

# Crop Profile for Apples in Delaware

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## Production Facts

- In 1996 (the last year that USDA/NASS production figures were published for Delaware apples), fifteen million pounds of apples were produced in the state for a value of \$2,770,000 (1).
- New Jersey reports that for mature bearing trees, it costs just over \$3,157 per acre per year to produce apples. Today 60-70% of the fruit is harvested for fresh market (2).

## Production Regions

Apple production in Delaware is in Sussex County.

## Cultural Practices (3)

In the early part of this century, Delaware was a major apple-producing state. By 1996, fewer than five commercial enterprises were in operation. The major varieties grown in 1996 were Red Delicious, Golden Delicious, Rome Beauty, Winesap, Jonathan, and York. Growers also produced other varieties like Granny Smith, Molly's Delicious, and Grimes Golden. Most apples are self-unfruitful. To get good fruit, at least two different varieties must be planted. Golden Delicious, Grimes Golden, Jonathan, and Winter Banana are excellent pollen producers. The pollen of Winesap, Spigold, and Mutsu is poor. Pollination will occur only if the trees bloom at the same time. Fruit trees need to be planted in full sun and well-drained soil. Apples normally bloom in late April to mid-May in Delaware. Planting distance between trees will depend on type selected. Standards are planted at least 35 feet apart, semidwarfs 20 and dwarfs 10 to 15 feet. Dwarf trees must be staked or trellised because of their small root systems. Standard trees take longer than semidwarfs or dwarfs to bear fruit.

There are over 6,000 named apple varieties, and many of them are not suited to Delaware's climate. The following is a list of varieties to consider: Redfree, Prima, Liberty, and Freedom are resistant to some diseases. Spartan, Jonathan, Red Delicious, Jonagold, Empire, Golden Delicious, Idared, Spigold, and Mutsu are popular varieties. Stayman, Winesap, or Black Twig are good keepers.

The maximum rate of fertilizer is 2.5 lbs per tree; pH should be maintained at 6.0 to 6.8. Enough fertilizer is being applied if there is a foot of new growth and good fruit is being produced. If new growth measures more than this, then too much nitrogen is being applied. Some apples, like Red Delicious, need a special nutrient spray of boron (1 tbs of borax per gal) at full bloom and 7 days later to prevent a cork spot.

Apple trees will often set more fruit than they can support. The fruit should be thinned so there are 6 to 10 inches between them. This needs to be done right after the undeveloped fruit drops off (June drop). Doing this every year will prevent limb breakage, increase fruit size, and encourage fruiting. Bees are necessary to carry the pollen from one blossom to another. Insecticides can not be sprayed during bloom.

#### Worker Activities & Timing (Adapted from Crop Profile for Apple in New Jersey [3])

A number of worker activities occur throughout the year that may affect application timing, as well as the specific pesticides used. Manual pruning is done during the dormant season, usually from late November through the middle of February. No pesticides are applied during that time. Although hand thinning can be done at any time after June, because of labor costs it is rarely a commercial practice. Therefore, fruit thinning is usually done with plant growth regulators through normal spraying practices in late May. Herbicides are applied in mid April to early May, but may be spot applied with a hand or backpack sprayer during June or July, depending on the weed species being controlled. Mechanical cultivation may be rarely carried out 2 to 3 times a season during early May through June. Mechanical and hand cultivation is more common in blocks of newly planted non-bearing trees that are not yet under a complete spray program. Well-managed orchards usually have grass or mixed vegetation aisles that are mowed at 10 day to 2 week intervals throughout the growing season. Harvesting is done by hand, usually starting in mid August for early cultivars, and continuing through early October for late cultivars. The latest insecticide applications stop by mid September, with some fungicide use continuing until 2 to 3 weeks prior to picking.

Chemical Controls. Many pesticide recommendations in this Crop Profile were taken from Cornell University Pest Management Guidelines, Table 33. Pesticide Spray Table – Apples: <http://ipmguidelines.org/TreeFruits/content/CH11/default2.asp>

## **Insect Pests**

Integrated Pest Management (IPM) programs in Delaware apples focus on using multiple control strategies for insect pests, while maximizing biological control of European red mites and other pests when possible. Materials that are toxic to beneficial arthropods are not used, or rates are reduced if needed. This has resulted in minimal use of Sevin and Lannate, which are toxic to mite predators, except in those cases where resistance has occurred to OPs. Synthetic pyrethroid use has also been minimized, since pyrethroids are well known for their ability to kill beneficial insects and mites, thus flaring mite populations. Substituting pyrethroids for OP materials would flair several insect populations, such as San Jose scale, wooly apple aphids, and mites. This would lead to an overall increase in insecticide and miticide use. IPM practices also utilize various trapping and pest monitoring methods, use of economic threshold and action levels, environmental and pest modeling to predict pest occurrences and spray timing, use of reduced pesticide rates where appropriate, and alternate row (half sprays) where appropriate.

## Aphid Species

**Biology and Life History :** The most common aphid species encountered in Delaware apple orchards include the Rosy apple aphid (RAA), *Dysaphis plantaginea* (Passerini); Apple aphid (AA), *Aphis pomi* DeGeer; and the Woolly apple aphid (WAA), *Eriosoma lanigerum* (Hausmann). All species occur annually and overwinter as eggs on trees (except WAA). RAA is the most important aphid species mainly occurring during the prebloom period with the majority of the egg hatch occurring during the green-tip period. The other aphid species are later season pests.

**Damage:** RAA causes both indirect and direct fruit damage in the form of reduced size, deformed fruit, and fruit drop. The other species can cause reduced plant vigor at high populations, or leave deposits and cause sooty mold on the fruit. In most seasons, 100% of the acreage is affected by aphid damage.

**Decision Making:** Treatments for RAA are usually applied at the 1/2 inch to tight cluster bud stage. The treatment threshold for RAA is 1 colony per tree. The treatment threshold for AA is 50% of terminals infested. WAA is rare and no treatment thresholds are available.

## Controls

**Biological:** Biological control AA in the form of various parasitic wasps, lady bird beetles, syrphid flies, and lacewings does occur, but is only significant when aphid populations reach high levels. Insecticides must be used for economical control.

**Cultural:** The removal of lush water sprouts and minimal use of nitrogen fertilizers helps to minimize AA populations.

**Chemical:** Prebloom insecticides target newly emerged aphids, while later season applications target established populations.

- Dormant Oil (60-70 sec.oil) - Applied during the dormant to delay dormant stages at a rate of 3-6 gallons per acre. Generally 1-2 applications needed. Provides good RAA control, applied to 100% of the acreage.
- Lorsban 4EC or 75WG or 50WS (chlorpyrifos)- Applied at the delayed dormant to tight cluster stage at a rate of 1.5 to 2 pt/acre. Only one application. Provides good RAA control, applied to 75% of the acreage.
- Supracide 25WP or Supracide 2EC (methidathion) 1-2lb/100 gal.
- Actara 25WDG (thiomethoxam)
- Assail 30SG (acetamiprid)
- Esteem 35 WP (2-(1-Methyl-2-(4-phenoxyphenoxy)ethoxy)pyridine)
- Lannate 90SP (methomyl) - Applied as a cover spray when economic levels of AA are present at a rate of 0.5 - 1 lb per acre. Up to 4 applications can be applied in-season. Provides good AA control; applied to 20% of the acreage.
- Proaxis 0.5CS (gammacyhalothrin)

- Provado 1.6F (imidacloprid) - Applied as a petal fall and cover spray at a rate of 6 - 8 oz per acre. Generally, 1-3 applications may be needed. Provides good RAA and AA control; applied on 30% of the acreage.
- Thionex 50WP or 3EC (endosulfan)
- Vydate 2L (oxamyl) - Applied as a delayed dormant spray for aphid management at a rate of 3 to 4 pts per acre. Good aphicide; applied on 50% of the acreage.
- Warrior 1CS (lambdacyhalothrin)

### **European red mite (ERM), *Panonychus ulmi* (Koch)**

**Biology and Life History:** The ERM overwinters on the tree in the egg stage, hatches around petal fall, and can increase rapidly in hot weather when injury is most severe, especially during periods of drought. There are differences in varietal susceptibility, with Red Delicious and Staymen being the most sensitive to injury.

**Damage:** ERM is an indirect foliage feeder, and an annual pest of apples grown in Delaware. It is often difficult to control since populations can easily become tolerant to miticides. Populations can reduce fruit size and color, and reduce the fruit set for the following season. Late season populations can result in eggs being deposited on the fruit, which downgrade fresh market value. In most years, 75-85% of the acreage has mite damage.

