was the most commonly recorded. A review of this list shows records of *Oomyzus scaposus* (Thomson) (=*Tetrastichus melanis* Burks) (Hymenoptera: Eulophidae) (Graham 1991) from pupae in Delaware and Massachusetts, an unknown species of *Tetrastichus* from a pupa in New Jersey, and one record of *Homalotylus terminalis* (Say) (Hymenoptera: Encyrtidae) from a late stage larva in Massachusetts. *Oomyzus scaposus* was also formerly known as *Tetrastichus coccinellae* Kurdjumov (Graham 1991). Several references were given under both previous names for pupal parasites reported by authors working in Europe or Asia where *C. septempunctata* is native. The purpose of this study was to determine the level of prepupal and pupal parasitization of *C. septempunctata* and *H. axyridis*, and the parasite species involved.

Methods

In 1994 and 1995 leaves bearing pupae and prepupae of *C. septempunctata* were collected in Montgomery County, Virginia, from alfalfa (*Medicago sativa* L.) and the roadside weed, mugwort (*Artemisia vulgaris* L.). Each specimen was put in an individual glass vial which was closed with cotton or cloth and kept in the lab until either an adult beetle or parasites emerged. In 1997 pupae of *C. septempunctata* were collected in Montgomery County from lambs quarter (*Chenopodium album* L.) and violet (*Viola* sp.) and kept for observation. An additional small sample of fourth instar larvae was obtained from an alfalfa field in Rockbridge County and these larvae were reared to adults.

Prepupae and pupae of *H. axyridis* were not as easy to find, but a limited number were collected from alfalfa and mugwort in Montgomery County in 1994, and from apple (*Malus x domestica* Borkhausen) in Nelson County in 1997. The pupae from apple were found after the adult beetles had emerged, but they were examined for evidence of parasitization.

Results

Three species of parasites were reared from *C. septempunctata*: *O. scaposus, H. terminalis*, and *Pachyneuron altiscutum* Cook (Pteromalidae). *Oomyzus scaposus* was by far the most abundant parasite. Parasitization levels of *O. scaposus* from pupae on mugwort ranged from zero on May 31, 1994, to 97% on June 22, 1994 (Table 1). In May 1995 parasitization was 40% for prepupae and 26% for pupae. Mid-September collections from alfalfa in 1994 yielded rates of 33% for prepupae and 50% for pupae. No parasites were obtained from 1997 samples.

Oomyzus scaposus is a gregarious parasite, and both males and females exist in the same host. Females predominated at average ratios of three or four to one. From three to 45 parasites were found per host, and from one to five emergence holes were seen.

We filmed *O. scaposus* emergence; you can catch the action at the "Insects in Motion" web site: http://everest.ento.vt.edu/~carroll/insect_video_home.html.

Homalotylus terminalis was reared from two prepupae on mugwort in May 1995. In both cases seven females emerged. Our one record of *P. altiscutum* is from a prepupa on alfalfa in September 1994, from which eight females emerged. The number of emergence holes matched the number of parasites for both of these species.

Table 2 summarizes our limited data for *H. axyridis*. No parasites were reared from this species (total specimens = 85).

Discussion

Semyanov (1986), using the former name *T. coccinellae*, reported that *O. scaposus* deposits its eggs in second or third instar larvae, laying them between the thorax and the abdomen, sometimes between pleurites, or rarely on the head capsule. One parasite may oviposit up to three times on one host larva. Adult parasites emerge from the pupa. His research showed parasitization levels from different regions in the U.S.S.R. ranged from 2% to 65 %, and the number of parasites per host were from 5 to 47. We found *O. scaposus* came from both prepupae and pupae; otherwise our results are similar to his findings. In England Dean (1983) studied parasitization of *C. septempunctata* on winter wheat (*Triticum aestivum* L.) and nettle (*Urtica dioica* L.) and found from 0 to 25% of pupae harbored *O. scaposus* (reported as *T. coccinellae*). In South Korea Won et al. (1996) found parasitization of *C. septempunctata* by *O. scaposus* ranged from 17 to 67 percent, and they observed *O. scaposus* attacking all larval stages.

