

# Crop Profile for Apples in Tennessee

Prepared: August, 2009

## General Production Information

- **State's ranking in national production of apples:** unranked
- **State's contribution to total US production of apples:** <1.5%
- **Yearly production numbers:** 8 million lbs in 2009, down 2 million lbs from 2008.
- **Total acres grown:** ~ 375
- **Total acres harvested:** ~ 345
- **Cash value:** \$2.99 million (2008 crop)
- **Production regions:** all areas of the state
- **Market destination:** Essentially the majority of Tennessee's apple crop is marketed as fresh fruit, mostly retail through local or on-farm outlets. However a small percentage is used in processing for beverage production and within specialty niche markets.
- **Production Regions:** Apples are produced in all parts of Tennessee. No one area in the state can be regarded as the major production area.
- **Production trends:** There are two types of trees grown for apple production purposes. These include the traditional trees and dwarf types. Dwarf types include; dwarf and semi-dwarf trees. Tennessee is moving away from traditional tree production.
- **Production Costs:** annual production cost averages around \$3,000 per acre excluding harvesting costs. Establishment costs range from \$3,000 for semi-dwarf or conventional to \$10,000 to \$12,000 per acre for dwarf types depending on variety/tree density.

## Cultural Practices

Site selection and preparation are very important aspects of apple production since they can impact the consistency of cropping as well as fruit quality. Site preparation begins at least 6 months to one year prior to planting. This time is utilized in clearing obstructions to air flow in and around the site, adjusting soil nutrition problems and eliminating noxious weeds. Apple trees perform best in a deep, well-drained, loamy soil. It is suggested that sites should provide for a minimum rooting depth of 30 inches.

Planting is done in late winter to early spring. For dwarf trees, some type of support system is installed at planting time. Most semi dwarf trees are trained to be free standing. Irrigation is installed in dwarf orchards for use the first growing season.

Fertilizer is applied in late winter to early spring. What to use and how much to use is determined by periodic soil testing, foliar analysis (especially important in dwarf trees), grower observation and growth and fruiting the previous year can be useful. Some nutrients may be applied through sprays (boron and calcium are suggested for one or more foliar applications annually).

The suggested orchard floor management program for Tennessee involves maintaining a strip about 6 to 8 feet wide free of any vegetation in the row and close mowing of the area between rows and around the orchard. Rows are oriented across slopes to allow for the use of this system and to enable more precise pesticide application. This floor management system can give a little additional frost protection and disease protection. The sod middles serve to slow down and diffuse runoff water, thus lessening the potential for erosion and nutrient leaching. It also is a good system to discourage vole movement into the orchard. Voles are especially destructive in all parts of the state. They account for more tree loss than any other single factor.

## **Cultural Pest Management**

### **Pruning:**

Pruning generally occurs in late fall and trees are pruned to open foliage areas to aid in insect and disease control. Dead wood and mummified fruit is removed or pruned out from the tree. Old cankers and fire blight strikes are removed/pruned out from the tree. Silver colored terminals are removed or pruned from the tree.

For the first few years of orchard life, tree training during the growing season is very important for dwarf trees. Some of the same practices are used in the semi dwarf orchard. Dormant pruning is not done to the same degree in dwarf trees as in semi dwarf trees since pruning delays the onset of fruiting. Early fruit production is a critical tree size controlling practice for dwarf trees.

### **Sanitation:**

In the fall, usually after first frost, leaves are mowed with a flail mower. A flail mower uses banks of flails (or “knives”) instead of blades. A flail is a short piece of metal that operates by beating the grass or fallen leaves (flailing) causing grass to break off or causing leaves to break into bits. This method helps break leaf litter into smaller pieces to aid in decomposition of fallen leaves therefore reducing overwintering habitats of disease organisms. Nitrogen fertilizers may be applied to help increase degradation of leaf litter.

Any red cedars are removed from surrounding locations. This process may occur in fall and may continue until early spring, when time permits.

Mowing throughout the season may be performed to reduce weed growth and competition for moisture and nutrients. Mowing occurs when labeled pesticides allow re-entry. Depending on environmental conditions, 4 to 10 mowings may occur each year within orchards.

### **Irrigation:**

Over head irrigation was in place on less than 10% of the apple acreage for the 2009 production season. Over head irrigation is used to help reduce damage caused by late spring freezing. Maintenance of irrigation equipment occurs from mid-March to late-April depending on weather conditions. Equipment is usually moved into the orchard and setup for use when heavy frosts are expected. Also, irrigation may occur during extremely dry conditions during the summer (July and August), however the 2009 season was unusually wet and irrigation was not necessary in most situations.

**Pesticide applications:**

Pest control in new orchards consists of controlling grasses and weeds around trees as they compete strongly for moisture and nutrients, often resulting in as much as 35 to 40% less growth as compared to sites where vegetation is controlled. Several diseases should be controlled during the first growing season and most fungicide applications are made as preventative sprays. Insect pests are controlled as they appear on an as needed basis.

Chemical weed control involves the use of pre and post-emergence herbicides during winter to early spring, occasionally a second application in the early to mid part of the growing season may be needed. Occasionally, spot sprays may be used to clean up problem areas throughout the growing season.

Pesticide applications are commonly made from the dormant stage of growth (during warm periods of February until mid-December) until fall depending on the targeted pest. Personal protective equipment is worn by workers during early re-entry, when required.

**Thinning:**

Thinning the crop is a very important aspect of apple production. Thinning is used to increase fruit size and quality and to reduce the tendency that some cultivars have for alternate bearing. Thinning is done primarily through the use of chemicals applied shortly after petal fall (April-May). Occasionally, hand thinning may be employed to refine the chemical thinning operation. Hand thinning is very expensive and if done too late, may give few of the responses seen by chemical thinning.

The majority of thinning is done as a chemical management process. Approximately 90 % of the apple acreage uses a chemical thinning process where the remaining acreage is thinned by hand. Workers who manually thin trees, generally use cotton gloves. Cotton gloves provide a better grip, therefore allowing easy fruit removal. This process begins when fruit are formed which is usually begins in late April - May.

**Harvesting:**

Tennessee apple growers produce cultivars that are harvested from the mid to latter part of July and as late as October. No Tennessee apples are stored for long periods of time. There are no controlled-atmosphere storage facilities for apples located within the state.

## **Growth Regulator Usage in Apples**

### **Prevention of Fruit Drop:**

Pre-harvest fruit drop can account for serious losses to Tennessee apple growers. There are no uses for dropped fruit, especially in view of the increasing knowledge of the food safety risks that this fruit presents. There are a few products which are used to aid in fruit retention. These include:

**Naphthaleneacetic Acid (NAA, K-salt)** -NAA is applied to aid in retention of the fruit on the tree. If applied, it should be applied when the first healthy fruits begin to drop. It may provide 10 to 14 days of controlled drop. A second application may be used if needed. When used in this manner, stop-drop control has varied greatly. Fruit softening can be a side effect. Recently, a "preloading" concept; involving application of 5 parts per million of NAA weekly for 4 weeks prior to anticipated harvest has been used. Preloading has given more consistent stop-drop results without the danger of fruit softening.

**ABG (ReTain)** -ReTain is a plant growth regulator used to retain fruits on the tree, and delay fruit maturity and ripening on the tree and in storage. It is applied one time four weeks before normal anticipated harvest. ReTain is effective if applied at the correct time. The delay in fruit maturity can, in some cases, be a desirable effect. However, it may not fit into all producer situations. Apples treated with ReTain frequently are larger, better colored and better flavored at harvest than the same cultivar not sprayed with ReTain.

### **Growth Regulators used for thinning:**

Growth regulators may be used in apple orchards, however most are used to assist in thinning the crop. Use of growth regulator products listed below lessen pre-harvest fruit drop and may be used to improve fruit shape.

### **Fruit Thinners:**

**Carbaryl (Carbaryl, Sevin)** -Carbaryl is an insecticide that also provides some thinning for apple orchards. If used as a plant growth regulator it is applied when the fruit size is 10-15mm in diameter. It may be applied more than once, if weather prevented the effectiveness of the first application. Temperature should be a minimum of 70°F for best results. Carbaryl causes the weaker, smaller and secondary cluster blossoms to drop from the tree, leaving the strongest fruit behind.

**Ethephon (Ethrel, Ethephon)** -Ethephon is often mixed with Amid-ThinW and may also be added to the carbaryl to enhance the thinning activity. Ethrel should not be used to thin Red Delicious because it may have a negative effect on fruit shape. Thinning may be accomplished later using ethephon than with the other chemical thinners.

**1-Naphthaleneacetamide (NAD, Amid-Thin W)** -This product is often mixed with ethephon and also may be added to the carbaryl to enhance the thinning activity.

**Naphthaleneacetic Acid (NAA, K-salt)** -This product may be used alone. It may also be added

to carbaryl to enhance the thinning activity.

**Ester-Naphthalenacetic acid (Tre-Hold A-112)** is an ester formulation of NAA.

**Improve Fruit Shape:**

**GA 4+7 & BA (Promalin)** -A plant growth regulator which may be applied during the bloom period to improve the shape of the apples.

**Integrated Pest Management**

Tennessee apple growers are increasingly using IPM technology in their apple orchards. Currently, many growers are using models available for scab and fireblight prediction as a way to time sprays. They are selecting pesticides based in part on their effect on predatory insects that might be in the orchard. Pheromone traps and the use of Growing Degree Day models are being evaluated by several growers, however cost of traps has limited their use within Tennessee.

**Cultural Practices for Pest Control**

Numerous cultural practices may be employed to lessen pest pressures in the apple orchard. Sanitation involves numerous points. When pruning, mummified fruit and wood containing cankers from various diseases are removed from the tree and destroyed by burning or chopping. The perimeter of orchards should be cleaned up to lessen movement of pests into orchards.

Site selection and preparation may lessen problems in the orchard. Elevated sites give some natural protection against frosts and diseases. Any impediments to free air drainage out of the orchard site need to be removed to recognize the full benefit of elevation. Cultivars and rootstocks need to be selected with thought given to any weaknesses or strengths they might possess in regards to pest resistance.

Training systems and pruning practices that promote good light and spray penetration throughout the tree canopy provides some assistance in pest control through reduced susceptibility of fruits and foliage and through improved spray coverage. Orchard floor management practices will impact pest pressures. Bare, firm soil under trees and close, frequent mowing of the areas between rows and around orchards will lessen vole activity in the orchard as well as facilitate good air drainage out of the orchard. Broadleaf weed species that are alternate hosts to certain pests in apples should be removed from the orchard floor. Any ground cover that might attract bees into the orchard should be removed to lessen the potential for kills due to insecticides used in the petal fall and cover sprays.

# Insect Pests

## San Jose Scale

(*Quadraspidiotus perniciosus*)

San Jose scale can weaken or kill limbs on trees as a result of feeding pressure. With high populations, crawlers may migrate onto fruit and cause a discolored area at the feeding site. Damaged fruit are unmarketable. Frequently, high populations are not recognized until damage has already occurred. High populations may kill scaffold branches and entire trees. Control usually focuses on the use of early season oil sprays. However, sprays can be applied for control of crawlers.

### Chemical Controls:

- Dimethoate (Dimethoate 4E/400): provides excellent control, is an organophosphate
- Diazinon (Diazinon 50WP): provides excellent control, is an organophosphate
- Azinphos-methyl (Guthion 50WP): 48-hour to 14-day REI depending on method of application. Has a 21-day PHI. Is an organophosphate, provides good control.
- Pyriproxyfen (Esteem 0.86EC): safe and provides excellent control.
- Buprofezin (Centaur 70WP): provides fair control.
- Acetamiprid (Assail 30SG): provides fair control.
- **NOTES:** best control is achieved when product is applied at crawler stage. Pyrethroid insecticides and carbaryl (Sevin) may promote scale populations.

### Biological Controls:

- Oil (Summer oil): provides fair control and enhances performance of other products.

### Cultural Controls:

- Use of pheromone traps may provide some benefit for monitoring purposes.
- Use of sticky traps may provide some benefit for monitoring purposes.
- Remove infested plants which may be growing adjacent to orchards.

## Rosy Apple Aphid

(*Dysaphis plantaginea*)

Feeding of the rosy apple aphid early in the season causes injury to fruit, leaves and stems. Fruit feeding is the greatest concern. It results in small fruit that is hard and knotty. Feeding on new shoots produces curled, twisted growth. Greatest injury occurs during cool springs, when conditions allow aphid populations to increase more rapidly than their enemies. Rosy apple aphids overwinter as eggs attached to the bark of twigs and branches on all parts of the tree, but especially in hidden crevices and depressions. Control is best accomplished from the tight cluster to the pink stage.

### Chemical Controls:

- Thiomethoxam (Actara 25WDG): provides excellent control.
- Acetamiprid (Assail 30SG): provides excellent control, fairly safe too honey bees.
- Thiocloprid (Calypso 4F): provides excellent control.
- Imidacloprid (Provado 1.6F): provides good control. Toxic to honey bees.
- Endosulfan (Thiodan 3EC, Phaser 3EC): provides good control, resistance has been observed in some areas.

- Diazinon (Diazinon 50W): provides good control, resistance has been observed in some areas.
- Dimethoate (Diamethoate 4EC/400): provides good control, resistance has been observed in some areas.
- Fenpropathrin (Danitol 2.4EC): provides good to excellent control, resistance has been observed in some areas.
- Superior-type Oil (oil): captan fungicide should not be used within two weeks of an oil application.
- **NOTES:** pink stage is the best time to use products to control rosy apple aphid.

**Biological Controls:**

- Lady beetles are predators of rosy apple aphids.
- Syrphid flies are predators of rosy apple aphids.
- Aphid lions are predators of rosy apple aphids.

