

Crop Profile for Grapes in Tennessee

Updated: March, 2008

General Production Information

- **State's ranking in national production of grapes:** unranked
- **State's contribution to total US production of grapes:** <1.5%
- **Yearly production numbers:** varies from year to year
- **Total acres grown:** 375
- **Total acres harvested in 2007:** approximately 15 acres, amount was reduced due to loss from late April freeze.
- **Cash value:** approximately \$10,000 (2007 crop). This is a drastic reduction from past years, due to losses incurred from a late freeze.
- **% of crop destined for wine:** 98% +

Grape production holds a very significant place in Tennessee's agricultural. In the search for alternative agricultural enterprises, grapes have found a place for numerous growers. Approximately 375 acres are currently devoted to grape production in Tennessee. Of this figure, 345 acres were expected to bear fruit, however the late freeze of 2007, reduced fruit set. In 2000, the grape crop totaled 727.5 tons having a commercial value of \$625,000. Over 98 percent of the Tennessee crop is marketed through wineries and the estimated value of the wines produced for 2000 was nearly \$5.5 million, making wineries one of the best examples of value-added enterprises in Tennessee. This figure was derived using a juice yield of 130 to 150 gallons per ton and a selling price of \$10 per bottle of finished wine, however value would have increased to approximately \$13 per bottle for 2007. Wineries have made an important contribution to the state by providing taxes on the wine and other items sold in the wineries, employment for many Tennesseans and a strong attraction of tourists. Table 2, provides information released in 2002, which estimates the potential of Tennessee's fruit usage in Tennessee's wineries.

Estimates place the cost of establishing a vineyard and caring for it until the first commercial harvest at \$5,200 per acre or more. This figure does not include land charges, labor or irrigation costs, since most Tennessee vineyards are not irrigated at this time. Annual production costs average \$1,700 to \$2,000 per acre excluding harvest.

For American and French-American hybrids, the average yield per acre is expected to be approximately 5 tons per acre. Depending on cultivar, site and cultural practices, this figure may range from 3 to 9 tons per acre. Muscadines have the potential for yielding in excess of 10 tons per acre, however, winter injury to vines keeps this figure lower. Vinifera cultivars do not yield as high as other types of grapes. Production will average less than 1.5 tons per acre. Variation from year to year is quite high due to cold injury and disease pressure.

Production Regions

Grapes are produced throughout Tennessee, however, most of the vineyards are found in the eastern half of the state. Commercial vineyards are fairly small, ranging from about one acre to thirty acres. New growers are strongly advised to start small and expand the size of the vineyard as their expertise and the market demand develops.

American and French-American hybrid cultivars do well throughout the state and comprise over 90 percent of the grape acreage. While muscadinies are grown along the southern border, winter injury to vines is an annual threat. *Vitis vinifera* cultivars have not performed satisfactorily or consistently in the areas in which they have been tested. Cold injury, disease pressure, low yields and a strong demand for wines made from the other types of grapes combine to make plantings of *V. vinifera* modest in size. Even with the American and French-American hybrids, spring frosts, high levels of rainfall and hot, humid summers present challenges in the consistent production of high quality crops for Tennessee wineries. Table 1, lists several varieties available for Tennessee producers and the variety's level of resistance to a common disease known as black rot.

Cultural Practices

Vineyard Establishment:

Many vineyards are established on slopes or elevated sites to reduce the potential for frost injury and disease. Shallow soils or those having poor internal and surface water drainage characteristics are avoided.

The first thing prospective growers are encouraged to do prior to planting the vineyard is to visit several wineries to ascertain what cultivars should be planted and what the demand for the crop might be when they begin harvesting commercial crops. Site selection and preparation starts at least six months to one year in advance of planting.

Several training systems are in use by Tennessee growers including the bilateral cordon, the umbrella kniffin and the Geneva double-curtain systems. In the first two systems, vines are generally set 8 feet apart in rows 10 to 12 feet apart (544 and 453 vines per acre, respectively).

Since most vineyards are set on sloping land, the preferred vineyard floor management plan consists of a clean strip 4 feet wide under the vines and close-mowed sod between rows. This system provides some passive protection against frosts and enables better pest control. Sod cover between rows lessens the erosion potential within the vineyard and provides support for equipment. Although it may not be the ideal sod cover, tall fescue is the dominant grass used in vineyards. While it is vigorous and competitive with vines, it is easy to establish and to control with herbicides. Rows are planted across slopes as opposed to up and down the slopes to lessen erosion potential and to facilitate more

precise application of pesticides. This floor management system is more conducive to mechanical harvesting which is being used by several producers.

The first commercial crop in the vineyard should be expected the fourth year following planting. A full crop can be expected the following year. While these goals have been reached in less time, the majority of the plantings follow this timetable.

Rooted cuttings are planted for American, French-American hybrid and muscadine cultivars. Grafted vines using either C-3309 or SO4 for the rootstock are suggested for *V. vinifera* cultivars. The newly set vines are pruned back to one cane having two buds prior to the onset of growth. The objective for the first year is to develop a straight trunk on the vine. To aid in accomplishing this, the new shoot growth is loosely secured to a stake set beside the vine or to a string tied to the trellis wire and the base of the vine.

Semi-transparent polyethylene tubes are being used in several new plantings to encourage development of a straight trunk. Control of vegetation around the vine is essential for good growth and to permit control of certain pests.

One of the primary objectives of site preparation is control of noxious weeds in the site. If this has been done, the pressure from grasses and weeds is reduced considerably the first year, although some method of vegetation control will be essential. New vines should also be sprayed with fungicides and insecticides to control several potentially devastating pests. Once fruit is allowed to remain on the vine, generally the third growing season following planting, the pest control program needs to be expanded to that recommended for bearing vineyards.

Bearing Vineyards:

Consistent yields of high quality crops are the goals of grape growers. To accomplish them, timely production practices including pruning, fertilization, weed and grass control, insect and disease control practices, cluster thinning, shoot positioning and leaf removal must be carried out. Time of harvest is related to the cultivar and weather conditions that favor development of an ideal sugar/acid ratio for the type of wine being produced. The exact time of harvest is based on analysis of fruit samples by the winery.

Worker Activities

General Management Guidelines

There are a number of cultural control practices that grape growers need to use to reduce problems caused by grape pests. These cultural practices include:

- **Sanitation: burying or removing leaves** under the vines during the winter. Plant residue is usually picked up by hand and most workers wear cotton gloves.
- **Summer pruning** vines to remove grape cane gallmaker and grape cane girdler before adult emergence. Cotton gloves are normally worn to reduce blistering of hands. All re-entry intervals times are followed. Other pruning is done when vines are dormant, although delayed pruning and double pruning are becoming more common practices where time and labor availability permit.