Our observations do not agree with those of Hodek (1973) who found for *T. coccinellae* only one emergence hole per pupa, versus zero to five in our case, and who saw only one sex per host, whereas we collected both sexes.

Pachyneuron altiscutum is a known primary parasite of aphids and predatory flies, as well as a secondary parasite of various hymenopteran parasites occurring with aphids (Grissell 1995). Schultz (1984) found it in eastern Virginia on endoparasites of oak lecanium [*Parthenolecanium quercifex* (Fitch)]. Because we did not dissect the pupa, it is possible that the one *P. altiscutum* we collected was a secondary parasite also.

The lack of parasites from pupae of *H. axyridis*, which only recently became abundant, is not surprising, but is significant when considering competition between that species and *C. septempunctata*. Now that *H. axyridis* is widespread and dominant in many habitats, it is quite likely that parasites will soon be found. Although it's armature in the larval stages is more formidable than *C. septempunctata*, the long ovipositor of a parasite could likely circumvent this protection. *Phalacrotophora* sp. (Diptera: Phoridae) was reared from both *C. septempunctata* and *H. axyridis* pupae in South Korea (Park et al. 1996, Won et al. 1996). Parasitization was up to 23% for *C. septempunctata*, but never more than 7% for *H. axyridis*. As far as we know, there are no collections as yet of any *Phalacrotophora* species from pupae from North America. Park et al. (1996) also reported *D. coccinellae* (=*Perilitus coccinellae*) emerged from pupae of *H. axyridis*.

Acknowledgements

Identification of parasites was done by E. E. Grissell and M. E. Schauff, Systematic Entomology Laboratory, Agricultural Research Service, U.S. Department of Agriculture. Determination of mugwort was made by T. Wieboldt, Herbarium, Virginia Polytechnic Institute and State University, Blacksburg, Virginia.

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Table 1. Parasitization of prepupae and pupae of *Coccinella septempunctata* by *Oomyzus scaposus*.

Sample	Host Stage	Sample Size	% Parasitized	Ave. # Emerg. holes (range)	Ave. Parasites/ host (range)
Montgomery Co.					
From mugwort					
5/31/94	Pupa	44	0		
6/9/94	Pupa	10	30.0	---	---
6/22/94	Pupa	36	97.2	2.2 (1-5)	24.8 (3-45)
5/23/95	Prepupa	15	40.0	1.5	19.0
5/23/95	Pupa	73	26.0	1.4	13.0
From alfalfa					
9/12-19/94	Prepupa	9	33.3	1 (1)	8.3 (6-11)
9/12-19/94	Pupa	90	50.0	2.2 (1-5)	17.6 (4-42)
From lambs quarter & violet					
5/5/97	Pupa	12	0		
Rockbridge Co.					
From alfalfa					
6/16/97	4th Instar	10	0		

Table 2. Parasitization of *Harmonia axyridis* prepupae and pupae.

Sample	Host Stage	Sample Size	% Parasitized
Montgomery Co.			
From mugwort			
6/9/94	Pupa	3	0
From alfalfa			
9/13/94	Prepupa	12	0
9/12-18/94	Pupa	34	0
Nelson Co.			
From apple			
7/23/97	Pupa	10	0
8/6/97	Pupa	26	0

Lure comparisons for raspberry crown borer

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Introduction: Raspberry crown borer (RCB), *Pennisetia marginata* (Harris) (Sesiidae) can be a severe pest in bramble plantings, and is found as far south as Florida (Brown & Snow 1985. Hosts include red raspberry, *R. idaeus* L., black raspberry, *R. occidentalis* L., himalaya blackberry, *R. procerus* Muell., cutleaf blackberry, *R. lacineatus* Willd., loganberry, *R. loganobaccus* Bailey, boysenberry, *R.* sp. cult., thimbleberry, *R. parviflorus* Nutt., and salmonberry, *R. spectabilis* Pursh (Raine 1962). Eggs are laid on undersides of new leaves, with 2-3 eggs per plant. After an incubation of 3-10 weeks, hatch begins the first week of September, lasting until early November. Larvae spin down to the crown, where they overwinter in hibernacula. In spring, they tunnel into the cambium. Cracks develop at the site, with reddish brown frass issuing from cracks in April. In the first summer, larvae feed at the base of new canes, girdling and causing galls. Galls are most evident in October. There is a two year life cycle. In the second summer, the larvae ascend into canes, girdling them a few inches above soil surface and causing them to wilt or break. Pupae form in late July-early Sept. Moths resemble yellow jackets, reportedly flying around brambles from August until September. Females begin to oviposit on the day of emergence, and live 3-11 days, averaging 103 eggs each.