**Cultural Controls:**

- Maintain properly trimmed trees to make conditions less favorable to aphids and to achieve better spray coverage.
- Monitoring beginning at early pink stage
- Variety selection, some varieties are more attractive to this pest

### **Codling Moth**

*(Laspeyresia pomonella (L))*

Codling moth is one of the most serious fruit feeding pests in Tennessee. It damages fruit by internal larval feeding and by stings on the fruit surface. Codling moth overwinters as a full-grown larva in a thick silken cocoon. Codling moth adults begin to emerge around petal fall. Peak emergence generally occurs around mid-May. Eggs are laid primarily on leaves near the fruit. Hatched larvae burrow into fruit at the calyx or through the side of the apple. They either feed just beneath the skin or burrow directly to the center of the fruit, where they feed on the seeds. Second generation larvae are active from July to around the first of August. Moth emergence peaks again in mid to late August. Insecticidal sprays should be applied to coincide with moth flights. Insecticides applied at petal fall and again at first and second cover sprays are generally effective. Abandoned orchards in the vicinity of managed orchards worsen problems from codling moth.

**Chemical Controls:**

- Azinphos-methyl (Guthion 50WP): an organophosphate
- Phosmet (Imidan 50WP): an organophosphate
- Methoxyfenozide (Intrepid 2F): safe
- Novaluron (Rimon 0.83EC): safe
- Fenpropathrin (Danitol 2.4EC): is a pyrethroid insecticide.
- Spinetoram (Delegate 35WP): safe
- Acetamiprid (Assail 30SG): safe for applicators, toxic to honey bees.
- Thiacloprid (Calypso 4F): safe for applicators, toxic to honey bees.

**Biological Controls:**

- *Cydia pomonella* granulovirus (CYD-X): is an insecticidal virus:

**Cultural Controls:**

- Scouting aids in monitoring activity.
- Monitoring degree days prior to spraying may help minimize the need for spraying.
- Pheromone trapping, however is expensive.

**Oriental Fruit Moth**

(*Grapholitha molesta* Busck)

Oriental fruit moth (OFM) larvae are borers which commonly tunnel into fruit and/or into succulent shoot tips. Earlier generations confine attacks to the succulent twig growth which causes tips to wither and turn brown. Wormy fruit produced by oriental fruit moth resemble those of codling moth. A mass of dark excrement will be found at the burrow exit. Burrows of oriental fruit moth follow a more meandering course than codling moth and the larvae usually do not feed on the seeds. Insecticidal control is directed at moth flights.

**Chemical Controls:**

- Azinphos-methyl (Guthion 50WP): an organophosphate
- Phosmet (Imidan 50WP): an organophosphate
- Indoxacarb (Avaunt 30WG): safe for applicators, toxic to honey bees.
- Carbaryl (Sevin XLR): a carbamate insecticide
- Acetamiprid (Assail 30SG): safe for applicators, toxic to honey bees.
- Thiocloprid (Calypso): safe for applicators, toxic to honey bees.
- Clothianidin (Clutch 50WDG): safe for applicators, toxic to honey bees.

**Biological Controls:**

- Various parasitoids have been reported attacking the OFM

**Cultural Controls:**

- Release pheromones for mating disruption may aid in control and is expensive.
- Degree Day models may aid in determining when to scout or spray
- Pheromone traps to determine presence of this pest

**Plum curculio**

(*Conotrachelus nenupar* Herbst)

Apples attacked by plum curculio have surface scarring from feeding and egg laying. Females make crescent-shaped cuts on the fruit surface during egg-laying. Scars develop at these sites regardless of whether or not eggs hatch. Immature infested apples often fall prematurely, or, if they stay on the tree, they may be hard, knotty and misshapened. Adult plum curculio overwinter under trash, usually in woods adjacent to the orchards. Movement from overwintering sites starts about at bloom and may occur over a period of 4 to 6 weeks. Larvae feed on the flesh, core and seeds. Full grown larvae leave the fruit and pupate in the soil. Second generation adults begin to emerge about 1 month after the larvae enter the soil. Egg laying by the second generation adults will normally begin in mid-June and continue through July.

**Chemical Controls:**

- Azinphos-methyl (Guthion 50WP): an organophosphate
- Phosmet (Imidan 70WP): an organophosphate

- Indoxacarb (Avaunt 30WG): safe product.
- Thiomethoxam (Actara 25WDG): possible threat to honey bees, but safe for applicator.
- Thiacloprid (Calypso 4F): toxic to honey bees but safe for applicator.
- Clothianidin (Clutch 50WDG): toxic to honey bees but safe for applicator.
- Carbaryl (Sevin XLR): a carbamate insecticide, may cause surge of other pests.

**Biological Controls:**

- Several species of wasps parasitize the eggs and larvae.
- Some fungi have been reported to kill larvae.
- Predators (ants, lacewings, and ground beetles)

**Cultural Controls:**

- Sanitation may aid in their control, but not proven.
- Scouting will inform producers when the pest is present.
- Winter prune to open up canopy in order to enhance spray coverage.
- Degree Day models may aid producers to determine when it may become present.
- Traps

### **White Apple Leafhopper**

*(Typhlocube pomaria)*

White apple leafhoppers suck sap from leaves destroying green tissue, causing the leaves to become speckled or mottled with white spots. Besides injuring leaves, leafhoppers deposit numerous small spots of excrement on fruit, potentially reducing its quality. White apple leafhoppers overwinter in the bark of 1- to 5-year-old wood. Eggs begin hatching at pink. Adults develop in June and are active for several weeks. During this period, they lay eggs in the petiole and veins of leaves. The eggs begin to hatch during June. Leafhoppers feed in the orchard into fall. Effective control of the first brood may prevent high populations of the second.

**Chemical Controls:**

- Carbaryl (Sevin XLR): is a carbamate insecticide.
- Thiomethoxam (Actara 25WDG): safe for applicators, toxic to honey bees.
- Acetamiprid (Assail 30SG): safe product.
- Thiacloprid (Calpyso 4F): safe for applicators, toxic to honey bees.
- Imidacloprid (Provado 1.6F): possible threat to honey bees.
- Indoxacarb (Avaunt 30WG): safe product.
- Clothianidin (Clutch 50WDG): safe for applicators, toxic to honey bees.
- Buprofezin (Centaur 70WP):
- **NOTES:** Use of the insecticide carbaryl (Sevin) as a thinner often provides excellent control of this pest.

**Biological Controls:**

- Parasitoids have been reported but not in Tennessee

**Cultural Controls:**

- Monitor presence of this pest
- Economic Threshold: For first generation leafhoppers would be one nymph per leaf:

## Spotted Tentiform Leafminer (STLM)

(*Lithocolletis blancardella*)

Spotted tentiform leafminers injure apple leaves by internal feeding or "mining." Each mature mine reduces the leaf's green tissue by about 5 percent. Mines buckle the leaf like a small tent. Excessive mining combined with drought, mite injury, or foliar diseases may be quite damaging. Mines remain visible after the leafminer has emerged or been killed by sprays. Leafminers feed in orchards from early spring until leaves drop in the fall. They overwinter as a pupa inside apple leaves on the orchard floor. Adult emergence begins around the ½ inch green stage and continues through bloom. A complete generation requires 35 to 55 days.

### Chemical Controls:

- Thiomethoxam (Actara 25WDG): safe for applicators, toxic to honey bees.
- Spinetoram (Delegate WG): safe for applicator
- Imidacloprid (Provado 1.6F): possible threat to honey bees.
- Spinosad (SpinTor 2SC): safe for applicator
- Acetamiprid (Assail 30SG): safe for applicators, toxic to honey bees.

### Biological Controls:

- A braconid wasp *Pholetesor ornigis* may provide some control, if present in the area.

### Cultural Controls:

- Select areas with large trees surrounding orchard may slow migration of this pest.

## European Red Mite (*Panonychus ulmi*)

European red mites feed on leaves. Severe injury produces bronzing of the leaves and reduction in photosynthetic capability which may reduce the quality and size of fruit and adversely affect return bloom. European red mites overwinter as eggs on twigs and smaller branches of trees. Eggs begin to hatch just before bloom. Ordinarily, mite populations build up slowly in spring. However, under hot, dry weather conditions, populations may reach very high levels in a short period of time. Red Delicious seems to be especially prone to mite problems.

### Chemical controls:

- Abamectin (Agri-Mek 0.15EC): commonly applied with oil. Provides excellent control.
- Oil (Superior oil): used as a preventative. Captan should not be used within 2 weeks prior to or after application. Ferbam should not be used within 7 days of application.
- Clofentezine (Apollo SC): provides excellent control.
- Hexythiazox (Savey 50WP): provides excellent control.
- Etoxazole (Zeal 72WDG): provides excellent control.
- Tert-butyl-p-toulate (Portal 0.4EC): provides excellent control.
- Spirodiclofen (Envidor 2SC): provides good to excellent control.

### Biocontrols:

- The predacious lady beetle, *Stethorus punctum*, feed on plant-feeding mites.
- Predatory mite, *Ambelacious fallacies*
- Predatory mite, *Zetzellia mali*
- **NOTES:** Careful examination of the orchard with a hand lens is necessary to determine predator populations. If predator numbers are low and plant-feeding mite populations are

high, use of a selective miticide might be warranted.

**Cultural controls:**

- None, however high populations have been associated with dirt roads and dusty foliage.

**Other occasional invaders**

Other occasional insect pests include; plant bugs, leafhoppers and leaf rollers. Maintaining clean groundcover helps eliminate the need to use insecticides for control. Other commonly used insecticides provide control of several pests and should provide control of occasional invaders.

**Insecticides available for use in apples:**

Several insecticides are available for use in apple production. Maintaining clean groundcover helps eliminate the need to use insecticides for control of plant bugs other insects. Maintaining groundcover also reduces the need for herbicide applications. Table 1, provides information concerning the relative effectiveness of insecticides and miticides use in apple production. Table 2, provides information concerning toxicity of pesticides to several beneficial arthropods that have been observed in apple production areas. Table 3, provides information concerning losses observed during 2009 from arthropod infestations. Infestations levels often vary greatly from orchard to orchard from year to year and the table lists average losses that were observed. Table 4, lists the estimated percent use of insect control products during 2009 apple production and of the area treated the percent receiving one, two and/or three insecticide applications.

**Organophosphate insecticides:**

- **Chlopyrifos** (Lorsban 4E):
  - Target pests: climbing cutworms, lygus, obliquebanded leafroller, pandemic leafrollers, rosy apple aphid, San Jose scale, American plum borer, apple bark borer, broad necked root borer, dogwood borer, flatheaded appletree borer, round headed apple tree borer, tilehorned prionus.
  - PHI: 28 days
  - REI: 12 hours
  - Signal word: Warning, and is a Restricted Use Pesticide
  - Frequency and rate: 0.5 to 4 pints to 1.5 quarts per acre depending on targeted pest. Higher rates are normally applied to the trunk of the tree. Only one application per year either a pre-bloom dormant/delayed dormant spray to the canopy or the trunk, or a post-bloom application to the lower 4 feet of the trunk.
- **Diazinon** (Diazinon 50W):
  - Targeted pest: San Jose scale, woolly apple aphid
  - PHI: 21-days
  - REI: 24 hour. Airblast application has a 4-day REI.
  - Signal word: Caution and is a Restricted Use Pesticide
  - Frequency and rate: one dormant and one foliar application or two foliar applications with a maximum of two applications per year. Retreatment interval is 14-days.
- **Methidathion** (Supracide 2E):

- Targeted pest: San Jose scale, rosy apple aphid
- PHI: N/A
- REI: 3-days
- Signal word: Danger, and is a Restricted Use Pesticide
- Frequency and rate: applied before blossoms open, no more than one application per season, treated areas are not to be grazed. Use 3 to 12 pints per acre.
- **Phosmet (Imidan 70WP):**
  - Targeted pest: Apple maggot, codling moth, European sawfly, leafrollers, green fruitworm, Japanese beetle, mealybug, Oriental fruit moth, San Jose scale, redbanded leafroller.
  - PHI: 7-days
  - REI: 3-days
  - Signal word: Warning
  - Frequency and rate: 2.12 to 5.33 lbs per acre per application and no more than 5.33 lbs maximum per application. No more than 30 lbs formulation per acre per season.
  - NOTES: should not be applied when bees are in the area.
- **Azinphos-methyl (Guthion 50WP):**
  - Targeted pest: Aphids, apple maggot, codling moth, European apple sawfly, leafhoppers, mealybug, plum curculio, San Jose scale, stink bug, green fruitworm, tarnished plant bug, other scales.
  - PHI: 14- 21-days depending on rate used.
  - REI: 33 to 44 days depending on PPE used.
  - Signal word: Danger
  - Frequency and rate: formulation rate of 2 to 3 lbs formulation per acre with a maximum rate is 3 lbs formulation or 1.5 lbs ai per acre.
  - NOTES: some species have developed resistance to this product. Product may not be used after Sept. 30, 2012. A vegetative buffer zone of 60 feet is required near waterways, ponds and occupied dwellings.