- **Fertilization** of the vineyard is generally carried out in advance of bud break. The analysis of fertilizer materials used is based on pre and post-plant soil testing and growth and yields from the previous year. Tissue testing is used primarily as a troubleshooting tool at this time. Fertilizer is applied by tractor drawn applicator.
- Use American rootstocks **resistant** to grape phylloxera.
- Maintaining good **weed control** and elimination of weedy or trashy harborages around the vineyard that serve as overwintering sites for pests is imperative to provide effective pest control.
- **Canopy management** practices, which may include shoot positioning and leaf removal will begin shortly after bloom and will continue up to within a couple weeks of harvest. These practices have been shown to have a positive impact on pest control and increased fruit quality. Re-entry intervals are observed for these tasks.
- **Scouting** usually occurs throughout the year, however the frequency varies depending on the season. Weekly scouting usually occurs from late March until harvest. As the fruit matures the vineyard may be scouted every two days. After harvest, the vineyard is usually monitored every three to four weeks. Use systematic **scouting** of vineyards to monitor for grape insects on a regular basis. Particular attention should be made to the ends of rows and rows bordering wooded areas. It is on these vines that insect problems may develop initially and with the greatest severity. During mid-summer, growers should examine around the bases of vines for evidence of grape root borer emergence. Growers should record and maintain notes of each visit to the vineyard. All re-entry intervals times are followed.
- **Irrigation:** irrigation may be installed prior to planting or after planting. Adjustments may be made to irrigation throughout the season. If adjustments are needed proper re-entry intervals would be followed.
- **Chemical Controls:**
 - **Weed control:** may be made by mowing or using chemicals. Weed and grass control begins with the application of a tank mix of pre and postemergence herbicides prior to the start of growth. A second herbicide application may be needed by early to midsummer to maintain clean ground under the vines. Generally herbicides are used to reduce mowing frequencies as well as to maintain weed control in close proximity of the main vine. Herbicides may be applied prior to planting and often in the spring when the vines are dormant. Weed control products would be directed towards the areas where weeds may become a nuisance. If applied in late spring or summer months, products would also be directed and/or shielded to avoid any possible crop injury.
 - **Insect and disease** control begins with a dormant application of lime-sulfur for anthracnose. Timing, pesticide selection and rate are all based on information contained in Extension Publication 1197. "Commercial Small Fruit Sprays." This publication is revised annually to reflect changes in pesticide availability and timing. Applications are suggested throughout the period of crop development and after harvest. The need for some applications are based on weather conditions that favor the development of

certain pests while others are based on monitoring the vineyard and pheromone trapping.

- **Disease control:** Products would generally be applied from March until September. However, timing and frequency would depend on targeted pest.
- **Insect control:** Products may be applied from February until October. However, timing and frequency would depend on targeted pest.

Insect Pests

Insect pests cause fruit loss, foliar damage, and can vector several diseases. Their populations fluctuate year to year and from field to field. During 2007, infestations from green June beetles and Japanese beetles were the most commonly observed pests. However, other arthropod pests were observed during 2007, but the adult Japanese beetles are the most feared, due to the ability to quickly defoliate plants. As larvae, they can also feed on developing roots. There were many pesticide products (see listing titled “Chemicals Available for Insect Control in Grapes”) available for Tennessee grape producers however, malathion, carbaryl, bifenthrin and chlorpyrifos are most commonly used. During 2007, Tennessee producers targeted Japanese beetles, and grape root borers with insecticide applications. Table 3, lists an estimate of products used during the 2007. Amounts listed in this table are lower than a typical growing season, due to the harsh spring freeze.

Japanese beetle (*Popillia japonica*)

Grapes are a preferred host for the adult beetles. At this time, Japanese beetles are found throughout East Tennessee and most of Middle Tennessee. They have not reached West Tennessee at this time, however, they are moving further west in the state each year. All vineyards in the current range of Japanese beetles are infested. Adults emerge from the ground and begin feeding in June and July. One generation hatches each season. Adults feed on leaves only. Damaged leaves have a lacy appearance. Depending on the vigor of the cultivar, the threshold for beginning spray applications will vary from 15 to 20 percent of the leaves. Without control, Japanese beetles can completely defoliate an entire vine. Premature leaf loss can adversely affect fruit quality, increase the vine's susceptibility to winter injury and reduce the vine's long term productivity. Control is difficult to achieve since Japanese beetles will move into a vineyard from perimeter areas and quickly reestablish high populations in the vineyard following sprays. With the current presence of Japanese beetle in Tennessee, lack of control could result in a loss of approximately 35 percent of the state's crop.

Chemical Controls:

- **Carbaryl** (Sevin 80S): very effective, has a longer residual than some of the other products.

Alternative Controls:

- **Malathion** (Malathion 57EC): Phytotoxic to some varieties.

Cultural Controls:

- Plant in areas away from pastures, sod or other grassy areas.
- Place pheromone traps in areas away (50+ yards) from production areas.

Biological Controls:

- *Bacillus Popillae* – Japademic, Doom, Milky Spore Disease.
- *Tiphia* sp. a parasitic wasp.
- Two tachnid flies (*Hyperecteina aldrich* and *Prosenia siberita*) may provide some control.
- Vertebrate pests, skunks, moles, birds, often dig up larvae, but may cause damage to the roots of established vines.

Post Harvest Control Practices:

- Cultivation of areas between the row may

Other Issues:**Grape Root Borers (*Vitacea polistiformis*)**

Grape root borers have been found in every Tennessee vineyard where pheromone traps have been used. Grape root borers will infest the root systems of vines causing a decline in vine vigor and productivity. They can kill vines, but more frequently will weaken them predisposing them to cold injury at temperatures well above that which would damage healthy vines. The grape root borer has a two-year life cycle, most of which is spent underground feeding on the root system of the vines. Infestations most likely come from wild vines surrounding plantings. Effective control involves both cultural and chemical practices. This practice is reinforced by using a directed insecticidal spray to the base of the vine to establish an insecticide barrier on the soil surface. Grape root borers can infest all types of grapes. French-American hybrid cultivars appear to be more seriously affected by grape root borers than American cultivars.

Chemical Controls:

- **Chlorpyrifos** (Lorsban 4E): has a 35-day PHI.

Alternative Controls:

- None

Cultural Controls

- **Pheromone traps** can be used in vineyards to monitor for the presence of grape root borers and to aid in determining the optimum time to apply chemical controls.
- In spring to early summer, larvae migrate to the upper 2 inches of soil and pupate. If soil is mounded several inches in depth around the base of vines after the pupae have moved up, it is possible to prevent emergence. Mounds must be removed later in the growing season. Mounding is expensive and timing is critical since mounding before the pupae have moved up will have little effect. Maintaining bare soil under the vines will help to control populations by reducing the number of adult egg-laying sites and, more importantly, increase mortality of newly-hatched larvae by increased desiccation before they enter the soil. Mounding soil makes it difficult for larvae to reach the roots or adults to emerge. Mound some soil 1 foot high for 1½ feet around each vine between early and mid-June. Remove the mounds around the later part of November.
- Remove any wild vines surrounding plantings, if possible.
- Such cultural methods, such as weed control, fertilization, irrigation, clean cultivation and weekly cultivation (disturbance of top 1 inch of soil) are helpful in

reducing injury. Hence, the condition of the vine, whether it is a healthy, good producer, or a weakened, poor producer because of the lack of good cultural practices, is a deciding factor in the decline of a vine as a result of injury by borers.

Biological Controls

- Natural enemies consist of barn swallows, mockingbirds, crested fly catchers, larvae of fireflies, a number of fungi and a species of nematodes. A number of other parasites and predators undoubtedly exist. However, these along with unfavorable weather conditions, fail to offer effective control.

Post Harvest Control Practices:

- None

Other Issues:

- None

Phylloxera (*Daktulosphaira vitifoliae*)

Two forms of the aphid-like phylloxera exist. The root gall form feeds on the outside of roots, causing galls or swellings. Most American and French hybrid varieties are resistant to the root gall form. Susceptible varieties (*V. vinifera*) are grafted onto a phylloxera-resistant rootstock. The foliar form occurs on the leaves and creates galls at the feeding sites. The foliar form causes the greatest problem in Tennessee vineyards, although damage is usually confined to small areas in the vineyard and may be regarded more as a curiosity rather than as a serious pest problem. During various years, foliar phylloxera may be found in all Tennessee vineyards except those with only muscadine cultivars. Leaves heavily infested with galls can result in defoliation and retarded shoot growth. By the time galls are visible, control sprays are ineffective. Therefore, preventive spray applications are made at bloom or as soon as galls appear. Leaves must be 70% infested with galls before yield loss occurs. Failure to control leaf phylloxera would result in a loss of about 10 percent of the state's crop.