Chemical control involves drenching the lower cane and crown areas with azinphosmethyl (diazinon was also formerly registered) in fall or spring. Some cultural control may be obtained by removing all wilting canes in June and July.

The pheromone is (*E,Z*)-3,13-octadecadien-1-ol (18OH) (Solomon et al. 1982, Brown & Snow 1985). Lures are not commercially available. Few trapping studies have been done, often with little variation in blend or loading rate, and with limited number of traps.

Materials and Methods: Septa with the active ingredient were obtained from Trece, at four loading rates. Traps were placed at Westmoreland Berry Farm, Westmoreland, Va. on 12 July, and at Kentland Research Farm, Whitethorne Va., on 24 July. Each loading rate was replicated three times at each site. Loading rates are proprietary; Rate 1 represents the highest load, Rate 4 the lowest. Data are provided below.

Results: Adult RCB are present earlier and for a longer duration than reported; males were already present on the first sampling date, 17 July, and were last captured on 26 September (Fig. 1). The peak of activity occurred on August 2. Persimmon borer, *Sannina uroceriformis* (Walker) was also captured in traps (Fig. 2); however, the population activity was already declining when trapping started in this study. Rate 1 was the most successful in attracting both species (Duncan's multiple range test, $P < 0.05$). There is a possibility that catches could be increased by increasing the loading rate. Male RCB were often seen hovering near empty lure envelopes or other equipment that had been in contact with traps, or even investigators after they had left the trapping sites. However, catches in the traps were relatively low. One dusky clearwing, *Paranthrene tabaniformis* (Rottenburg), was also collected on 2 August, in a Rate 3 trap at Westmoreland. The pheromone of *S. uroceriformis* has as its principle component (*E,Z*)-3,13-18OH, but with 20% addition of (*Z,Z*)-3,13-18OH (Nielsen et al. 1979), or 10% composition of (*E,Z*)-3,13-18Ac (Solomon 1982). The main component (*E,Z*)-3,13-18OH has also been reported as the pheromone of *P. tabaniformis* (Greenfield &

Karandinos 1979, Zhang et al. 1986). Nielsen et al. (1979) reported a 10% composition of (*Z,Z*)-3,13-18 Ac.

Numbers collected in the small fruit planting at Kentland were much lower than in the bramble planting at Westmoreland, probably because the Kentland trapping relied on populations from wild canes.

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Table 1. Numbers of raspberry crown borer collected in pheromone traps at Westmoreland Berry Farm and Kentland Research Farm

	Moths per Trap	
Loading Rate	Westmoreland	Kentland
1	32.3	5.6
2	8.3	1.7
3	3.3	0.7
4	2.0	0.0