**Carbamate insecticides:**

- **Carbaryl (Sevin 50WP, XLR)**
  - Targeted pest: leafhopper, apple aphid, codling moth, apple rust mite, apple maggot, European sawfly, Gypsy moth, Japanese beetle, Lesser appleworm, Lygus bugs, plum curculio, redbanded leafroller, scale insects, tarnished plant bug, woolly apple aphid, periodical cicada.
  - PHI: 3-days
  - REI: 12-hour
  - Signal word: Caution
  - Frequency and rate: when using XLR, 0.5 to 3 quarts per acre per application. For thinning 2 to 6 pints per acre. No more than 8 applications per year, no more than 15 quarts of XLR per year.
  - NOTES: product should not be applied when bees are present. If weeds are in bloom, mow areas in orchard floor prior to application.
- **Methomyl (Lannate 90SP):**
  - Targeted pest: apple aphid, rosy apple aphid, tufted apple budworm, green fruitworm, tarnished plant bug, codling moth, leafrollers, lesser appleworm, white

- apple leafhopper, tentiform leafminer, cutworms
- PHI: 14-days
- REI: 72-hours
- Signal word: Danger and is a Restricted Use Pesticide.
- Frequency and rate: formulation rate range of 0.5 to 1 lb per acre with no more than 5 applications per season and no more than 5 lbs formulation per acre per season.
- NOTES: should not be used early on Macintosh or Wealthy varieties.
- **Oxamyl** (Vydate 2L)
  - Targeted pests: rosy apple aphid, apple aphid, spotted tentiform leafminer, European red mite, two-spotted spider mite, white apple leafhoppers.
  - REI: 48-hours
  - PHI: 14-days
  - Signal word: Danger, is a Restricted Use Pesticide
  - Frequency and rate: applied at the formulation rate range of 4 to 8 pints per acre.
  - NOTES: should not be applied at bloom or within 30 days of bloom, due to fruit thinning issues.

**Pyrethroid insecticides:**

- **Esfenvalerate** (Asana XL 0.66):
  - Targeted pest: apple maggot, codling moth, green fruitworm, lesser appleworm, oblique banded leafroller, oriental fruit moth, periodical cicada, plant bugs, plum curculio, red-banded leafroller, rosy apple aphid, San Jose scale, tentiform leaf miner, variegated leafroller, white apple leafhopper, tufted apple bud moth.
  - PHI: 21-days
  - REI: 12-hour
  - Signal word: Warning, is a Restricted Use Pesticide
  - Frequency and rate: 0.025 to 0.075 lbs per acre or 4.8 – 14 fl.oz. per acre. Livestock should not be grazed on treated orchard floors. Do not apply more than 0.525 lbs ai per acre per season. May be detrimental to beneficial insects.
- **Fenpropathrin** (Danitol 2.4EC):
  - Targeted pest: potato leafhopper, rosy apple aphid, spotted tentiform leafminer, tarnished plant bug, white apple leafhopper, apple maggot, codling moth, European apple sawfly, European red mite, green fruitworm, Japanese beetle, lesser appleworm, lygus bug, Obliquebanded leafroller, oriental fruitmoth, pandemic leafroller, plum curculio, redbanded leafroller, stinkbugs, tufted apple budmoth, twospotted spider mite, variegated leafroller,
  - PHI: 14-days
  - REI: 24 hours
  - Signal word: Warning, is a Restricted Use Pesticide
  - Frequency and rate: 10.66 fl.oz. to 21.33 fl.oz. No more than 0.8 lbs ai and two application per season. Do not allow livestock to graze in treated areas. Applications for aphids generally made as a pre-bloom spray.
  - NOTES: timing is critical for aphid control.
- **Lambda-cyhalothrin** (Warrior 2.08):
  - Targeted pest: apple aphid, apple maggot (adult), codling moth, green fruitworm, Japanese beetle, leafhopper species, leafroller species, lesser appleworm,

Omnivoriuns leafrollers, Oriental fruit moth, periodical cicada, plant bug species, rosy apply aphid, San Jose scale, stink bug species, tentiform leaf miner species, tree borer species, tufted apple budworm, webworm species.

- PHI: 21-days
- REI: 24-hours
- Signal word: Warning and is a Restricted Use Pesticide.
- Frequency and rate: Applied at the rate range of 1.28 to 2.56 fl.oz. formulation per acre or 0.02 to 0.04 lbs ai per acre per application. No more than 0.2 lbs ai per acre per season and no more than 0.16 lbs ai per acre per year post-bloom should be applied.
- **Permethrin** (Ambush 2E):
  - Targeted pest: apple aphid, redbanded leafroller, oblique banded leafroller, plum curculio, white apple leafhopper, spotted tentiform leafminer, tarnished plant bug, green fruitworm.
  - PHI: N/A
  - REI: 12-hours
  - Signal word: Warning and is a Restricted Use Pesticide.
  - Frequency and rate: applied at the rate range of 6.4 to 25.6 floz per acre 0.1 to 0.4 lbs ai per acre per application. Should not be applied during petal fall and no more than 0.6 lbs ai per acre per season.

#### **Insect Growth Regulators:**

- **Pyriproxyfen** (Esteem 35WP): is a growth regulator.
  - Targeted pest: codling moth, aphids, leafminer, scale insects, and suppression of leafrollers.
  - PHI: 45-days
  - REI: 12-hours
  - Signal word: Caution
  - Frequency and rate: 3 to 5 oz. and not to exceed 2 applications per growing season. Multiple applications should be made at 14-day or greater intervals. Should be rotated with other insecticides containing different modes of action to reduce resistance within the pest populations.
- **Etoxazole** (Zeal 72WDG): is a mite growth inhibitor.
  - Targeted pest: European red mite, two spotted spider mite and other spider mites.
  - PHI: 28-day
  - REI: 12-hour
  - Signal word: Caution
  - Frequency and rate: 2 to 3 oz. per acre and no more than 3 oz per acre and no more than one application per year.

#### **Neonicotinoid Insecticides:**

- **Acetamiprid** (Assail 30SG) is a neonicotinoid insecticide.
  - Targeted pest: aphids, tentiform leafminer, leafhoppers, codling moth, Oriental fruit moth, lesser appleworm, Japanese beetle, European apple sawfly, dogwood borer, apple maggot, plum cucurlio, and suppression of San Jose scale.
  - PHI: 7-days
  - REI: 12-hours

- Signal word: Caution
- Frequency and rate: application rate range from 2.5 to 8.0 fl.oz. or 0.047 to 0.15 lbs ai per acre per acre. No to exceed 5 applications per season and not to exceed more than 0.56 lbs ai (29.3 fl.oz) per acre per growing season.
- NOTES: toxic to honey bees.
- **Clothianidin** (Clutch 50WDG): is a neonicotinoid insecticide.
  - Targeted pest: aphids, leafhoppers, plum curculio, apple maggot, leafminers, suppression of Oriental fruit moth, and leafrollers
  - PHI: 7-days
  - REI: 12-hour
  - Signal word: Caution
  - Frequency and rate: Apply at post bloom when at economic threshold levels and not after populations have greatly passed threshold. Applied at the formulation rate range of 2 to 6 oz per acre per application. No more than 6.4 oz formulation or 0.2 lbs ai per acre per season should be applied. Do not apply treatments less than 10 days apart. For post-bloom applications.
  - NOTES: Livestock should not be feed or be allowed to graze on cover crops from treated areas. Toxic to honey bees.
- **Imidacloprid** (Provaodo 1.6F): is a neonicotinoid insecticide
  - Targeted pest: leafhoppers, apple maggot, leafminers, aphids (except woolly apple aphid)
  - PHI: 7-days
  - REI: 12-hours
  - Signal word: Caution
  - Frequency and rate: applied at the formulation rate range of 4 to 8 fl.oz per acre per application with a maximum amount of 40 fl. oz or 0.5 lbs ai per acre per season.
  - NOTES: should not be applied pre-bloom or during bloom to reduce harm to bees. Toxic to mite predator *Stethorus punctum*.
- **Thiacloprid** (Calypso 4F): neonicotinoid insecticide
  - Targeted pest: aphids (except woolly apple aphid) leafminers, leafhoppers, mirid bugs, apple maggot, codling moth, European apple sawfly, Oriental fruit moth, plum curculio, and suppression of scale insects.
  - PHI: 30-day
  - REI: 12-hours
  - Signal word: Warning
  - Frequency and rate: applied at the rate range of 2 to 8 fl.oz. per acre. Allow 7 or more days between applications. No more than 16 fl.oz. (0.5 lbs ai) per acre per season.
  - NOTES: Toxic to honey bees.
- **Thiomethoxam** (Actara 25WDG) is a neonicotinoid insecticide.
  - Targeted pest: apple aphid, apple grain aphid, green peach aphid, leafminers, mullein bug, rosy apple aphid, leafhoppers, European sawfly, plum curculio.
  - PHI: 14 to 35 days depending on rate used.
  - REI: 12-hour
  - Signal word: Caution

- Frequency and rate: Applied at the formulation rate range of 2 to 5.5 oz. per acre. do not apply after pre-bloom (early pink growth stage) or before post bloom (petal fall growth stage). Should not exceed more than 16.5 oz/acre or 0.258 lbs ai/acre per season. Should not be applied by air.
- NOTES: Bees are highly sensitive to this product, so do not spray when plants in areas intended to be treated are at bloom.

**Insecticides with other modes of action:**

- **Endosulfan** (Thiodan, Phazer 3EC) is a cyclodiene organochlorine insecticide.
  - Targeted pest: aphids, apple rust mites, green fruitworms tarnished plant bugs, tentiform leafminers, white apple leafhoppers (first generation).
  - PHI: 21-day
  - REI: 48-hours
  - Signal word: Warning
  - Frequency and rate: 0.66 quarts (0.495 lbs ai) per 100 gallons of solution. Culled fruits should not be fed to livestock. No more than two applications may be made during the fruiting period and no more than 3 applications per year and not to exceed 2.5 lbs ai per acre per season.
  - NOTES: some resistance by rosy apple aphid has been reported.
- **Hexakis** (Vendex 50WP): is an organochloride insecticide.
  - Targeted pest: apple rust, spider mites
  - REI: 48-hours
  - PHI: 14-days
  - Signal word: Danger and is a Restricted Use Pesticide
  - Frequency and rate: 1 – 2 lbs formulation per acre per application. No more than two application or 4 lbs formulation per acre per season.
- **Dicofol** (Kelthane 50WP): has an unknown mode of action
  - Targeted pest: mite control
  - REI: 48-hours
  - PHI: 7-days
  - Signal word: Danger
  - Frequency and rate: no more than two applications per season. Applied at the rate of 3 to 6 lbs per acre per application.
- **Clofentezine** (Apollo 1 SC): is a tetrazine compound which is a mite growth inhibitor.
  - Targeted pest: spider mites, European red mites and other mites.
  - PHI: 45-days
  - REI: 12-hours
  - Signal word: Caution
  - Frequency and rate: applied at the formulation rate range of 4 to 8 oz. at delayed dormant until first sign of mites.
  - NOTES: Use when predatory mite populations are low. Should not apply this product or Savey in successive years.
- **Hexythiazox** (Savey 50WP): is a mite growth inhibitor.
  - Targeted pest: European red mite, two-spotted spider mite, and several other spider mites.

- PHI: 28-day
- REI: 12-hour
- Signal word: Caution
- Frequency and rate: formulation rate of 3 to 6 oz. with no more than one application per year.
- NOTES: not to be used at petal fall or as a second cover spray. Should not be used by itself or in successive years with Apollo to minimize the potential for resistance.
- **Fenpyroximate** (Portal 0.4EC): Site I electron transport inhibitor and a phenoxy-pyrazol compound.
  - Targeted pest: European red mite, mealy bug species, two spotted spider mite, white apple leafhopper, other mites and suppression only of the glassy-winged sharpshooter and apple rust mite.
  - PHI: 14-day
  - REI: 12-hour
  - Signal word: Warning
  - Frequency and rate: 1 to 2 pints with no more than 2 pints per season and no more than two applications per year.
  - Practically nontoxic to bees and wasps.
- **Spirodiclofen** (Envidor 2SC): is a tetronic acid which inhibits acetyl CoA carboxylase activity.
  - Targeted pest: Apple rust mite, European red mite, twospotted spider mite and other mites.
  - PHI: 7-day
  - REI: 12-hour
  - Signal word: Caution
  - Frequency and rate: 16 to 18 fl.oz. or 0.25 to 0.28 lbs ai per acre per application with no more than one application per crop season.
- **Indoxacarb** (Avaunt 30WG): oxadiazine insecticide.
  - Targeted pest: Beet armyworm, provides some suppression of leafhoppers
  - PHI: 3-days
  - REI: 12-hours
  - Signal word: Caution
  - Frequency and rate: 2.5 to 6 oz. or 0.045 to 0.11 lbs ai per acre and not to exceed 0.44 lbs ai per acre per year.
- **Buprofezin** (Centaur 70WP): Inhibits chitin biosynthesis.
  - Targeted pest: leafhoppers, mealybugs, scales
  - PHI: 60-days
  - REI: 12-hours
  - Signal word: Caution
  - Frequency and rate: applied when peak crawlers emerge. Applied at the formulation rate of 34.5 oz per acre and no more than one application per season.
- **Kaolin** – hydrated aluminum silicate (Surround 95 WP):
  - Target pests: cutworms, eastern tent caterpillar, European apple sawfly, Gypsy moth, Japanese beetle, June beetle, green fruitworm, leafrollers, periodical cicada, stink bug, tarnished plant bug, apple maggot, leafhoppers, codling moth, oriental