Chemical Controls:

- **Endosulfan** (Thionex 3EC):
- **Fenpropathrin** (Danitol 2.4 EC Spray):

Alternative Controls:

- **Carbofuran** (Furadan 4F): labeled in California, for use on wine grapes only excluding Thompson. Product is extremely toxic to applicators and handlers.

Cultural Control:

- Resistant root stocks

Biological Controls:

- None

Post Harvest Control Practices:

- None

Other Issues:

- None

Grape berry moth (*Endopiza viteana*)

Grape berry moth is a primary insect pest of Tennessee grapes. Infestations vary from vineyard to vineyard, within a vineyard, and from year to year. Potentially, infestation could affect 100 percent of the grape acreage. The grape berry moth overwinters in cocoons on the vineyard floor and in adjacent woodlots. The first generation emerges in June. The second generation appears in August. A third generation occurs in the South and occasionally in the North. The second generation causes the most damage by tunneling into and feeding on green fruit. A single larva can destroy two to six grapes in a cluster, and several larvae often feed on a cluster. Sprays should begin within three weeks of the appearance of adult male moths in pheromone traps, to target the egg hatch, or when scouting finds more than 5% larval damage to grape clusters. Insect damage usually causes less than 10% loss. But without control, damage will increase each year. Egg laying occurs two to three weeks following the trapping of adult male moths. A protective spray at this time reduces or eliminates the need to spray later in the season. While pheromone rope ties can be used to disrupt male grape berry moths, vineyards should be over five acres. Therefore, most Tennessee vineyards would not be candidates for them.

Chemical Controls:

- **Carbaryl** (Seven 80S): 2.5 lbs formulation per acre. Has a 66-day PHI.
- **Malathion** (Malthion 25WP): has a 66-day PHI.
- **Pyrethrins and Rotenone** (Pyrellin EC): has a 66-day PHI. Is a Restricted Use Pesticide.
- **Phosmet** (Imidan 70WP): has a 66-day PHI.

Alternative Controls:

- **Azinphos-methyl** (Guthion 50WP): Product **no longer labeled**.

Cultural Controls:

- **Sanitation** - leaves may be raked and burned in the fall

Biological Controls:

- **Pheromones** – mating disruption. Traps should be used in vineyards which have a history of this pest.
- An egg parasite, *Trichogramma minutum*

Post Harvest Control Practices:

- Destroying dead leaves in the fall or early spring kills overwintering pupae

Other Issues:

Grape flea beetle (*Altica chalybea*)

Although considered a minor pest, the grape flea beetle can pose a serious threat to developing buds on grapevines. Grape flea beetle is found across the state, but is not a problem every year and if present is only present from April until May.. Overwintered beetles emerge and feed on buds in April. Adults chew holes in developing buds, killing the primary shoot, which reduces yield. Larvae and adults also feed on leaves but do not cause significant damage. Sprays should be applied when damage exceeds 4 percent of the buds. While cultivating between rows will destroy pupae, it will not control beetles entirely. In addition, virtually all Tennessee vineyards utilize a sod cover between rows

so cultivation is not an option. Cleaning up brushy areas near vineyards will limit overwintering sites for grape flea beetles and reduce pressures during the growing season.

Chemical Controls:

- Most broad spectrum insecticides used for other common pest will usually control this pest, if applied when this pest is present.

Alternative Controls:

- **Azinphos-Methyl** (Guthion): Product **no longer labeled** in grapes.

Cultural Controls:

- Remove debris and leaf litter on the edges of wooded areas and wastelands located near vineyards to eliminate overwintering sites.
- Scouting - Sampling should be done during bud swell to first-leaf separated from shoot-tip stages (twice a week), by checking for damaged buds and flea beetles. If 5% of the buds are damaged, control measures should be applied.

Biological Controls:

- None

Post Harvest Control Practices:

- None

Other Issues:

- None

Grape Cane Gallmaker (*Ampelogypter sesostris*)

Grape cane gallmaker is commonly observed pest of grapes in Tennessee. This insect produces noticeable red galls on new shoot growth just above nodes. While these are commonly found in vineyards, the majority of the galls are beyond the fruit clusters and usually cause no serious yield loss. Canes with galls are capable of producing a crop the following year. The adult is a dark brown snout beetle about 1/8 inch long and is very similar in appearance to the grape cane girdler. The grub is slightly larger when full grown, and is white with a brown head and legless. In May and June, the female lays an egg in one of a series of holes she chews along the cane just above a node when canes are 10 to 20 inches long. The larva feeds inside the cane which has developed a reddish swelling 3/4 to 1 inch long. The larva becomes fully developed in late July and pupates within the gall. Adult beetles emerge during August and remain in or near the vineyard area, overwintering in trashy borders. Galls are usually found along vineyard borders near wooded trashy areas or at the ends of rows.

Chemical Controls:

NOTE: usually does not warrant pesticide application for control.

Alternative Controls:

- Products used to control flea beetles should control this pest.

Cultural Controls:

- If galls are present should be removed by pruning, it should be done by mid-July before emerging adults exit galls.

Biological Controls:

Post Harvest Control Practices:

Other Issues:

Redbanded Leafroller (*Argyrotaenia velutinana*)

Redbanded leafroller is an occasional pest of clusters and fruits, and its symptoms are very similar to grape berry moth. Larvae of this insect will feed on both foliage and clusters. Unlike grape berry moth larvae, redbanded leafroller larvae do not crawl into the berry but remain concealed in webbing on the cluster stem and feed on the stem as well as berries. While redbanded leafrollers are numerous in Tennessee and may be found on various plant species, are only an occasional pest of grapes.

The adult redbanded leafroller is a 1/2 inch long reddish-brown moth with small areas of silver, gold and orange. The moth is recognized by the red band extending across the front wings when at rest. The larva is a small, yellowish-green, unmarked caterpillar. The head capsule is the same color as the rest of the body.

The redbanded leafroller overwinters as pupae in leaf litter on the soil surface. Adults emerge in April and begin laying clusters of eggs on canes. Larvae of this early generation feed on unfolding leaves and are not usually of major concern. Larvae of the second and third generations feed during the summer and are of economic importance due to berry feeding. Second and third generations are larger than the first, and egg laying occurs over an extended period of time.

Chemical Controls:

- **Bifenthrin** (various): provide excellent control if applied prior to leaves being rolled.

Alternative Controls:

- **Malathion** (Malathion 57EC):
- **Carbaryl** (Sevin 80S):

Cultural Controls:

- Scouting to observe for presence and populations.

Biological Controls:

- Pheromone traps are available to monitor for redbanded leafroller. Trap catches are an indication of moth activity and can be used to more accurately time insecticide applications.

Post Harvest Control Practices:

- None

Other Issues:

Aphids (various species)

Aphids feed by piercing and sucking plant sap from leaves and tender maturing vines. Feeding reduces nutrients needed for fruit development. Aphids may also serve as vectors for several viruses.

Chemical Control:

- **Acephate** (Orthene 97):
- **Pyrethrin** and **rotenone** (Pyrellin):

Alternative Control:

Cultural Control:

Biological Control:

- Lady bugs
- Various parasites.

Post Harvest Control Practices:

- None

Other Issues:

- Possible resistance buildup within the population if products are used on a continuous basis.

Chemicals Labeled for Insect Control in Grapes Production:

Not all products listed are available for use in Tennessee production. Products that are listed are listed to provide the reader information concerning possible options that may be provided to grape producers. Products used are generally applied with an air blast sprayer as a cover spray. Many insecticides are tank mixed and applied with fungicides on an as-needed basis.

Organophosphate insecticides

Acephate (Orthene 97): has Caution listed as the signal word.

