

Crop Profile for Apples in West Virginia

Prepared: February, 1999

Revised: June, 2003



General Production Information

Production Statistics: Apple production in West Virginia has averaged 113 million pounds (2.7 million bushels), with an average value of \$10.6 million, over the past five years resulting in a state ranking of ninth in U.S. production (1). Approximately 17% of the crop was marketed as fresh and 83% for processing during this period. Apple production has occurred on an average of 7,600 acres representing 126 commercial fruit growers over the past five years (2). Ninety-five percent of the apple trees in West Virginia are located in the four eastern counties of Berkeley, Hampshire, Jefferson and Morgan (2). In 1994, the top five varieties were Red Delicious, York, Golden Delicious, Rome and Stayman, representing 83% of the total number of trees (2). In the past few years, increased planting of newer varieties such as Gala, Ginger Gold and Fuji has occurred. In 1994, 41% of existing trees were standard and 59% were semi-dwarf and dwarf trees (2). Recent plantings consist almost entirely of dwarf and semi-dwarf trees.

Production Practices: The apple production season begins with bud break in late March or early April, bloom in the latter part of April, and harvest for most varieties in September and October. Spring frosts and hail damage are problems for some growers in most years, and drought conditions can effect yields in some years. Typical culture consists of Kentucky-31 tall fescue between the tree rows and a weed-free strip within the tree row maintained with herbicides. Approximately 8 to 11 applications of crop protection chemicals are made annually for the control of 20 to 25 arthropod pests and diseases (3, 4). Plant growth regulators (2 to 3 applications) are applied to thin fruit, control tree growth, improve fruit quality, and for drop control prior to harvest (3, 4). Growers are very active in monitoring their orchards and spray decisions are made on a block by block basis, and even for a specific variety within a block. Materials selected and rates of application can vary widely among growers. Most orchards receive annual pruning during the dormant season.

Cultural Practices

Worker Activities: Workers spend about two weeks in June hand thinning fruit and removing watersprouts on approximately 50 percent of the apple acreage. Summer pruning is conducted for about two weeks in July on approximately 10 percent of the acreage. Orchard mowing is conducted every 3-4 weeks from April through August.

Insect Pests



Aphids [rosy apple aphid, *Dysaphis plantaginea* (Passerini); spirea aphid, *Aphis spiraecola* Patch]: Rosy apple aphid is the most serious of the five aphid species found on apple, and is the most important prebloom insect pest. It causes leaf, fruit and systemic root damage, and is capable of causing up to 50% fruit injury in severe outbreaks. Spirea aphid is less of a problem, causing discoloration of fruit from sooty mold growth on honeydew deposits only under moderate to high populations.

Chemical control: In order to prevent fruit injury from rosy apple aphid, 1 to 2 insecticide applications are typically made during the prebloom period (green tip to half-inch green stage and tight cluster to pre-pink stage). If control is not achieved



during the prebloom period, a rescue treatment is usually applied at petal fall, however, some fruit injury may still result. Spirea aphid control, if needed, usually consists of a single insecticide application (material used usually has efficacy against other pests present at the same time) about 4 to 6 weeks after petal fall.

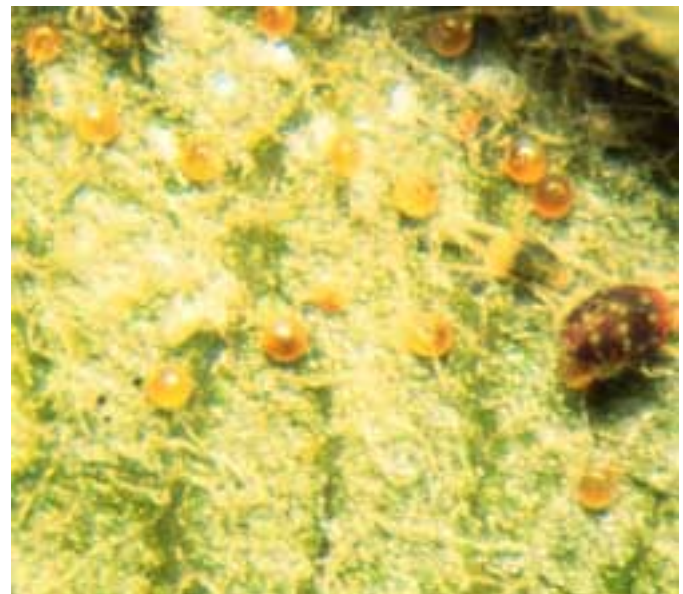


Insecticide	% of Acres Treated	Amount Used	
		lb a.i./acre/application	lb a.i./acre/year
Acetamiprid	0	0.05 - 0.075	0.05 - 0.075
Chlorpyrifos	10	1 - 1.25	1 - 1.25
Dimethoate	15	0.75	0.75
Endosulfan	3	1.50	1.50
Esfenvalerate	38	0.03	0.03
Imidacloprid	28	0.05	0.05
Methomyl	15	0.34	0.34
Thiamethoxam	<1	0.07	0.07

Biological control: Predation of aphids occurs by adults and larvae of ladybird beetles, and larvae of syrphid flies, aphid midges and green lacewings. This biological control is insufficient to prevent fruit injury and the need for insecticide application to control rosy apple aphid. Biological control of spirea aphid is likely to occur if greater than 20% of the aphid colonies have predators.

Cultural control: Removal of watersprouts in the center of trees will reduce populations of spirea aphids.

European red mite, *Panonychus ulmi* (Koch): European red mite is a major, and one of the most difficult pests to control on apple in West Virginia. Varieties such as Red Delicious and York are especially vulnerable to injury. Moderate to high populations of this foliage-feeding pest can reduce fruit size, and result in the production of fewer and less vigorous fruit buds for the following season. This injury is more severe during periods of drought stress. High populations late in the season can result in the indirect downgrading of fruit by depositing overwintering eggs in the calyx end of fruits.





Chemical control: Acaricide applications to control

European red mite are typically targeted at the overwintering egg stage during the prebloom period (½-inch green stage to pink) and/or the motile stages during the postbloom period. In some cases, a single acaricide application during prebloom or at petal fall may provide season-long control. The need for postbloom applications (1 to 2) is determined by monitoring motile stages, and is based on specific action thresholds as a function of crop load (bushels/acre) and time of season.

Acaricide	% of Acres Treated	Amount Used	
		lb a.i./acre/application	lb a.i./acre/year
Abamectin	10	0.0125	0.0125
Bifenazate	0	0.375 – 0.50	0.375 – 0.50
Clofentezine	1	0.125	0.125
Dicofol	1	2.0	2.0
Hexythiazox	1	0.09	0.09
Oxamyl	3	0.375 - 0.75	0.375 - 0.75
Petroleum distillate	48	3 - 6 gallons	3 - 6 gallons
Pyridaben	20	0.165	0.165

Biological control: Over 55% of fruit growers monitor populations of the black ladybird beetle, *Stethorus punctum* (Leconte), for the biological control of European red mites. Biological control is likely to occur if the number of *S. punctum* adults and larvae per 3 minute tree examination is at least 2.5 times as abundant as the number of mites per leaf.



San Jose scale, *Quadraspidiotus perniciosus*

(Comstock): San Jose scale was an important pest of apple in West Virginia as late as the 1980s, however, pest status of this insect has declined with the increased planting of smaller sized trees which facilitate more thorough spray coverage. Isolated outbreaks still occur in large, poorly pruned standard-sized trees that do not receive adequate spray coverage.

Chemical control: Control is achieved with a single insecticide application at the green tip to ½-inch green stage against the overwintering immature scale and multiple applications (1 to 3) against the nymphal (crawler) stage during the postbloom period.

Insecticide	% of Acres Treated	Amount Used	
		lb a.i./acre/application	lb a.i./acre/year
Chlorpyrifos	3	1.25	1.25
Diazinon	<1	1.50	1.50 – 4.50
Methidathion	<1	0.75	0.75
Petroleum distillate	10	3 - 6 gallons	3 - 6 gallons
Pyriproxyfen	<1	0.09 – 0.11	0.09 – 0.11

Cultural control: Annual dormant pruning, especially of large trees, improves spray coverage and reduces the severity of this pest.

Spotted tentiform leafminer, *Phyllonorycter blancardella* (Fabr.):

Spotted tentiform leafminer has widespread occurrence throughout the commercial fruit production area, but does not reach important pest status in all orchards. Problem sites within the last 20 years have been primarily due to the development of resistance to organophosphate insecticides. Average mine density in excess of two per leaf can reduce fruit quality and quantity, decrease size, cause premature leaf and fruit drop, and reduce fruit set the following year.



Chemical control: Insecticide applications are typically targeted against spring brood adults and first and/or second generation sap-feeding larvae. A sequential sampling scheme is used to assess mine density to determine the need for spray applications.

Insecticide	% of Acres Treated	Amount Used	
		lb a.i./acre/application	lb a.i./acre/year
Abamectin	10	0.0125	0.0125
Acetamiprid	0	0.05 - 0.075	0.05 - 0.075
Esfenvalerate	38	0.03	0.03
Imidacloprid	28	0.05	0.05
Methomyl	9	0.34 - 0.45	0.34 - 0.90
Oxamyl	8	0.375 - 0.75	0.375 - 0.75
Thiamethoxam	<1	0.07	0.07

Biological control: A complex of predators and parasitoids exert biological control on

spotted tentiform leafminer, with three parasitoids being quite common in most orchards. Insecticide control of the third generation of spotted tentiform leafminer is discouraged in order to allow parasitoid survival to reduce the overwintering leafminer population.



Plum curculio, *Conotrachelus nenuphar* (Herbst): Plum curculio tends to be a sporadic pest in West Virginia apple orchards. Most fruit injury occurs in those orchards adjacent to hedgerows and woodlots. Problems also occur in orchards of multiple varieties with different bloom periods. In this situation, injury typically occurs on varieties that have completed bloom, while waiting for later blooming varieties to reach petal fall in order to apply insecticides.

Chemical control: Plum curculio can usually be controlled with a single insecticide application at petal fall. In higher pressure situations, a second application may be needed in 10 to 14 days.