- fruit moth, plum curculio, and thrips. Also provides control of Fabrea leafspot.
  - PHI: 0-days
  - REI: 4-hours
  - Signal word: Caution
  - Frequency and rate: Applied at the formulation rate range of 25 to 50 lbs per acre. Applied to fresh market apples that are not to be waxed.
- **Bifenazate** (Acramite 50WS):
  - Targeted pests: mites
  - REI: 12-hours
  - PHI: 7-days
  - Signal word: Caution
  - Frequency and rate: 0.75 to 1 lbs only one application per year allowed.
- **Spirotetramat** (Movento 2): tretronic and tetramic acid derivative which inhibits acetyl CoA carboxylase.
  - Targeted pests: aphids, mealybugs, San Jose scale, whiteflies and pear psylla.
  - REI: 24-hours
  - PHI: 7-days
  - Signal word: Caution
  - Frequency and rate: No more than 25 fl.oz. (0.4 lbs ai) per acre per season should be applied. Should not be applied until after petal fall.
- **Chlorantraniliprole** (Altacor 35W): diamide classification and a ryanodine receptor modulator.
  - Targeted pests: green fruitworm, spotted tentiform leafminer, codling moth larvae, European corn borer, leaf rollers, Oriental fruit moth, and suppression of the white apple leafhopper, plum curculio and apple maggots.
  - REI: 4-hours
  - PHI: 14-days
  - Signal word: Caution
  - Frequency and rate: applied at the formulation rate of 2.5 to 4.5 oz or 0.055 to 0.099 lbs ai per acre per application. No more than 4 applications or more than 9 oz. per crop per season
- **Chlorantraniliprole** and **thiamethoxam** (Voliam Flexi WDG): is a mixture of 20% chlorantraniliprole and 20% thiamethoxam.
  - Targeted pests: codlin moth, green fruitworm, leaf hoppers, leafroller, Oriental fruit moth, leafminers, tufted apple budmoth, apple aphid, mealybug, rosy apple aphid, European apple sawfly, plum curculio, leafminers, pear psylla.
  - REI: 12-hour
  - PHI: 35-days
  - Signal word: Caution
  - Frequency and rate: Applied at the formulation rate range of 4 to 7 oz per acre. No more than a total of 16 oz. per acre or more than 4 applications per season. Do not apply after pre-bloom or before post-bloom
  - NOTES: Do not allow treatment to drift in areas where bees may be visiting.
- **Flubendiamide** (Belt 4SC): diamide classification and a ryanodine receptor modulator.
  - Targeted pests: codling moth, fall webworm, leafrollers, lesser appleworm, Oriental fruit moth, tufted apple bud moth

- REI: 12-hours
- PHI: 14-days
- Signal word: Caution
- Frequency and rate: applied at the formulation rate of 3 to 5 (0.156 lbs ai) fl. oz. per acre, with no more than 15 fl.oz. (0.468 lbs ai) per acre per crop season. No more than three applications per season.
- **Pyridaben** (Nexter 75WP): is a pyridazinone compound
  - Targeted pest: mites, leafhopper nymphs and suppression of aphids
  - REI: 12-hours
  - PHI: 25-days
  - Signal word: Warning
  - Frequency and rate: applied at the formulation rate of 5.2 to 10.67. Only one application per season.
  - NOTES: May not be applied by air.
- **Sulfur** (Thiolux 80WP):
  - Target pest: mites, powdery mildew and scab.
  - REI: 24-hours
  - PHI: N/A
  - Signal word: Caution
  - Frequency and rate: 10 to 30 lbs pre-bloom and petal fall
  - NOTES: Should not be applied when temperatures exceed 95 degrees.

#### **Biological Controls:**

- **Abamectin** (Agri-Mek 0.15EC): macrocyclic lactone insecticide
  - Targeted pest: European red mite, tentiform leafminer, twospotted spider mite, and white apple leafhopper.
  - PHI: 28-day
  - REI: 12-hour
  - Signal word: Warning, is a Restricted Use Pesticide
  - Frequency and rate: It is commonly mixed with oil and is applied between petal fall and third cover. Should not be applied within 14 before or after applying Captan. May cause russetting on light-skinned varieties. No more than two applications per season. Applied at the rate range of 10 to 20 fl.oz per acre. No more than 20 fl.oz. or 0.023 lbs ai per acre per season.
  - NOTES: Livestock should not be allowed to graze in treated areas.
- ***Bacillus thuringiensis*** (Dipel 2X, CryMax, XenTari): is a bacteria, which disrupts the insect's mid-gut membranes.
  - Targeted pest: various caterpillars, leafrollers, plum curculio, Oriental fruit moth.
  - PHI: none listed
  - REI: 4-hours
  - Signal word: Caution
  - Frequency and rate: 0.5 to 2 lbs formulation per application per acre.
  - NOTES: considered an organic method of control.

- ***Cydia pomonella* granulovirus (CYD-X)**: is an insecticidal virus:
  - Targeted pest: codling moth
  - PHI: none listed
  - REI: 4-hours
  - Signal word: Caution:
  - Frequency and rate: 1 to 6 fl.oz. per acre
  - NOTES: best if applied when temperatures are below 90 degrees.
- **Spinosad (SpinTor 2SC)**: is a naturally insecticide
  - Targeted pest: leafminers, codling moth, European corn borer, gypsy moth, leafrollers, light brown apple moth, Oriental fruit moth, thrips, tufted apple budmoth.
  - PHI: 7-days
  - REI: 4-hours
  - Signal word: Caution
  - Frequency and rate: formulation rate range of 4 to 10 fl.oz. per acre. Do not apply more than 29 fl.oz. per acre per season.
  - NOTES: control of leafminers and thrips may be improved with the addition of an adjuvant.
- **Spinetoram (Delegate WG)**: is a spinosyn insecticide.
  - Targeted pest: codling moth, oriental fruit moth, European corn borer, gypsy moth, leafminers, leafrollers, lesser appleworm, thrips, tufted apple budmoth, and suppression of the apple maggot and plum curculio.
  - PHI: 7-days
  - REI: 4-hours
  - Signal word: Caution
  - Frequency and rate: 4.5 to 7 oz per acre with no more than 4 applications per year and no more than 28 oz formulation or 0.438 lbs ai per acre per year. Multiple applications should not be made less than 7 days apart.

## Pheromones

Pheromones are natural chemicals emitted by insects that mediate communications between individuals of the same species. Pheromones serve a number of functions including identifying the location of food sources, alarming other individuals about potential dangers, and locating potential mates. Pheromones are ubiquitous in the environment, and are not considered to be air pollutants.

In apple production, commercially developed pheromones are used to disrupt insect mating and pheromone traps should be erected by green tip stage to detect first emergence of the oriental fruit moth (OFM): Several available pheromone products include; CheckMate OFM, CheckMate OFM-F, Disrupt OFM, Isomate-M 100, and Isomate-M Rosso. Pheromone products used to aid in control of codling moths include: CheckMate CM-XL 1000, Disrupt CM-Xtra, Isomate-C TT, and Isomate CM/OFM TT.

**NOTES:** Pheromones are less likely to be used in Tennessee due to high cost of pheromones.

## Diseases

Disease pressure varies from orchard to orchard and from year to year. Producers are encouraged to scout fields for signs of diseases and practice sanitation to help reduce diseases from becoming problems in following years. Table 5, lists several diseases which were observed during the 2009 production season and estimated losses and Table 6, lists the relative effectiveness of fungicides used in apple orchards.

### Apple scab

(*Venturia inaequalis*)

Apple scab occurs on leaves, petioles, blossoms and fruit. A severe infection can cause extensive defoliation. Infection in spring is related to the duration of leaf wetness and temperature. Secondary infection can follow primary infection in less time than it took for primary infection to occur.

#### Chemical Controls:

- Ferbam (Ferbam 76WDG): provides fair to good control.
- Kresoxim-methyl (Sovran 50 WG): provides excellent control. Has a 30-day PHI.
- Mancozeb (various): provides good control, however has a 77-day PHI.
- Myclobutanil (Nova 40W): provides excellent control.
- Captan (Captan 50W): normally applied with myclobutanil
- Metiram (Polyram 80DF): provides good control, normally applied with myclobutanil, however has a 77-day PHI.
- Pyraclostrobin and boscalid (Pristine): provides excellent control and has a 0-day PHI.
- Pyrimethanil (Scala SC): provides good to excellent control and has a 72-day PHI.
- Dodine (Syllit): provides excellent control, but does not control some of the other common diseases. Some resistance has been reported in the Northeast.

#### Biological Controls:

- *Microsphaeropsis ochracea* may provide control, but currently no data for TN.

#### Cultural Controls:

- Resistant cultivars that have a early maturity date.
- Sanitation of overwintering inoculum.
- Chopping up fallen leaves and adding urea fertilizer to enhance degradation.
- Mills table to predict if a scab infection period has occurred

### Fireblight

(*Erwinia amylovora*)

Fireblight is a bacterial disease that can be devastating in some cultivars and rootstocks of apple. Infection can occur from overwintering cankers, through the blossom, through the youngest leaves on new shoots and through injuries resulting from hail, high winds or driving rain. Control is based on elimination of overwintering cankers prior to the initiation of growth in spring, the use of copper sprays shortly before bloom, streptomycin sprays during bloom if weather conditions favor infection, and through the use of a modest nitrogen fertilization program. Apogee, a new growth regulator, shows some promise in fireblight control by reducing the length of time in which shoots are elongating and are, therefore, susceptible.

**Chemical Controls:**

- Streptomycin sulfate (Agri-Mycin 17): has a 50-day PHI.
- Coppers (Various):
- Prohexadione calcium (Apogee): a growth regulator which aids by reducing the length of time in which shoots are elongating which may aid in fireblight control.

**Bio-controls:**

- *Erwinia herbicola* may control, but no data in Tennessee.
- *Pseudomonas* spp. have been reported to inhibit growth of this organism, but no data.

**Cultural Controls:**

- Differences among cultivars and rootstocks in regards to fireblight susceptibility exist and may offer another method of lessening fireblight.
- Eliminate overwintering cankers prior to initiation of growth in the spring by pruning.
- Modest nitrogen fertilization.

**Powdery mildew**

(*Podosphaeria leucotricha*)

Losses from powdery mildew result from the death of vegetative shoots and flower buds. Loss of fruit quality may also occur due to russeting which lessens its marketability. Powdery mildew overwinters in buds that were infected the previous summer. Spores from powdery mildew germinate readily at high humidity and temperatures between 60 and 80 degrees F.

**Chemical Controls:**

- Trifloxystrobin (Flint): provides good control.
- Mancozeb (Dithane DF): should be mixed other fungicides to provide optimum control.
- Kresoxim-methyl (Sovran): possible resistance build up with multiple uses.
- Myclobutanil (Rally 40W): provides excellent control when mixed with captan or mancozeb or metiram.
- Boscalid and Pyraclostrobin (Pristine): provides a broad range of control for most diseases.
- Captan (Captan, Captec): usually needs another product mixed with it to provide adequate control.

**Bio-controls:**

- Possible control using epiphytic yeast, but no data for Tennessee.

**Cultural Controls:**

- Scout for the presence of this pest.

**Cedar apple rust**

(*Gymnosporangium juniper-virginiana*)

Cedar apple rust spends part of its life cycle on eastern red cedar. The pathogen requires 2 years to complete its life cycle. Cedar apple rust overwinters in reddish-brown galls in cedar. With wet weather in spring, spores are carried to apple. Infection will not occur below 43 degrees F. Apple fruits are most susceptible for a 2 to 3 week period beginning at bloom. Leaves are most susceptible when they are 4 to 8 days old. Lesions develop within 1 to 3 weeks following infection.

**Chemical Controls:**

- Fenarimol (Rubigan): provides excellent control when mixed with mancozeb or metiram.
- Thiophanate-methyl (Topsin M):
- Mancozeb (Dithane DF): should be mixed with other fungicides to obtain optimum control.
- Myclobutanil (Rally 40W): provides excellent control when used with other fungicides.
- Boscalid and Pyraclostrobin (Pristine): provides good control.
- Captan (Captan, Captec): provides only fair control when used alone.
- Metiram (Polyram): commonly mixed with other fungicides to obtain optimum control.

**Biological Controls:**

- None

**Cultural Controls:**

- Remove cedar trees that are in close proximity of orchard.

**Black rot**

(*Botryosphaeria obtusa*)

Leaf infection is called frog-eye leaf spot. Leaf symptoms first appear 1 to 3 weeks after petal fall. Sepal infection may occur prior to bloom resulting in early fruit abortion or blossom end rot later in the season. Fruit infection occurs after petal fall. Black rot overwinters in dead bark, twigs, cankers and mummified fruit. The optimum temperature for leaf infection is 80 degrees F accompanied by 4 ½ to 13 hours of leaf wetting. Optimum fruit infection occurs at 68 to 75 degrees F with 9 hours of leaf wetting.

**Chemical Controls:**

- Captan (Captan 50W, 5L): commonly mixed with ziram or captan to provide optimum control.
- Thiophante-methyl (Topsin-M): commonly mixed with captan.
- Kresoxim-methyl (Sovran): provides good control.
- Trifloxystrobin (Flint): provides good control.
- Ziram (Ziram): commonly mixed with captan to provide optimum control.
- Thiram (Thiram): **no longer labeled for apples.**
- NOTES: other commonly used fungicides may provide additional control.

**Biological Controls:**

- None

**Cultural Controls:**

- None

**White rot**

(*Botryosphaeria dothidea*)

This disease overwinters in dead bark, twigs and cankers in the tree. Fruit infection can occur throughout the growing season, but rot doesn't occur before soluble solids reach about 10%. Fruit infection can occur in 2 to 4 hours at 80 degrees F. White rot has the potential of destroying a large percentage of the crop within just a few days.

**Chemical controls:**

- Captan (Captan 50W, 5L): commonly mixed with ziram to provide optimum control.
- Thiophante-methyl (Topsin-M): provides good control.
- Kresoxim-methyl (Sovran): provides good control.
- Trifloxystrobin (Flint): provides good control.
- NOTES: other commonly used fungicides may provide additional control.

**Biological controls:**

- None

**Cultural controls:**

- Scouting may aid in detection, however must be done regularly.

### **Bitter rot**

*(Colletotrichum cingulata)*

Bitter rot overwinters in dead wood or mummified fruit hanging on the tree. Conidia are spread primarily by rain. Fruit is susceptible from 3 weeks after petal fall until harvest. A temperature of 80 to 90 degrees F is most favorable for bitter rot development.