Fig. 1. Raspberry Crown Borer Flight Activity

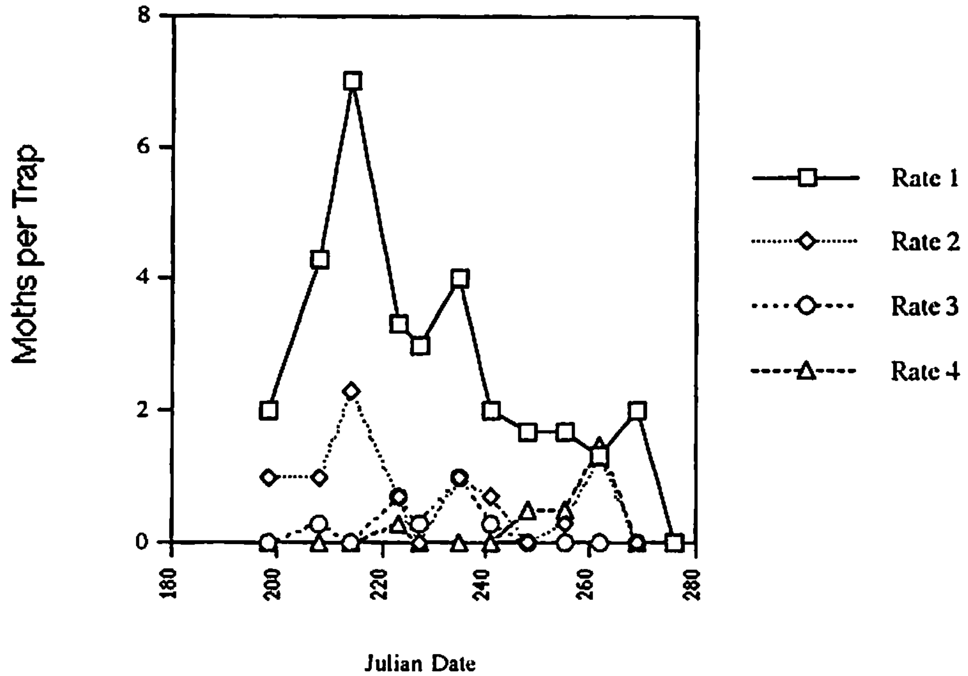
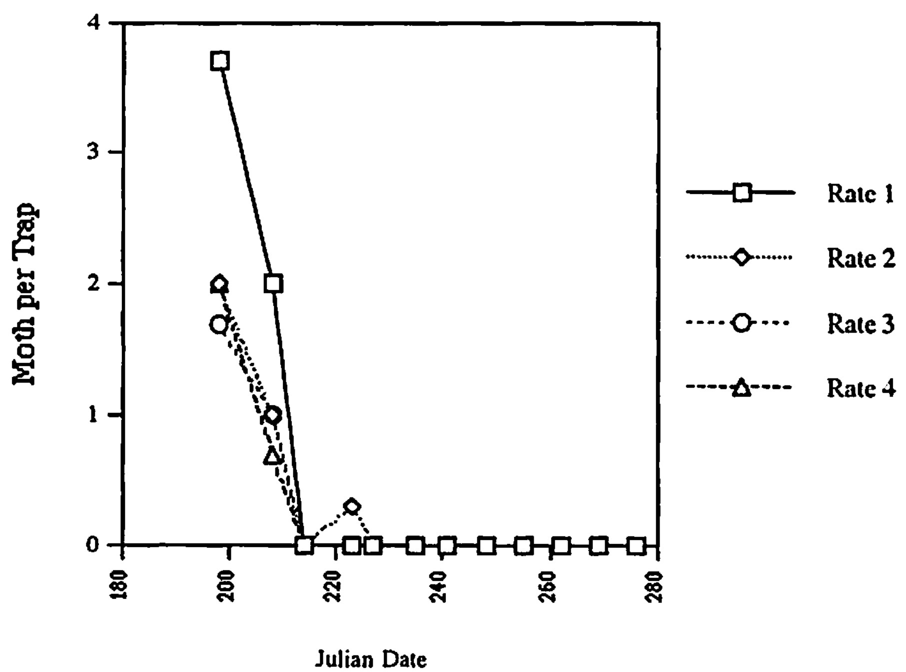


Fig. 2. Persimmon Borer Flight Activity



A Comparison of the Potential Role of Two Leafhopper Species in Fire Blight Transmission in Apple - 1997

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I. Introduction: Fire blight (FB) is an important bacterial disease of several rosaceous fruit crops, primarily pear and apple. Infections can lead to limb death, or in cases where infection reaches the trunk or rootstock, death of the entire tree. Several new apple cultivars (including Gala, Fuji, and Braeburn) are more sensitive to FB than traditional varieties. The trend toward earlier bearing, higher density tree plantings of these susceptible scion/rootstock combinations, and increased potential for resistance in *Erwinia amylovora* to the antibiotic streptomycin (Loper et al. 1991; McManus and Jones 1994), have heightened concerns about FB management in recent years.

Various insects have been associated with the transmission of FB. Flies and bees, visiting oozing cankers in early spring and picking up bacteria before visiting blossoms, are a generally accepted mode of transmission for blossom blight. The role of insects in the transmission of shoot blight is much less understood. More than 77 genera of insects are listed by van der Zwet & Keil (1979) as "reportedly associated" with FB; several leafhoppers are on their list, including potato leafhopper (PLH), *Empoasca fabae* Harris. In discussing shoot blight, van der Zwet & Beer (1991) listed white apple leafhopper (WALH), *Typhlocyba pomaria* McAtee, in addition to other sucking insects, as a vector of the FB bacterium.