Insecticide	% of Acres Treated	Amount Used	
		lb a.i./acre/application	lb a.i./acre/year
Azinphos-methyl	80	0.5 - 0.75	0.5 - 1.50
Indoxacarb	1	0.11	0.11
Phosmet	9	1.1 - 1.4	1.1 - 2.8



White apple leafhopper, *Typhlocyba pomaria* McAtee: This foliage-feeding insect can be tolerated at low populations. Moderate to high populations can cause indirect damage to fruit in the form of black speckling (sooty mold) which grows on honeydew deposits. An abundance of adult leafhoppers at harvest can also be a nuisance to pickers.

Chemical control: An insecticide is applied in the early postbloom period for first generation control and/or in August for second generation control based on an action threshold averaging 1 to 3 nymphs per leaf.

Insecticide	% of Acres Treated	Amount Used	
		lb a.i./acre/application	lb a.i./acre/year
Acetamiprid	0	0.05 - 0.075	0.05 - 0.075
Dimethoate	15	0.75	0.75
Imidacloprid	28	0.05	0.05
Methomyl	30	0.34 - 0.45	0.34 - 0.90

Thiamethoxam	<1	0.07	0.07
--------------	----	------	------



Codling moth, *Cydia pomonella* (Linnaeus): Codling moth is present throughout the commercial fruit production area. Although populations are low in many orchards, levels of fruit injury are high enough in an increasing number of orchards to result in load rejection by processors. A contributing factor to increased levels of injury is that newer chemistries are generally not as effective as organophosphate insecticides, and must be timed more precisely to be efficacious.

Chemical control: Insecticides for codling moth control are applied (1-3 applications) in those orchards where the pheromone trap catch exceeds five moths per trap per week. Degree days are accumulated from first trap capture in the spring (biofix) in order to time insecticide applications to coincide with egg hatch of two or three generations per year.

Insecticide	% of Acres Treated	Amount Used	
		lb a.i./acre/application	lb a.i./acre/year
Acetamiprid	0	0.075 – 0.15	0.15 – 0.30
Azinphos-methyl	47	0.5 - 0.75	0.5 - 1.50
Indoxacarb	1	0.11	0.11 – 0.22
Methoxyfenozide	20	0.19 – 0.25	0.19 – 0.57
Phosmet	35	1.4 – 2.1	1.4 – 4.2

Mating disruption: Pheromone dispensers are commercially available for installation in orchards to provide codling moth control by preventing mating. This technology has been used on <1% of the acreage thus far because of cost, and variable control due to the presence of wild hosts and abandoned apple orchards which provide a source of codling moth populations to infest commercial orchards. Since the use of this technology would still require insecticide applications for the control of other pests which occur at the same time as codling moth, mating disruption is currently not as economical when compared with insecticidal control of all pests.

Oriental fruit moth, *Grapholita molesta* (Busck): Although primarily a pest of peach, the incidence of adults and injury (identical to codling moth) from this insect has been increasing in apple orchards. An increasing number of fruit loads have been rejected by processors in recent years due to injury from this insect. Apple orchards adjacent to peach are most vulnerable to attack, especially if peaches are not sprayed because of crop loss due to cold temperatures. The elimination of some insecticide applications because of below trap threshold populations of codling moth may be contributing to increased levels of

oriental fruit moth. The specific timing of current insecticide applications (based on degree days) for codling moth and leafrollers may be permitting the survival of oriental fruit moth, which had been previously controlled by calendar-type applications. The possibility exists that oriental fruit moth may be developing resistance to some of the commonly used organophosphate insecticides, and newer more selective chemistries are typically not as efficacious.

Chemical control: Insecticides for oriental fruit moth control are applied (6-8 applications) in those orchards where the pheromone trap catch exceeds 10 moths per trap per week. Degree days are accumulated from first trap capture in the spring (biofix) in order to time insecticide applications to coincide with egg hatch of the first through third generations. Insecticides for control of the fourth and fifth generations are applied within 7-10 days of exceeding the pheromone trap threshold.

Insecticide	% of Acres Treated	Amount Used	
		lb a.i./acre/application	lb a.i./acre/year
Azinphos-methyl	30	0.5 - 0.75	3.0 – 4.5
Indoxacarb	1	0.11	0.11 – 0.22
Methoxyfenozide	10	0.19 – 0.25	0.19 – 0.57
Phosmet	25	1.4 – 2.1	4.2 – 6.3

Mating disruption: Pheromone dispensers and a sprayable pheromone formulation are commercially available for use in orchards to provide oriental fruit moth control by preventing mating. This technology has been used on about 14% of the acreage thus far with excellent results. Since the use of this technology would still require insecticide applications for the control of other pests which occur at the same time as oriental fruit moth, mating disruption is currently not as economical when compared with insecticidal control of all pests.

Redbanded leafroller, *Argyrotaenia velutinana* Walker: Redbanded leafroller was once the most important leafroller in the eastern U.S., reaching its greatest severity in the mid-Atlantic states. It is generally controlled effectively by growers using conventional organophosphate-based spray programs, but occasional outbreaks occur where there is resistance to this group of compounds.



Chemical control: Insecticides are typically applied for the control of redbanded leafroller at petal fall (first generation), latter part of June to early July (second generation) and August (third generation).

		Amount Used

Insecticide	% of Acres Treated	lb a.i./acre/application	lb a.i./acre/year
Azinphos-methyl	50	0.44 - 0.75	0.44 - 2.82
Methomyl	50	0.34 - 0.45	0.34 - 1.80
Phosmet	15	1.1 - 1.4	1.1 - 1.4
Spinosad	1	0.08 – 0.13	0.08 – 0.13
Methoxyfenozide	10	0.13	0.26



Tufted apple bud moth, *Platynota idaeusalis* (Walker) and Variegated leafroller, *Platynota flavedana* Clemens: Until recently, tufted apple bud moth was the most serious direct pest of apple in the most eastern West Virginia counties of Berkeley and Jefferson. Because of this insect's development of resistance to the organophosphate and carbamate insecticides, it had become very difficult to limit fruit injury to under 5%. The increased use of Intrepid and SpinTor in the past few years has significantly reduced the level of injury caused by this insect. Variegated leafroller is the most important leafroller species in the most western fruit producing counties of Hampshire and Morgan, but injury has been more sporadic and less severe than that caused by the tufted apple bud moth.

Chemical control: Degree days are accumulated from first pheromone trap capture in the spring (biofix) in order to time insecticide applications to coincide with egg hatch of two generations per year (June and August).

		Amount Used	
Insecticide	% of Acres Treated	lb a.i./acre/application	lb a.i./acre/year
Azinphos-methyl	70	0.44 - 0.75	0.44 - 1.50
Esfenvalerate	10	0.03 – 0.04	0.03 – 0.04
Methomyl	50	0.34 - 0.45	0.34 - 0.90
Methoxyfenozide	70	0.13	0.26 – 0.39
Spinosad	5	0.08 – 0.13	0.08 – 0.13

Dogwood borer, *Synanthedon scitula* (Harris): Dogwood borer has become a recent problem in some orchards on dwarfing rootstocks by feeding in "burr knots" (adventitious root primordia) that can result in tree girdling and death.



Chemical control: Pheromone traps are used to time insecticide applications directed at the lower trunk region of trees to prevent larval infestation of "burr knots".



Insecticide	% of Acres Treated	Amount Used	
		lb a.i./acre/application	lb a.i./acre/year
Chlorpyrifos	25	1.5	1.5 - 3.0

Cultural control: Incidence of dogwood borer can be reduced by the removal of spiral-wrap and other types of tree trunk guards which prevent spray coverage. Mounding soil around the trunk to cover "burr knots" will also prevent infestation.



Apple maggot, *Rhagoletis pomonella* (Walsh): Except for a few isolated situations, apple maggot has generally not been a problem in the past in commercial apple orchards in West Virginia. High fly populations and fruit injury can occur in abandoned orchards, which pose a threat to adjacent commercial orchards. As more orchards become abandoned because of increasing urbanization, it will become necessary to control apple maggot in adjacent commercial orchards in order to prevent fruit injury and load rejection by processors. The successful control of apple maggot in commercial orchards will be significantly influenced by the fate of organophosphate insecticides, as newer, more selective replacements for controlling other pests are less effective against

apple maggot.

Chemical control: Yellow panel and red sphere visual/bait traps are used to time insecticide applications based on fly capture threshold levels. Where trap thresholds are exceeded, one to three insecticide applications may be needed to control the single generation per year.

Insecticide	% of Acres Treated	Amount Used	
		lb a.i./acre/application	lb a.i./acre/year
Azinphos-methyl	2	0.5 – 0.75	0.5 – 2.25
Phosmet	2	1.4 – 2.1	1.4 – 6.3

Table 1. Control periods for arthropod pests of apple.

Arthropod Pest	Prebloom	Days After Full Bloom							
		7-15	15-30	30-45	45-60	60-75	75-90	90-105	105-120
Rosy apple aphid	X	X							
Spirea aphid				X	X				
European red mite	X	Based on action threshold							
San Jose scale	X			X	X			X	X
Spotted tentiform leafminer	X	X			X				
Plum curculio		X	X						
White apple leafhopper		X						X	
Codling moth			X	X			X	X	X
Oriental fruit moth		X		X	X		X	X	X
Redbanded leafroller		X			X				X
Tufted apple bud moth				X	X			X	X
Variegated leafroller									
Dogwood borer			X				X		
Apple maggot							X	X	X

Future Potential Insect Pests

European apple sawfly, *Hoplocampa testudinea* (Klug): Fruit injury from this hymenopteran pest was first observed in West Virginia orchards in 2000. Female wasps oviposit into developing fruits during the bloom to early petal fall period. The larva initially mines just under the skin of the apple, creating a russeted, circular scar that originates from the calyx. Larvae often leave the first infested fruit and tunnel to the core of additional fruits which often results in abscission by midsummer. Injury is likely to be most severe during years with prolonged bloom, especially in orchards of mixed cultivars with a wide range in bloom periods. In this situation, injury typically occurs on the earlier blooming cultivars while waiting for the later blooming cultivars to reach petal fall so that insecticides can be applied.



European apple sawfly fruit injury

Mullein plant bug, *Campylomma verbasci* (Meyer): is a predaceous mirid for most of the season, but can inflict injury to developing fruitlets around bloom. Feeding causes a reaction in the fruit, resulting in the appearance of a dark, raised, corky wart, often surrounded by a shallow depression. Warts may occur individually or be clustered in one area on the fruit. Since feeding occurs primarily around bloom, lack of a pink spray or any delay in applying the petal fall spray because of a prolonged bloom period can increase the likelihood of this injury. Injured fruit was first observed in a few West Virginia orchards in 2002.