**Chemical controls:**

- Ferbam (Ferbam): provides good to excellent control.
- Pyraclostrobin & boscalid (Pristine): has two modes of action.
- Thiophanate-methyl (Topsin M): provides good control.
- Thiram (Thiram): no longer labeled for apples.
- Trifloxystrobin (Flint): provides good control.
- NOTES: other commonly used fungicides may provide some control.

**Biological controls:**

- None

**Cultural controls:**

- Pruning of old dead wood
- Sanitation – removal of fallen limbs and fruit

### **Sooty blotch and flyspeck**

These diseases overwinter on twigs of many woody plants. Sooty blotch is spread by water. Flyspeck is airborne. Fruit infection can occur anytime after petal fall, but is most prevalent mid to late summer. Infection is favored by high temperature, high humidity and abundant rainfall. Sooty blotch grows on the surface of fruits and uses nutrients and plant saps and insect excrement. High humidity promotes these pests. Heavy fruit coverage reduces consumer appeal.

**Chemical controls:**

- Ziram (Ziram): preferred for sooty peach
- Captan (Captan): provides fair to good control

**Biological controls:**

- Any pest which feeds on aphids, scales, mealy bugs may reduce sooty blotch infestations.

**Cultural controls:**

- Pruning may help aeration of foliage.

### **Alternaria blotch** (*Alternaria* spp.)

This disease overwinters in fallen leaves and in buds. Infection (mid-May to early June) can occur in as little as 5 hours under favorable temperatures. Strains of Delicious and Empire appear to be the most susceptible.

#### **Chemical Controls:**

- **NOTES:** Most fungicides used for other diseases, control this pest.

#### **Biological Controls:**

- None

#### **Cultural Controls:**

- Monitoring (scout weekly) during weather with 800 to 900 degree days.
- Thinning fruit may aid since clustering of fruit is conducive to higher levels of injury from this pest.

### **Necrotic Leaf Blotch** (*Glomerella cingulata*)

Necrotic leaf blotch or Glomerella leaf spot is usually more common on the variety golden delicious and has been observed on Gala. Heavy infection reduces energy needed to produce fruit.

#### **Chemical Controls:**

- Thiram (Thiram 75WDG): no longer labeled for apples..
- Ziram (Ziram 76W or WDG): provides excellent control.
- Zinc oxide (Zinc oxide 39.8%): provides excellent control. Has a 0-hour REI and a 0-day PHI.
- **NOTES:** sprays from mid-June through early August are most critical.

#### **Biological Controls:**

- None

#### **Cultural Controls:**

- Avoid the variety Golden Delicious
- Scouting

## **Fungicides**

#### **Antibiotic Fungicides:**

- **Streptomycin Sulfate** (Agri-Mycin 17, Streptrol, Firewall): is an antibiotic which is formulated at 22.4% ai.
  - Targeted pests: fire blight
  - REI: 12-hours
  - PHI: 50-days
  - Signal word: Caution
  - Frequency and rate: 4oz to 8oz or 100ppm per acre is applied at bloom on a 3 to 5 day schedule and stop when fruit begin to develop. This could result in the range of 6 to 8 applications, if weather conditions are conducive for spread of the disease.
  - **NOTES:** cost ranges from \$3.81 to \$7.63 per acre per application.

### **Strobilurin fungicides:**

- **Boscalid and Pyraclostrobin (Pristine 38W):** Is a mixture containing 25.2% boscalid and 12.8 % pyraclostrobin. Pyraclostrobin is a strobilurin fungicide and must be rotated with non-strobilurin fungicides after two applications of the same fungicide classification. Boscalid is classified as a pyridine-carboxamide fungicide.
  - Targeted pest: Alternaria blotch, apple scab, bitter rot, black rot, cedar apple rust, flyspeck, frog-eye leaf spot, powdery mildew, sooty blotch, white rot.
  - REI: 12-hours
  - PHI: 0-day
  - Signal word: Caution
  - Frequency and rates: application rate of 14.5 to 18.5 oz per acre with no more than 4 applications per season and a maximum rate of 74 oz. per acre per season.
  - NOTES: cost ranges from \$42.63 to \$54.39 per acre per application.
- **Trifloxystrobin (Flint 50WG):** is a strobilurin fungicide
  - Targeted pests: scab, cedar apple rust, powdery mildew, sooty blotch, sooty blotch, flyspeck, Alternaria blotch, and suppression of white rot, bitter rot
  - REI: 12-hours
  - PHI: 14-days
  - Signal word: Caution
  - Frequency and rate: 1.5 to 3 oz per acre and do not apply more than 11 oz per acre per year. Do not exceed more than 4 applications per season.
  - NOTES: must be rotated with non-strobilurin fungicides after two applications of the same fungicide classification. Cost ranges from \$21.75 to 43.50 per acre per application.
- **Kresoxim-methyl (Sovran 50WG):** is a Strobilurin fungicide.
  - Targeted pest: scab, powdery mildew, frog-eye leafspot, fly speck, sooty blotch, white rot, Brook's fruit spot, black rot, rusts, and alternaria blotch.
  - REI: 12-hours
  - PHI: 30-days
  - Signal word: Caution
  - Frequency and rate: 4 to 6.4 fl.oz. per acre per application and a maximum of 25.4 fl.oz. per year. Applied at green tip to ½ in. green, 3<sup>rd</sup> & 4<sup>th</sup> cover.
  - NOTES: strobilurin fungicide and must be rotated with non-strobilurin fungicides after two applications of the same fungicide classification. No more than 3 consecutive applications and no more than 4 applications per season. Cost was not available for this product.

### **Triazole – DMI Fungicides:**

- **Difenoconazole (Inspire Super 2.08):**
  - Targeted pest: rusts, scab, powdery mildew, sooty blotch and flyspeck.
  - REI: 12-hours
  - PHI: 72-days
  - Signal word: Warning
  - Frequency and rate: applied at the rate of 1.3 to 4 fl.oz or 0.021 to 0.065 lbs ai per acre. Maximum of 20 fl.oz or 0.33 lbs per acre with no more than 2 consecutive applications, due to possible resistance problems. Spray at ¼ to ½ green tip or when environmental conditions are conducive for disease development.

- NOTES: recommended to be mixed with Vanguard to obtain effective control.
- **Fenbuconazole** (Indar 2L): is a triazole fungicide.
  - Targeted pest: flyspeck, powdery mildew, rusts, scab, sooty blotch.
  - REI: 12-hours
  - PHI: 14-days
  - Signal word: Caution
  - Frequency and rate: apply at 6 to 8 fl.oz (0.94 to 0.12 lbs ai ) per acre. No more than 4 applications per acre per year.
  - NOTES: Livestock should not be allowed to graze in treated areas or fed cover crops grown in treated areas. This product is very important for rust control. Commonly mixed with Captan, mancozeb and/or metiram.
- **Myclobutanil** (Rally 40W): is a triazole fungicide.
  - Targeted pests: scab, powdery mildew, cedar apple rust and quince rust
  - REI: 24-hours
  - PHI: 14-days
  - Signal word: Caution
  - Frequency and rate: 5 to 10 oz. per acre per application with no more than 6 applications per season. Applied at green tip to petal fall.
  - NOTES: very important for rust control. Cost ranges from \$21.00 to \$42.00 per acre per application. Commonly mixed with Captan, mancozeb and/or metiram.
- **Triflumizole** (Procure 50WS): is an imidazole or DMI fungicide.
  - Targeted pests: powdery mildew, scab, cedar apple rust
  - REI: 12-hours
  - PHI: none listed
  - Signal word: Caution
  - Frequency and rate: applied at green tip until tree is fully leaved at the formulation rate range of 8 to 16 oz per acre. With no more than 64 oz. formulation per acre per year.
  - NOTES: Livestock should not be allowed to graze or feed in treated areas. ): very important for rust control. Closely related to the triazole fungicides and is placed within the same fungicide grouping. Commonly mixed with captan or mancozeb or metiram or ziram.

#### **Dithiocarbamate fungicides:**

- **Ferbam** (Ferbam Granuflo): is a dithiocarbamate fungicide
  - Targeted pests: used to control apple scab, black rot, bitter rot, sooty blotch, fly speck, Brook's spot, cedar apple rust and quince rust.
  - REI: 24-hours
  - PHI: 7-days
  - Signal word: Caution
  - Frequency and rate: 3 to 8 lbs formulation or 0.75 to 2 lbs ai per acre.
  - NOTES: should not be sprayed within 7 days of an oil application. Cost ranges from \$13.50 to 36.00 per acre treated.
- **Mancozeb** (Dithane, Manzate, Pencozeb, 80W, 75DF or 4F): is a dithiocarbamate fungicide
  - Targeted pest: fabrea leaf spot, rusts, scab, powdery mildew.

- REI: 24-hours
- PHI: 77-days
- Signal word: Caution
- Frequency and rate: Pre-bloom to bloom and extended schedule use at 3 to 6 lbs formulation per acre. No more than 21 lbs (15.75 lbs ai) formulation per acre per year.
- NOTES: Cost ranges from \$14.82 to 29.64 per acre per application.
- **Metiram** (Polyram 80W): is a dithiocarbamate fungicide.
  - Targeted pests: apple rusts, apple scab
  - REI: 24-hours
  - PHI: 77-day
  - Signal word: Caution
  - Frequency and rate: 3 to 6 lbs formulaton with a maximum rate of 21-24 lbs formulation per year.
  - NOTES: Livestock should not be allowed to feed in treated areas or fed treated fruit.
- **Thiram** (Thiram 65W): is a dithiocarbamate fungicide.
  - Targeted pests: sooty mold, flyspeck, rusts, bitter rot.
  - REI: 24-hours
  - PHI: 7-days
  - Signal word: Caution
  - Frequency and rate: 0.5 to 1.8 lbs formulation per 100 gallons of spray.
  - NOTES: aids in inhibition of wildlife feeding on fruit. **NO LONGER labeled** for apples.
- **Ziram** (Ziram 76DF or 76WDG): is a dithiocarbamate fungicide.
  - Targeted pests: apple scab, cedar apple rust, quince rust, sooty blotch, fly speck, bitter rot, suppression of necrotic leaf blotch, scab, brown rot, peach leaf curl and shot hole
  - REI: 48-hours
  - PHI: 14-days
  - Signal word: Danger
  - Frequency and rate: applied from pre-bloom through cover sprays as needed. Applied at the rate range 6 to 8 lbs. Do not apply more than 42.6 lbs ai per acre per year.
  - NOTES: Cost ranges from \$20.64 to \$27.52 per acre per application. This product is commonly mixed with thiophanate-methyl to improve white rot, black rot, sooty blotch and fly speck control.

#### **Fungicides of Various Classifications:**

- **Thiophanate-methyl** (Topsin M 70W, 4.5L, others): is a benzimidazole fungicide
  - Target diseases: scab, rusts, Brooks spot, black rot, white rot, bitter rot, sooty blotch, flyspeck
  - PHI: 14 days
  - REI: 48 hours
  - Signal word: Caution
  - Frequency and rate: petal fall, cover sprays; 8 to 12 oz./acre
  - NOTES: Used with captan or ziram in cover sprays for optimum control. Some

resistance to benzimidazole fungicides has been observed in several locations.

- **Captan** (Captan 50W, 80W, 80WDG): is a phthalimide fungicide
  - Targeted pest: control of black rot, frog-eye leaf spot, powdery mildew and rust diseases.
  - REI: 96-hour
  - PHI: 0-day
  - Signal word: Danger
  - Frequency and rates: 4 to 8 lbs of 50W formulation per acre and no more than 32 lbs ai per acre per season.
  - NOTES: captan used alone will not control powdery mildew or rust diseases. . Powdery mildew may be more severe in trees sprayed with captan than trees not receiving an application. This product should not be applied within 2 weeks of an oil spray. Commonly mixed with Procure, Nova, Rubigan, and/or Indar. Cost ranges from \$19.20 to 38.40 per acre per application.
- **Cyprodinil** (Vanguard 75WG): is an aniline-pyrimidine fungicide.
  - Targeted pest: Scab
  - REI: 12-hours
  - PHI: 72-days
  - Signal word: Caution
  - Frequency and rates: 3 to 5 oz. per acre and no more than 1.4 lbs ai per acre per season.
  - NOTES: product is more active during cool temperatures. Often mixed with products containing mancozeb or metiram.
- **Pyrimethanil** (Scala 5SC): is a aniline-pyrimidine fungicide
  - Targeted pests: scab
  - REI: 12-hours
  - PHI: 72-days
  - Signal word: Caution
  - Frequency and rate: 7 to 10 fl.oz or 0.27 to 0.39 lbs ai per acre per year. No more than 40 fl.oz. formulation per crop season.
  - NOTES: not compatible with captan, do not apply more than 4 applications with fungicides of this mode of action. Possible resistance development when applying multiple applications.
- **Dodine** (Syllit FL 3.4): is a guanidine fungicide which has recently been cancelled.
  - Target pest: black spot, scab
  - PHI: 7-days
  - REI: 48-hours
  - Signal word: Danger
  - Frequency and rate: delayed dormant and pre-bloom sprays at the formulation rate of 1.5 to 4.5 pints per acre per application
  - NOTES: not compatible with captan, may cause russetting with Golden Delicious and Grimes Golden Delicious varieties. Possible development of resistance by scab.
- **Fenarimol** (Rubigan 1E): is a pyrimidine or DMI fungicide.
  - Targeted pest: scab, powdery mildew and rust (cedar-apple).
  - REI: 12-hours