White apple leafhopper, a secondary pest of apple, has been increasing in abundance in recent years, mainly because of resistance to commonly used orchard pesticides (Trammel 1974), along with reductions in natural enemy populations caused by conventional pesticide programs. There are two generations annually. Nymphs from the first generation appear at bloom, about mid-April in Virginia; second-generation nymphs are present in August through October. WALH is a mesophyll feeder; vascular tissue is only rarely attacked (Putman 1941), and although feeding by WALH may inhibit photosynthesis, relatively severe visual injury must occur before photosynthesis is reduced to any great extent (Marshall et al. 1942).

Potato leafhopper (PLH), *Empoasca fabae* Harris, unlike WALH, does not overwinter in Virginia; it appears in mid-May (Pfeiffer et al. 1995) at a time when shoot blight is common. Unlike the mesophyll-feeding habits of WALH, PLH feeds in vascular tissue in precisely those tissues most vulnerable to infection by FB, that is, young, vigorously growing shoot tips. While not often incriminated as a vector of FB in recent years, PLH appears close to the appearance of shoot blight, is more active than WALH, and could better serve to disseminate bacteria from tree to tree. There are 2-4 generations annually.

In the past, action thresholds for WALH have been fairly conservative, e.g. 0.5 nymphs per leaf in the first generation and 1.0 per leaf in the second (Leeper 1980; Howitt 1993). Recent work in Virginia has shown that WALH population densities up to 4 nymphs per leaf had no effect on fruit yield or quality (Welker et al. 1995); consequently, action thresholds have been increased to 3 nymphs per leaf (Pfeiffer et al. 1995), minimizing selection pressure for insecticide resistance already found in WALH. In conflict with this recommendation is the fruit pathological recommendation that a much lower action threshold for WALH be used, in order to aid in FB management. For example, Steiner and Lightner (1992) recommend treating for "suspect" insect species (leafhoppers, plant bugs, psylla) as soon as they appear in the orchard. In view of the contradictory recommendations by entomologists and pathologists, to raise and lower action thresholds, respectively, it is imperative to clarify the role of WALH and PLH in the transmission of FB disease.

Results from 1995 and 1996 studies (Duane et al. 1995 and Killian et al. 1996, respectively) suggested that PLH may play a role in the transmission of FB, and that WALH probably does not. The following study represents a third year of our study.

II. Materials and Methods: Young 'Gala' apple trees were grown as whips in 3.8-liter pots and maintained in a growth room at Mary Washington College in Fredericksburg, VA. Trees were fertilized, watered, and otherwise maintained as previously described by Kaakeh et al. (1993). Experimental units consisted of individual potted trees, allocated in a 2X2 factorial design, with six trees per treatment (24 trees total). There were two levels of WALH and PLH (absent versus present), and two levels of *E. amylovora* inoculum (absent versus present).

On 15 July and 29 Aug, a 10^6 CFU (Colony Forming Units) suspension of *E. amylovora* in buffer (monophasic, anhydrous potassium phosphate and diphasic, trihydrate potassium phosphate) was applied as an atomized spray to 12 of 24 trees. Trees not sprayed with *E. amylovora* suspension in buffer were sprayed with buffer alone. Adult PLH, collected from a local alfalfa field, were then placed on 6 of the trees sprayed with the bacterial suspension, and on 6 of the trees without the suspension. To prevent leafhopper escape, each shoot was enclosed in a transparent mesh bag; each shoot without leafhoppers was also enclosed. After 4 days, all leafhoppers and bags were removed from the shoots. After 2 weeks, trees were examined for FB infection.

During these trials, the midribs of three leaves (on one tree) were punched using a paper punch, and sprayed with a suspension of *E. amylovora* to test the viability of the inoculum.