Mullein plant bug fruit injury

Stink bugs, various species: Within the past couple of years, injury resembling cork spot has been identified as being caused by stink bugs. The reason for this occurrence is not known. It's possible that changes in pest management programs, such as more selective chemistries and fewer broad spectrum organophosphates, may be contributing to increased population levels and subsequent injury from this group of pests.



Stink bug fruit injury

Critical Uses and Needs

Due to rapid urbanization in the Eastern Panhandle of West Virginia, an increasing number of commercial orchards are being abandoned, with trees left standing until the land is developed. These abandoned orchards support significant pest populations which often invade adjacent commercial orchards, resulting in more complex and costly management programs.

Specific uses for various insecticides and acaricides are listed below. Some of these products are quite new, and additional experience is needed before they can be considered as suitable pest management options.

Organophosphates

Azinphosmethyl: The most important use of this material has been for the control of redbanded leafroller at 7-15 days after full bloom (DAFB), plum curculio (7-30 DAFB), codling moth (15-45 DAFB and 75+ DAFB), and more recently oriental fruit moth (7-15 DAFB, 30-60 DAFB, and 75-120 DAFB). This material has a good fit in an IPM program because it is well tolerated by *Stethorus punctum* (Leconte), a ladybird beetle predator of European red mite. The use of this OP against the second generation of codling moth (75+ DAFB) would also control apple maggot, which is believed to be a major reason for the lack of apple maggot establishment in commercial orchards in West Virginia, especially in those that are adjacent to abandoned orchards.

Chlorpyrifos: The most important use of this product is for the control of dogwood borer in burr knots

(15-30 DAFB and 75-90 DAFB). The liquid formulation of chlorpyrifos has been used in some orchards for the control of rosy apple aphid and overwintering San Jose scale during the delayed dormant period. The low usage is primarily due to the cheaper cost of esfenvalerate, which is an effective alternative at this stage for rosy apple aphid control. Chlorpyrifos serves as a good resistance management alternative to esfenvalerate for rosy apple aphid control.

Dimethoate: The major use of this product is for the control of rosy apple aphid during the late prebloom period, and for the control of white apple leafhopper at petal fall. This material has a fair fit in an IPM program, with toxicity ranging from low to high depending upon the predator species.

Methidathion: This product has been used on a limited basis for the delayed dormant control of rosy apple aphid and San Jose scale.

Phosmet: This material has the same usage pattern against the same pest spectrum as azinphosmethyl. Although it is a little more expensive than azinphosmethyl, use has increased in the past few years because of increased restrictions on azinphosmethyl due to FQPA.

Carbamates

Carbaryl: The major use of this product is as a fruit thinning agent in the early postbloom period. Because of its moderate to high toxicity to predators it does not have a good fit in an IPM program. The XLR PLUS formulation is somewhat safer to predators than wettable powder formulations. When used as a thinning agent, this product also provides suitable control of white apple leafhopper, plum curculio and oriental fruit moth if higher rates are applied.

Methomyl: This product is primarily used in a tank mix (at reduced rates) with an OP insecticide (usually azinphosmethyl or phosmet at reduced rates) for the control of tufted apple bud moth and variegated leafroller (30-60 DAFB and 90+ DAFB). This use also provides fair to good control of spirea aphids, second generation spotted tentiform leafminer and second generation white apple leafhopper. This product has moderate toxicity to predators at reduced rates, and generally does not have a good fit in an IPM program.

Oxamyl: This product has minimal use for the control of spotted tentiform leafminer and European red mite. It has moderate to high toxicity to predators and does not have a good fit in an IPM program. Oxamyl has also had some use as a fruit thinning agent during the early postbloom period.

Miscellaneous Insecticides and Acaricides

Abamectin: Use of this product is increasing during the early postbloom period for the control of European red mite and spotted tentiform leafminer, with suppression of white apple leafhopper. Toxicity to predators is moderate from spray contact, but low from contact with residues which makes this product a generally good fit with an IPM program. This material is a good resistance management tool

for rotation with other acaricides of different chemistry.

Acetamiprid: This product is the newest member of the neonicotinoid class of chemicals to receive registration on apples. It is expected to provide very good control of sucking insects and codling moth, but none has been used as of yet.

Bifenazate: This is the newest acaricide to receive registration on apples. It is recommended for summer application at a low mite threshold in a rotation program with other acaricides. Very little has been used as of yet in West Virginia.

Clofentezine: This material is primarily an ovicide, applied for the control of eggs of European red mites and twospotted spider mites. It has low toxicity to predators and a good fit in an IPM program. Use has been limited in West Virginia because of cost, narrow spectrum of activity (only effective against mites), and the product must be applied on a preventive basis before the potential severity of a mite problem is known. It is very effective, and can provide season long control, when applied in the early postbloom period. It is also a good resistance management tool to rotate with other materials for postbloom mite control.

Endosulfan: This product has minimal use for the control of rosy apple aphid during the prebloom period. It has low to moderate toxicity to predators and has a fairly good fit in an IPM program. Dimethoate is an effective alternative that receives more use because it is less expensive, even though it is slightly more toxic to predators. This is a good resistance management tool for the organophosphates as it is the only chlorinated hydrocarbon used on apple.

Esfenvalerate: This pyrethroid is the most widely applied insecticide on apple during the green tip to pre-pink period, primarily for the control of rosy apple aphid. Although this material is moderately to highly toxic to predators, this effect is reduced by making the application as close to green tip as possible. Delaying the application can be disruptive to an IPM program and necessitate the use of acaricides for mite management. Some orchards receive late season applications of this product for the control of leafrollers, codling moth and oriental fruit moth.

Fenpropathrin: This pyrethroid would be used in a similar fashion to esfenvalerate, but due to its greater cost has had very limited use in West Virginia. Although it is also highly toxic to predators, it differs from esfenvalerate in having acaricidal activity.

Hexythiazox: This material is primarily an ovicide, applied for the control of eggs of European red mites and twospotted spider mites. It has low toxicity to predators and a good fit in an IPM program. Use has been limited in West Virginia because of cost, narrow spectrum of activity (only effective against mites), and the product must be applied on a preventive basis before the potential severity of a mite problem is known. It is very effective, and can provide season long control, when applied in the early postbloom period. It is also a good resistance management tool to rotate with other materials for postbloom mite control.

Imidacloprid: The use of this product is increasing as it is very effective against aphids, white apple leafhopper and spotted tentiform leafminer during the postbloom period. It has a low to moderate toxicity to predators and generally has a good fit in an IPM program. It is a good resistance management tool for rotation with OP and carbamate insecticides, and is of low mammalian toxicity.

Indoxacarb: This member of the oxadiazine class of chemicals has received limited use in West Virginia in the early postbloom period for the control of plum curculio, oriental fruit moth, and white apple leafhopper, and in the summer for control of codling moth and oriental fruit moth. Control of spotted tentiform leafminer has also been demonstrated when used in combination with an adjuvant, such as oil. It is moderately toxic to predators, and use has been limited to 2-3 applications per year.

Isomate C+: This rope-type dispenser is installed at the rate of 400 per acre for the mating disruption of codling moth. One installation provides season long control. Control results were variable on a small amount of acreage that received treatment during 2002.

Isomate M100: This rope-type dispenser is installed at the rate of 100 per acre for the mating disruption of oriental fruit moth, which provides control for 90-100 days. Excellent control resulted from application on about 10% of the acreage in West Virginia during 2002.

Methoxyfenozide: This insect growth regulator (IGR) is the primary insecticide used for the control of tufted apple bud moth and variegated leafroller, which has been highly effective. Some use has also been targeted for the control of codling moth and oriental fruit moth. It has an excellent fit in IPM programs due to its low toxicity to predators.

Petroleum distillate: This product is applied during the green tip to tight cluster stage primarily for the control of overwintering eggs of European red mite, and in some cases for overwintering San Jose scale control. It has low toxicity to predators and good fit in an IPM program. It is a good resistance management tool because pests have not developed resistance to its physical mode of action.

Pyridaben: This product is the primary acaricide that is used for the management of summer populations of European red mite and twospotted spider mite. Toxicity to predators is moderate, but can be reduced by lowering the application rate while still maintaining effective mite control in an IPM program. This is currently the most effective acaricide for summer use and a good tool for rotation with other mite management products.

Pyriproxyfen: This IGR is recommended for the delayed dormant control of rosy apple aphid and overwintering San Jose scale, as well as summer control of San Jose scale crawlers. There has been very limited use in West Virginia thus far because the cost is significantly greater than alternatives.

Spinosad: Derived from a soil microorganism, this product has been used on a small amount of acreage for the control of tufted apple bud moth and spotted tentiform leafminer. Leafminer control is enhanced

by the addition of a penetrating agent. Good activity against apple maggot has been demonstrated on a short application interval. It has a short residual, and fits well in IPM programs because of its low toxicity to predators.

Sprayable OFM Pheromone: This sprayable formulation of pheromone provided excellent control of oriental fruit moth on approximately 4% of the acreage in West Virginia during 2002.

Thiamethoxam: This product is a member of the neonicotinoid class of chemicals, and has had limited use in West Virginia for the control of aphids, leafhoppers and leafminers.

Weeds

Weeds are an important pest problem in West Virginia apple orchards because they: 1) compete with the tree for water and nutrients; 2) can interfere with pollination if their flowering period coincides with apple bloom; 3) can interfere with harvest (poison ivy and brambles); and 4) can harbor insects, rodents and diseases that can affect fruit trees.

Chemical control: Most fruit growers apply a combination of a postemergence, non-selective, contact or systemic herbicide along with one or more preemergence residual herbicide/s as a single application per year for weed control within the tree rows. This may be followed by a second application of a non-selective postemergence herbicide, either as a broadcast application, or as a spot treatment for perennial weed problems. Perennial weeds are reported to be better-managed now by spot-applying a systemic herbicide in fall.

		Amount Used
Herbicide	% of Acres Treated	lb a.i./acre/year
2,4-D	25	1.83
Diuron	40	3.12
Glyphosate	60	1.31
Norflurazon	5	2.91
Paraquat	20	1.12
Simazine	10	2.77
Terbacil	40	1.01
Oryzalin	5	2.25

Cultural control: In some orchards, especially those on more sloping sites, ground vegetation may exist within the tree row that is managed with mowing. Alley ways between the tree rows typically consist of Kentucky-31 tall fescue that is managed with mowing.