- PHI: 30-days
- Signal word: Warning
- Frequency and rate: applications made from green tip to tight cluster at the rate of 8 to 12 fl. oz. formulation or 0.0625 to 0.093 lbs ai per acre. Do not apply over 12 oz./acre or 84 oz. per acre per season
- NOTES: livestock should not be allowed to feed or graze in treated areas. Commonly mixed with Captan, mancozeb and/or metiram.
- **Sulfur** (Thiolux and others):
  - Targeted pest: powdery mildew, scab and mites
  - REI: 24-hours
  - PHI: N/A
  - Signal word: Caution
  - Frequency and rate: 1 to 3 lbs active ingredient per acre for powdery mildew and 10 to 30 lbs for scab. Dormant, pre-bloom and petal fall.
  - NOTES: not safe to use when temperatures exceed 90 degrees. Product should be avoided after bloom on Golden Delicious, Red Delicious and Stayman to have best fruit finish.
- **Lime-Sulfur** (various):
  - Targeted pest: powdery mildew
  - REI: 24-hours
  - PHI: 0-days
  - Signal word: Caution
  - Frequency and rate:
  - NOTES: use on Rome Beauty before bloom. May cause phytotoxicity when applied above 85 degrees or when drying conditions are slow. Not compatible with oil, many insecticides and some fungicides.
- **Fosetyl-AI** (Aliette 80WDG): is an ethyl phosphonate fungicide
  - Targeted pest: collar rot
  - REI: 12-hours
  - PHI: 365 days
  - Signal word: Caution
  - Frequency and rate: 2.5 to 5 lbs formulation per acre
  - NOTES: Livestock should not be allowed to graze treated orchard floors. Cocker County is limited to 3.75 lbs formulation per acre per application.
- **Mefenoxam** (Ridomil Gold 4E): is an acylalanine fungicide.
  - Targeted pest: Phytophthora crown, collar rot and root rot.
  - REI: 48-hours
  - PHI: 1-day
  - Signal word: Caution
  - Frequency and rate: 2 quarts per acre and applied in the spring after planting before growth begins
  - NOTES: Applications are delayed for 2 weeks after planting to reduce possible phytotoxicity. Do not allow livestock to feed or graze treated orchards. Cost ranges from \$113 to \$226 per application.
- **Kerosene/water emulsion** (Gallex): is a growth regulator
  - Targeted pest: crown gall

- REI: N/A
- PHI: N/A
- Signal word: Warning
- Frequency and rate: is a 1% solution applied to galled area.
- NOTES: generally not used.
- **Hydrogen peroxide (Oxidate):**
  - Targeted pest: powdery mildew, rust, and scab.
  - REI: 0-hours
  - PHI: 0-days
  - Signal word: Danger
  - Frequency and rate: 1:100 to 1:300ppm or 40 to 128 fl.oz. per 100 gallons solution per treated acre.
  - NOTES: difficult to obtain product and cost was not available.
- **Polyoxin D and Zinc Salts (Endorse WP):**
  - Targeted pest: apple scab and alternaria blight.
  - REI: 4-hours
  - PHI: NA
  - Signal word: Caution
  - Frequency and rate: 2.2 lbs formulation per 100 gallons of water per acre.
  - NOTES: possible resistance, difficult to obtain product and cost was not available.
- **Phosphite groups (Prophyt 4.2, Agrifos):**
  - Targeted pest: scab, alternaria, flyspeck, phytophthora crown rot
  - REI: 4-hours
  - PHI: NA
  - Signal word: Caution
  - Frequency and rate: When using Prophyt apply 4 to 6 pints per acre.
  - NOTES: due to availability cost was not provided.

## Biologicals

- **Bacillus subtilis (Serenade):**
  - Targeted pest: fire blight, and scab suppression and control of powdery mildew.
  - REI: 4-hours
  - PHI: 0-day
  - Signal word: Caution
  - Frequency and rate: applied at the rate of 1 to 4 lbs per acre.
  - NOTES: cost was not available
- **Bacillus pumilus strain QST 2808 (Sonata):**
  - Targeted pest: suppression of scab and control powdery mildew
  - REI: 4-hours
  - PHI: 0-day
  - Signal word: Caution
  - Frequency and rate: 2 to 4 qts per acre.
  - NOTES: cost was not available.

## Weeds

Herbicide-based management programs have replaced cultivation for weed control. Orchard floor management consists of maintaining a 6 to 8 ft. wide vegetation-free strip down tree rows and close mowed sod between rows to support equipment travel and to reduce erosion from runoff water. Weeds and grasses compete strongly for moisture and nutrients - especially in young orchards and may result in up to 50% reduction in tree growth. Certain broadleaf weeds are alternate hosts for pests that can attack apples. Their elimination will increase the success of reducing pesticide applications. Orchard mowing occur from 4 to 10 times per year and highly depend on annual rainfall.

### Weed Management

Post-emergence herbicides are used to burn down existing vegetation. Pre-emergence herbicides are used to control germinating weed seeds. Tables 7 and 8, lists weed responses to several of the herbicides available for use in apple production. Noxious weeds should be controlled before trees are set. Care must be taken to use a non-persistent herbicide. Pre-emergence herbicides labeled for young trees can be used to control annual grasses and some small seeded broadleaf weeds. Post-emergence herbicides will be needed to control large seeded broadleaf weeds and perennial grasses. In established orchards, winter annuals can be controlled with the use of a fall pre-emergence herbicide plus a burn down material if needed. Winter annual broadleaf weeds are alternate hosts for some insects that attack apples. In spring, a pre-emergence herbicide (or combination of herbicides) may be used with a burn down material to control emerged weeds and to provide for residual weed control. After trees have been planted, the majority of herbicides are applied as a directed spray along each side of the tree row. Chemical weed control is used in approximately 90% of apple orchards and mowing occurs in all orchards. Table 9, lists an estimate of herbicide usage during the 2009 apple production season.

#### Chemical Controls:

- **Glyphosate** (Roudup, Gly-4, Gly-4 Plus, others): is a glycine herbicide.
  - Targeted pest: all perennial and annual weeds.
  - REI: 4-hours
  - PHI: 1-day
  - Signal word: Caution
  - Frequency and rate: applied at the formulation rate range 8 to 48 fl. oz. per acre.
  - NOTES: : Apply to trees established at least 2 years, do not contact foliage or green tissue with spray, can be used with pre-emergence herbicides as a tank mix. Cost ranges from a low of \$2.10 to \$22.22 per acre, depending on formulation and rate used.
- **Sethoxydim** (Poast 1.5): is a cycloheanedione (DIM) herbicide.
  - Targeted pest: grasses
  - REI: 12-hours
  - PHI: 0-day

- Signal word: Warning
- Frequency and rate: applied at the formulation rate of 0.5 pints per acre and only one application per season.
- NOTES: rotation with a different mode of action should be considered to reduce possibility of resistance. Cost of \$5.35 per acre.
- **Clethodim** (Select 2E, Arrow): is a cycloheanedione (DIM) herbicide.
  - Targeted pest: selective postemergence herbicide used for control of annual and perennial grasses.
  - REI: 24-hours
  - PHI: 365-days
  - Signal word: Warning
  - Frequency and rate: applied at the formulation rate range of 6 to 8 fl. oz. per acre.
  - NOTES: may only be applied to trees that will not be bearing fruit at least one year after application. Use of a non-ionic surfactant is recommended. Cost ranges from \$6.09 to \$8.13 depending on rate used.
- **Fluazifop** (Fusilade 2 DX): is a aryloxyphenoxypropionate (FOP) herbicide.
  - Targeted pest: annual and perennial grasses
  - REI: 12-hours
  - PHI: 365-days
  - Signal word: Caution
  - Frequency and rate: formulation rate range of 16 – 24 fl.oz. per acre and no more than 72 fl.oz. per acre per season.
  - NOTES: should not be applied to a crop intended for harvest within one year of application. Cost ranges from \$23.50 to \$35.25 depending on rate selected.
- **Glufosinate** (Rely 1.67): is a phosphinic acid herbicide.
  - Targeted pest: annual, perennial and broadleaf weeds.
  - REI: 12-hours
  - PHI: 14-days
  - Signal word: Warning
  - Frequency and rate: Applied at the formulation rate of 77 to 115 fl.oz. per acre per application with no more than 345 fl.oz. formulation per acre per calendar year. Lower rates are used on weeds shorter than 8 inches in size.
  - NOTES: cost ranges from \$40.30 to \$60.19 per acre depending on rate used.
- **Paraquat** (Paraquat, Gramoxone Inteon 2): is a bipyridylum herbicide.
  - Targeted pest: is a non-selective contact herbicide
  - REI: 12-hours
  - PHI: none listed, but a 28-day is listed for other crops
  - Signal word: Danger, is a Restricted Use Pesticide
  - Frequency and rate: 1.7 to 2.7 pints generic, Inteon rate ranges from 2.5 to 4 pints.
  - NOTES: depending on formulation requires use of a nonionic surfactant. Avoid contact with green bark or leaves of trees, may be tank mixed with certain pre-emergence herbicides. Cost ranges from \$9.88 to \$18.00 per acre depending on rate and/or formulation selected.
- **2-4-D** amine (Orchard Master 3.8, others): is a phenoxy herbicide.
  - Targeted pest: various broadleaf weeds
  - REI: 48-hours

- PHI: 14-days
- Signal word: Danger
- Frequency and rate: applied at the rate of 2 – 3 pints formulation or 1 to 1.4 lbs ai per acre. With a maximum of 2 application per acre per season.
- NOTES: do not apply more than 2 times per season or within 2 weeks of bloom. Usually not applied when temperature exceed 80 degrees or when wind velocity exceeds 5 mph. Cost ranges from \$4.60 to \$6.90 per acre per application depending on rate used.
- **Saflufenacil** (TreeVix 0.7): is an amide herbicide.
  - Targeted pests: broadleaf weeds
  - REI: 12-hours
  - PHI: 3 months prior to planting
  - Signal word: Caution
  - Frequency and rate: 1 oz. per application not to exceed 3 oz per crop season.:
  - NOTES: **recently came on the market for apples only.** Pricing was not available.
- **Pendimethalin** (Prowl 3.8 H<sub>2</sub>O): is a dinitroaniline herbicide.
  - Targeted pests: various perennial and annual weeds
  - REI: 24-hours
  - PHI: 60-days
  - Signal word: Caution
  - Frequency and rate: applied as a pre-emergent herbicide at the formulation rate of 2 to 4 quarts or 1.9 to 3.8 lbs ai per acre of Prowl H<sub>2</sub>O. Should not exceed 3.8 lbs ai per acre per year.
  - NOTES: Applied to orchards which have been newly planted once soil has settled. Rainfall is needed within 21 days of application to activate the herbicide. Do not feed forage or graze treated orchards. Cost ranges from \$20.60 to 41.20 per acre depending on rate used.
- **Dichlobenil** (Casoron 4G): is a nitrile herbicide.
  - Targeted pests: broadleaf and grasses
  - REI: 12-hour
  - PHI: N/A
  - Signal word: Caution
  - Frequency and rate: applied 4 weeks after transplant at the rate of 100 to 150 lbs formulation or 4 to 6 lbs ai per acre.
  - NOTES: Livestock should not graze treated areas. Cost ranges from \$120 to \$180 per acre depending on rate selected.
- **Flumioxazin** (Chateau 51WDG): is a N-phenylphthalimide herbicide.
  - Targeted pests:
  - REI: 12-hours
  - PHI: N/A
  - Signal word: Caution
  - Frequency and rate: 6 to 12oz per acre. Applied after transplant usually after area has received at least one inch of rainfall.
  - NOTES: cost ranges from \$33.75 to \$67.50 depending on rate selected.

- **Oxyfluorfen** (Goal 2XL, Galigan or OxiFlo, GoalTender 4EC): is a D-phenylether herbicide.
  - Targeted pests: broadleaf weeds especially nightshades, groundcherry and pigweed.
  - REI: 24-hours
  - PHI: N/A
  - Signal word: Warning
  - Frequency and rate: pre-emergent and early post-emergence weed applications. Applied to non-bearing trees or when bearing trees are dormant. Applied at the rate of 2 to 8 pints per acre. No more than 6 pints per acre broadcasted and no more than 8 pints per acre applied in bands.
  - NOTES: Should not be applied to trees if buds have begun to swell. Livestock should not be allowed to graze in treated orchards. Cost would range from \$27.50 to \$110 per acre.
- **Pronamide** (Kerb 50W): is a benzamide herbicide.
  - Targeted pests: seedling and established grasses and some broadleaf weeds
  - REI: 24-hours
  - PHI: N/A
  - Signal word: Caution and is Restricted Use Pesticide
  - Frequency and rate: Applied during cool temperatures (Oct. – Dec.) at the formulation rate of 2 to 8 lbs per acre. No more than one application per year.
  - NOTES: Should not be applied to fall-planted apple trees established less than 1 year, or spring-plant trees established less than 6 months. Do not feed or allow livestock to graze treated areas. Cost would range from \$86 to \$344 per application depending on rate selected.
- **S-Metolachlor** (Pennant Magnum 7.62): is a chloracetanilide herbicide.
  - Targeted pests: grasses and select broadleaf weeds
  - REI: 24-hours
  - PHI: 365-days
  - Signal word: Caution
  - Frequency and rate: 1.3 to 2.6 pints per acre. Applied to non-bearing trees only. Rate is dependent on soil texture. Applied as a pre-emergent just after transplant when soil has not settled. Cost would range from
  - NOTES: Cost ranges from \$17.19 to \$34.38 per acre depending on rate selected.
- **Terbacil** (Sinbar 80WP): is a uracil herbicide.
  - Targeted pests: broadleaf weeds and grasses.
  - REI: 12-hours
  - PHI: 60-days
  - Signal word: Caution
  - Frequency and rate: Trees must have been established for 3 years or more. Application rate dependent on soil texture and ranges from 2 to 4 lbs per acre. May be applied in the spring or fall, but must be applied after harvest. Limited to one application per year.
  - NOTES: may not be applied to soils with less than 1% organic matter. Livestock should not be fed or allowed to grazed treated areas. A maximum cost of \$7.00 per acre.