**Decision Making:** Treatment thresholds for ERM vary throughout the season. Treatments are suggested when ERM populations reach the following levels per leaf: May-early June- 2; Late June-mid July- 5; mid-late July- 7.5; late July-mid-Aug- 10; and late August until harvest- 20 or more.

### **Controls**

**Biological:** There are a number of naturally occurring predators, which can control ERM populations either alone or in combination with low rates of miticides. The most common predators are the small black ladybeetle, *Stethorus punctum* (Leconte), and the predatory mite, *Amblyseius fallacis* (Garman). Minimal rates of acaricides are often used in combination with predators in order to properly 'balance' the predator:prey ratio and achieve full season biological control.

**Cultural:** Management of ground covers to preserve food sources for beneficial insects of ERM can help to conserve beneficials. However, one of the primary food sources for beneficials is the two-spotted spider mite which can also be a pest of apples. It is often difficult to maintain the correct balance.

### **Chemical:**

- Acramite 50WSB (bifenazate) - Only one cover spray is used at a rate of 12-16 oz per acre. This material is a very effective miticide but has only recently be labeled for apples; applied on 5% of the acreage.

- Agrimek .15EC (abamectin) - Applied at petal fall and first cover at a rate of 10 - 20 oz per acre. Agrimek penetrates quickly into leaves to form a reservoir of active material. It provides good mite control but must be applied with a minimum 1% or 1 gallon of oil per acre before leaves harden-off; applied to 80% of the acreage.
- Apollo 4SC (clofentezine) - Generally, one application is used; however may apply at the delayed dormant or petal fall stage at a rate of 4 - 8 oz per acre. It is primarily an ovicide but also controls young motile stages. Best results are achieved in spring when red mite eggs are hatching and before adults are present; applied to 50% of the acreage.
- Dormant Oil (60-70 sec.oil) - One - two applications are made at the dormant to delayed dormant stages at a rate of 3 - 6 gal per acre. Used to smother ERM eggs and it an important part of a total mite management program; applied on 100% of the acreage.
- Savey DF (hexythiazox) - Generally only one application is used from the tight cluster to petal fall stage at a rate of 3 - 6 oz per acre. Applied to 5% of the acreage.
- Vendex 50WP (fenbutatin-oxide) - Applied one to 2 times per season at petal fall or as a cover spray at a rate of 1- 2 lb per acre. Vendex is relatively slow acting so applications must be made before mite infestations are well established; applied to less than 5% of the acreage.
- Kanemite 15SC (1,4-Naphthalenedione, 2-(acetyloxy)-3-dodecyl-)
- Kelthane 50WS (dicofol)
- Omni Supreme or PureSpray Green (Aliphatic petroleum hydrocarbons\_)
- Vydate 2L (oxamyl) - Applied at a rate of 3 - 4 pt. It cannot be applied within 30 days after petal fall because of possible fruit thinning; generally not used as a miticide in Delaware.
- Nexter 75 WS
- Zeal 72WS (Etoxazole )

### **Twospotted Spider Mite (TSM), *Tetranychus urticae* Koch**

TSM has a slightly different life cycle than ERM in that it overwinters on the ground as an adult feeding on various weeds. Populations move into the trees as spring temperatures rise. Damage is similar to that caused by ERM, as are chemical and biological controls. Generally, 25-30% of the acreage may be treated each year.

#### **Chemical:**

- Acramite 50WSB (bifenazate) - Only one cover spray is used at a rate of 12-16 oz per acre. This material is a very effective miticide but has only recently be labeled for apples; applied on 5% of the acreage.
- Agrimek .15EC (abamectin) - Applied at petal fall and first cover at a rate of 10 - 20 oz per acre. Agrimek penetrates quickly into leaves to form a reservoir of active material. It provides good mite control but must be applied with a minimum

1% or 1 gallon of oil per acre before leaves harden-off; applied to 80% of the acreage.

- Apollo 4SC (clofentezine) - Generally, one application is used; however may apply at the delayed dormant or petal fall stage at a rate of 4 - 8 oz per acre. It is primarily an ovicide but also controls young motile stages. Best results are achieved in spring when red mite eggs are hatching and before adults are present; applied to 50% of the acreage.
- Savey DF (hexythiazox) - Generally only one application is used from the tight cluster to petal fall stage at a rate of 3 - 6 oz per acre. Applied to 5% of the acreage.
- Vendex 50WP (fenbutatin-oxide) - Applied one to 2 times per season at petal fall or as a cover spray at a rate of 1- 2 lb per acre. Vendex is relatively slow acting so applications must be made before mite infestations are well established; applied to less than 5% of the acreage.
- Kanemite 15SC (1,4-Naphthalenedione, 2-(acetyloxy)-3-dodecyl-)
- Kelthane 50WS (dicofol)
- Omni Supreme (Aliphatic petroleum hydrocarbons\_)
- Nexter 75WS
- Zeal 72WS (Etoxazole )
- Stylet-Oil

### **San Jose Scale (SJS), *Quadraspidiotus perniciosus* (Comstock)**

**Biology and Life History:** SJS is an annual pest that overwinters as partially grown immatures on the bark. Crawlers first emerge in early June with two more generations usually occurring in mid to late summer. After settling down on either fruit or wood surfaces, a protective waxy layer is secreted which remains on the insect for the rest of its life

**Damage:** Fruit damage will be marked by red spots with small gray centers. High populations can debilitate a tree, kill branches or entire trees. In most years, 100% of the acreage is affected by this pest.

**Decision Making:** Treatment is recommended at the dormant to delayed dormant stages at 300-350DD(base 50 degreesF) after first adults are caught in pheromone or when first crawlers are caught on sticky tapes.

### **Controls**

**Biological:** Some natural enemies exist, their populations are sufficient to control problem SJS populations.

**Cultural:** Annual dormant pruning continues to be a cultural practice that can remove portions of established populations and increase spray penetration for insecticide efficiency.

**Chemical:** This pest is controlled with annual use of oil in combination with organophosphate insecticides during the dormant to delayed dormant period, and organophosphate applications during the growing season.

- Dormant Oil (60-70 sec.oil) - One to two applications at a rate/acre of 3 - 6 gal are applied at the dormant to delayed dormant stages. At the green-tip to 1/2-inch green stage, it may be combined with Lorsban 4E at the 1.5 to 2.0 pints per acre rate. Used on 100% of the acres.
- Esteem .35WP (pyriproxyfen) - In combination with a dormant oil, it effectively controls San Jose scale when applied at the delayed dormant stage at a rate of 13-16 oz per acre. Applied to 5% if the acreage.
- Lorsban 4E (chlorpyrifos) - One application is combined with dormant oil at the green-tip to 1/2-inch green stage at a rate of 1.5-2 pt/acre. Provides good SJS control and used on 100% of the acres.
- Supracide 25WP or Supracide 2EC (methidathion)

### **Spotted Tentiform Leafminer (STLM), *Phyllonorycter blancardella* (Fabr.)**

**Biology and Life History:** STLM is an annual pest in Delaware. Pupae overwinter in fallen leaves with adults emerging when the first green tissue appears. There are three to four generations per season.

**Damage:** The damage is the same for each generation in that mines are made in the leaves, but the damage is cumulative with each mine reducing leaf surface by about 5%. Loss of leaf surface with about 3 or more mines per leaf can lead to reduced fruit size and premature fruit drop. Damage is augmented during periods of drought, or in combination with other indirect pests such as ERM and leafhoppers. Approximately 75% of the acreage is affected each year.

**Decision Making:** Treatment for the first generation at the pink and petal fall stages is recommended if leafminers were a significant problem last season. For the second generation, the threshold is 0.5 to 1 mine per leaf. In late July, the threshold for the third generation increases to 2 or mines per leaf. In late August to early September, a spray may be needed if control was not achieved early in the season. Fruit drop can occur if you find 10 or more mines per leaf.

### **Controls**

**Biological:** STLM is potentially the most highly parasitized insect in apple orchards. However, most parasites are killed by the use of broad spectrum insecticides, augmenting the problem with STLM. Three Hymenopteran species in particular are important, two Eulophids and one Braconid. Minimizing insecticides for STLM during the late summer can encourage parasite build-up during the fall.

**Cultural:** Although generally no practical, the removal of infested leaves that fall to the orchard floor in the fall after harvest can help to reduce the problem for the following season.