Critical Uses and Needs

Herbicide use to manage weeds within the tree row is an important component of an IPM program. In young trees, weed competition can cause permanent yield reductions, and may also provide cover for rodents like voles that can cause tree losses, and increase the risk of causing mechanical injury from cultivation and mowing. Management of weeds with herbicides is, therefore, critical, especially in newly established orchards so that tree growth is not impaired and trees can fill their growing space as quickly as possible.

Fruit Quality and Tree Growth

Thinning of fruit with plant growth regulators promotes return bloom, improves fruit size and color, and reduces limb and tree breakage from excessive crop loads. Plant growth regulators may also be used to control excessive vegetative growth, improve fruit quality (finish, shape, red color, maturity, cracking) and delay fruit drop which can reduce fruit losses and increase fruit size.

Chemical practices: Plant growth regulators are typically used in 1 to 3 applications for chemical thinning and improving fruit quality, and 1 application for drop control near harvest. Multiple applications may be used in some situations to control excessive vegetative growth.

		Amount Used
Plant Growth Regulator	% of Acres Treated	lb a.i./acre/year
Benzyladenine	2	0.04
Cytokinins	9	0.02
Carbaryl	15	0.80
Ethephon	9	0.50
Naphthaleneacetic acid (NAA)	24	0.03
Naphthylacetamide (NAD)	9	0.09
Oxamyl	6	0.5 - 0.75

Cultural practices: In some orchards fruit is thinned by hand, as a substitute for or follow-up to chemical thinning.

Critical Uses and Needs

Plant growth regulators are especially critical for thinning and preventing drop of fruit. Hand thinning of fruit is not economically practical, and failure to adequately thin results in small fruit and poor return bloom. Failure to prevent fruit drop with plant growth regulators can result in excessive fruit loss at harvest. During seasons of crop loss due to frost, application of a plant growth regulator can be a critical management tool to control excessive vegetative growth and prevent tree crowding.

Diseases



Apple scab (caused by *Venturia inaequalis*): Acreage affected: 100%. Apple scab is of major economic importance in the mid-Atlantic region. If not controlled, the disease can cause extensive losses (70 percent or greater) where humid, cool weather occurs during the spring months. Losses result directly from fruit or pedicel infections, or indirectly from repeated defoliation which can reduce tree growth and yield.

Management: Management of apple scab is based on the application of fungicides to control leaf and fruit infections caused by overwintering ascospores. The use of resistant cultivars and sanitation practices are used to varying degrees, depending on the orchard system being used and the goals of the grower.

Chemical control: Apple scab is controlled almost exclusively with fungicide sprays. A variety of fungicide sprays with differing modes of action are available. When and how they are used depends upon their mode of action. Protectant fungicides prevent the spores from germinating or penetrating leaf tissue. To be effective, they must be applied to the surface of susceptible tissue before infection occurs. Occurrence of infection can be predicted with an accurate weather forecast and the infection period table. Protectant fungicides are applied routinely at 7 to 10 day intervals or according to anticipated infection periods. Postinfection fungicides control the scab fungus inside leaves and fruit. These chemicals can penetrate plant tissues to eliminate or inhibit lesion development. The ability of these fungicides to stop infections is limited to a few hours, or up to few days (depending upon the specific fungicide), and often varies with temperatures during the first 24 to 48 hours after infection. Some fungicides can inhibit the fungus even later into the incubation period (the time between infection and the appearance of symptoms). Eradication of scab lesions after they appear does not usually occur, but can be achieved with the proper rate and timing of certain fungicides. The selection of fungicides for management of scab is based on several factors, including the entire spectrum of other diseases that must be managed at that time, the potential for resistance in the scab fungus to the selected chemical, the history of the disease in a particular orchard, the final market for the fruit, and other social and economic

factors. Good horticultural practices, such as proper site selection, tree spacing and annual pruning, facilitates chemical control by improving spray coverage and reducing the length of wet periods.

Chemical Management

Fungicide	% of Acres Treated	lb a.i./acre/application
Captan	53	1.5 - 4
Copper	19	4 - 8
DMI's (Nova 40W)	48	0.125 - 0.188
Dodine	11	1.0
EBDC's	62	2.4 - 4.8
Strobilurin	48	0.06 - 0.188
Sulfur	29	6 - 9
Ziram	32	2.5 - 6

Alternatives: Environmental monitoring of scab infection periods helps optimize fungicide spray timing but may not be useful for large acreages that require 24 to 48 hours to complete a spray application. Some niche market growers can produce disease resistant cultivars, eg. Liberty, Enterprise, Goldrush, Pristine etc., but only on the limited basis that their market allows.



Resistant Cultivars: Most of the major apple cultivars are susceptible to the apple scab fungus, although this varies somewhat. Breeding programs to develop high quality disease-resistant apple cultivars are underway at the New York State Agricultural Experiment Station in Geneva, and cooperatively among Purdue University, Rutgers University, and the University of Illinois. In addition, several foreign countries have active apple breeding programs with disease resistance as an objective. More than 25 scab-resistant cultivars have been released, including Prima, Priscilla, Jonafree, Redfree, Liberty, Freedom, Goldrush, and Pristine. Most are adapted to the more

northern apple-growing areas of the U.S. All scab-resistant cultivars vary in their susceptibility to other early-season diseases; and all are susceptible to the summer diseases. Some recently released apple cultivars that have not been bred specifically for resistance to scab show varying levels of scab susceptibility, also. None of the scab-resistant cultivars is grown commercially on a large scale.

Sanitation: Prevention of pseudothecial formation in overwintering apple leaves would probably eliminate scab as a serious threat to apple production in the U.S. Unfortunately, complete elimination of pseudothecia is not possible under orchard conditions with

current methods. The potential for severe scab can be reduced with several methods that vary in practicality, depending on orchard size. Leaf pickup and destruction in late autumn can be employed if orchard size is extremely small; although diseased leaves from neighboring areas can be blown in. Flail mowing in late autumn to chop litter can help reduce numbers of pseudothecia, thus reducing inoculum in the following spring. Applications of 5% urea to foliage in autumn can hasten leaf decomposition, thus reducing formation of pseudothecia. Applications should be made just prior to leaf fall to avoid stimulating tree growth and predisposing the trees to winter injury. Since they are not 100% effective in destroying inoculum, sanitation practices are ineffective in years when disease incidence is high.



Powdery mildew (caused by *Podosphaera leucotricha*): Acreage affected 40%. Powdery mildew can be a persistent disease of susceptible apple cultivars throughout the mid-Atlantic region. It is the only fungal apple disease that is capable of infecting without wetting from rain or dew. Mildew severity and the need for control measures are related to cultivar susceptibility and intended fruit market.

Management: The management of powdery mildew in commercial orchards must be integrated with several other diseases having different environmental requirements (i.e. apple scab and cedar-apple rust). Where mildew-susceptible cultivars are grown, include a mildewcide in the scab program to control both diseases. The DMI fungicides are effective against both diseases, as well as the rust diseases. Begin sprays at tight cluster and continue until terminal growth stops. Early season sprays (tight cluster to petal fall) are essential if mildew is to be managed successfully. The interval between sprays is generally 7 days during the stages of rapid leaf development before petal fall and 12 - 14 days during the post bloom period. During the early season, fungicide applications at lower rates on a 7-day schedule are more effective for controlling mildew than higher rates applied on a 10-day schedule.

Chemical Management:

Fungicide	% of Acres Treated	lb. a.i./acre/application
DMI's (Nova 40W)	48	0.125 - 0.188
Strobilurin	48	0.06 – 0.188
Sulfur	29	6 - 9
Topsin-M	14	0.35 - 0.44

Alternatives: As soon as first noticed (about pink stage), branches or twigs showing systemic or overwintering mildew can be pruned out to reduce secondary mildew. This is particularly beneficial in young blocks but may have no effect in years favorable for development of mildew. In niche markets, mildew resistant cultivars also can be planted to a limited extent.



Cedar-apple rust (caused by *Gymnosporangium juniperi-virginianae*): Cedar-apple rust is the most important rust of apple in eastern North America. While most Red Delicious cultivars and strains are immune, the fungus can infect leaves and fruit of most other cultivars in the mid-Atlantic region. The disease is prevalent wherever the alternate host, eastern red cedar (*Juniperus virginiana* L.) occurs. On susceptible cultivars it can cause serious crop loss, reduction of crop value, as well as almost total defoliation. Two other rusts, quince rust and hawthorn rust, can be significant problems in some areas in some years, depending upon availability of alternate hosts and environmental conditions.

Management: Fungicides that are effective against the rust diseases should be applied periodically from the pink stage of bud development through third cover to protect the emerging leaves and developing fruit. Removing cedars located within a 2-mile radius of the orchard interrupts the life cycle of the fungus and makes control with fungicides easier. Removing all cedars within 4 to 5 miles of the orchard will provide complete control. Cedar removal is not a practical option for most commercial orchardists.

Chemical Management:

Fungicide	% of Acres Treated	lb a.i./acre/application
DMI's (Nova 40W)	48	0.125 - 0.188
EBDC's	62	2.4 - 4.8
Strobilurin	48	0.06 – 0.188
Ziram	32	2.5 - 6

Alternatives: To a limited extent, some growers can plant resistant cultivars if they have a niche market.



Fire blight (caused by *Erwinia amylovora*): Fire blight is a highly destructive bacterial disease of apples and pears that kills blossoms, shoots, limbs, and, sometimes, entire trees. The disease is generally common throughout the mid-Atlantic region, although outbreaks are typically very erratic, causing severe losses in some orchards in some years and little or no significant damage in others. This erratic occurrence is attributed to differences in the availability of

overwintering inoculum, the specific requirements governing infection, variations in specific local weather conditions, and the stage of development of the cultivars available. The destructive potential and sporadic nature of fire blight, along with the fact that epidemics often develop in several different phases, make this disease difficult and costly to control. Of the apple varieties planted in the mid-Atlantic region, those that are most susceptible include 'York', 'Rome', 'Jonathan', 'Jonagold', 'Idared', 'Tydeman's Red', 'Gala', 'Fuji', 'Braeburn', 'Lodi', and 'Liberty'. 'Stayman' and 'Golden Delicious' cultivars are moderately resistant and all strains of 'Delicious' are highly resistant to fire blight, except when tissues are damaged by frost, hail or high winds.