Targeted pests: aphids, plant bugs and thrips.

Frequency and rate: 0.5 to 1 lb formulation per acre per application.

REI:24 hours

PHI: 1 year

NOTES: may only be applied to non-bearing plants. Livestock should not be allowed to graze treated areas.

Estimated cost: ranges from \$5.05 to \$10.10 per acre depending on rate selected.

Azinphos-methyl (Guthion 50WP): has Danger listed as the signal word, and is a Restricted Use Pesticide.

Target pest: grape berry moth

Frequency and rate: was limited to 2 applications, Guthion 50 WP was applied at 1.5-2.0 lb/acre.

PHI: 10 days

REI: 48 hours

Comments: Restricted Use Pesticide. Previously it could not be used more than three times a season. **No longer** labeled for use in grape production.

Estimated cost: ranges from \$17.63 to \$23.50 per acre per application.

Chlorpyrifos (Lorsban 4E): has Warning listed as the signal word. Is a Restricted Use Pesticide.

Target pest: grape root borer

Frequency and rate: Lorsban 4E - 4.5 pints per 100 gal. water, apply 2 quarts of spray solution directed to a 15 sq. ft. area around the base of each vine. Only one application allowed at least 35 days before harvest.

PHI: 35 days

REI: 4 days

Comments: take care to avoid contacting fruit and foliage with the spray. Application should be made with a handgun so material may be directed and applied at relatively low pressure.

Estimated cost: \$20.36 per 100 gallons of solution which would treat 200 plants.

Malathion (Malathion 57EC): has Caution listed as the signal word.

Target pest: Mealy bug

Frequency and rate: 1.5 pints mixed with 200 to 275 gallons of water applied to one acre on a 7 to 10 day interval. Generally no more than 2 applications would be needed.

REI: 12-hour

PHI: 3-days

Comments: may be phytotoxic to some varieties.

Estimated cost: \$5.16 per acre per application.

Phosmet (Imidan 70WP): has Warning listed as the signal word.

Target pests: grape berry moth, Japanese beetle, and several other minor pests.

Frequency and rate: 1.33 -2.12 lb/acre as needed (higher rate used to control Japanese beetle)

PHI: 14 days

REI: 24 hours

Comments: no more than 6.5 lbs formulation per acre per year.

Estimated cost: ranges from \$11.64 to 18.55 per acre per application depending on rate used.

Carbamate insecticides:

Carbaryl (Sevin 80SP): has Warning listed as the signal word.

Targeted pests: grape flea beetle, grape berry moth, Japanese beetle. Leaf hoppers, leaf rollers, flea beetles.

Frequency and rate: 1.25 to 2.5 lb. formulation / acre, 2-3 applications maybe needed for control but no more than 5 applications per season. May be sprayed on a 7-day spray schedule, if needed.

PHI: 7 days

REI: 12 hours

Estimated cost: ranging from \$8.75 to \$17.50 per acre per application depending on rate selected.

Methomyl (Lannate 2.4LV, SP): has Danger listed as the signal word and is a Restricted Use Pesticide.

Targeted Pests: Grape berry moth, leafhoppers, leaf rollers

Frequency and rate: 1.5 to 3 pints or 0.45 to 0.9 lbs active ingredient per acre.

REI: 7-days.

PHI: 14-days for wine grapes, 1-day for fresh.

Comments: No more than 5 applications per crop or no more than 15 pints per crop.

Estimated cost: ranges from \$11.38 to 22.76 per acre per application.

Carbofuran (Furadan 4F): has Danger listed as the signal word and is a Restricted Use Pesticide.

Targeted pests: grape phylloxera, and root weevils.

Frequency and rate: other crops applied at 1 to 2 pints

REI: 48 hrs in California

PHI: Product is applied to soil after harvest in California.

NOTE: not labeled in Tennessee, only in California

Estimated cost: would range from \$10.06 to \$20.13 per acre.

Pyrethroid insecticides

Bifenthrin (Fanfare 2EC) has a signal word of Warning and is a Restricted Use Pesticide.

Targeted pests: leafhoppers, black vine weevil, glassywinged sharpshooter, and two-spotted spider mites.

Frequency and rate: applied at the formulation rate range of 3.2 to 6.4 fl.oz. per acre. No more than 0.1 lbs ai per acre per season.

REI: 12 hours.

PHI: 30 days

NOTE: should be rotated with non-pyrethroid insecticides for resistance management.

Estimated cost: ranges from \$3.95 to \$7.90 per acre per application.

Fenpropathrin (Danitol 2.4 EC Spray) has Warning listed as the signal word and is a Restricted Use Pesticide.

Targeted pests: Japanese beetle, red banded leafroller, rose chafer, twospotted spider mites, grasshoppers, flea beetles, leafhoppers, skeletonizers, grape berry moth, grape cane gallmaker, and grape phylloxera-foliar feeding.

Frequency and rate: May be applied at the rate range from 5.33 to 10.66 fl.oz. or 0.1 to 0.2 lbs ai per acre per treatment. Not to exceed 0.8 lbs ai per acre per season.

REI: 24 hr

PHI: 21-days

NOTE: For resistance management purposes no more than two Danitol applications per season. This product should be rotated with non-pyrethroid insecticides.

Estimated cost: ranges from \$6.61 to \$13.23 per acre per application.

Pyrethrins and rotenone (Pyrellin EC): has Caution listed as the Signal word. This product contains 0.60% (0.042 lbs ai) pyrethrin and 0.50% (0.035lbs ai) rotenone (a botanical insecticide) per gallon of product.

Targeted pest: various worms and provides control of aphids.

Frequency and rate: applied at the formulation rate of 1 to 2 pints per acre.

REI= 12-hour.

PHI= 12-hour.

Estimated cost: NA

Organochlorine insecticides:

Endosulfan (Thiodan 50WP, Thionex 3EC): has Danger listed as the signal word. This product is a Restricted-Use-Pesticide.

Target pests: phylloxera (foliar form), grape leafhopper, rose chafer.

Frequency and rate: Generally only 2 applications, at bloom and 2 weeks later.

Thiodan 50WP 2 - 3 lb/acre. The 3EC formulation is applied at the rate of 1.33 to 2 quarts or 1 to 1.5 lbs ai per acre per application. No more than 3 lbs ai per acre per season. No more than three applications per season.

PHI: 7 days

REI: 24 hours

Comments: Endosulfan is the only recommended insecticide used for control of the foliar form of phylloxera. Endosulfan can cause phytotoxicity in sensitive varieties (such as Concord). Carbofuran is an alternative, but not frequently recommended. Product has recently been cancelled for use on other crops.

Estimated cost: Ranges from \$9.14 to \$13.75 for the EC formulation and \$16.00 to 24.00 for the WP formulation, per acre per application depending on rate used.

Non-organophosphate, non-carbamate, and non-pyrethroid insecticides:

Sulfur (Thiolux 80%): has Caution listed as the signal word.

Target pests: Powdery mildew, bud mite, blister mite, spider mites.

Frequency and Rate: applied at the formulation rate of 6 lbs or 4.8 lbs ai per acre.

REI: 24-hr

PHI: 0-day

Comments: applied at early dormant stage or early shoot development. Product may cause burning of leaves when sprayed when temperatures exceed 85F or greater.

Estimated cost: \$9.00 per application per acre.

Bacillus thuringiensis (DiPel DF, ES): has a signal word Caution.

Targeted pests: Grapeleaf skeletonizer (ground only), grape leafroller, Achema Sphinx Moth (Hornworm), saltmarsh caterpillar (ground only), omnivorous leafroller (ground only), looper, orange tortrix, oblique banded leafroller, grape berry moth, melonworm, cutworms, armyworms, cranberry fruitworm, cherry fruit worm, tobacco budworm and gypsy moth.