## Chemical:

- Asana XL.66EC (esfenvalerate) - Also not recommended for postbloom applications because of the effect on mite predators. One application is made at the 4.8-8 oz/acre rate at the delayed dormant stage; applied to 10% of the acres.
- Actara 25WDG (thiomethoxam)
- Ambush 25WP (permethrin)
- Assail 30SG (acetamiprid)
- Avaunt 30WDG (indoxacarb)
- Aza-Direct 1.2L (Azadirachtin)
- Baythroid XL 1L (cyfluthrin)
- Calypso 4F (Chloronicotinyl)
- Danitol 2.4EC (fenproparthrin)
- Neemix 4.5L (Azadirachtin)
- Proclaim 5SG (emamectin)
- Pyrenone 0.5EC
- Lannate 2.4L or 90SP (methomyl) - Lannate is damaging to mite predators; therefore, it is generally only used as a cover spray 1-2 times late in the season at a rate of 0.5-1 lb/acre and only in combination with other insecticides. Provides good STLM control; applied to 10% of the acre.
- Provado 1.6F (imidacloprid) - Applied at a rate of 6 - 8 oz per acre 1-3 times as a cover spray. It is translaminar so provides good control of STLM; applied to 20% of the acreage.
- Proaxis 0.5CS (gammacyhalothrin)
  
- Vydate 2L (oxamyl) - One application is used from tight cluster to the pink stage at a rate of 3 - 4 pt per acre; applied to 35% of the acres.
- Warrior 1CS (Lambdacyhalothrin)

### **White Apple Leafhopper (WALH), *Typhlocyba pomaria* McAtee**

**Biology and Life History:** WALH is the most common leafhopper in apple orchards. Eggs hatch around bloom time, with the first generation in May, and a second generation in August. While there are three generations per year, only two are on apples, with the first generation appearing in late June to early July, and the second appearing in August and overlapping with second generation WALH.

**Damage:** Leafhoppers feed with piercing sucking mouthparts, and cause a white stippling on the leaves, and can cause complete chlorosis. High populations of late season leafhoppers cause a dark speckling on the fruit resulting from honeydew deposits, and can be a nuisance for pickers, particularly in pick-your-own operations. Generally, 100% of the acreage is affected annually.

**Decision Making:** A treatment is recommended when you find three nymphs per leaf.

## Controls

**Biological:** Several parasites and predators can attack both species. Predatory Mirid bugs can be common in August during the second generation. Under heavy populations, natural enemies are not sufficient to achieve control.

**Cultural:** None available.

### Chemical:

- Agrimek .15EC (abamectin) - Applied one time at a rate of 10 - 20 oz at the petal fall stage. It penetrates quickly into leaves to form a reservoir of active material. It must be applied with a minimum 1 percent or 1 gallon of oil per acre before leaves harden-off; applied to 80% of the acres.
- Asana XL.66EC (esfenvalerate) - Also not recommended for postbloom applications because of the effect on mite predators. One application is made at the 4.8-8 oz/acre rate at the delayed dormant stage; applied to 10% of the acres.
- Lannate 90SP (methomyl) - Lannate is damaging to mite predators; therefore, it is generally only used as a cover spray 1 time late in the season for second generation WALH at a rate of 0.5-1 lb/acre. Provides good WALH control; applied to 10% of the acre.
- Provado 1.6F (imidacloprid) - One application is used at a rate of 6 - 8 oz per acre as a cover spray. It is translaminar so provides good control of WALH; applied to 20% of the acreage
- Actara 25WDG (thiomethoxam)
- Assail 30SG (acetamiprid)
- Avaunt 30WDG (indoxacarb)
- Aza-Direct 1.2L (Azadirachtin)
- Baythroid XL 1L (cyfluthrin)
- Calypso 4F (Chloronicotinyl)
- Danitol 2.4EC (fenproparthrin)
- Neemix 4.5L (Azadirachtin)
- Proaxis 0.5CS (gammacyhalothrin)
- Vydate 2L (oxamyl) - One application is used from tight cluster to the pink stage at a rate of 3 - 4 pt per acre; applied to 35% of the acres.
- Warrior 1CS (Lambdacyhalothrin)
- Sevin 80WS, 80S or Sevin XLR Plus 4EC or Sevin 4F (carbaryl)
- Thionex 50WP or 3EC (endosulfan)

### **Plum Curculio (PC), *Conotrachelus nenuphar* (Herbst)**

**Biology and Life History:** Adult beetles overwinter in hedgerows, woods and underbrush. They first emerge on warm spring days near bloom time. Most damage occurs just after petal fall and shortly thereafter on young fruit. While there is usually

one generation per season, recent evidence has shown there to be a southern race which can reproduce and damage fruit in late July to early August.

**Damage:** Females chew an area on the fruit surface and deposit an egg in a crescent shaped egg scar. Larvae feed inside the fruit causing large cavities. It is considered an annual pest, but only sporadic damage usually occurs.

**Decision Making:** No treatment thresholds available.

### **Controls**

**Biological:** None available

**Cultural:** None available.

**Chemical:**

- Avaunt 30WDG (indoxacarb)- Applied 2-3 times as a cover spray at a rate of 5 - 6 oz per acre. Given its wide pest spectrum, it may only be used a maximum of 4 times per season with a 28 day PHI; applied to 30% of the acres.
- Guthion 50WP (azinphos-methyl) - Two to four cover sprays are applied at a rate of 1.5 - 2 lbs. per acre. This material is an organophosphate insecticide with broad-spectrum activity against many tree fruit pests. It is recommended for use in IPM programs because it is not highly toxic to mite predators when applied according to label directions; applied to 100% of the acres.
- Imidan 70WP (phosmet) - Two to four cover sprays are applied at a rate of 2-3 lbs per acre. It is an organophosphate insecticide not highly toxic to mite predators when applied according to schedule; applied to 10% of the acreage.
- Actara 25WDG (thiomethoxam)
- Avaunt 30WDG (indoxacarb)
- Baythroid XL 1L (cyfluthrin)
- Calypso 4F (Chloronicotinyl)
- Danitol 2.4EC (fenproparthrin)
- Lorsban 70WP (chlorpyrifos)
- Proaxis 0.5CS (gammacyhalothrin)
- Warrior 1CS (Lambdacyhalothrin)
- Sevin 80WS, 80S or Sevin XLR Plus 4EC or Sevin 4F (carbaryl)
- Surround 95WP (Kaolin)

### **Apple Maggot (AM), *Rhagoletis pomonella* (Walsh)**

**Biology and Life History:** Apple maggot regularly occurs in DE orchards but is seldom a pest, owing to the traditional use of organophosphate and carbamate insecticides. The insect overwinters as a pupa in the soil, and emerges as an adult in early June through early August. Eggs are laid just under the fruit skin, and larvae develop inside the fruit.

**Damage:** Multiple maggot larvae may infest a single fruit as they tunnel throughout the fruit flesh. The fruit surface will be dimpled, and infested fruit will drop prematurely. Earlier maturing fruit are the most commonly attacked, but all varieties are susceptible. Specific insecticide applications are usually not required, since multiple applications of insecticides targeted for other pests have controlled AM. AM are able to infest all acreage, but usually only sporadic, infesting 1 - 5% of acreage.

**Decision-Making:** Treatment is recommended when 2-5 adult flies are found per red sticky ball trap per week.

## Controls

**Biological:** None available.

**Cultural:** Work in Massachusetts has shown that when used in sufficient numbers, baited sphere traps, or biodegradable spheres can trap out adults as they move into an orchard. Due to the high cost of materials and labor, this is probably not practical on a commercial scale

### Chemical:

- Assail 30SG (acetamiprid)
- Baythroid XL 1L (cyfluthrin)
- Calypso 4F (Chloronicotinyl)
- Danitol 2.4EC (fenproparthrin)
- Dimethoate 4EC
- Surround 95WP (Kaolin)
- Avaunt 30WDG (indoxacarb) - Two to three cover sprays are applied at a rate of 5 - 6 oz per acre. It is the only new non-OP that will also control apple maggot; applied to 30% of the acres.
- Guthion 50WP (azinphos-methyl) - Two to four cover sprays are applied at a rate of 1.5 - 2 lbs. per acre. This material is an organophosphate insecticide with broad-spectrum activity against many tree fruit pests. It is recommended for use in IPM programs because it is not highly toxic to mite predators when applied according to label directions; applied to 100% of the acres.
- Imidan 70WP (phosmet) - Two to four cover sprays are applied at a rate of 2-3 lbs per acre. It is an organophosphate insecticide not highly toxic to mite predators when applied according to schedule; applied to 10% of the acreage.
- Lannate 2.4L (methomyl)

## Codling Moth (CM), *Cydia pomonella* (Linnaeus)

**Biology and Life History:** This is a principal insect pest throughout most areas where apples are grown in the U.S., including DE. CM overwinters as a full grown larva in a cocoon, with the first flight beginning around bloom time. There are two generations per year which coincide with peak adult activity and bracket egg hatch and larval emergence.