Management: Many practices can help reduce the incidence of fire blight and may help reduce the severity of the disease when it occurs. Not all measures suggested below are necessary or even feasible in every planting, since planting systems play a large role in contributing to the level of risk of disease development. No single control method is adequate and, in regions where it is established, a conscious effort must be made to control the disease each year. Even under the most conscientious efforts, in some years losses from fire blight can be devastating.

Chemical and biological control: A copper spray applied at the 1/4-inch green tip stage may reduce the amount of inoculum on the outer surfaces of infected trees. At bloom, antibiotic sprays are highly effective against the blossom blight phase of the disease. These sprays are critical because effective early season disease control often prevents the disease from becoming established in an orchard. Predictive models, particularly Maryblyt, help to identify potential infection periods and improve the timing of antibiotic treatments, as well as avoid unnecessary treatments. Strains of the pathogen that are resistant to streptomycin are present in some orchards in the eastern U.S., and are widespread in most apple and pear regions of the western U.S. Biological control agents have provided only partial control of blossom infections, and are not widely used. More effective biological agents are required if their use is to become widespread. There are no biological controls available to prevent infections of shoots.

Removing sources of infection: Dormant pruning to remove overwintering infections helps reduce inoculum for the next season. Make cuts about 4 inches below any signs of dead bark. Remove pruned material from the orchard. Beginning about one week after petal fall, monitor the orchard to locate blighted limbs for removal. For the greatest effect on the current season's damage severity, infected limbs should be removed as soon as early symptoms are detected and before extensive necrosis develops. Where the number and distribution of strikes is too great for removal within a few days, it may be best to leave most strikes and cut out only those that threaten the main stem. On young trees, and those on dwarfing rootstocks, early strikes in the tops of the trees often provide inoculum for later infections of shoots and sprouts on lower limbs near the trunk, which may result in tree loss. Give these early strikes in the tops of trees a high priority for removal. Do not combine the practices of fire blight removal with pruning and training of young, high-density trees.

Insect control: The role of insects in the transmission of fire blight bacteria is under investigation. It is likely that insects that cause wounds (leafhoppers, plant bugs, pear

psylla) can create places for bacteria to enter the tree, and some summer infections (shoot blight) are probably facilitated by insects. Where fire blight is a problem, and until more is known about their specific role in the spread of the disease, controlling these insects at levels below their economic injury threshold is advised.

Cultural practices: Use management systems that promote early cessation of tree growth without adversely affecting tree vigor. Excessive vigor is an important component of orchard risk for fire blight. When tree growth continues past mid summer, the likelihood that late season infections will overwinter increases. Orchards should be established on well-drained soils, avoiding low, frost-prone or potentially water-logged areas, and nitrogen fertilizer should be applied based on analyses of foliage N levels.

Resistant cultivars: When establishing new orchards, consider susceptibilities of the scion and rootstock to fire blight. Although none are immune, there is considerable variation among apple cultivars (and pear cultivars) in susceptibility to fire blight. Some cultivar/rootstock combinations are so susceptible to fire blight that investments in these are extremely high risk. In the eastern U.S., Gala on M.26 is a good example. Long range plans for establishing new orchards with fire blight susceptible cultivars should include contingency plans for controlling the disease without streptomycin.

Chemical Management: Affected Acreage – Potentially 70%, although sporadic infections usually infect only limited acreage.

Bactericide	% of Acres Treated	lb a.i./acre/applicationm
Copper	19	4 - 8
Streptomycin	30	0.2





photo 2-36 - J. W. Travis

Black Rot and White Rot: Affected Acreage – Present on 100% of acreage, but with sporadic problems. Black rot is a fungal disease that can cause serious losses in apple orchards, especially in warm, humid areas. Three forms of the disease can occur: a fruit rot, a leaf spot known as frog-eye leaf spot, and a limb canker. Infected fruit become unmarketable, severe leaf spotting can result in defoliation which weakens the tree, and limb cankers can girdle and eventually kill entire branches. The fungus causing white rot is ubiquitous in nature, occurring on a wide variety of woody plants including birch, chestnut, peach, and blueberry. White rot is often referred to as Botryosphaeria rot or Bot rot and is a serious pathogen of apple fruit and wood. Fruit rot infection is most common in areas of the southeastern U.S. where losses of up to 50 percent have been reported. The canker phase of the pathogen can also cause considerable loss in many regions of the south, midwest, and northeast. Drought stress and winter injury have also been associated with an increase in infection and canker expansion.

Management: Black rot is managed by removal of inoculum sources (dead wood and mummies) and application of fungicides. Fungicide applications from silver tip through harvest may be necessary where the disease is a recurrent problem. White rot is managed by removal of inoculum sources (dead wood and mummies) and application of fungicides. Prompt removal of fire blighted twigs also helps reduce inoculum since the fungus rapidly colonizes and reproduces on dead woody tissues. Fungicide applications from bloom through harvest may be necessary where the disease is a recurrent problem. The differences in varietal susceptibility to fruit rot are small, although Cortland, Golden Delicious, Empire, and Jersey Mac may be slightly more susceptible. Irrigation during hot, dry weather may help prevent occurrence of twig and branch infections, although irrigation is not a practical alternative for most growers.

Chemical Management:

Fungicide	% of Acres Treated	lb a.i./acre/application
Captan	53	1.5 - 4
EBDC's	62	2.4 - 4.8
Strobilurin	48	0.06 – 0.188
Topsin-M	14	0.35 - 0.44
Ziram	32	2.5 - 6

Alternatives: Management practices such as pruning out dead and cankered wood, and removing

mummies helps to minimize the disease.



Bitter Rot: The bitter rot fungi are almost worldwide in distribution and cause an especially important disease in the southern areas of the U. S. Epiphytotic (outbreaks) can occur rapidly and losses can be severe, especially under prolonged warm, wet weather. Affected Acreage – All apple varieties are susceptible, but the disease is sporadic and highly dependent on the correct environmental conditions. Some West Virginia orchards have experienced 30 - 40% crop loss during certain years. Several host species can be affected. On peach and nectarine, the same fungi cause a disease known as anthracnose, and on grape they cause ripe rot. Although bitter rot can cause leaf spot and cankers, these phases of the disease are rare; therefore, the discussion below is limited to fruit infection.

Management: Fungicides, applied at appropriate intervals from petal fall through harvest, are necessary for managing the disease on susceptible cultivars.

Alternatives: Removal of mummified fruit, dead wood, and twigs killed by fire blight are important sanitation measures that can reduce the incidence and severity of the disease in some years. Removing newly infected fruit from trees during the growing season may also help reduce the rate of disease spread, but is generally not practical. Apple cultivars do not vary widely in their susceptibility to the bitter rot fungi; however, the disease is often more severe on Empire, Freedom, Golden Delicious, Fuji, Granny Smith, Nittany and Arkansas Black. The use of a calcium as a nutritional supplement may reduce the incidence and severity of bitter rot in some years, although it is not a suitable replacement for effective fungicides.

Chemical Control:

Fungicide	% of Acres Treated	lb a.i./acre/application
Captan	53	1.5 - 4
EBDC's	62	2.4 - 4.8
Strobilurin	48	0.06 – 0.188
Topsin-M	14	0.35 - 0.44
Ziram	32	2.5 - 6



Sooty blotch and Flyspeck: Sooty blotch and flyspeck are surface blemish diseases that commonly appear together on apple or pear in late summer and fall. Although these diseases may shorten the storage life of fruit due to increased water loss, they do not cause



decay, and losses are attributed to unacceptable appearance. During wet growing seasons, losses of 25 percent or more are commonly found even in orchards treated with fungicides.



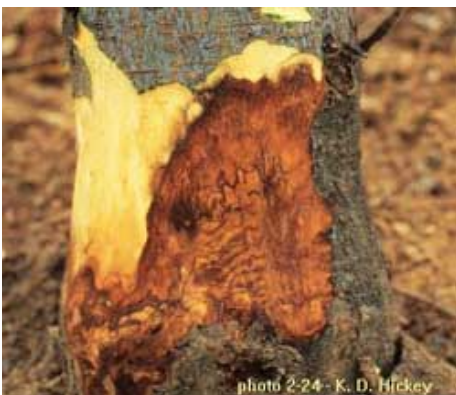
Management: The diseases are managed exclusively by fungicides.

Alternatives: The effectiveness of the fungicide program may be improved, in some years, by orchard sanitation. Removing reservoir hosts, especially brambles, from the orchard and surrounding hedgerows helps

reduce the amount of inoculum from external sources, but in wet years this practice alone is not adequate for disease control. Some cultural practices may help reduce the severity of sooty blotch and flyspeck. These include dormant and summer pruning to open up the tree canopy and thinning to separate fruit clusters. In addition to facilitating the drying of fruit after rain or dew, these practices favor better spray coverage and improve fruit quality. Both diseases are difficult to control in orchards with restricted air movement. A predictive model for sooty blotch was developed in North Carolina. The model is driven by the accumulation of wetting hours beginning 10 days after petal fall. The goal of the model is to help time the first spray for sooty blotch based on the appearance of sooty blotch symptoms.

Chemical Control:

Fungicide	% of Acres Treated	lb a.i./acre/application
Captan	53	1.5 - 4
EBDC's	62	2.4 - 4.8
Strobilurin	48	0.06 – 0.188
Topsin-M	14	0.35 - 0.44
Ziram	32	2.5 - 6



Phytophthora root, collar, and crown rot: Phytophthora root, crown, and collar rots are common and destructive diseases of fruit trees throughout the world. In eastern North America, apple, cherry, peach, and apricot trees are most commonly attacked, whereas pear and plum trees appear to be relatively resistant. True collar rot (infection of only the scion portion of the trunk near the graft union) is relatively rare in this region, although the term often is applied to diseased root and/or



crown portions of the rootstock, which are much more common. Trees declining from *Phytophthora* root and crown rots are frequently diagnosed as suffering from "wet feet" (mistakenly assumed to be root asphyxiation or "drowning"), and sometimes are confused with those suffering from winter injury.