- **Bentazon** (Basagran 4L): is a benzothiadiazinone herbicide.
  - Targeted pest: sedges, lambsquarter, spreading dayflower, Pennsylvania smartweed, ladysthumb, Canadian and musk thistle.
  - REI: 48-hours
  - PHI: N/A
  - Signal word: Caution
  - Frequency and rate: post-emergent weed control at the rate of 1.5 to 2 pints per acre. No more than 2 lbs ai per acre per season.
  - NOTES: non-bearing orchards. Cost ranges from \$19.80 to \$26.40 per acre depending on rate used.
- **Rimsulfuron** (Matrix 25 FNV): is a sulfonyleurea herbicide.
  - Targeted pest: broadleaf weeds, sedges and grasses
  - REI: 4-hours
  - PHI: 7-days
  - Signal word: Caution
  - Frequency and rate: 4 oz per acre.
  - NOTES: apply only when rainfall is expected within 2 to 3 weeks of application. No more than two applications per year. Product difficult to obtain.
- **Norflurazon** (Solicam 80DF): is a pyridazinone herbicide.
  - Target weeds: annual grasses, broadleaf weeds, some perennials
  - REI: 12-hours
  - PHI: 60-days
  - Rate and frequency: apply after harvest in fall or in spring; 2.5 to 5 lbs./treated acre
  - NOTES: do not apply to newly transplanted trees until 6 months after planting, apply to soil that is firm and free of depressions that rain or irrigation water could accumulate, may be tank mixed with simazine for a broader spectrum of weed control. Product difficult to obtain, cost would range from \$40 to \$80 per acre depending on rate used.
- **Oryzalin** (Surflan 4AS): is a dinitroaniline herbicide.
  - Target weeds: annual grasses and small-seeded broadleaf weeds
  - REI: 24-hours
  - PHI: N/A
  - Signal word: Caution
  - Rate and frequency: 1 application per year; 2 to 4 qts./acre. Provides best control if applied when rain expected within 2 weeks of application.
  - NOTES: do not apply to newly transplanted trees until soil has settled and no cracks are present, may be tank mixed with paraquat, Princep, glyphosate or Solicam. Do not graze or feed treated materials from orchards to livestock. Material difficult to obtain and cost ranges from \$40.50 to \$81 per acre depending on rate selected.
- **Simazine** (Princep 80WP, 4L): is a triazine herbicide.
  - Target weeds: annual broadleaf weeds
  - REI: 48-hours
  - PHI: 15-days
  - Signal word: Caution

- Rate and frequency: 1 application per year; 2 to 4 lbs ai./treated acre
- NOTES: use only under trees established at least 1 year, may be tank mixed with other preemergence herbicides or with postemergence herbicides. Cost range from \$12.35 to \$24.70 per acre depending on rate used.
- **Isoxaben** (Gallery 75DF): is a benzamide herbicide.
  - Targeted weeds: pre-emergent broadleaf weed control.
  - REI: 12-hours
  - PHI: 365-days
  - Signal word: Caution
  - Rate and Frequency: 0.66 lbs formulation or 0.5 lbs ai per acre.
  - NOTES: use on non-bearing trees only. Cost was not available.

**Biological Weed Controls:**

- None are currently used in Tennessee's apple production systems.

**Cultural Weed Controls:**

- Mowing
- Cultivation

## Voles

### **Voles observed in Tennessee orchards:**

Pine vole (*Microtus pinetorum*), Meadow vole (*Microtus pennsylvanicus*), Prairie vole (*Microtus ochrogaster*), and the cotton rat (*Sigmodon hispidus*) may also be found in some orchards in Middle and West Tennessee. It causes damage similar to meadow vole and prairie vole.

Orchard floor management practices can have an influence on vole problems found in Tennessee orchards. Tall fescue is the most common grass in orchards and it will support a large, breeding population of voles. Maintaining a bare area extending at least 2 to 3 feet away from the trunk plus close, frequent mowing of the areas between rows and around the orchard will limit vole movement into the orchard and vole activity in the orchard.

Stations should be used to monitor for the presence of voles. If populations are high, toxicant rodenticides should be used in late fall. voles.

### **Repellents**

A repellent may aid in keeping vertebrates and or insect pests from damaging plants and or fruit. Repellents utilizing thiram (a fungicide) or capsaicin (the “hot” in chilis) as an active ingredient are registered for meadow voles. These products (or repellents are registered for other species) may afford short-term protection, but this has not been demonstrated in Tennessee. Thiram has been reported to reduce damage caused by white tail deer, however is no longer labeled for use in apple production.

### **Toxicants**

Zinc phosphide is the only rodenticide labeled for use in Tennessee orchards. The bait should be broadcast in the sod near trees for meadow voles, prairie voles and cotton rats. For pine voles, the rodenticide should be seeded into breather holes. It may also be placed under the concentration stations that were used to monitor for the presence of voles. Zinc phosphide is a single-dose toxicant available in pelleted and grain bait formulations and as a concentrate. Zinc phosphide baits generally are broadcast at rates of 6 to 10 pounds per acre (7 to 11 kg/ ha), or are placed by hand in runways and burrow openings. Although pre-baiting (application of similar non-treated bait prior to applying toxic bait) is not usually needed to obtain good control, it may be required in some situations, such as when a population has been baited several times and bait shyness has developed. Zinc phosphide baits are potentially hazardous to ground-feeding birds, especially waterfowl. Placing bait into burrow openings may reduce this hazard to non-targeted species.

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**Table 1. Relative Effectiveness of Insecticides and Miticides<sup>1</sup>**

Product	Pest																	Fruit Finish
	SJS	RAA	AA/SA	WLH	PB	PC	CM	OFM	TABM	VLR/RBL	STLM	CMB	AM	JB	WAA	ERM	TSM	
Acramite	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	5	5
Actara	4	5	5	5	4	4	2	2	1	1	3	3	3	3	4	-	-	5
Agri-Mek	-	-	-	5	-	-	-	-	-	-	5	-	-	-	-	5	5	4
Ambush	-	3	4	5	3	3	-	-	-	-	4	-	-	-	1	-	-	4
Apollo	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	5	5
Asana	-	3	4	5	3	3	4	5	5	5	4	-	3	4	-	-	-	4
Assail	3	5	5	5	3	3	4	4	2	2	4	5	4	4	2	-	-	5
Avaunt	-	-	-	5	2	5	3	3	4	4	-	-	2	4	-	-	-	5
B. Thuringiensis	-	-	-	-	-	-	1	1	3	3	-	-	-	-	-	-	-	5
Calypso	3	5	5	5	4	4	4	4	2	2	4	4	4	4	2	-	-	5
Centaur	5	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	5
Clutch	-	5	5	-	-	4	3	3	1	1	3	-	3	3	-	-	-	5
CYD-X	-	-	-	-	-	-	4	-	-	-	-	-	-	-	-	-	-	5
Danitol	-	4	4	5	5	4	4	5	5	5	3	3	3	4	-	3	3	5
Delegate	-	-	-	1	-	2	5	5	5	5	5	-	3	-	-	-	-	5
Diazinon	5	1	1	1	4	4	4	4	3	3	2	5	3	3	2	-	-	3
Dimethoate	5	5	5	3	4	3	2	2	2	2	2	5	2	1	3	1	1	4
Envidor	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	4	5
Esteem	5	2	2	-	-	-	4	4	2	2	4	-	-	-	-	-	-	5
Protal	-	-	-	5	-	-	-	-	-	-	-	3	-	-	-	5	5	4
Guthion	4	1	1	1	4	5	4	5	2	4	1	1	5	4	1	-	-	5
Imidan	2	1	1	1	4	5	4	5	2	4	1	1	5	4	1	-	-	5
Intrepid	-	-	-	-	-	-	4	4	5	5	4	-	-	-	-	-	-	5
Kelthane	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	3	4
Lannate	3	3	3	5	4	3	3	3	4	4	4	2	3	2	1	-	-	4
Lorsban	5	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5
Oil	4	2	-	-	-	-	1	-	1	-	-	-	-	-	-	4	2	3
Oil + Lorsban	5	3	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-	3
Oil +	5	5	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-	3

Supracide																		
Nexter	-	-	-	5	-	-	-	-	-	-	-	-	-	-	-	5	3	4
Provado	2	5	5	5	2	2	2	2	2	2	4	4	3	4	4	-	-	5
Rimon	-	-	-	-	-	-	5	5	5	5	-	-	-	-	-	-	-	4
Savey	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	5	5
Sevin	2	-	-	5	3	3	4	3	2	2	2	-	4	5	-	-	-	4
SpinTor	-	-	-	-	-	-	2	2	5	5	5	-	3	-	-	-	3	5
Supracide	5	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4
Surround	-	-	-	-	-	4	2	2	2	2	1	-	4	2	-	-	-	5
Thiodan	3	3	3	5	5	4	2	3	2	2	4	-	3	3	4	-	-	4
Vendex	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	4	4
Vydate	3	4	3	5	3	-	1	1	1	1	4	2	-	2	2	2	3	4
Warrior	-	4	5	5	4	3	4	5	5	5	4	-	3	4	-	-	-	4
Zeal	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	5	5

<sup>1</sup>Relative effectiveness ratings for specific insecticides reflect their efficacy as labeled. For instance, if a product is effective against an insect but it cannot be used because the pre-harvest interval prevents its application when the insect is present, it would be rated as no activity. - = no activity, 1=least effective, 5 = most effective or best fruit finish.

**Pest key:**

SJS = San Jose scale

PC = Plum curculio

STLM = Spotted tentiform  
leafminer

ERM = European red mite

RAA = Rosy apple aphid

CM = Codling moth

CMB = Comstock mealybug

TSM = Two-spotted spider mite

AA/SA = Apple aphid / spirea  
aphid

OFM = Oriental fruit moth

AM = Apple maggot

WLH = White apple leafhopper

TABM = Tufted apple bud moth

JB = Japanese beetle

PB = Plant bugs

VLR/RBL = Variegated/redbanded  
leafroller

WAA = Woolly apple aphid

**Table 2. Toxicity of Pesticides to Beneficial Arthropods**

Pesticide	Mite Predators			Aphid Predator	Generalist predators	Parasitic Wasp
	<i>Stethorus punctum</i>	<i>Amblyseius fallacis</i>	<i>Zetzellia mali</i>	<i>A. aphidomyza</i>		<i>Trichogramma</i> spp.
Actara	2	1	1	-	2	-
Agri-Mek	2	2	2	-	-	-
Ambush	3	3	3	2	3	2
Apollo	0	1	1	1	1	-
Asana	3	3	3	2	3	2
Assail	3	1	1	-	2	-
Avuant	2	1	1	2	2	-
Bacillus thuringiensis	0	0	0	0	2	0
Calypso	3	1	1	-	2	-
Centaur	2	-	-	-	1	-
Clutch	3	1	1	-	2	-
CYD-X	0	0	0	0	0	0
Danitol	3	3	3	3	3	-
Diazinon	2	2	-	3	2	-
Dimethoate	1	3	2	3	2	-
Envidor	1	-	-	-	1	-
Esteem	2	0	0	1	2	-
Portal	1	2	11	1	1	-
Guthion	1	2	1	3	2	2
Imidan	1	2	1	1	1	1
Intrepid	0	0	0	0	0	1
Lannate	3	3	2	3	3	3
Lorsban	1	1	2	2	2	3
Oil	1	1	2	1	1	1
Nexter	2	1	-	-	2	-
Provado	2	1	1	-	2	1
Rimon	2	1	1	2	1	-
Sevin	3	3	2	3	2	3

SpinTor	0	1	0	0	0	-
Thiodan	2	2	-	2	2	-
Vendex	1	1	1	1	1	-
Vydate	2	3	3	2	3	-
Zeal	0	1	1	-	1	-

Generalist predators include; lady beetles, lacewings, syrphids, *Orius* spp.