In Winchester, 18 of 30 trees were inoculated with *E. amylovora*, and six trees were inoculated with buffer on 2 July. Nine of the 18 trees contained 4 PLH each, and the other nine did not contain leafhoppers. The six trees inoculated with buffer each contained four PLH. The six trees left untreated did not contain leafhoppers; these were used as controls. Out of this set of trees, three trees containing both *E. amylovora* and PLH, and three trees containing only inoculum were placed in the headhouse under an overhead lamp. The other 24 trees were placed in a growth chamber (all trees were bagged prior to their placement in the headhouse or growth chamber). Trees were examined for fire blight on 7 July. Trees in Winchester were kept moist by misting during the inoculation period, unlike trees in Fredericksburg or Blacksburg.

A second trial in Winchester, using 'York' trees, was initiated on 8 July, where three concentrations of *E. amylovora* (10^6 , 10^5 and 10^4 CFU) were each applied in buffer versus deionized water, and compared with buffer alone and an untreated control group. Infection was rated when trees were removed from the growth chamber on 10 July.

The factorial experiment was initiated in Blacksburg, with the 10^6 CFU suspension of *E. amylovora* applied to half of 24 trees, and half of each of these treatments infested with PLH. Two tree had leaves punched with a paper punch to serve as a mechanical control; none of the trees became infected (including the punch controls), and these trees will be discussed no further.

III. Results and Discussion: 1997 results for PLH support conclusions made from the 1995 and 1996 studies, namely that PLH plays a role in FB transmission. In the first Fredericksburg trial, one of the six trees treated with both the FB inoculum and adult PLH developed FB; none of the trees treated with FB inoculum alone developed FB, and FB did not develop in any of the other 12 trees. In the second trial, none of the six trees treated with both FB inoculum and adult PLH developed FB; none of the trees treated with FB inoculum alone developed FB, and FB did not develop in any of the other 12 trees. Of the trees injured with the paper punch, all developed FB indicating viability of the inoculum.

In Winchester, of the trees from the headhouse, one of the three trees containing both PLH and *E. amylovora* was infected. Of the three with only *E. amylovora*, all were infected with fire blight. Of the 24 trees in the greenhouse factorial trial, the 12 trees inoculated with *E. amylovora* became infected, regardless of PLH status; PLH trees had no fire blight unless inoculated with *E. amylovora*. However, by 9 July, all experimental trees showed symptoms of infection except for a single tree with neither PLH nor *E. amylovora* inoculation.

The Winchester *E. amylovora* concentration comparison showed generally high levels of FB infection. In the treatments applied in buffer, 12 out of 16 trees treated with 10^6 became infected. Three out of 4 trees with 10^5, and all four trees with 10^4. Half of the trees treated with either 10^6 or 10^5 CFU in sterile, deionized water became infected; three out of four with 10^4 did so. Three out of four trees with buffer alone, and one out of four untreated trees showed symptoms of FB.

After three years of trials, there is evidence for association between PLH and FB infection. Environment appears to play a role as well, specifically the presence of free moisture at the time of inoculation. Moist leaves have a much higher rate than dry leaves. This should be considered in any trial investigating the role of insects in transmitting or facilitating fire blight. Although none of the 1997 trials involved trials with WALH, trials from 1995 and 1996 indicate that WALH plays no role in fire blight transmission.

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ALTERNATIVES TO NOMATE® SPIRALS IN THE APPLICATION OF TABM PHEROMONE

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Abstract

We developed a liquid formulation of tufted apple bud moth (TABM) pheromone in paraffin and tested various methods of applying it to the trees. We also made solid paraffin discs containing TABM pheromone which can be hung in the orchards. All methods were compared to the conventionally used NoMate® spirals in terms of their effectiveness for TABM control. The paraffin discs seemed to be the most promising method of applying TABM pheromone. Their application was easiest and least time consuming, are 100% biodegradable and produced satisfactory trap shutdown rates. Future research will show if they could be a viable and marketable alternative to NoMate® spirals.

Introduction

Mating disruption is an environmentally safe method of managing TABM on apple. It is harmless to vertebrates and invertebrates alike and can therefore be used in combination with biological control (Cardé et al., 1990, 1995; Biddinger et al., 1994). By reducing the need for pesticide applications it also helps alleviate problems with pesticide resistance which occur in many TABM populations. For these reasons large scale application of mating disruption in apple growing regions would be desirable.