Management: Management of *Phytophthora* root and crown rots is best accomplished using an integrated program of cultural practices and, sometimes, chemical control. Soils that are excessively slow to drain or subject to periodic waterlogging should be avoided. Marginal sites should be modified as necessary to provide the additional drainage recommended for growing tree fruit crops, e.g., install drain tiles, create diversion ditches, rip underlying pan layers, *etc.* Planting trees on ridges or berms will raise much of the crown area above the zone of significant zoospore activity and provides an important margin of safety, especially in a wet year. Where irrigation is practiced, avoid excessive rates of application and arrange drip emitters to avoid puddling around the trunk.

Tree species and rootstocks should be selected to match the soil and drainage characteristics of an orchard. However, rankings of resistance and susceptibility to *Phytophthora* root and crown rots must be recognized as generalizations only, due to the array of *Phytophthora* species that potentially can be involved. Pears are the fruit tree with the greatest resistance to these diseases, and are the most likely to remain healthy in a relatively wet site. Apple rootstocks vary widely in susceptibility, but generally are more susceptible than pears and more resistant than stone fruit rootstocks other than plums. Among apple rootstocks, seedling is relatively resistant, as are M.9, M.2, and M.4; M.7 (and M.7a), M. 26, and MM. 111 are moderately susceptible; MM.106 and MM.104 are highly susceptible. The new CG (Cornell Geneva) rootstock series has been bred to show resistance to some *Phytophthora* species under greenhouse conditions, but there is insufficient experience to determine whether this will hold under field conditions (note that MM.106 also appeared resistant in initial greenhouse trials). Among stone fruits, plums are relatively resistant, whereas the remainder are susceptible to very susceptible. Mahaleb is the most susceptible cherry rootstock, whereas Mazzard, Morello, and Colt are somewhat more resistant and would be recommended on the heavier cherry soils. Some of the newer clonal cherry rootstocks may have an additional measure of resistance, but these have not been sufficiently evaluated in the field to determine. Seedling peach and apricot rootstocks are very susceptible, although the range of suitable soils may be expanded if these fruits can be grown without other problems on plum-type rootstocks.

Preplant soil fumigation should not be relied upon to control *Phytophthora* root and crown rots, since the fumigant never completely eradicates existing inoculum from the soil and *Phytophthora* spp. are easily reintroduced. Some fungicides have activity against *Phytophthora* and a narrow range of related organisms, and can be effective when used preventively in combination with the cultural practices described above. Because *Phytophthora* disease occur sporadically, it is seldom economical to treat entire orchards on a regular preventative basis. Rather, it is best to target such applications to sections of the orchard and seasons that are most conducive to disease development (e.g., wet spots or orchard sections with previous *Phytophthora* problems, excessively wet spring and/or fall seasons). Also note that these fungicides seldom are effective in reviving trees once the crown has become infected and moderate symptoms of decline have appeared. Check current labels and recommendations for approved

materials and timings.

Chemical Management:

Fungicide	% of Acres Treated	lb a.i./acre/application
Fosetyl-al (Aliette)	< 1	2.0
Metalaxyl (Ridomil)	< 1	0.62

Fosetyl-al (Aliette), applied to less than 1% of the acres at an average rate of 2.0 lbs. a.i. per acre. It is used as a preplant treatment for nonbearing trees only. It can also be applied as a foliar spray.

Metalaxyl (Ridomil), applied to less than 1% of the acres at an average rate of 1.25 lbs. per acre. The application rate varies with the method of application and the size of the trees. Applications are made in early spring (before budbreak) and fall (after harvest).

Potential Future Disease Problems



Alternaria leaf blotch: Alternaria blotch has been a serious problem in North Carolina since the late 1980s. By 1993, growers in nine counties in southern and central Virginia reported seeing this problem, some with as much as 50 to 60 percent defoliation on 'Delicious'. Although leaf blotch severity may vary from year to year, there are strong indications that it has spread to new areas in North Carolina and Virginia, and could become a problem in more northern areas of the mid-Atlantic region. Disease severity is aggravated by mite infestation. Maintaining good mite management is an important factor in preventing severe disease development. No fungicides currently are registered for the control of this potentially devastating disease.

Critical Uses and Needs

A broad spectrum of fungicides with differing modes of action are required for effective apple disease management and to prevent the emergence of fungicide-resistant disease organisms. With the diversity of disease-causing organisms that must be effectively managed to produce a profitable crop, and the varying effectiveness of the available fungicides against individual organisms, loss of any class of fungicide materials listed below would seriously threaten the stability of the apple industry.

Benzimidazoles:

Thiophanate-methyl (Topsin-M) is formulated as a 70WP and is available in water-soluble bags. Thiophanate-methyl (Topsin-M) belongs to the same family of chemical compounds as Benlate (benomyl). Topsin-M is effective for scab, powdery mildew, black rot, sooty blotch, and flyspeck control. Thiophanate-methyl is part of the same family of fungicides as benomyl. Consequently, extended use of Topsin-M without other non-related fungicides can result in the development of resistant plant-pathogenic fungi. Furthermore, since these two fungicides are related, fungi that become resistant to one of these compounds are also cross-resistant to the other compound. Since Benlate is no longer registered, thiophanate-methyl is a logical replacement for previous Benlate uses. Generally, those disease-causing fungi that are resistant to benomyl (Benlate) also are resistant to Topsin-M.

Strains of apple scab resistant to thiophanate-methyl and benomyl have been detected in many counties in Virginia and West Virginia. Thiophanate-methyl appears to have no compatibility problems with those pesticides that commonly are used in apple orchards. However, do not tank-mix with copper-containing chemicals or with highly alkaline pesticides such as Bordeaux mixture or lime sulfur.

Thiabendazole (Mertect 340-F) is benzimidazole-type fungicide registered for postharvest treatment of apples and pears for control of *Penicillium* blue mold and several other rots. Use a suspension of 16 fl oz per 100 gal water for application as a dip, flood or spray to harvested fruit. Apples may be treated before and after storage; pears may be treated only once. Do not treat longer than 3 minutes. Because thiabendazole is a benzimidazole-type fungicide, it will not be effective on strains of fungi resistant to Benlate or Topsin-M. To prevent infection of fruit in the dip tank by strains of resistant rot fungi, it is suggested that captan be included in the postharvest treatment.

DMI's:

Fenarimol (Rubigan 1E), a sterol-inhibiting fungicide, is registered on apples for control of scab, powdery mildew and rusts. The Rubigan label offers three use patterns on apples: regular schedule, extended regular schedule, and post-infection schedule. Research experience has shown that the most reliable program is the extended regular schedule which combines Rubigan's strong post-infection scab activity with the more residual protectant action of fungicides such as mancozeb, metiram, captan, ziram or dodine. Typically, a half rate of the protectant fungicide is tank-mixed with 8 - 9 fl oz of Rubigan per acre. The 9 fl oz/A rate should be used post-infection for scab and under heavy rust pressure. The 8 fl oz/A rate should suffice under light to moderate scab pressure where rusts are not a problem. Up to 12 fl oz/A may be applied. Where rust pressure is heavy, use a companion protectant fungicide which is effective for rust control. When determining rates for small trees based on tree-row volume, the Rubigan rate should not be reduced to less than 6 fl oz/A plus a protectant fungicide. On a post-infection schedule, 9 - 12 fl oz of Rubigan/A must be applied within 96 hr of an infection period. When used on a post-infection schedule, reddish or yellowish, partially inhibited scab lesions may appear and a follow-up application should be made 7 days after the first post-infection application (totaling two complete applications within 11 days after the infection period) to inactivate such lesions which would appear 10 to 20 days after the infection period. When spraying on an alternate middle schedule, two half-sprays should be applied as soon as possible after the infection period, followed by two more half-sprays

starting 7 days after the first half-spray following the infection period.

As with most sterol-inhibiting fungicides, Rubigan is not effective against all moldy core fungi and summer diseases and is less effective for scab control on fruit than on foliage. Also, there is evidence that the apple scab fungus can develop cross resistance to all sterol-inhibiting fungicides (Rubigan, Nova, Procure) when used alone for scab control. To avoid these potential weaknesses and to lengthen the effective life of this class of fungicides, it is recommended that the sterol-inhibiting fungicides be used in conjunction with protectant fungicides (captan, mancozeb, metiram, ziram, dodine, etc.), preferably as a tank-mix combination as permitted by the label.

Do not apply Rubigan closer than 30 days to harvest or use more than 84 fl oz per acre per season on apples and pears. Rubigan may be used on cherries up to the day of harvest at a maximum of 6 fl oz/A per application and 26 fl oz/A per season prior to harvest.

Myclobutanil (Nova 40W) is a sterol-inhibiting fungicide which is highly effective for control of apple scab, powdery mildew, cedar rust, and quince rust. It can be used as a preventive or 96-hour post-infection treatment on scab. The dilute rate selection of 1.25 to 2.5 oz per 100 gal, depending upon the target disease and time of treatment, is concentrated per acre according to tree size as indicated on the label. When used on a post-infection schedule, reddish or yellowish, partially inhibited scab lesions may appear and a follow-up application should be made 7 days after the first post-infection application (totaling two complete applications within 11 days after the infection period) to inactivate such lesions which would appear 10 to 20 days after the infection period. When spraying on an alternate middle schedule, two half-sprays should be applied as soon as possible after the infection period, followed by two more half-sprays starting 7 days after the first half-spray following the infection period.

As with most sterol-inhibiting fungicides, Nova is not effective against all moldy core fungi and summer diseases and is less effective for scab control on fruit than on foliage. Also, there is evidence that the apple scab fungus can develop cross resistance to all sterol-inhibiting fungicides (Rubigan, Nova, Procure) when used alone for scab control. To avoid these potential weaknesses and to lengthen the effective life of this class of fungicides, it is recommended that the sterol-inhibiting fungicides be used in conjunction with protectant fungicides (captan, mancozeb, metiram, ziram, thiram, dodine, etc.), preferably as a tank-mix combination as permitted by the label.

Nova is sold in water-soluble PVA bags. Some precautions should be taken to assure that the material is properly suspended in the spray tank. The bag should be dissolved and the fungicide fully-suspended before adding other spray materials to the tank. This is particularly true with spray oils and Solubor (and other materials releasing boron) because these materials cause a reaction which prevents the bag from dissolving. Once in suspension, Nova is compatible with most common spray materials except basic copper-containing fungicides. Nova is not fully compatible with Ambush 2E and requires strong spray tank agitation to keep it in suspension.

Do not apply Nova to apples within 14 days of harvest and do not apply more than 5 lb per acre per

season. Do not graze livestock in treated areas or feed cover crops grown in treated areas to livestock.