**Damage:** Eggs are laid on leaves near fruit or directly on the fruit. Larvae emerge and bore into the fruit, making their way to the core, and feeding on the seeds and surrounding flesh. Fully infested fruit are culls.

**Decision Making:** Treatments usually fall around the last part of May to the first half of June and again during the last part of July and first half of August. Use of pheromone traps and degree day driven models helps to focus spray timing. CM is a direct pest. CM is usually well controlled with organophosphate and carbamate insecticides and not a problem under good management. Treatments start at 250-360 DD (degree days) after first moth catch, and again at 1260-1370 DD after first catch. Potentially 100% of the acreage is affected annually, but usually close to 20% has an economic problem.

### Controls

**Biological:** Biological control with NPV (virus) has also not given the control required for commercial production.

**Cultural:** Mating disruption has been used on an experimental basis in eastern fruit growing areas, but with little practical success. Since other pests would also have to be treated for at the same time, this is not an economic alternative.

### Chemical:

- Avaunt 30WDG (indoxacarb) - Two to three cover sprays are applied at a rate of 5 - 6 oz per acre. Given its wide pest spectrum, it may only be used a maximum of 4 times per season with a 28 day PHI applied to 30% of the acreage.
- Guthion 50WP (azinphos-methyl) - Two to four cover sprays are applied at a rate of 1.5 - 2 lbs. per acre. This material is an organophosphate insecticide with broad-spectrum activity against many tree fruit pests. It is recommended for use in IPM programs because it is not highly toxic to mite predators when applied according to label directions; applied to 100% of the acres.
- Imidan 70WP (phosmet) - Two to four cover sprays are applied at a rate of 2 - 3 lbs. per acre. It is an organophosphate insecticide not highly toxic to mite predators when applied according to schedule; applied to 10% of the acreage.
- Intrepid 2F (methoxyfenozide) - Three to four cover sprays can be applied at a rate of 8 - 12 oz per acre. It is an insect growth regulator and is closely related to Confir and has a similar spectrum, but also controls oriental fruit moth and lesser appleworm; applied to less than 5% of the acreage.
- Assail 30SG (acetamiprid)
- Aza-Direct 1.2L (azadirachtin)
- Baythroid XL 1L (cyfluthrin)
- Biobit XL 1L (B.t.)
- Calypso 4F (Chloronicotinyl)
- Deliver 18WG (B. t.)
- Dipel 10.3DF (B.t.)
- Entrust 80WP (spinosad)
- Surround 95WP (Kaolin)

- Lannate 2.4L (methomyl)
- Neemix 4.5L (azadirachtin)
- Proclaim 5SG (emamectin)
- Lorsban 75WG (clorpyrifos)
- Sevin XLR Plus, 4F or Sevin 80S, 80WS, 4F (carbaryl)
- SpinTor 2SC (spinosad)
- Pheromone disruption:
  - Checkmate CM-F
  - Isomate-C TT
  - Checkmate CM-OFM Duel
  - Isomate-CM/OFM TT

**Green Fruitworms (GFW), *Lithophane antennata* (Walker), *Orthosia hibisci* (Guenée), *Amphipyra pyramidoides* Guenée**

**Biology and Life History:** Adults are medium brown moths about 1.5 inches across. Larvae are robust green. They overwinter either in the egg stage or as pupae.

**Damage:** Larvae damage young fruit by feeding on the outside, causing deep cavities. A single larva may injure several fruit. Only a sporadic pest, usually not a problem, but controlled at petal fall with other pests with same materials used for WALH, STLM and ERM.

**Oriental Fruit Moth (OFM), *Grapholita molesta* (Busck)**

**Biology and Life History:** Full-grown larvae overwinter in cocoons in protected areas in and around orchards. They pupate in March, and adults start to emerge when green tissue starts to show. While this is a major pest in peach orchards, it has only recently become problematic in apple plantings. Adults lay eggs on leaf petioles or directly on fruit. There are four generations per year. Larval damage can be seen from any one generation starting about 2 to 3 weeks after petal fall.

**Damage:** On peach trees larvae will also bore into terminal growth and cause flagging of new shoots. This is rarely the case in apples, where the larvae emerge and bore directly into the fruit. Infested fruit will be a total loss.. In recent years this insect has exhibited tolerance to organophosphates in specific orchards. This may be one reason why OFM is more problematic in apple orchards that are close to peaches.

**Decision-Making:** Each generation must be treated if populations are high. Pheromone traps and a degree day model help time insecticide applications. A petal fall application made for other pests, followed by another application at 350 – 375 DD after first emergence will target the first generation. Treatments applied at 1150-1200 DD and again at 1450 –1500 DD will target the second generation. Third and fourth generations must also be controlled. Approximately 5% acres with a problem.

## Controls

**Biological:** None available.

**Cultural:** Pheromone based mating disruption has been used successfully in peaches for OFM control. It has also been successfully integrated into apple production in other states, but is quite costly given the fact that other pests must also be controlled with insecticides

### Chemical:

- Avaunt 30WDG (indoxacarb) - Three to four cover sprays are applied at a rate of 5 - 6 oz per acre. Given its wide pest spectrum, it may only be used a maximum of 4 times per season with a 28 day PHI; applied to 30% of the acreage.
- Guthion 50WP (azinphos-methyl) - Three to four cover sprays are applied at a rate of 1.5 - 2 lbs. per acre; applied to 100% of the acreage.
- Imidan 70WP (phosmet) - Three to four cover sprays are applied at a rate of 2 - 3 lbs per acre; applied to 10% of the acreage.
- Intrepid 2F (methoxyfenozide) - Two to three cover sprays applied at a rate of 8 - 12 oz per acre. It is an insect growth regulator that effectively controls oriental fruit moth; applied to less than 5% of the acreage.
- Assail 30SG (acetamiprid)
- Baythroid XL 1L (cyfluthrin)
- Biobit XL 1L (B.t.)
- Calypso 4F (Chloronicotinyl)
- Deliver 18WG (B. t.)
- Dipel 10.3DF (B.t.)
- Lannate 2.4L (methomyl)
- Neemix 4.5L (azadirachtin)
- Proclaim 5SG (emamectin)
- Lorsban 75WG (clorpyrifos)
- Sevin XLR Plus, 4F or Sevin 80S, 80WS, (carbaryl)
- Pheromone disruption:
  - Checkmate CM-F
  - Isomate-C TT
  - Checkmate CM-OFM Duel
  - Isomate-CM/OFM TT

### **Redbanded Leafroller (RBLR), *Argyrotaenia velutinana* Walker**

**Biology and Life History:** RBLR was once of more significance than it is today, and is usually well controlled by organophosphate and carbamate insecticides. There are three generations throughout Delaware, with a partial fourth during some years. First generation larvae are present just after petal fall, second generation about late June to early July, and third generation about late August to early September.

**Damage:** Larvae will web a leaf to a fruit surface and feed between the leaf and the fruit, causing a surface feeding on the fruit surface. Injured fruit will be unmarketable for the fresh market. While the injury can be peeled off, processors will usually turn injured fruit away and often reject entire loads if injured fruit are present.

**Decision-Making:** Pheromone traps can be used to determine when moths are flying; however, no specific thresholds are available.

### Controls

**Biological:** – Eggs can be parasitized by a chalcid wasp, along with several other parasites that attack larvae and pupae. A granulosis virus can also attack the larvae. None of these natural enemies can currently be managed for effective programs.

**Cultural:** None available.

### Chemical:

- Agree WG 3.8WS (B. t.)
- Guthion 50WP (azinphos-methyl) - Three to four cover sprays are applied at a rate of 1.5 - 2 lbs. per acre; applied to 100% of the acreage.
- Imidan 70WP (phosmet) - Three to four cover sprays are applied at a rate of 2 - 3 lbs per acre; applied to 10% of the acreage.
- Baythroid XL 1L (cyfluthrin)
- Biobit XL 1L (B.t.)
- Deliver 18WG (B. t.)
- Dipel 10.3DF (B.t.)
- Javelin 7.5WDG (B.t.)
- Lannate 2.4L (methomyl)
- Proclaim 5SG (emamectin)
- Lorsban 75WG (clorpyrifos).