Unfortunately grower acceptance of this method is still relatively poor. NoMate TABM is the only commercial formulation of TABM pheromone available for mating disruption. To date, results have been inconsistent and the relatively short time over which pheromone is released form dispensers results in control of only one generation per application. In addition, the polyvinyl chloride spirals are not biodegradable.

In an effort to develop an improved TABM pheromone dispenser that is also biodegradable, we examined a liquid formulation of TABM pheromone in paraffin, and used small plots to test the efficacy. We also tested solid paraffin discs impregnated with pheromone. These discs contained a greater amount of TABM pheromone than an individual NoMate® spiral. Consequently, a smaller number of discs were used on a per acre basis.

Materials and Methods

NoMate® spirals were supplied by Ecogen Inc. (Langhorne, PA). According to the manufacturer each NoMate® spiral contains 0.05g of active ingredient E-11 Tetradecen-1-yl Acetate and E-11 Tetradecen-1-ol in a 1:1 ratio). The paraffin emulsion formulation contained paraffin, emulsifiers, antioxidants and TABM pheromone.

Manual applications

Paraffin emulsions were applied to trees with a grease gun, back pack sprayer, and squirt bottle. To test the various manual applications methods, we designed a randomized complete block experiment which was replicated in four orchards (replicates). Plots consisted of 0.3 acres of trees with a 100 ft buffer zone between plots. In each orchard, one of the plots served as a control where no pheromone was applied, while the other plots received one of the following five treatments (methods of application):

- grease gun adjusted to deliver 25mg of pheromone per squirt (25 gm pheromone/acre)
- grease gun adjusted to put out 35mg of pheromone per squirt (35 gm pheromone/acre)
- regular, lab-type squirt bottle delivering 25 mg of pheromone per squirt (25 gm pheromone/acre)
- backpack sprayer (25 gm pheromone/acre)
- NoMate® spirals at a rate of 500 spirals per acre (25 gm pheromone/acre)

Pheromone applications were made on 29 April (late bloom of 'Delicious'). A pheromone-baited sticky trap was placed in the center of each plot. Traps were checked for male TABM and cleaned weekly. To evaluate success of the methods, trap shutdown rates were calculated with the following formula: % trap shutdown = [1- trt / con]*100, where trt is the number of males caught per plot and con is the number of males caught in the control plot of the same orchard. Whenever the number of males caught in a treatment plot exceeded that in the control plot we calculated trap shutdown with a slightly modified equation: % trap shutdown = [con / trt -1]*100. Treatment means were log-transformed and compared to each other with an ANOVA analysis (SAS Institute).

Airblast-sprayer

Application of the pheromone with an air-blast sprayer was an additional treatment which for organizational reasons was set up as a separate experiment in only one orchard. Six plots of 0.5 acres each were established in a 16-acre orchard. Three plots were treated with a pheromone/paraffin emulsion mixture with an air-blast sprayer, and the remaining untreated plots served as a control. The plots were separated from each other by a 200 ft buffer area. A pheromone-baited sticky trap was again placed in the center of each plot and traps were checked and cleaned weekly. Trap catches in treated and untreated plots were compared to each other with a t-test.

Paraffin discs

At the beginning of the second TABM generation (early August) solid paraffin discs containing 0.25mg of pheromone each were prepared and compared to NoMate® spirals in a randomized complete block experiment with four orchards as replications. Dispensers were placed in the orchards on 8 August at rates of 100 discs per acre and 600 spirals per acre. Consequently, the pheromone concentration in the NoMate® plots was higher than in the plots with paraffin discs (30mg per acre vs. 25mg per acre). Methods were the same as for the manual applications. Trap shutdown rates were calculated for both treatments and compared with a t-test after a log-transformation of the data.

Results

Manual applications

During the first generation, four of the treatments could not be statistically separated from each other (Table 1). Only the back pack sprayer led to significantly lower trap shutdown rates. This application failed completely in all four orchards. In fact it frequently led to negative trap shutdown rates, which makes it seem likely that males were attracted to this treatment. Possibly the pheromone concentration was high enough to attract males from a distance, but not effective in preventing them from finding the trap. Although the other four treatments were not significantly different from each other, they fell into two groups: means above 90% (NoMate® spirals and Grease Gun 25mg) and means between 80 and 90% (Squirt Bottle and Grease Gun 35).