**Table 3. 2009 Arthropod Loss Estimates for Apples**

Arthropod Pest	% Loss	Comments:
Dogwood borer	0.5	occasionally found in adventitious tissues, burr knots
European red mite	0.5	
Twospotted spider mite	0.5	
Lesser appleworm	0.02	
Green apple aphid	0.1	
Mealybugs	0	
Woolly apple aphid	0.1	
Rosy apple aphid	0.2	
Redbanded leafroller, variegated leafroller, obliquebanded leafroller	0.5	
Spotted tentiform leafminer	0.1	
Apple maggot	0.1	
Potato leafhopper	0.1	
White apple leafhopper	0.05	
Oriental fruit moth	0.1	
Tufted apple bud moth	0.2	
Codling moth	0.2	
San Jose Scale	0.3	
Plant bugs	3.0	
Stink bugs	0.5	
Cicada	0.1	
Plum curculio	0.5	
Leafminers	Trace	

Estimates provided by Frank Hale, Entomology and Plant Pathology,

**Table 4. Estimated Insect Control Products Used During 2009 Apple Production**

Product	% total acreage treated	Of treated, % with 1 or more apps.		
		1 app	2 apps	3 apps
Oil	87	85	15	
Chlorpyrifos (Lorsban)	40	100		
Methidathion (Supracide)	3	100		
Pyriproxyfen (Esteem)	15	100		
Diazinon	20	100		
Fenpropathrin (Danitol)	30	100		
Esfenvalerate (Asana)	3	100		
Permethrin (Ambush)	4	100		
Lambdacyhalothrin (Warrior)	3	100		
Thiomethoxam (Actara)	7	100		

Acetamiprid (Assail)	5	100		
Thiacloprid (Calypso)	5	100		
Endosulfan (Thiodan, Phaser)	40	75	25	
Dimethoate	3	100		
Abamectin (Agri-Mek)	20	100		
Clofentezine (Apollo)	30	90	10	
Hexythiazox (Savey)	30	90	10	
Etoxazole (Zeal)	5	100		
Tert-butyl-p-toluatoate (Portal)	5	100		
Spirodiclofen (Envidor)	5	100		
Azinphos-methyl (Guthion)	80			100
Phosmet (Imidan)	80			100
Indoxacarb (Avaunt)	5	100		
Carbaryl (Sevin)	0			
Buprofezin (Centaur)	4	100		
Imidacloprid (Provado)	5	100		
Spinetoram (Delegate)	5	100		
Bacillus thuringiensis (Dipel, Crymax)	2	90	10	
Novaluron (Rimon)	5	100		
insecticidal virus (CYDX-)	2	75	25	
Methoxyfenozide (Intrepid)	2	100		
Kaolin (Surround)	2	70	30	
Spinosad (SpinTor)	3	100		
Bifenazate (Acramite)	10	90	10	
Chloropyridazin (Nextar)	10	90	10	
Fenbutatin-oxide (Vendex)	5	50	10	
Sulfur	4	100		
Clothianidin (Clutch)	5	100		
Spirotetramat (Movento)	1	100		
Chlorantraniliprole (Altacor)	10	60	40	
Chlorantraniliprole and thiamethoxam (VoliamFlexi)	1	65	35	
Flubendiamide (Belt)	1	70	30	
Isomate Rosso	<0.1	100		
Isomate CM/OFM TT	<0.1	100		
CheckMate OFM	<0.1	100		

Estimates provided by Frank Hale, Entomology and Plant Pathology

**Table 5. 2009 Disease Loss Estimates for Apples**

<b>Disease</b>	<b>% Loss</b>	<b>Comments:</b>
Scab	2.0	
Fireblight	0.5	
Black rot	1.0	
White Rot	2.0	
Crown rot/collar rot	0.1	
Cedar apple rust	1.0	
Quince rust	0.2	
Powdery mildew	0.3	
Frogeye leaf spot	0.0	
Fly speck	1.0	
Sooty blotch	1.0	
Bitter pit	0.0	
Alternaria blotch	0.1	
Necrotic leaf blotch	0.1	
Bitter rot	2.0	

Estimates provided by Steve Bost, Entomology and Plant Pathology

**Table 6. Relative Effectiveness of Apple Fungicides\***

Fungicide and Rate of Usage per 100 gallons of Spray	Rate	Relative Control Rating							Safety Rating	
		Scab	Rusts	Brooks spot	Black rot/ White rot	Bitter rot	Sooty blotch and flyspeck	Powdery mildew	Golden Delicious	Red Delicious
Captan 50W (1.5 lb)	1.5 lb. <sup>1</sup>	4	2	3	3	3	3	-	6	5
Captan 50W (2.0 lb)	2.0 lb. <sup>1</sup>	5	2	4	4	4	4	-	6	6
Captan 50W + Ziram 76W (1 lb) or Thiram 75WDG (1lb)	1.0 lb	4	4	5	5	4	5	2	4	5
Captan 50W + ProPhyt 0.75qt.	2 lbs	5	2	4	4	5	5	1	6	6
Cyprodinil (Vangard 75W)	1.25 oz.	5	-	-	-	-	-	1	6	6
Dodine (Syllit 65W)	0.5 lb	5	-	?	-	-	2	1	3	4
Fenarimol (Rubigan 1E) w/ captan 50W 0.75 lb	3 oz.	6	5	2	2	1	1	5	6	6
Fenarimol w/ mancozeb 0.75 lb	3 oz	6	6	3	1	2	3	5	6	6
Fenarimol w/metiram 0.75 lbd	3oz	6	6	3	1	2	3	5	6	6
Fenbuconazole (Indar 75WSP) + Captan 0.75 lbs	2.67 oz.	6	5	2	2	1	3	5	6	6
Fenbuconazole (Indar 75WSP) + Mancozeb 0.75 lb	2.67 oz + 0.75 lbs	6	6	3	1	2	4	5	6	6
Fenbuconazole (Indar 75WSP) + metiram 0.75 lb	2.67 oz. + 0.75 lbs	6	6	3	1	2	3	5	6	6
Ferbam (Ferbam 76WDG)	2 lb	3	5	4	2	5	4	1	3	4
Kresoxim-methyl (Sovran 50WG)	1 to 1.6 oz.	6	4	5	4	3	5	4	6	6
Mancozeb (75DF, 80W, or 4F)	1.5 lb or 1.2 qts	4	5	3	2	3	3	1	4	5
Metiram (Polyram 80W)	1.5 lb	4	5	3	2	3	3	1	5	5
Myclobutanil (Nova, Rally 40W) +	1.25 – 2	6	5	4	2	1	1	6	6	6

Captan 0.75 lb	oz.									
Myclobutanil (Nova, Rally 40W) + mancozeb 0.75 lbs	1.25 – 2 oz.	6	5	4	1	2	3	6	6	6
Myclobutanil (Nova, Rally 40W) + metiram 0.75 lbs	1.25 – 2 oz.	6	6	1	1	2	3	6	6	6
Pyraclostrobin & Boscalid (Pristine)	3.6 to 4.6 oz	6	4	5	4	4	5	4	6	6
Pyrimethanil (Scala SC)	1.75 to 2.5 oz.	5	-	-	-	-	-	1	6	6
Sulfur	3 lb	1	1	-	-	-	-	4	4	4
Thiophanate-methyl (70W) <sup>2</sup>	2 to 3 oz.	- <sup>2</sup>	-	4	4	-	5	4	5	6
Thiophanate-methyl + Captan 2.0 lbs	2 oz. & 2 lbs	5	2	5	5	4	5	2	6	5
Thiophanate-methyl + Captan 1.0 lbs	2 oz. & 1 lb.	4	4	5	5	4	5	2	4	5
Thiram (Thiram 75WDG)	1.7 lb	3	4	4	3	4	5	1	5	5
Triadimefon (Bayleton 50DF)	0.5 to 2.0	2	5 <sup>3</sup>	-	-	-	-	5	5	5
Trifloxystrobin (Flint 50WG)	0.5 to 6.25 oz.	6	4	5	4	4	5	4	5	5
Triflumizole (Procure 50WS)+ captan 0.75 lbs	1 to 2 oz.	6	5	4	1	2	1	5	6	6
Triflumizole (Procure 50WS) + mancozeb 0.75 lb	1-2 oz. + 0.75 lbs	6	5	4	1	2	3	5	6	6
Triflumizole (Procure 50WS) + metiram 0.75 lbs	1-2 oz. + 0.75 lbs	6	5	4	1	2	3	5	6	6
Ziram (Ziram 76W) <sup>4</sup>	2 lbs	3	4	4	3	4	5	1	4	5

<sup>1</sup> Equivalent rates of Captan 4L are 0.75 qt. and 1 qt per 100 gallon for 1.5 to 2lb rate of Captan 50W. Equivalent rates of Captan 80W or 80WDG are 0.47, 0.63, 0.94, and 1.26 lbs for 0.75, 1.0, 1.5 and 2.0 lbs rates of Captan 50W.

<sup>2</sup>Thiophanate-methyl is not recommended alone, due to possible resistance of the apple scab fungus to benzimidazole fungicides.

<sup>3</sup>Triadimefon is registered only for control of cedar apple rust.

<sup>4</sup>Ziram is commonly mixed with thiophanate-methyl to improve control of white rot, black rot, sooty blotch and flyspeck.

\*Modified from the 2008 Integrated Orchard Management Guide for Commercial Apples in the Southeast, (- = ineffective, 1 = slightly effective, 6 = very effective or very safe on fruit finish).

**Table 7. Weed Response to Pre-Emergence Herbicides**

	Chateau	Diuron	Devirrol	Solicam	Prowl	Oryzalin	Simazine	Sinbar	Oxyfluorfen	Pennant Magnum	Matrix
<b>Biennial and perennial weeds</b>											
Bermudagrass	0	0	0	0	0	0	0	2	0	0	0
Briars	0	1	-	0	0	0	0	-	0	0	-
Dallisgrass	2	2	2	2	1	1	1	-	2	0	-
Dogfennel	2	3	-	5	2	2	3	4	3	0	-
Horsenettle	2	1	0	0	0	0	1	3	0	0	-
Johnsongrass (rhizome)	0	0	0	0	2	2	2	-	0	0	-
Musk thistle	-	4	3	4	0	4	5	2	2	0	-
Plantains	4	0	1	4	2	2	4	4	2	0	-
Wild garlic	-	2	0	4	0	0	-	4	1	0	-
Yellow nutsedge	0	0	0	3	0	0	1	3	0	4	3
<b>Annual Grasses</b>											
Barnyardgrass	4	4	4	4	4	4	3	4	3	5	3
Crabgrass	4	4	4	4	5	5	3	4	5	5	3
Fall panicum	4	3	4	4	4	4	3	5	3	5	-
Goosegrass	4	4	4	4	5	5	4	4	4	5	-
Johnsongrass (seedling)	4	2	3	3	4	3	2	5	3	3	-
Signalgrass (broadleaf)	4	3	1	3	5	5	2	4	2	4	-
<b>Broadleaf Weeds</b>											
Chickweed	5	4	5	5	5	3	4	5	5	-	-
Cocklebur	4	3	0	2	0	0	3	3	1	0	3

Evening primrose	4	3	4	-	2	2	4	5	5	-	-
Galinsoga	-	4	4	4	0	2	4	4	4	5	-
Horseweed	5	3	3	4	0	1	4	5	2	-	4
Jimsonweed	5	3	0	2	1	1	3	2	-	-	-
Lambsquarters	5	4	4	4	2	2	4	5	3	-	3
Morningglories	5	4	0	1	2	2	4	5	0	0	4
Nightshades	5	3	0	4	1	1	3	5	3	5	3
Pigweeds	5	4	4	4	4	4	5	5	4	5	5
Prickly sida	4	2	1	4	1	1	4	5	2	0	3
Ragweed	5	5	4	4	1	2	5	5	5	-	3
Spotted spurge	5	0	-	3	3	3	2	5	-	-	5
Wild radish, mustards	5	4	4	4	2	2	5	5	4	0	-

**Table 8. Weed Response to Post-Emergent Herbicides**

	Rely	Glyphosate	Paraquate	2,4-D	Basagran	Fusilade	Poast	Select	Aim	Matrix
<b>Biennial and Perennial Weeds</b>										
Bermuda grass	2	3	1	0	0	5	4	5	0	0
Briars	3	4	1	3	0	0	0	0	0	-
Dallisgrass	4	4	4	0	0	3	3	3	0	-
Dogfennel	-	5	0	3	0	0	0	0	0	-
Horsenettle	2	3	2	1	0	0	0	0	0	-
Johnsongrass (rhizome)	4	4	1	0	0	4	4	4	0	-
Musk thistle	4	5	2	5	4	0	0	0	0	-
Plantains	-	5	2	4	-	0	0	0	0	-
Wild garlic	4	3	1	3	0	0	0	0	0	-
Yellow nutsedge	2	4	1	0	4	0	0	0	0	3
<b>Annual Grasses</b>										
Barnyardgrass	4	5	3	0	0	4	4	4	0	4

Crabgrass	5	5	4	0	0	5	5	5	0	4
Fall panicum	5	5	4	0	0	5	5	5	0	4
Goosegrass	5	5	4	0	0	4	4	4	0	-
Johnson grass (seedling)	5	5	4	0	0	5	5	5	0	-
Signalgrass (broadleaf)	4	5	4	0	0	4	4	4	0	-
<b>Broadleaf Weeds</b>										
Chickweed	5	5	5	2	0	0	0	0	1	4
Cocklebur	5	5	5	5	5	0	0	0	4	2
Evening primrose	4	2	3	5	1	0	0	0	2	-
Galinsoga	5	5	5	3	5	0	0	0	0	-
Horseweed	3	5	2	3	1	0	0	0	0	3
Jimsonweed	4	5	5	5	5	0	0	0	4	-
Lambsquarters	4	5	5	5	4	0	0	0	5	2
Morningglories	5	4	4	4	1	0	0	0	4	-
Nightshades	5	5	5	5	1	0	0	0	4	2
Pigweeds	5	5	5	4	1	0	0	0	5	5
Prickly sida	5	5	4	4	4	0	0	0	0	-
Ragweed	5	5	5	5	5	0	0	0	0	2
Spotted spurge	5	5	5	5	-	0	0	0	1	-
Wild radish, mustards	5	4	3	5	5	0	0	0	3	4

**Table 9. 2009 Estimated Herbicide Usage in Apple Production**

<b>Active ingredient</b>	<b>Tradename</b>	<b>% usage</b>	<b>Avg. # apps</b>
glyphosate	Gly-4, others	65	2
Sethoxydim	Poast	30	1
Clethodim	Selec	20	1
Fluazifop	Fusilade	5	1
Glufosinate	Rely	40	1
Paraquat	Gramoxone	60	2
2,4-D amine	Various	10	2
Saflufenocil	TreeVix	0	0
Pendamethalin	Prowl	5	1
Dichlobenil	Casoron	5	1
Flumioxazin	Chateau	20	2
Oxyfluorfen	Goal	5	1
Pronamide	Kerb	5	1
S-Metolachlor	Pennant Magnum	0	0
Terbacil	Sinbar	5	1
Bentazon	Basagran	5	1
Rimsulfuron	Matrix	2	1
Norfluazon	Solicam	10	1
Oryzalin	Surflan	30	1
Simazine	Princep	45	1

Estimates provided by David Lockwood, University of Tennessee, Plant Sciences