Tufted Apple Budmoth (TABM), *Platynota idaeusalis* (Walker);  
Variegated Leafroller (VLR), *Platynota flavedana* Clemens

**Biology and Life History:** Both insects are present in Delaware. TABM is a consistent pest, while VLR is found only occasionally. TABM is one of the more serious pests. In recent years the insect has become resistant to organophosphates, and to some extent, carbamates. Larvae overwinter in various instars inside leaf shelters. Adults first appear in mid to late April and again in late July through August.

**Damage:** Larvae web leaves to fruit and alternate their feeding between the fruit and leaf surface. Damage appears as a surface feeding, although scattered in various spots. Damaged fruit are unmarketable for the fresh market, and although damage can be peeled, fruit processors often reject it.

**Decision Making:** Treatments are degree based, but are applied through much of June and August. TABM must be specifically targeted for control on about 80% of commercial acreage.

## Controls

**Biological:** – Larvae can be subject to virus infection and can be attacked by a number of parasitoids. None of these can be practically managed in commercial production.

**Cultural:** None available.

### Chemical :

- Lannate 90SP (methomyl) - Two to three cover sprays are applied at a rate of 0.5 - 1 lb per acre. It is a carbamate insecticide that provides good control of, tufted apple bud moth and leafrollers. It is damaging to mite predators; therefore, in pest management programs it is only recommended late season and in combination with other products; applied to 35% of the acreage.
- Biobit XL 1L (B.t.)
- Deliver 18WG (B. t.)
- Dipel 10.3DF (B.t.)
- Javelin 7.5WDG (B.t.)
- Lannate 2.4L (methomyl)

## Weeds

### Preemergence Herbicides

**Devrinol (napropamide)—2 - 4 lb ai (active ingredient)/A.** Use 4 - 8 lb/A Devrinol 50DF. Applied in late fall and/or early spring to weed-free soil, or with an appropriate postemergence herbicide to kill existing vegetation. The high rate is used for long-term control (4 to 8 months) and the low rate for short-term control (2 to 4 months). Devrinol controls primarily annual grasses. Tank-mix with Princep plus 2,4-D in late fall or with Goal 2XL/Galigan 2E or reduced rates of Princep, Karmex, OR Sinbar in the spring when labeled for the crop to control annual broadleaf weeds. Use when interplanting young, established orchards.

**Gallery 75DF (isoxabin) )— 0.75 – 1.0 lb ai/A.** Use rate is 1.0 to 1.33 lb/A Gallery 75DF, applied in late fall or early spring to weed-free soil to control many broadleaf weeds. In newly planted trees, the soil needs to settle and fill any depressions around the tree before application. A postemergence herbicide will improve the control of emerged weeds. Gallery primarily controls annual broadleaf weeds. It is tank-mixed with Prowl to control annual grasses.

For newly planted (nonbearing) apples, not labeled for bearing fruit trees.

**Goal 2XL/Galigan 2E (oxyfluorfen)—2 lb ai/A.** Use rate is 4 qt/A Goal 2XL or Galigan 2E applied in early spring before bloom. Addition of an appropriate postemergence herbicide to kill existing vegetation is recommended. Goal 2XL/Galigan 2E controls annual broadleaf weeds and suppresses annual grasses. Tank-mixed with Prowl, Devrinol, or Surflan will improve the length of annual grass control. It should not be incorporate into the soil with a disk or other implement, or reduced weed control may result. For newly planted or established trees.

**Karmex (diuron)—1.0 - 3 lb ai/A.** Use rate of 1.25 - 3.75 lb/A Karmex 80DF, applied in late fall or spring to weed-free soil is helped with the addition of an appropriate postemergence herbicide to kill existing vegetation. Primarily for annual broadleaf weed control. Tank-mix with Prowl (nonbearing only), Surflan, Solicam, Devrinol, OR a reduced rate of Sinbar at one-half the labeled Karmex use rate alone for the soil type to improve crop safety and the range of weeds controlled. For application to apples established a minimum of 1 year.

**Norosac/Casoron (dichlobenil)—4 - 6 lb ai/A.** Recommended rates of 100 -150 lb/A Norosac/Casoron 4G, applied between November 15 and February 15 to control labeled perennial/biennial weeds or in early spring, before weed growth begins and daily high temperatures exceed 50 oF, to control labeled annual weeds. Norosac/Casoron is volatile in warm temperatures and must be irrigated or incorporated after application if applied in warm weather. For established (bearing) apples.

**Princep (simazine)—2-4 lb ai/A.** Recommended rates of 2.2 - 4.4 lb/A Princep 90DF (or other labeled formulations) are applied in late fall or spring to weed-free soil, or with an appropriate postemergence herbicide to kill existing vegetation. Primarily for annual broadleaf weed control. It is tank-mixed with Prowl (nonbearing only), Surflan, Solicam, or Devrinol at one-half the labeled Princep use rate alone for the soil type to improve crop safety and the range of weeds controlled. Recommended for to trees established a minimum of 1 year.

**Prowl (pendimethalin)—2 - 4 lb ai/A.** Rates of 2.4 - 4.8 qt/A Prowl 3.3Ecare applied in late fall and/or early spring to weed-free soil or with a postemergence herbicide to control emerged weeds. Used with 2, 4-D in early spring before bloom to control susceptible broadleaf weeds or with an appropriate postemergence herbicide to kill existing vegetation. The high rate is for long-term control (4 to 8 months) and the low rate for the short-term control (2 to 4 months). Prowl controls primarily annual grasses. It can be tank-mixed with Princep plus 2, 4-D in late fall or with Goal 2XL/Galigan 2E, Karmex, or Sinbar in the spring to control annual broadleaf weeds.

For newly planted (nonbearing) trees, and not labeled for bearing trees.

**Sinbar (terbacil)—1.0 - 3.0 lb ai/A.** Rates of 1.25 - 3.75 lb/A Sinbar 80DF, applied in the spring to weed-free soil, or with an appropriate postemergence herbicide to kill existing vegetation. It can be tank-mixed with Surflan, Devrinol, or a reduced rate of Karmex at one-half the labeled Sinbar use rate alone for the soil type to improve crop

safety and the range of weeds controlled. Recommended for trees established a minimum of 3 years.

**Solicam (norflurazon)—2 - 4 lb ai/A.** Rates of 2.5 - 5 lb/A Solicam 80DF, applied in late fall or spring to weed-free soil, or with an appropriate postemergence herbicide to kill existing vegetation. Primarily for annual grass control, Solicam may provide partial control of many broadleaf weeds. It can be tank-mixed with Princep plus 2, 4-D in late fall or with Goal 2XL/Galigan 2E, Karmex, or Sinbar in the spring when labeled for the crop to improve the control of broadleaf weeds. For newly planted (nonbearing) and established (bearing) trees.

**Surflan (oryzalin)—2 - 4 lb ai/A.** Rates of 2 - 4 qt/A Surflan 4AS (or other labeled formulations), applied in late fall and/or early spring to weed-free soil, or with an appropriate postemergence herbicide to kill existing vegetation. The high rate is for long-term control (4 to 8 months) and the low rate for short-term control (2 to 4 months). Surflan controls primarily annual grasses. It can be tank-mixed with Princep plus 2,4-D in late fall or with Goal 2XL/Galigan 2E, Karmex, or Sinbar in the spring to control annual broadleaf weeds. For newly planted (nonbearing) and established (bearing) trees.

### Postemergence Herbicides

**2, 4-D—1 lb ai/A.** It controls a wide variety of broadleaf weeds, effectiveness depending on herbicide rate, weed species, and growth stage. It is applied to weed foliage in the fall after harvest (including drops), or in early spring before trees or dandelions flower. Fall applications are more effective and reduce the risk of herbicide drift injury to adjacent crops. Weeds are most susceptible to 2, 4-D when they are growing vigorously, not under stress, and before flower buds appear. It should be applied before the leaves of perennial weeds lose normal summer green color. For established (bearing) trees.

**Fusilade DX 2EC (fluazifop butyl) — 0.18 - 0.38 lb ai/A.** Rates of 12 - 24 fl.oz./A Fusilade DX 2EC with 2 pints crop oil concentrate or nonionic surfactant to be 0.25% of the spray solution (1 qt. per 100 gallons of spray solution.) are recommended. The lower rate can be used on most annual grasses less than 6 inches tall and to johnsongrass. The higher rate is used to control other perennial grasses, crabgrass, and annual grasses more than 6 inches tall. For newly planted (nonbearing) apples.