Triadimefon (Bayleton) is a sterol-inhibiting fungicide registered for the control of cedar-apple rust and powdery mildew on apples. Test data in northern Virginia indicate that Bayleton is also effective for quince rust control. It is formulated as a 50DF to be used at the rate of 0.5 - 2.0 oz per 100 gal dilute or 2-8 oz per acre concentrate. Bayleton may be applied up to the day of harvest but no more than 24 oz Bayleton 50DF may be applied per acre per season. The following tank mix is not compatible: Bayleton + Cyprex 65W + Guthion 2S. Bayleton is not registered on stone fruits.

Triflumizole (Procure 50WS) is recently registered sterol-inhibiting fungicide. Procure is registered for control of powdery mildew and scab on pears. Formulated use rates on both apples and pears are 2-4 oz per 100 gal dilute and 8-16 oz per acre. Restrictions on both apples and pears are a limit of 4 lb per acre per year, a 14 day pre-harvest interval and a 24 hour restricted entry interval.

EBDC's and Related Fungicides:

Ferbam (Carbamate) is formulated as a 76WDG powder and used at rates of 0.6 to 2.0 lb per 100 gal. Ferbam may be used on processing fruit to control most apple diseases because finish is not as critical. It has tended to roughen the finish of Golden Delicious, and has been an important factor in the development of enlarged lenticels on Stayman and Delicious varieties. York and Rome usually finish well with ferbam. Fruit coloring may be slightly delayed when ferbam is used.

Mancozeb (Dithane Rainshield NT, 75DF, Manzate 75DF, Penncozeb 80W, and/or various wettable and flowable formulations) is a coordinated product of zinc ion and manganese ethylene bisdithiocarbamate. It differs from maneb, or maneb plus zinc ion products. It is formulated as an 80W powder, flowable or 75DF dry flowable and when used at the rate of 1 lb per 100 gal (or equivalent rate of another formulation), it provides supplemental control against a broad range of apple diseases including: apple scab, apple rust, black rot, bitter rot, sooty blotch, and fly speck. Note that EBDC labels now permit the use of mancozeb and metiram (Polyram) interchangeably on the same crop, but the total amount applied per acre per year is now governed by the most restrictive label (usually a 75DF formulation).

Metiram (Polyram), an EBDC fungicide, is formulated as an 80DF powder and is registered for the control of apple scab, cedar apply rust, fly speck, sooty blotch, and as an aid in reduction of European red mite. It has been effective in reducing the severity of leaf blotch defoliation on Golden Delicious. Note that EBDC labels now permit the use of mancozeb and metiram (Polyram) interchangeably on the same crop, but the total amount applied per acre per year is now governed by the most restrictive label (usually a 75DF formulation).

Thiram is formulated as a 65W powder and used at the rate of 0.6 to 2.0 lb per 100 gal of spray. Thiram is a dithiocarbamate chemical, as are ferbam and ziram. It is frequently used in place of ferbam because it is light colored and generally less injurious to the finish of sensitive varieties, including Golden

Delicious. Thiram combines readily with dormant oil sprays, while ferbam may mix poorly. Thiram will control rust infections, but is less effective than ferbam. It is less effective against apple scab than captan and other dithiocarbamate fungicides.

Ziram: Ziram is a dithiocarbamate fungicide that was recently re-registered for use on the following tree fruit crops in the Eastern U. S.: apples, pears, peaches, nectarines and cherries. Ziram is a zinc salt derivative of dithiocarbamic acid, the precursor to a wide variety of organic sulfur fungicides, such as the EBDC's. On apple, it can be applied from pre-bloom through cover sprays for use in controlling scab, both cedar-apple and quince rusts, sooty blotch, flyspeck, bitter rot, and necrotic leaf blotch. Diseases for which ziram is labeled include scab, quince and cedar-apple rust, sooty blotch, fly speck, bitter rot and necrotic leaf blotch on apples; scab and Fabrea leaf spot on pears, leaf curl on peach, brown rot on cherries, peaches and nectarines, scab on peach and nectarine, and cherry leaf spot. On apples and pears, the registered rates for the 76DF formulation are 6-8 lb per acre per application and a limit of 56 lb per acre per year. Rates of 4.5-8 lb per acre per application and 72 lb per acre per year are permitted on peaches and nectarines. On cherries, the use rate 5-8 lb per acre with a maximum of 40 lb per acre per year. On all Eastern U. S. tree fruit crops, the pre-harvest interval is 14 days. Ziram dust may cause irreversible eye damage and irritation of nasal passages, throat and skin. To avoid exposure, loader/applicators should be properly protected and use low-dust DF, WDG or flowable formulations.

Strobilurin Fungicides:

Flint 50WG (trifloxystrobin) is a strobilurin fungicide registered for use on apple, pear, crabapple, loquat, mayhaw, and quince. Like other strobilurin fungicides, Flint exhibits broad-spectrum activity against a variety of fungal diseases. Flint provides excellent control of scab, sooty blotch, and flyspeck; good control of powdery mildew; and fair control or suppression of white rot and bitter rot when used at higher rates. The level of black rot control has yet to be determined; a limited number of studies indicate poor control of rust. Preventative applications of Flint should be applied at 7-14 day intervals, depending on target pathogen and level of disease pressure. Excellent control of scab, sooty blotch, and flyspeck can be achieved at 2 oz / A, while a 2.5 oz / A rate will be needed for cultivars that are very susceptible to powdery mildew. A higher 3.0 oz / A rate is needed for bitter and white rot suppression. Up to 100 hours curative capability is possible when applying Flint for post-infection scab control. In this case, the higher 2.5 oz / A rate, followed by a second application at 7-10 days later is needed.

For best resistance management, sprays should be alternated with another fungicide having a different chemistry, such as Nova, Rubigan, Procure, or Vanguard, or Flint should be used in no more than two consecutive sprays. For summer disease control, a mixture of Flint at 1.5 oz / A plus Captan 50W at 2 lb. / A provides good control.

Sovran 50WG (kresoxim-methyl) is a strobilurin fungicide registered for use on apple, pear, quince, crabapple, loquat, mayhaw, and oriental pear. This broad-spectrum fungicide provides excellent control of scab, sooty blotch, and flyspeck; good control of powdery mildew, white rot, and black rot / frog-eye leaf spot; fair control of cedar apple rust; and no efficacy against bitter rot. In addition, limited tests have

shown good control of brooks spot. Labeled rates for Sovran are 4.0 to 6.4 oz per acre at 10-14 day intervals. Results of efficacy studies in NJ indicated excellent control of sooty blotch and flyspeck at the lower 4.0 oz/A rate and 100 gpa volume. For scab control, Sovran also exhibits up to 96 hours of curative capability. However, when used for post-infection control, the higher rate should be applied, followed by a second application 10-days later. Antisporulant activity also occurs against scab and powdery mildews.

For resistance management, limit the number of consecutive sprays of Sovran to three before switching to a fungicide of different chemistry; or use an alternate spray strategy. Thus, Sovran makes an excellent partner in spray programs that have relied heavily on the sterol-inhibiting fungicides Nova, Rubigan, or Procure. Furthermore, Sovran provides an additional management tool for summer diseases.

Miscellaneous Fungicides:

Captan 50W or 80W formulations are used at 6.0-8.0 lb/A of Captan 50W or 3.75-5.0 lb/A of Captan 80W, for control of diseases on apple; other formulations should be used according to label direction. On apples Captan has proven effective in the control of apple scab, black rot, Brooks spot, Botryosphaeria rot, blotch, bitter rot, Botrytis blossom infection, fly speck, and sooty blotch. Captan's residual life is relatively short, consequently, sooty blotch, fly speck, and fruit rot control may not be satisfactory where sprays are discontinued more than 3 weeks prior to harvest. The higher indicated rates are for severe summer disease pressure.

Captan may produce frog-eye-like spotting of the foliage of Delicious, Stayman, and Winesap early in the season. The small spots do not enlarge and are no cause for alarm. The inclusion of sulfur in the spray mixture may increase this type of injury.

Captan should not be used with lime or other alkaline materials. Do not use it with oil or within four days of an oil spray. Do not use in combination with EC formulations of parathion. Captan should be used with caution in bloom sprays, especially on varieties which are hard to pollinate (e.g. Red Delicious). Captan has been shown to severely reduce pollen viability for 24 - 48 hours after application.

Although new Captan labels permit application to apples up to the day of harvest, Captan has a 4-day re-entry interval which makes pre-harvest application more restrictive. A label exception is made for the last 48 hours of the re-entry interval during which workers may enter the treated area to perform hand labor or other tasks involving contact with anything that has been treated, without time limit, if they wear all of the following: coveralls, waterproof gloves, shoes and socks, and protective eye wear.

Coppers: Fixed copper is a term that refers to several relatively insoluble forms of copper which are safer and more conveniently prepared than Bordeaux mixture. The addition of spray lime is usually necessary for applications on fruit crops, depending upon timing (not required for Tenn-Cop 5E). Some examples include Kocide, Tenn-Cop, Champ, and Nu-Cop. Copper fungicides are effective against many diseases; however they must be limited to only certain sprays on specific fruit crops because of the

potential for injury to fruit and foliage. Fixed coppers are especially useful on apples and pears as an early season spray (dormant to 2 inch green) to reduce overwintering fire blight inoculum. Fixed copper compounds are available under many trade names although they can be grouped into several general categories: (Kocide 101, 50% copper, Kocide DF, 40% copper), and tribasic copper sulfate (53% or 26% copper). Dust preparations contain from 5% to 7% metallic copper.

Some pesticide labels warn about incompatibility with copper materials due to their alkalinity. Copper materials also have potential for phytotoxicity to leaves and fruit. Phytotoxic potential is generally increased when copper-containing spray mixtures are acidified.

Bordeaux mixture is a mixture in water of copper sulfate and hydrated spray lime and is usually used as a dormant application on apples and pears to reduce overwintering fire blight inoculum, on peaches for leaf curl, and on cherries in postharvest sprays for leaf spot. The recommended amount of each ingredient varies according to use and is designated by a three number formula, e.g. Bordeaux 8-8-100. The numbers represent the amounts of copper sulfate in pounds, spray lime in pounds, and water in gallons, respectively. Bordeaux mixture is generally unsafe for use on fruit crops after the 1/2-inch green stage. Pears seem to tolerate copper better than apples, and it can be used during bloom for fire blight if disease pressure is not severe. It also has some activity against collar rot. Bordeaux mixture has some compatibility problems, therefore, when used in combination with other materials, the labels of the pesticides involved should be examined thoroughly.