Frequency and rate: use ½ -2 pounds per acre.

REI: 4 hrs

PHI: 0-day

NOTE: Recommended only in organic production.

Estimated cost: ranges from \$5.58 to \$22.30 per acre per application.

Spirodiclofen (Envidor 2SC) has Caution listed as the signal word.

Targeted pests: European red mite, Pacific spider mite, two-spotted spider mite.

Frequency and rate: may be applied at the formulation rate of 16.0 to 18.0 fluid ounces per acre with no more than one application per crop season.

REI: 12 hrs

PHI: 14-days

NOTE: would only be needed occasionally for the two-spotted spider mite.

Estimated cost: ranges from \$33.00 to \$37.00 per acre per application.

Imidacloprid (Provado Solupak 75% wettable powder, Admire Pro, Alias 2F) has Caution listed as the signal word.

Targeted pests: sharpshooters, leafhoppers and mealybugs Aids in control of Phylloxera infestations.

Frequency and rate: per application is 0.75-1.0 oz. acre and more than 2.0 ounces of Provado 75% WP per year. If using Admire Pro applied from 7 to 14 fl oz per acre.

REI: 12 hours.

PHI: 30-day PHI

Estimated cost: ranges from \$60.20 to \$86 per acre.

Methoxyfenozide (Intrepid 2F) has the signal word of Caution.

Targeted pests: leaf rollers, skeletonizers and orange tortix.

Frequency and rate: rate of application for grape berry moth is 4-8 fl oz. per acre. Rate of application for the following target pests are 10-16 fl.oz. which controls grape leaf folder, omnivorous leafroller, obliquebanded leafroller, orange tortix, redbanded leafroller, and western grapeleaf skeletonizer. No more than 16 fl oz. per acre per application may be made.

REI: 4 hours

PHI: 30 days

Estimated cost: ranges from \$9.88 (4 oz) to \$39.53 (16 oz) depending on rate selected.

Abamectin (Abba 0.15EC) has Warning listed as the signal word.

Targeted pest: spider mites and leaf hoppers

Frequency and rate: 8 to 16 fl oz. per acre. No more than two applications in one growing season.

REI: 12-hours

PHI: 28-days of harvest.

Comments:

Spinosad (SpinTor 2SC) has Caution listed as the signal word. This product is a naturalyte insecticide.

Targeted pest: grape berry moth, thrips, leaf rollers

Frequency and rate: 4 to 8 fl.oz. per acre

REI: 4-hour

PHI: 7-day.

Comments: no more than three applications within a 30-day interval.

Bifenazate (Acramite-50WS): has the signal word Caution listed on the label.

Targeted Pest: spider mites.

Frequency and rate: 0.75 to 1.0 lbs formulation per acre. Limited to one spray per season.

REI: 12-hours, except 5 days for cane turning, tying, and girdling of table grapes.

PHI: 14-day.

Comments:

Dicofol (Kelthane 50WSP) has Danger listed as the signal word.

Targeted pests: spider mites

Frequency and rate: application rate is 2 ½ lb. per acre and apply just after bloom. No more than two applications per season.

REI: 48 hours

PHI: 7 days.

NOTE: Toxic to fish and should not be applied where runoff is likely to occur.

Estimated cost: \$13.13 per acre per application.

Diseases

Diseases pose the single greatest threat to profitable grape production. Most fungicides are applied as preventive sprays since fungal diseases are nearly impossible to control once they have become established. Table 5, lists an estimate of fungicides used during the 2007 growing season. Amounts listed are not reflective of a normal growing season due to the late spring freeze.

Black rot (*Guignardia bidwellii*)

Black rot is the biggest concern of grape growers in Tennessee. It has the potential for causing heavy crop losses each year. The fungus overwinters in mummies (dried, shriveled grapes) on the ground or vines. In the spring, rain releases and splashes the spores from the mummies onto the leaves, forming lesions that release spores which infect leaves and fruit all season. Wind is also responsible for movement of spores. Growers use a spray schedule to control black rot, which also controls other foliar diseases. Infection of the fruit occurs beginning after bloom and extending until veraison. Infected berries will shrivel and become hard, black mummies. Foliar infection, which appears as irregular necrotic areas on the leaf surface, can develop after veraison.

Chemical Controls:

- **Azoxystrobin** (Abound): provides excellent control.
- **Tebuconazole** (Elite): provides excellent control.
- **Trifloxystrobin** (Flint): provides excellent control.
- **Ferbam** (Ferbam Granuflo 76WDG): should be used early season only due to black powdery residue. Provides excellent control.
- **Mancozeb** (Dithane DF rainshield, Manzate): inexpensive, provides excellent control.
- **Maneb** (Various): provides excellent control.
- **Myclobutanil** (Nova): provides excellent control.
- **Kresoxim-methyl** (Sovran): provides excellent control.
- **Ziram** (Various): provides excellent control.
- **Captan** (Various): provides fair control.

Alternative Controls:

- **Triadimefon** (Bayleton): no longer manufactured. Previously labeled on table and raisin grapes. Product was moderately toxic.

Cultural Controls:

- **Pruning** to promote good light penetration throughout the canopy will lessen infection pressure and enable better spray coverage resulting in improved control.
- Effective control depends on good vineyard **sanitation** including removing mummified fruit from vines and the vineyard floor.
- **Resistant cultivars** – several cultivars are available, see Table 1.

Biological Controls:

- None

Post Harvest Control Practices:

- None

Other Issues:

- No more than two sequential applications of strobilurin products should be made to reduce the chance of developing resistance within fungal populations.

Downy mildew (*Plasmopara viticola*)

The fungus overwinters in leaf debris on the ground. Rain splashes the spores onto the grapevine. Infection can occur as early as bud break and continue throughout most of the growing season. Severe outbreaks may be seen in wet years. Leaves develop yellowish brown lesions on the upper surface and white patches on the underside. Severely infected leaves curl and drop. Young shoots, tendrils, and stems become distorted, thickened, or curled. White, cottony patches appear on fruit during humid conditions. Loss in yield can exceed 25 percent. Defoliation will adversely affect fruit growth and quality and increase vine susceptibility to winter injury. Infection can develop after harvest.

Chemical Controls:

- **Azoxystrobin** (Abound): Provides excellent control.
- **Captan** (various): Provides good control.
- **Copper plus lime**: Copper may cause injury during cool slow drying conditions.
- **Trifloxystrobin** (Flint): Should not be used on Concord varieties.
- **Kresoxim-methyl** (Sovran):
- **NOTE**: product should be applied in mid-to-late-season, when downy mildew is active.
- **Mancozeb** (Dithane DF): used on copper sensitive varieties. Used from harvest to first killing frost. Inexpensive.
- **Phosphorus acid** (ProPhyt, Phostrol): recommended after harvest until first killing frost.

Alternative Controls:

- **Ferbam**(Carbamate 76WP): should be used early season only due to black powdery residue. Provides fair control.

Cultural Controls:

- Several varieties have been reported to be **tolerant** to downy mildew

Biological Controls:

- *Bacillus subtilis* QST713 (Serenade ASO): may provide some control.
- *Trichoderma harzianum* T39 (Trichodex):
- *Clonostachis rosea* and *T. harzianum* mixed in combination (A. Vecchione, L. Zulini, I. Pertot and R. Musetti. Biological Control of Plasmopara Viticola: A Multisite Approach, IN:Proc. Intl. WS on Grapevine Eds. V. Nuzzo et al Acta Hort. 754, ISHS 2007).

Post Harvest Control Practices:

- Remove fallen leaf debris if possible.

Other Issues:

- Resistance issues when using strobilurin materials. Strobilurin products should be limited to no more than two consecutive applications.