**Kerb (pronamide)—2 - 4 lb ai/A.** Rates of 4 - 8 lb/A Kerb 50WP, applied in November when soil temperatures are between 35o and 55oF (1.67o and 12.80C) are suggested. It primarily controls perennial grasses, including quackgrass, bluegrass, ryegrass sp., fescue sp., and also provides early control of annual grasses the following spring. It can be followed with Surflan, Prowl, Solicam, or Sinbar the following May or June for full season annual grass control. It can be tank-mixed with Kerb with 2, 4-D and Princep for postemergence and residual broadleaf weed control. For established (bearing) trees.

**Poast (sethoxydim)—0.2 - 0.5 lb ai/A.** It is applied at 1 - 2.5 pt/A with 2 pints crop oil concentrate per acre. The lower rate to controls annual grasses less than 6 inches tall. The higher rate controls annual grass 6 to 12 inches tall and perennial grasses. For newly nonbearing and bearing trees.

**Select 2EC (clethodim)— 0.125 - 0.25 lb ai/A.** Rates of 8 to 16 fluid ounces of Select 2EC per acre are recommended to control most grass weed species, including certain hard to control grass weeds, such as small grain volunteers and cover crops, and perennials such as hard fescue, tall fescue, Bermudagrass, orchardgrass, quackgrass, Johnsongrass, and wirestem muhly. The lower rate to controls annual grasses and the perennial grasses listed above. The application is repeated if regrowth occurs. For use with oil concentrate at 1% of the spray solution, or a minimum of 1 pint per acre. For nonbearing trees only.

**Gramoxone Extra (paraquat)—0.5 lb ai/A.** A rate of .8 qt/A Gramoxone Extra 2.5SC is used. It is a contact killer only with no translocation or residual activity. Best results occur when weeds are 6 inches tall or less. Regrowth may occur from the root systems of established weeds. It should be combined with a surfactant at 0.25% of the spray solution (1 qt. per 100 gallons of spray solution). It also combined with recommended preemergence herbicide(s) for residual weed control. A nonselective material bearing and nonbearing trees.

**Roundup Ultra Max, Touchdown, Glyphomax Plus 4SC (glyphosate)** will control many serious annual and perennial weeds in orchards. It is a translocated, slow-acting herbicide with no soil or residual activity. Results will become evident 1 to 3 weeks after application. Optimum rate and time of application depend on weed species and growth stage. Weeds should be growing vigorously when treated. Use rates depend on target weed specie and application method. It may be broadcast, used as a spot treatment or with a ropewick applicator. It is a nonselective material that will harm trees if directly contacted with spray material.

In addition to the above, the following herbicides are registered for apple weed control in Delaware:

- Aim 2EC, 1.9EW (carfentrazone-ethyl)
- Rely (glufosinate)
- Unison (2,4-Dichlorophenoxyacetic acid )

## Diseases

(adapted from Crop Profile for Apple in New Jersey [3])

### Apple Scab, *Venturia inaequalis*

This disease is the most important apple disease in Delaware, affecting 100% of the acreage. The disease will reduce fruit yield and fruit size, cause cracking and misshapen fruit. All infected fruit have dark brown to black lesions, which make infected fruit unmarketable. Severely infected trees will exhibit considerable foliar infection which

can lead to leaf drop and reduced fruit size, even if fruit is not infected. The fungus overwinters in fallen leaves on the ground. Ascospores (sexual spores) are released from these fallen leaves when they become wet during spring rains. The critical period for spore release is from the time green tissue is first visible through third cover. Any infections which occur during this period result in primary scab, since the ascospores are the initial inoculum for the growing season. Primary scab infection periods can be predicted by gathering data on wetness period duration and average air temperature during the wetness period. Wetness duration and average air temperatures can be determined by visual observations and use of a min/max thermometer. However, a variety of mechanical and electronic devices can be purchased to help automate data gathering.

A variety of fungicides are available for control of scab during the primary period. However, whether or not a fungicide is prone to the development of resistant scab influences how it is used. If a fungicide is selected that is not at-risk to resistance, then it can be used alone (e.g., captan or ziram). If a material is selected that is at-risk, then it should be mixed with a fungicide that is not at risk. For example, Nova or Rubigan should be used in combination with another non-risk fungicide, such as captan. When used in combination, the non-risk fungicide is applied at half the standard rate. In general, if scab is properly controlled with fungicides during the primary scab period, then no further disease control is needed for the remainder of the season. However, if field observations at the end of the primary period indicate the presence of primary scab lesions, then additional sprays will be necessary.

### **Chemical Control:**

- Nova 40WP (myclobutanil)
- Procure 50WS (triflumizole)
- Rubigan 1EC (fenarimol)
- Flint 50WDG (trifloxystrobin)
- Sovran 50WDG (kresoxim-methyl)
- Polyram 80DF (metiram)
- Manzate, Dithane, Pencozeb 75DF, 80DF (mancozeb)
- Captan 50WP, 80WP (captan)
- Vangard WG (cyprodinil)
- Ferbam 76WDG (carbamate)
- Ziram 76DF (ziram)
- Topsin-M 70W (thiophanate-methyl)
- Scala 600SC (pyrimethanil)
- Pristine 38WP (F500 and boscalid)

Alternatives - Environmental monitoring of scab infection periods will help optimize fungicide spray timing. 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.

## **Powdery Mildew, *Podosphaera leucotricha***

The powdery mildew fungus overwinters as mycelia in the terminal buds and affects 60% of the acreage. Although the disease is present every year, it is more prevalent during years when weather is dry and morning dews are heavy. Since mycelium becomes active early in the season, control usually begins at the pre-pink stage. Additional sprays are required through the third cover spray. The disease will cause whitish lesions, longitudinally curled and folded leaves, stunted gray twig growth, and fruit russeting. Blossoms can abort, return bloom and yield the following season can be reduced, and growth can be stunted. Varieties not sensitive to sulfur russet are Rome Beauty, McIntosh, Cortland, and Golden Delicious. Varieties sensitive to sulfur russet include Starr, Twenty Ounce, Rhode Island Greening, Stayman, and Delicious.

### **Chemical Control:**

- Nova 40WP (myclobutanil)
- Procure 50WS (triflumizole)
- Rubigan 1EC (fenarimol)
- Flint 50WDG (trifloxystrobin)
- Sovran 50WDG (kresoxim-methyl)
- Sulfur 95WP, 6F (sulfur)
- Topsin-M 70W (thiophanate-methyl)
- Bayleton 50DF (Triadimefon) 2-8oz/A (0.5 – 2 oz/100 Gal)
- JMS Stylet-Oil

Alternatives - As soon as first noticed (about pink stage), branches or twigs showing systemic or over-wintering mildew can be pruned out to reduce secondary mildew. This is particularly beneficial in young blocks. In niche markets, disease resistant cultivars can also be planted to a limited extent.

## **Cedar Apple Rust, *Gymnosporangium juniperi-virginianae***

Cedar apple rust overwinters in galls on cedar trees. During the early spring, wetting of the cedar galls produces spore horns on the galls and the production of basidiospores. Given the proper wetting periods, spores are carried to apple trees and infect both leaves and fruit. Fruit lesions appear bright orange to brown, and may crack as the fruit matures. Lesions will appear on twigs and leaves, but do not affect fruit quality. Infections which occur early can occur on the fruit and leaves. Infections which occur after first cover infect only the leaves. Since they are deformed, infected fruit can only be sold for juice processing. Secondary infections do not occur from apple to apple. Since the cedar gall produces spores for only one season, there is only one disease cycle per year. Rust infections can occur between the pre-bloom pink bud stage through mid June.

Affected Acreage – The disease can infect most commercial cultivars, but 'red delicious' cultivars are almost immune. Where there are cedar trees, the disease is regularly treated from the pink bud stage through the first cover spray, or four applications.

## **Chemical Control:**

- Nova 40WP (myclobutanil)
- Procure 50WS (triflumizole)
- Rubigan 1EC (fenarimol)
- Polyram 80DF (metiram)
- Manzate, Dithane, Pencozeb 75DF, 80DF (mancozeb)
- Ferbam 76WDG (carbamate)
- Bayleton 50DF (triadimefon)
- Thiram 75WDG (thiram)

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

## **Fire Blight, *Erwinia amylovora***

Fire blight is a bacterial disease that can be highly destructive when it occurs on susceptible varieties and under the right conditions. The pathogen overwinters in cankers on limbs that were infected during the previous season. As temperatures warm in the spring, bacteria multiply and produce a bacterial ooze on the canker margins. Insects that are attracted to the ooze carry and spread the bacteria through the orchard. Under suitable wetting conditions, infections are readily established on open flowers, causing blossom blight. Winds and rain can help further establish the disease in shoot blight and canker blight phases. The disease is erratic, and may occur in only a few areas during some seasons, but may kill half an orchard during another season. Varieties that are most susceptible include Rome, Jonathan, Jonagold, Idared, Gala, Fuji, Braeburn, Mutsu, and Paula Red.