Dodine (Syllit) is formulated as a 65W powder and is used from 0.4 to 0.75 lb per 100 gal dilute. It has been outstanding in its ability to control apple scab; however, it is not effective for control of rust infections, fruit rots, or powdery mildew. In some areas under heavy usage for scab control over a period of years, tolerance to dodine has developed in the apple scab fungus.

Dodine is not compatible with lime and other alkaline products. Physical incompatibilities with some pesticides have occurred when the combination has been mixed in hard water. Dodine has "battered out" in some spray waters when mixed with oil. Be sure that Dodine is thoroughly suspended in the tank before adding oil or other potentially incompatible materials. Dodine-oil mixtures are not compatible with wettable powder malathion, carbaryl, ferbam and sulfurs.

Dodine may russet yellow varieties, particularly Golden Delicious. It has sometimes caused fruit spotting of Stayman and some other red varieties, so excessive rates of usage should be avoided. Resistance of the apple scab fungus to dodine has been shown in some areas of the eastern U.S.A. including some orchards in Clarke and Warren Counties, Virginia; therefore, dodine should be used with caution under heavy scab conditions.

Fosetyl-Al (Aliette 80WDG) is registered for control of *Phytophthora* collar rot on bearing and non-bearing apple trees. Dilute rate per 100 gal is 2.5-5.0 lb. Begin applications at tight cluster. Use 3-4 foliar sprays during the season at 60 day intervals at the 5.0 lb per 100 gal rate or 6-8 applications at 2.5 lb per 100 gal on a 30 day interval. Do not apply more than 5.0 lb of Aliette per acre per application and

no more than 20.0 lb per acre per year. Alliette can not be applied within 14 days of harvest. Can be applied to the tree after harvest but do not apply within 2-3 weeks of leaf senescence.

Aliette is registered in West Virginia as a pre-plant tree root dip for control of Phytophthora root and collar rot at the rate of 3.0 lb per 100 gal. Mix the appropriate amount in the desired volume of water and dip the entire root system for 30-60 minutes prior to planting in the field. The Aliette label indicates that it can be used for fire blight control, but experience in the mid-Atlantic region and elsewhere indicates that it is not as effective as streptomycin and may give less than adequate control.

Metalaxyl (Ridomil 2E) is registered as an aid in control of Phytophthora crown rot on bearing and non-bearing apple trees. Applications should be made before symptoms appear, especially in orchards favorable for disease development. Metalaxyl should not be expected to revitalize trees showing moderate to severe crown rot symptoms. To apply, Ridomil 2E is diluted at the rate of 1 qt per 100 gal and poured around the trunk of each tree. The amount of diluted mix applied per tree is based on the trunk diameter as follows: diameter less 1 inch, 1 qt; 1-3 inch diameter, 2 qt; 3-5 inch diameter, 3 qts; greater than 5 inch diameter, 4 qt. Make one application at the time of planting or in the spring before growth starts. Make another application in the fall after harvest. Ridomil is highly specific and will not control other agents causing similar tree decline symptoms such as other root rots, graft union necrosis (Tomato Ring Spot Virus) and vole damage.

Ridomil Gold EC is a more highly refined, more biologically active, 46.6% formulation of metalaxyl isomer. Because of its increased biological activity and higher percent formulation the diluted use rate is lower: 0.5 pt/100 gal. The amount of diluted fungicide to apply as a drench is the same as listed above for Ridomil 2E. The restricted entry interval for the recently registered Ridomil Gold EC is 48 hours.

Oxythioquinox (Morestan 25W) is registered as a prebloom miticide and mildewcide on apples. Morestan provides protective powdery mildew control when applied at the registered rate of 0.5-1.0 lbs per 100 gal dilute during the tight cluster to pink stage. Do not apply after bloom appears. Injury of foliage may occur when applied under slow drying conditions. Do not apply in combination with oil or spreader-stickers or with EC pesticide formulations, or within 10 days of an oil spray.

Streptomycin (Agri-mycin 17) is an antibiotic widely used against fire blight of apples and pears, is formulated as streptomycin sulfate 17W. It is commonly used at 60 to 100 ppm in blossom sprays and at 100 ppm in post-blossom sprays. The effectiveness of streptomycin can be increased by including the adjuvant Regulaid at the rate of 1 pt per 100 gal of tank mix; however, the increased uptake of streptomycin with Regulaid is more likely to result in streptomycin injury.

Sulfur: Wettable sulfurs are finely divided, elemental sulfur particles with a wetting agent added so that the sulfur can be mixed with water and remain in suspension while being applied. The most readily available forms of sulfur are dry, wettable powder (95% sulfur) and fused bentonite sulfur (30% to 81% sulfur depending upon the brand). Sulfur dusts are available and generally are more finely divided and therefore more adherent and effective than the coarser wettable powders. Flowable sulfur products are

available and their advantage over wettable sulfurs include being effective at lower rates and having better retention properties. Generally, sulfur is used in apple programs for the control of apple scab and powdery mildew. For scab, dry wettable sulfur (95WP) is used at a rate of 5 lbs per 100 gallons in early-season sprays in a protective program. It can be used during bloom without reducing fruit set significantly, however fruit russetting and yield reduction may result if it is used under high temperature conditions. However, many orchardists growing fruit for the processing market routinely use sulfur in post-bloom sprays without adverse economic effects. Sulfur is also the cornerstone for early-season and summer disease control in organic orchards. Sulfur is very effective against powdery mildew and can be combined at reduced rates (3 lbs/100 gallons) with most pesticides.

Do not use any sulfur products within two weeks before or after an oil spray. Copper, sulfur, and liquid lime-sulfur should be used by growers who intend to produce fruit for the organic market. Growers are cautioned to be aware of the disadvantages and limitations of these materials, compared to synthetic fungicides: sulfur is incompatible with oil, it has poor residual activity, it acidifies soil when used in seasonal programs, and it is phytotoxic to fruit and foliage when used in hot weather; liquid lime-sulfur is extremely caustic and may be dangerous to apply, it may also be phytotoxic to foliage and it may reduce leaf size and yield, several consecutive applications may need to be made to effectively eradicate scab lesions; copper sprays have better residual activity than sulfur sprays and some coppers can be used to tight cluster if surface russetting of the fruit is not a problem. Only a few copper formulations are registered for application after petal fall. Because of these problems, organic growers are best served by planting many of the excellent scab-immune cultivars that are available commercially.

Vanguard WG (cyprodinil) represents a new class of fungicides, the anilinopyrimidines, for use on both stone and pome fruits. Cyprodinil has low toxicity and has been classified by the EPA as a reduced risk compound. On apple, Vanguard provides 48 hours post-infection capability for scab control, with six days residue for forward, preventative activity. It also exhibits good suppression of apple powdery mildew. Cyprodinil shows no cross-resistance to other classes of fungicides due to its novel chemistry. However, since it controls pathogenic fungi by attacking a specific site, the risk of resistance development may be high. Thus, users should either limit the number of applications or tank-mix / alternate with another fungicide.

Table 2. Seasonal activity of apple diseases in West Virginia

Growth Stage	Scab	Powdery Mildew	Cedar-apple Rust	Fire Blight	Black Rot	Sooty Blotch and Flyspeck	Bitter and White Rots
Green tip	+						
Tight cluster	+	+ S	+				
Pink	+	+ S	+		+		

Bloom	+ S \$	+ S \$	+	+	+ S		
Petal fall	S \$	+ S \$	+ S	+ S	+ S		
First cover	S \$	S \$	+ S	+ S \$	+ S		
Second cover	S \$	S \$	+ S	S \$	+ S	+	+
Third cover	S \$	S \$	S	S \$	S	+	+
Fourth cover	S \$	S \$	S	S \$	S \$	+	+ S
Fifth cover	S \$	S \$	S	S	S \$	+ S	+ S \$
Sixth cover	S \$	S \$	S	S	S \$	+ S	+ S \$
Seventh cover	S \$	S \$	S	S	S \$	S \$	+ S \$
Eighth cover	S \$	S \$	S	S	S \$	S \$	S \$

Note: + = initial infections possible; S = observable symptoms; \$ = secondary infection. Data for development of diseases may vary more than a month from year to year and by location in West Virginia.

Vertebrates

Rodents

Meadow and pine voles can cause significant tree losses by girdling the trunk and roots of apple trees. This damage usually occurs during the late fall, winter, or early spring, when more desirable ground cover becomes dormant or frozen. Rodenticides, such as zinc phosphide, chlorophacinone and diphacinone are used by most growers as part of an IPM program to manage vole populations.

Contacts

Profile Prepared By:

Henry W. Hogmire

Extension Specialist - Entomology

Alan R. Biggs

Extension Specialist - Plant Pathology

Kearneysville Tree Fruit Research and Education Center

P. O. Box 609

Kearneysville, WV 25430-0609

Phone: 304-876-6353

Fax: 304-876-6034

E-mail: hhogmire@wvu.edu; abiggs2@wvu.edu

Acknowledgments:

Support for updating this crop profile on apples was provided through the Northeast Pest Management Center grant with cooperative efforts of the West Virginia Liaison Representative office. For information contact:

John F. Baniecki, Ph.D.

West Virginia Liaison Representative

414 Brooks Hall, West Virginia University, Morgantown, WV 26506

Ph.#(304)293-3911

Fax.(304)293-2872

e-mail: jbanieck@wvu.edu

M. Essam Dabaan, Ph.D.

Program Research Assistant

West Virginia University

Special appreciation is expressed to:

Rakesh Chandran, Ph.D.

Weed Specialist, IPM Coordinator

West Virginia University

References

1. West Virginia Agricultural Statistics Service. 2001. Bulletin No. 32. 56 pp.
2. West Virginia Agricultural Statistics Service. 1994. West Virginia Fruit Tree Survey. 27 pp.
3. Virginia, West Virginia and Maryland Cooperative Extension. 2002. Spray Bulletin for Commercial Tree Fruit Growers. Publication No. 456-419. 136 pp.
4. Baniecki, J. F. and M. P. Culik. 1995. Usage of newer pesticides by apple, alfalfa, and tobacco growers. 37 pp.