Powdery mildew (*Uncinula necator*)

Powdery mildew overwinters in bark crevices of the grapevine. Spores released by spring rains are the primary inoculum. Wind carries the fungus where it grows on any green surface of the vine. The infected area has a dusty or powdery appearance. Spores produced in infected areas provide secondary inoculum for infections throughout the growing season. French-American hybrid and European cultivars are more susceptible to powdery mildew than native American cultivars. Powdery mildew can be a problem in dry years. Powdery mildew infects all green tissue. Infected clusters drop blossoms before the fruit sets. Infected grapes split before maturity. Infected leaves have reduced photosynthetic capability which can reduce fruit quality. Wines made from grapes infected with powdery mildew may have an off-flavor. Early season control reduces the total number of fungicide applications. Susceptible varieties often require late-season sprays. Optimum temperatures for disease development are 68-77°.

Chemical Controls:

- **Azoxystrobin** (Abound): provides excellent control.
- **Tebuconazole** (Elite): provides excellent control.
- **Triflozystrobin** (Flint): should not be used on Concord varieties.
- **Myclobutanil** (Nova): provides excellent control.
- **Triflumazole** (Procure): difficult to obtain.
- **Fenarimol** (Rubigan): provides excellent control.
- **Kresoxim-methyl** (Sovran): provides excellent control.
- **Sulfur** (various): may cause burning when temperatures exceed 85 degrees.

Alternative Controls:

- **Thiophanate methyl** (Topsin M): resistance may occur if used repeatedly.

Cultural Controls:

- Train vines to grow so it will **reduce shading**.
- Encourage a growing environment for increased **air circulation**.

Biological Controls:

- *Bacillus subtilis* QST713 (Serenade ASO):

Post Harvest Control Practices:

Other Issues:

- Careful use of sterol inhibitors is important to reduce fungicide resistance.

- Resistance to thiophanate methyl may develop if this material is used repeatedly.

Phomopsis cane and leaf spot (*Phomopsis viticola*)

The fungus overwinters in lesions on 1- to 3-year old vines. Rain spreads the fungus to new shoots, leaves, and (later) developing grapes. Infected fruit appears similar to black rot. Heavily infected shoots are prone to wind damage. The fungus enters small green grapes but the disease is not apparent until close to harvest as the disease is not active during the warm summer months. As grapes ripen they become light brown and shrivel. The first scheduled spray application is to control Phomopsis. Yield is reduced because of fruit loss and weakened vines.

Chemical Controls:

- **Azoxystrobin** (Abound 2F): Provides fair control.
- **Boscalid** and **Pyraclostrobin** (Pristine): provides excellent control.
- **Captan** (Captan, Captec): provides excellent control.
- **Thiophanate-methyl** (Topsin-M): provides fair control.
- **Copper hydroxide** (Kocide 101, DF, 2000): provides fair control.
- **Kresoxim-methyl** (Sovran 50WG): provides fair control.
- **Mancozeb** (Dithane DF, others): provides excellent control.
- **Maneb** (various): provides excellent control.
- **Trifloxystrobin** (Flint 50WP): product has limited activity.
- **Ziram** (Ziram): product has good control.
- **Lime sulfur** (various): provides fair control.

Alternative Controls

- **Ferbam** (Ferbam Granuflo): should be used early season only due to black powdery residue. Provides fair control.

Cultural Controls

- Widen width between rows to reduce spread by rain.
- Diseased portions of the plant should be removed and destroyed at dormancy.

Biological Controls

- ***Bacillus subtilis* QST713** (Serenade ASO):

Post Harvest Control Practices:

- None

Other Issues:

- None

Botrytis bunch rot (*Botryotinia cinerea*)

Botrytis bunch rot, or gray mold, quickly spreads from grape to grape. Varieties with tight-clustered bunches are more susceptible. The fungus overwinters in debris on the ground and on the vine. Infection occurs throughout the growing season, mostly at bloom and again at veraison (the onset of ripening as the grapes begin to soften and swell significantly). Damage appears on leaves as brown, necrotic lesions. Botrytis rapidly spreads throughout the grape cluster. Botrytis bunch rot can destroy entire bunches, resulting in 25-50% yield loss in susceptible varieties. Tissue previously injured by hail,

wind, birds, or insects is susceptible to Botrytis infection. Critical time for control is at bloom, at bunch closing and at veraison.

Chemical Controls

- **Iprodione** (Rovral 50WP, 4F): provides fair to good control.
- **Cyprodinil** (Vangard 75WG): provides excellent control.
- **Fenheximide** (Elevate 50WDG): provides excellent control.
- **Boscalid + Pyraclostrobin** (Pristine 38WG): should not be applied to Concord, Worden, Fredonia and Niagara varieties. Has a 14-day PHI.
- **Boscalid** (Endura 30WG): Has a 14-day PHI.

Alternative Controls:

- None

Cultural Controls:

- Pulling leaves surrounding fruit

Biological Controls:

- *Bacillus subtilis* QST713 (Serenade ASO):

Post Harvest Control Practices:

- None

Other Issues:

- Most fungicide products are applied at bloom to control this disease.

Anthracnose – Bird’s-Eye Rot (*Elsinoe ampelina*)

This fungus may attack the berries, young shoots, tendrils, petioles, leaf veins, and/or fruit stems. Spots occasionally occur on young shoots and may combine and girdle the shoot which often dies due to infection. Spots may also develop on petioles and leaves, especially on the underside of the leaf surface. The disease gets its name from the characteristic spots which develop on berries. The spots are circular, sunken and ashy gray and dark-bordered in late stages of the disease cycle.

Chemical Controls

- **Ferbam** (Carbamate 76WP): should be used early season only due to black powdery residue which may remain on fruit.
- **Liquid lime/sulfur** (various): provides good control. Applied as a dormant spray.

Alternative Controls:

- None

Cultural Controls:

- Destroy pruned canes and clusters during dormancy.

Biological Controls:

- None

Post Harvest Control Practices:

- None

Other Issues:

- None

Bitter Rot (*Greeneria uvicola*)

Can be severe on certain varieties, such as Catawba. The fungus enters the berry from the stem, and a grayish discoloration of the berry begins on the stem side. The appearance of tiny black fungal fruiting bodies and a shriveling of the berry into a hard, dry mummy can cause this disease to be mistaken for black rot.

Chemical Controls:

- **Azoxystrobin** (Abound 2SC): no more than 2 sequential applications of QoI fungicides.
- **Mancozeb** (Dithane DF rainshield): provides excellent control, and is inexpensive.
- **Ferbam** (Ferbam): applied late may leave a dark residue.
- **Captan** (Captan, Captec): provides excellent control.

Alternative Controls:

- None

Cultural Controls:

- Destroy prunings and mummified berries.
- Variety selection can be very important method of control.

Biological Controls:

- None

Post Harvest Control Practices:

Other Issues:

- Most other products that are applied at post bloom will control this disease.

Eutypa Dieback (Dead Arm) (*Eutypa lata*)

Infections develop slowly and is usually only observed in older grapevines. Symptoms consist of dying arms and yellowed, cupped leaves on new growth in the spring. Leaves develop small necrotic spots and tattered margins. Infection occurs on trunk and main branches through pruning wounds. Spores are present throughout the year.

Chemical Controls:

- None

Alternative Controls:

- None

Cultural Controls:

- Protect pruning wounds from infection.
- Avoid pruning during and before wet weather, and make clean, close cuts to encourage callusing. Identify infected plants in spring and remove and burn infected canes when weather is not rainy.