Symptoms vary depending on the part of the plant infected and the age of the infection. Freshly infected blossoms will become water soaked with a gray-green appearance before turning brown to black. Entire terminals will wilt and turn dark brown to black, giving a scorched appearance. As the season and disease progresses, the shoot blight will work its way down to older wood. Infected fruit or fruit on blighted branches will often shrivel, and have red to brown lesions. Droplets of bacterial ooze are exuded during periods of warm humid weather.

The most critical time to control the disease is during bloom. Antibiotics or coppers can also be applied at any time that infections are known to occur, given the proper environmental and infection conditions. Coppers applied at the 1/2" green stage are thought to be helpful in reducing the levels of exposed inoculum present. Predictive models can also help identify infection periods, and improve application timing.

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

## **Chemical Control:**

- Bordeaux mixture, 8-8-10 (copper sulfate) (spray lime) plus (oil)
- Champ flowable (copper hydroxide)
- C-O-C-S (copper oxychloride sulfate)
- Cuprofix Disperss (copper)
- Kocide 2000 (copper)
- Streptrol 17WP (streptomycin)
- Firewall 17WP (streptomycin)
- Regulaid (*B. subtilis*)
- Apogee 27.5DF (plant growth regulator)

Alternatives - In addition to the use of the above chemicals, good management practices include: a) the removal of infection sources or pruning, b) insect control, c) cultural practices, and d) use of more resistant scion/cultivar combinations where possible. Pruning - The most recent theory on control suggests that infected shoots should not be cut out until the terminals harden-off. After terminals harden-off and before leaf fall, prune twigs 4-6 inches below any visible evidence of the disease. If the disease progresses into the main trunk, the trunk should be cut back 4-6 inches below any visible symptoms. Insect Control - Insect populations should be kept below treatment levels. While insect transmission is not fully understood, populations of potato leafhopper should be minimized if they are found in an infected orchard. Cultural Practices - Excessive tree vigor should be avoided. Trees should be managed so tissue hardens off before mid summer. Excessive use of nitrogen fertilizer should be avoided. Varieties and Scions - Planting sensitive varieties on sensitive rootstocks (Mark, M9, M26) should only be done along with a good fire blight management plan.

### **Black Rot**, *Botryosphaeria obtusa*; **White Rot**, *Botryosphaeria dothidea*

Black rot is especially common in warm, humid areas. It can be found as a fruit rot, a leaf spot (frog-eye leaf spot), and a limb canker. Limb cankers can girdle and fill entire branches. Excessive leaf spotting can lead to partial defoliation. While fruit lesions render the infected fruit unmarketable. Fruit infections vary in appearance, but usually appear as a firm, dark brown to black rot with concentric rings starting from the calyx end of the fruit. The fungus overwinters in cankers, in mummified fruit, or on dead bark. Ascospores may be produced during petal and the early part of the season, while conidia are produced during rainy periods throughout the season. Infections occur through fruit and leaf stomata, while later season fruit infections occur through lenticels, cracks and wound areas. Injuries made after harvest may also become infected and lead to a storage rot.

The white rot pathogen is widespread, and also found on birch, chestnut, peach, and blueberry. White rot can be a serious disease causing considerable crop loss. Up to 50% crop losses have been reported from individual orchards in mid-Atlantic areas. Drought stress and winter injury can augment the disease and increase canker growth. The disease involves both wood and fruit tissue, but not the foliage. Wood infections and cankers are similar in appearance to black rot. Fruit infections start as small sunken brown spots with a red halo. They progress to a light watery appearance, soft to the touch. Cankers can girdle branches, leading to defoliation and crop loss. Fruit infection

may at any time, although some literature suggests that infection only occurs during the last six to eight weeks of the season.

Affected Acreage – Present on 100% of acreage, but with sporadic problems.

**Chemical Control:**

- Flint 50WDG (trifloxystrobin)
- Sovran 50WDG (kresoxim-methyl)
- Polyram 80DF (metiram)
- Manzate, Dithane, Pencozeb 75DF, 80DF (mancozeb)
- Captan 50WP, 80WP (captan)
- Vanguard WG (cyprodinil)
- Topsin-M 70W (thiophanate-methyl)
- Scala 600SC (pyrimethanil)
- Pristine 38WP (F500 and boscalid)
- Manex (maneb)

Alternatives - Management practices such as pruning out dead and cankered wood, and removing mummies helps to minimize the disease.

**Bitter Rot, *Glomerella cingulata***

The pathogen is widespread and infects other hosts such as peach and nectarine. Prolonged periods of hot, moist weather are favorable for disease infection. While infection may occur early in the season, bitter rot is usually thought of as a late season disease, with symptoms visible from July through August. Lesions start as small light brown circular spots. They enlarge to a round, sunken depression, often with concentric rings where fruiting bodies appear in pink masses. The rot forms a perfect cone towards the interior of the fruit. Rotted fruit are complete culls. Rotted fruit may hang on the tree and overwinter as a mummy.

Affected Acreage – All varieties are susceptible, but the disease is sporadic and highly dependent on the correct environmental conditions. Some orchards in the mid-Atlantic region have experienced 30 - 40% crop loss during certain years.

**Chemical Control:**

- Flint 50WDG (trifloxystrobin)
- Polyram 80DF (metiram)
- Manzate, Dithane, Pencozeb 75DF, 80DF (mancozeb)
- Captan 50WP, 80WP (captan)
- Ferbam 76WDG (carbamate)
- Ziram 76DF (ziram)
- Thiram 75WDG (thiram)

Alternatives - Sanitation by removing mummies, dead wood and twigs killed by other causes removes some of the overwintering sites.

### **Sooty Blotch**, *Gloedes pomigena*; **Flyspeck**, *Zygophiala jamaicensis*

The diseases cause surface blemishes that usually appear together on the same fruit. The fungi are found on the woody tissue of many plants, and can infect apples as early as two to three weeks after petal fall. The disease does not become visible until July or later, and is commonly thought of as a late season disease. Favorable infection periods include frequent rains with poor drying conditions. Environmental models are now available that help predict favorable disease conditions and time fungicide applications. Sooty blotch infections appear like sooty or olive green smudges on the fruit surface. Flyspeck lesions consist of 10 to 50 black specks clustered in 5/16 to 1 inch colonies. The fruit does not rot from either infection, but their presence can degrade the fruit surface, leading to water loss in storage and a downgrading from fresh market to process grade. The disease is more pronounced on light skinned fruit, especially yellow and green cultivars. Affected Acreage – 100% of acreage is affected, especially light colored cultivars. Depending on the quality demands from processors, it usually more of an issue with only fresh market fruit.

#### **Chemical Control:**

- Flint 50WDG (trifloxystrobin)
- Sovran 50WDG (kresoxim-methyl)
- Polyram 80DF (metiram)
- Manzate, Dithane, Pencozeb 75DF, 80DF (mancozeb)
- Captan 50WP, 80WP (captan)
- Ziram 76DF 76DWG plus sulfur (ziram)
- Topsin-M 70W (thiophanate-methyl)
- Pristine 38WP (F500 and boscalid)
- Thiram 75WDG (thiram)
- Manex 4F (maneb)

Alternatives - Pruning trees so that they have an open canopy helps improve airflow and drying conditions, and therefore minimize the disease, and improves spray penetration. Good thinning practices that break up fruit clusters also help improve drying conditions. Removal of alternate hosts such as brambles and other woody plants around orchards may also help, but is seldom practical.

### **Brooks Spot**, *Mycosphaerella pomi*

Brooks spot is a sporadic disease that in some years has caused considerable losses in the mid-Atlantic region. Ascospores which are discharged from overwintered leaves, infect both leaves and fruit during the late spring to early summer. Infections do not become visible until late summer. Fruit infections usually show up in late July to August, with foliar infections showing up slightly later. Fruit symptoms start as sunken dark green lesions near the calyx end, and progress to dark red or purple on red fruit, but

remaining dark green on yellow fruit. There is a very shallow flesh browning under the lesion. Those cultivars that are most susceptible to the disease in the region include Jonathan, Golden Delicious, Staymen, Winesap, and Rome.

Affected Acreage – A sporadic disease, although in specific orchards in the region up to 30-40% of the crop has been infected during some years. Depending on the severity, symptoms may be able to be peeled by the processor. If quality demands are high, then infected fruit is culled for both processing and fresh markets, and only available for juice.