In the second generation all treatments led to very poor results. The highest trap shut down rates were achieved with the Grease Gun applications, followed by the NoMate® spirals. The squirt bottle was intermediate between NoMate® and Back Pack Sprayer which again failed completely.

From our experience a shutdown rate of above 95% is required for adequate control of TABM. None of the treatments approached this level in the second generation, and even in the first generation satisfactory control would probably not have been achieved with any of the treatments. In terms of ease of application, NoMate® spirals were easiest to apply and required less time than any of the other treatments.

Table 1: Mean trap shutdown rates and standard errors produced by five different modes of manual application. N is the sample size. Means with the same letter are not statistically different from each other.

	Generation I		Generation II	
Treatment (gm/acre)	n	Mean (SE)	n	Mean (SE)
Grease gun (25 gm)	52	93.7 (3.7)a	56	68.4 (5.4)a
Grease gun (35 gm)	52	96.3 (5.3)a	56	69.9 (4.2)a
Backpack spryaer (25 gm)	52	4.4 (7.5)b	56	0.7 (6.5)a
Squirt bottle (25 gm)	52	83.4 (4.6)a	56	24.6 (7.1)c
NoMate TABM (25 gm)	52	91.0 (3.1)a	56	55.3 (6.7)b

Air-blast sprayer

Application of the pheromone with an air-blast sprayer did not result in positive results. Pheromone trap catches did not differ between the treatment and untreated control (Table 2). This this result was not surprising, because the paraffin emulsion applied with the airblast sprayer was a very thin formulation , which contributes to a very rapid release of pheromone from the paraffin.

Table 2: Comparison of mean trap catches in plots treated with an air-blast sprayer and control plots. Stderr is the standard error of the mean, N is the sample size. Means with the same letter are not statistically different from each other.

	Generation I		Generation II	
Treatment (gm/acre)	n	Mean (SE)	n	Mean (SE)
Treated	33	66.2 (8.7)a	30	72.6 (11.7)a
Control	33	73.2 (9.61)a	30	73.3 (11.1)a

Paraffin Discs

No difference in performance could be detected between the paraffin discs and the NoMate® spirals, despite the fact that the concentration of pheromone in the NoMate plots was greater than the paraffin disc plots Both treatments led to very high trap shutdown rates (Table 3).

Approximately 140 minutes per acre were required to hang the spirals, while only 40 minutes per acre were required to hang the paraffin discs.

Table 3: Mean trap shutdown rates and standard errors produced by application of paraffin discs and NoMate® spirals in the second generation. N is the sample size. Means with the same letter are not statistically different from each other.

	Generation I	
Treatment (gm/acre)	n	Mean (SE)
Paraffin discs (25 gm)	20	97.1 (1.7)a
NoMate TABM (35 gm)	20	99.1 (0.6)a

Summary

Overall none of the treatments applied for the first TABM generation produced satisfactory results. The high TABM populations in 1997 probably accounted for these poor results. All applications gave significantly lower trap shutdown rates during the second generation.

Application of the pheromone in a thin paraffin emulsion with the back pack sprayer and air-blast sprayer was completely unsuccessful. Of all manual methods tested, paraffin discs were easiest to apply and required the least time, with their application being ca. three times faster than that of NoMate® spirals. In addition, paraffin dics resulted in trap shutdown rates as high as a higher rate of NoMate® spirals. We therefor intend to test paraffin discs in a more elaborate

experiment for the length of the whole summer in 1998. We will also try to improve application methods for the liquid formulation.

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James F. Walgenbach
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Dear Dr. Walgenbach:

I received the Proceedings of the Cumberland-Shenandoah Fruit Workers Conference and noticed that the paper, "Response of Young Apple and Peach Trees in Sites Treated with Diuron, Simazine, and Terbacil," by Hardison, et. al. was not included. This paper was presented in the Horticulture Session and the abstract was given to the session chairman as described in the guide for contributors. Ms. Hardison is a graduate student whose accomplishment is important to her. I am including a copy of the abstract.

Sincerely,

THOMAS TWORKOSKI
Plant Physiologist

Enclosure

COPY