Biological Controls:

- ***Bacillus subtilis*** (Serenade ASO):

Post Harvest Control Practices:

- None

Other Issues:

- None

Crown Gall (*Agrobacterium vitis*)

Knots form on roots, crowns and sometimes, on canes. These galls may grow to several inches in diameter. The amount of damage to the plant varies from none to death of the plant. Winter-injured vines frequently become infected.

Chemical Controls

- None

Alternative Controls:

- None

Cultural Controls:

- Plant winter-hardy varieties, avoid sites with a history of crown gall and avoid injuries to the canes.

Biological Controls:

- Non-tumorigenic *Agrobacterium vitis*, however has not been tested in the state.

Post Harvest Control Practices:

- Remove infected plants.

Other Issues:

Nonchemical control of grape diseases:

Control of diseases depends on chemical and non-chemical means. Site selection can affect disease pressure. Locating vineyards in elevated sites as opposed to low areas having poor air drainage should be considered, and where possible, plant cultivars that are not highly susceptible to the more common diseases. Using a trellis and pruning practices that promote good sunlight penetration air circulation and spray penetration throughout the canopy will lessen disease pressure and improve pesticide performance. Maintaining a vineyard floor that will not impede air circulation and spray coverage is critical to disease and insect control. Sanitation is an essential disease control practice. Removing mummified fruit and weak or dead wood from the canopy and the vineyard floor will lessen infection pressure.

Chemical Control Products Labeled for Control of Grape Diseases:

Not all of the following products were used during the 2007 growing season. Products listed, are provided to demonstrate what control options were available to grape producers.

Protectant fungicides:

Sulfur Fungicides:

Lime-sulfur /Calcium polysulfide with sulfur added: has Danger listed as the signal word. Is formulated with 3 lbs ai calcium polysulfide per gallon, and 1 to 4 lbs 50% sulfur should be mixed with product in 100 gallons of water. Three-hundred gallons of spray solution may be needed to obtain thorough coverage of vineyard.

Target disease: anthracnose, phomopsis, powdery mildew and mealy bugs.

Rate and frequency: 1 application during dormancy at 10 gallons per acre. When foliage is present 100 to 300 gallons solution per acre.

REI: NA

PHI: NA

Comments: sulfur materials may burn plants when temperatures exceed 85F during the heat of the day. Normally applied when plants are dormant.

Estimated cost: \$3.60 to \$5.00 per acre per application.

Sulfur (Kumulus 80 DF) has Caution listed as the signal word.

Targeted pests: Powdery mildew, phomopsis, blister mites, red spider mites.

Frequency and rate: applied at the rate ranging from 2 to 10 lbs per acre on a 7 to 14 day schedule.

REI: 24-hr

PHI: NA

Comments: Often causes burning of foliage if sprayed when temperatures exceed 85 F. Has good activity for powdery mildew, but may damage certain varieties, such as, Concord, Norton and Chambourcin.

Estimated cost: ranges from \$2.62 to \$13.10 per acre per application.

Copper Fungicides:

Copper Hydroxide (Kocide 101, 2000, DF, 4.5 LF): have Caution, Warning or Danger listed as the signal words, depending on formulation.

Targeted pests: Black rot, downy mildew, phomopsis, powdery mildew.

Frequency and Rates: Kocide 101 is applied at the rate of 2-4 lbs per acre. Generally applied at bud break and sprayed throughout the season.

REI: 24-hr

PHI:

Comments: foliage injury may occur on some varieties.

Estimated cost: ranges from \$9.00 to \$18.00 per acre per application.

Biological Fungicides

***Bacillus subtilis* QST713** (Serenade ASO): has Caution listed as the signal word.

Targeted pests: Gray mold, sour rot, powdery mildew, downy mildew, phomopsis, Eutypa

Rate and Frequency: applied at the formulation rate of 2 to 6 qts per acre. Applied at bloom up to day of harvest. For Eutypa, applied at a 2 to 5% solution when pruning for wounds that are encountered due to pruning.

REI: 4-hr.

PHI: 0-day.

Comments: product is extremely safe to use.

Estimated cost: NA

Phthalimide fungicides:

Captan (Captan 50WP, 4L, 80WDG): has Danger listed as the signal word.

Target diseases: downy mildew, Phomopsis cane and leaf spot, suppression of black rot.

Rate and frequency: 2 lb – 4 lb s formulation or 1 to 2 lbs ai /acre at 10-14 day intervals as needed. Generally sprayed as shoots reach 3 to 5 inches in length. The 50 WP formulation may be applied at the 2 to 4 lb per acre rate not to exceed 24 lbs per acre per crop cycle. The 80WDG formulation is applied at the rate of 1.25 to 2.5 lbs with no more than 15 lbs per acre per crop cycle. The 4L formulation may be applied at the rate of 0.75 to 1 quart per acre with no more than 12 quarts formulation per crop cycle.

PHI: 0 days

REI: 48hr to 4-days depending on formulation Comments: Often used later in season when PHI prevents use of mancozeb.

Estimated cost: ranges from \$8.20 to \$16.40 per acre per application.

Dithiocarbamate Fungicides:

Mancozeb (Dithane 80WP, F-45): has Caution listed as the signal word.

Target diseases: black rot, downy mildew, bunch rot, Phomopsis cane and leaf spot

Rate and frequency: 3 to 4 lb/acre applied at 7-10 day intervals as needed. No more than 19.2 qts f-45 per acre per season.

PHI: 66 days (limits use to early season applications)

REI: 24 hours

Comments: Mancozeb provides good control of most diseases except powdery mildew.

Should be applied with a sterol inhibitor when preventing powdery mildew. Has an increased PHI. Fairly inexpensive product.

Estimated cost: \$8.55 to \$11.40 per acre per application.

Maneb (Maneb 75, 80): has Caution listed as the signal word.

Targeted pests: Black rot, bunch rot, downy mildew, phomopsis.

Frequency and Rate: 1.5 to 4 lbs of the 80% formulation on a 7 to 10 day spray schedule.

REI: 24-hrs

PHI: 66-days

Comments: no more than 19.2 lbs ai per acre per season.

Estimated cost: \$4.60 to \$12.26 per acre per application.

Ferbam (Ferbam 76WDG): has Caution listed as the signal word.

Target diseases: black rot, downy mildew

Rate and frequency: 2 lbs formulation/acre/200 gallons of water at 10-14 day intervals as needed. Normally applied just prior to bloom or just after bloom.

PHI: 7 days

REI: 24 hours

Comments: Maximum of three applications. Applied instead of captan or mancozeb.

May leave a visual spray residue if applied when fruit are present.

Estimated cost: \$8.20 per acre per application.

Ziram (Ziram 76DF): has Danger listed as the signal word.

Target diseases: black rot, Phomopsis cane and leaf spot, downy mildew, botrytis.

Rate and frequency: 3 lbs – 4 lbs formulation./acre, apply at bud break, 3 to 5 inch shoot length, 8 to 10 inch shoot length, pre-bloom

PHI: 21 days

REI: 48 hours

Comments: Should not be applied after bloom.

Estimated cost: \$8.79 to \$11.72 per acre per application.

Systemic fungicides:

Sterol inhibitors:

DMI fungicide:

Myclobutanil (Nova 40WP, Rally 40W): has Warning listed as the signal word.

Target diseases: black rot, powdery mildew, anthracnose

Rate and frequency: 3-5 oz or 0.075 to 0.125 lbs ai /acre at 7-14 day intervals

PHI: 14 days

REI: 24 hours

Comments: Potential for development of resistant strains of powdery mildew fungus limit use to maximum of 24 oz or 0.6 lbs ai /acre/season.

Estimated cost: ranges from \$13.84 to \$23.06.

Triflumizole (Procur 50W): has Caution listed as the signal word.

Targeted pest: powdery mildew.