#### **Chemical Control:**

- Polyram 80DF (metiram)
- Manzate, Dithane, Pencozeb 75DF, 80DF (mancozeb)
- Captan 50WP, 80WP (captan)
- Topsin-M 70W (thiophanate-methyl)

Alternatives - None

#### **Crown Rot or Collar Rot, *Phytophthora cactorum***

The disease is usually seen in trees planted in low areas, or on poorly drained soils. It is particularly troublesome in trees grown on M104 and M106 rootstocks. The pathogen can last several years in the soil, or on dead roots and plant tissue. Prolonged periods with cool wet soils favor infection. The period between the pink stage of bloom to the beginning of shoot growth is when most new infections take place. Infections may also take place in the fall, or at other times when the proper conditions exist.

Infected trees will exhibit delayed bud break, leaf discoloration and twig dieback. Fruit may remain undersized color prematurely. Leaves can prematurely color and drop in the fall. While a large mature tree may survive for several years, it will steadily decline and eventually die. While either the collar (scion) portion of the tree, the crown (rootstock) portion may be involved. A necrotic area marked with a distinct margin that is orange to reddish-brown to dark brown will be present at the affected site. While the disease usually works its way from the roots (crown rot), the tree is not killed until the entire crown is completely girdled.

Affected Acreage - Sporadic, depending on prolonged weather conditions, about 5 - 10% of acreage.

Chemical Control - Ridomil 2E, Ridomil Gold, and Aliette are labeled for control in bearing and nonbearing blocks. Copper-containing fungicides have provided some measure of control when applied as a drenching spray to the trunk: 2 pounds of actual copper in 100 gallons of spray with 1 gallon of spray per tree applied in late March to mid-April and again in late September to mid-October.

Alternatives - Control consists of using more tolerant rootstocks and improving drainage. Trees planted in hills and well drained sites are less likely to succumb to the disease. The disease can be brought into the orchard with infected trees, so care should be used when purchasing trees.

### **Fruit Quality, Tree Growth and Plant Growth Regulators (PGRs)**

(from Crop Profile for Apple in New Jersey [3])

A number of cultural and chemical practices are used to maintain fruit quality and proper tree growth. PGRs are used for fruit thinning, return bloom, maintaining fruit size and color, decrease fruit cracking, and to regulate fruit maturity and picking times. They may also be used to maintain tree growth, reduce fire blight susceptibility, and avoiding excessive sprout formation and foliage growth. Typical applications include one application for return bloom, one application for thinning, one to two applications for pre harvest drop control. Depending on the cultivar, two to four applications may be made to prevent fruit cracking. One to two other applications may be made to control tree growth.

#### **Thinning:**

**NAA** is one of the oldest and most reliable thinners. It is marketed by Amvac in two formulations: Fruitone N (NAA) and Amid-Thin W (NAD). **Fruitone N (naphthaleneacetic acid 3.5% -NAA)** can be applied from petal fall to 20 mm fruit size at rates of 5ppm to 20ppm in at least 100 gallons/acre. **Amid-Thin W (naphthaleneacetamide 8.4% -NAD)** is a mild form of NAA and is used at PF and early fruit set only. It is very effective on summer varieties such as Paulared, Jersey mac, Macintosh cultivars and Macoun. It is usually applied at 40-50 ppm per 100 gallons/acre at PF-5mm.

**ACCEL (benzyladenine + gibberellins A<sub>4</sub>+A<sub>7</sub>)** is a newer material that works as a mild thinner but has the ability to increase fruit size over and above the thinning response. It is valuable for use on small fruited cultivars like Empire. Accel is best applied PF to 8mm and used at the maximum rate of 30 grams/A. It is best used in combination with other materials for effective thinning. It may be combined with Sevin or Vydate.

**Sevin** is a carbamate insecticide that is a standard thinner for apples. Only Sevin XLR-Plus should be used. It is safer on bees and has been reported to have less toxicity to mite predators. It has the same concentration of active ingredient as Sevin 50W and thus, the thinning effect is the same. Sevin is a mild thinner at the full rate of 1 quart/acre. It can be used at PF till 20 mm and is best used in combination with other thinners (NAA or ACCEL) with most varieties. When used alone it may underthin some cultivars in NJ.

**Vydate L** is a carbamate insecticide that works the same way as Sevin. It received a NJ state label in 1996. It too is a mild thinner like Sevin, and should be used in combination with another thinner for best results (NAA or ACCEL). At 1-2 pints per 100 gallons, it

should be applied dilute between PF/5 mm and 20 mm. Up to two applications can be made per season. Vydate may be less toxic to mite predators than Sevin, and at the 1-2 pint/100 gallon rate may have activity on spotted tentiform leafminer and white apple leafhopper.

**Ethephon (Ethephon 27.5%) (Ethephon 2)** is a synthesized natural hormone of apples that has many uses including apple thinning. It is rate dependant and sensitive to temperature at both the time of application and for several days following application. The rate depends on both the timing of the application and the variety. It is labeled on apple for thinning at 1 1/2 to 8 pints per acre. NJ experience follows those of other mid-Atlantic states, in that Ethephon or Ethrel work better as a late rescue treatment for thinning in the 15-25mm window. It is rate dependent with certain cultivars being more sensitive.

### **Tree Growth Control and Fire Blight Suppression**

**Apogee (prohexadione Ca 27.5%)** is the first growth control product available since the loss of Alar, with the added benefit of reducing the tree susceptibility to shoot fire blight. Apogee is a unique production management tool that will suppress vegetative growth by blocking gibberellin synthesis, the plant hormone responsible for vegetative growth. Apple blocks that have a light crop and apple cultivars that are particularly sensitive to fire blight are good candidates for Apogee.

### **Preharvest Drop Control**

**Fruitone N (NAA)** is labeled for all varieties. It becomes active within a few days of application and may be used at 10 or 20 ppm. At 10 ppm, drop is controlled for about 1 week; and at 20 ppm, drop is controlled for about 10 to 14 days.

**ReTain** is a new harvest management tool labeled for both apples and/or pears.

### **Fruit Ripening**

**Ethephon** has been used to a limited extent on McIntosh and most red summer apples. Not all results have been satisfactory, but, in most instances, ethephon has hastened maturity, increased color development and made possible the harvest of the entire crop in one picking. It has been used on Julyred, Raritan, Jersey mac, Britemac, Paulared, Opalescent, Wealthy, Mollie's Delicious and McIntosh.

### **Return Bloom**

**NAA** is used at 30 days and sometimes again at 45 days post bloom. **Ethephon** can also be used during this time period.

## **Fruit Elongation**

**Promalin (gibberellins A<sub>4</sub>A<sub>7</sub> 2%)** is a growth regulator that has been used to increase the length of Delicious fruit. It should be applied at 1 pint Promalin per 100 gallons, with no more than 1.5 pints per acre. Applications are made when king blossoms are open.

## **Water Sprout and Sucker Control**

**Tre-Hold Sprout Inhibitor A112** is registered for bearing and nonbearing apple trees to control watersprouts and root suckers. It is used at .67 pint Tre-Hold to a mixture of water and interior-grade latex paint to make a volume of 1 gallon. It may also be used in a spray when applied to newly developing shoots.

## **Preharvest Fruit Cracking Suppression**

**Provide (benzyladenine 3.6%)** is applied at 16 ounces per acre per application. From 4-6 applications are made, starting the first application 2 weeks before cracking begins, typically from early to mid-July.

## **Vertebrate Pests**

Voles are the most economically important rodents in Delaware apple production. The two most common types of voles are the meadow vole and the woodland vole. Meadow voles, also called meadow mice, are a more significant pest than are woodland voles. They are about 5 ½ to 7 ½ inches long, have variable colored fur ranging from gray to yellow-brown with black-tipped hairs, and have a bi-colored tail. Woodland voles are about 4 to 6 inches in length, have reddish-brown fur, and their relatively short tail is about the same length as the hind foot. Meadow vole damage is usually in the form of gnawing on the bark and girdling the base of the tree. Other vertebrate pests are: white-tailed deer, raccoons, and Virginia opossums.

Vole control consists of integrating cultural, exclusion and chemical practices when needed. Cultural practices and habitat modification include the control of ground vegetation with herbicides, mowers, or disking. This helps limit voles by reducing potential cover. Exclusion includes the use of tree guards, particularly on young trees. Chemical control includes the use of the toxicants, zinc phosphide (ZP Rodent Bait), and anticoagulants (Rozol Pellets). Active ingredients include zinc phosphide, chlorophacinone, and diphacinone.

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