Frequency and rate: 4 to 8 oz formulation. Begin before bloom and continue on a 14 to 21 day interval. And on a 14-day interval for suppression of botrytis rot.

REI: 12-hr

PHI: 7-day

Comments: do not exceed 32 oz formulation per acre per season. This mode of action has a high risk of resistance development within the fungal population.

Estimated cost: NA

Fenarimol (Rubigan 1EC): has Warning listed as the signal word.

Target diseases: powdery mildew

Rate and frequency: 2 to 6 fl oz/acre applied at 14-18 day intervals. Used as a pre-bloom, post-bloom or summer spray.

PHI: 21 days

REI: 12 hours

Comments: Resistant strains of the powdery mildew fungus limits application to a maximum of 19 oz/acre/season. Surfactant added to material will aid in leaf coverage.

This mode of action has a high risk of resistance development within the fungal population.

Estimated cost: \$6.05 to \$18.22 per acre per application.

Other systemic fungicides:

QoI-Fungicides

Azoxystrobin (Abound 2F): has Caution listed as the signal word.

Target diseases: black rot, downy mildew, powdery mildew, Phomopsis cane and leaf spot, and bunch rot suppression.

Rate and frequency: 10 to 15.5 fl oz/acre at 10-14 day intervals applied in an alternating block spray program.

REI: 4 hours

PHI: 14 days

Comments: Only fungicide that controls all four major diseases that occur in Tennessee. Maximum of 6 applications/season. To prevent disease resistance, should not be applied as two consecutive applications or with another Group 11 fungicide. No more than 1.5 lbs ai per acre per season.

Estimated cost: ranges from \$21.83 to \$33.90 per acre per application.

Trifloxystrobin (Flint 50WP): has Caution listed as the signal word.

Targeted pests: powdery mildew, botrytis bunch rot, phomopsis cane and leaf spot, black rot and disease suppression of botrytis bunch rot, phomopsis cane and leaf spot and downy mildew.

Frequency and rate: applied at the rate of 1.5 to 4 oz. or 0.093 to 0.25 lbs ai per acre. Applied when shoots reach 0.5 inches and again when they reach 5 to 6 inches in length.

REI: 12-hr

PHI: 0-day

Comments: no more than 6 applications per season. No more than 1.5 lbs per acre per season. No more than two sequential applications before using another product in a fungicide group other than Group 11. Should not be applied to Concord grapes. This mode of action has a high risk of resistance development within the fungal population.

Estimated cost: \$16.35 to \$43.60 per acre per application.

Oximinoacetate Fungicide:

Kresoxim-methyl (Sovran 50WG): has Caution listed as the signal word.

Target diseases: black rot, Phomopsis cane and leaf spot, downy mildew and suppresses Botrytis bunch rot.

Rate and frequency: 3.2 - 4.8 oz. formulation per acre, apply at bud break, shoot length 3 - 5 inches, shoot length 8 - 10 inches, prebloom, petal fall. Sprayed on

a 7 to 10 day schedule. With light pressure from powdery mildew, the spray schedule may be extended to 21-days.

PHI: 14 days

REI: 12 hours

Comments: Maximum of 4 applications a year and no more than 25.6 oz per year, do not make over 3 consecutive applications before rotating to a fungicide having a different mode of action. This mode of action has a high risk of resistance development within the fungal population.

Estimated cost:

Dicarboximide fungicides:

Iprodione (Rovral 4F, Iprodione 4L): has Caution listed as the signal word.

Target disease: Botrytis bunch rot

Rate and frequency: 1 - 2 pints/acre applied 4 times per season. For table grapes no more than one application per season early to mid-bloom.

PHI: 7 days

REI: 48 hours

Comments: livestock should not be allowed to graze in treated areas. Cover crops grown in treated areas should not be fed to livestock. This mode of action has a high risk of resistance development within the fungal population.

Estimated cost: ranges from \$11.30 to \$22.60 per acre per application.

Triazole fungicides:

Tebuconazole (Elite 45WP): has Warning listed as the signal word.

Targeted pests: black rot, powdery mildew, will enhance other products control of botrytis.

Frequency and rate: 4 oz or 0.1125 lbs ai per acre.

REI: 12-hrs

PHI: 14-day

Comments: Maximum of 2 lbs formulation per acre per season. Is a DMI fungicide and should be alternated with non-DMI fungicides. This mode of action has a high risk of resistance development within the fungal population.

Estimated cost: NA

Anilinopyrimidine Fungicides:

Cyprodinil (Vanguard 75WDG): has Caution listed as the signal word.

Targeted pest: Botrytis bunch rot, and suppression of powdery mildew.

Frequency and rate: applied at the rate range of 5 to 10 oz per acre. Applied at early bloom to pre-harvest.

REI: 12-hrs

PHI: 7-days

Comments: no more than 30 oz or 1.4 lbs ai per acre per season. This mode of action has a high risk of resistance development within the fungal population.

Estimated cost: NA

Fenhexamid (Elevate): has Caution listed as the signal word.

Targeted Pests: Botrytis bunch rot, powdery mildew suppression

Frequency and rate: applied at the 1 lb formulation rate or 0.5 lbs ai per acre. Applied at early bloom, bunch pre-closure, veraison up to day of harvest.

REI: 12-hrs

PHI: 0-day

Comments: No more than two sequential applications before rotating. No more than 3 lbs formulation per acre per season. This mode of action has a high risk of resistance development within the fungal population.

Estimated cost: \$35.50 per acre per application.

Thiophanate methyl (Topsin-M): has Caution listed as the signal word.

Targeted Pest: bitter rot, black rot, powdery mildew, phomopsis cane and leaf spot, bunch rot.

Frequency and rate: applied at the formulation rate of 0.75 to 1.5 lbs per acre. Applied at 14 to 21 day intervals

REI: 7-day

PHI: 14-days

Comments: Botrytis has shown resistance in some areas to this active ingredient. No more than 2.8 lbs ai per acre per season. This mode of action has a high risk of resistance development within the fungal population.

Estimated cost: ranging from \$13.74 to \$27.49 per acre per application.

Quinazolinone fungicides:

Quinoxifen (Quintec) contains 2.08 lbs ai per gallon. Has Caution listed as the signal word.

Targeted Pest: powdery mildew.

Frequency and rate: Applied at the formulation rate of 3 to 4 fl.oz. No more than 6.6 fl.oz of formulation per acre per application and not to exceed 33 fl.oz. per acre per season.

REI: 12-hrs

PHI: 14-days

Comments:

Estimated cost: ranges from \$9.90 to \$13.20 per acre per application.

Anilino pyrimidine fungicides:

NOTE: This fungicide class has a high risk of resistance development.

Pyrimethanil (Scala brand 5SC): has Caution listed as the signal word. Has 5 lbs ai per gallon of formulation.

Targeted pests: used to control botrytis.

Frequency and rate: 9 to 18 fl.oz. formulation per acre with no more than 36 fl oz per acre per crop.

REI: 24 hrs.

PHI: 7-days

Comments:

Estimated cost: ranges from \$15.33 to \$30.66 per acre per application.

Cyprodinil (Vanguard WG) has Caution listed as the signal word

Targeted pests: botrytis bunch rot control and powdery mildew suppression.

Frequency and rate: If used alone used at the rate of 10 oz formulation per acre. May be used at lower rates of 5 to 10 oz per acre, when using other products .

REI: 12-hr

PHI: 7-day

Comments: No more than 20 oz of formulation per acre per crop year. This mode of action has a high risk of resistance development within the fungal population.

Estimated cost: ranges from \$17.90 to \$35.80 depending on rate used.

Combination fungicides:

Boscalid + Pyraclostrobin (Pristine): has Caution listed as the signal word.

Targeted Pest: Angular leaf spot, anthracnose, black rot, downy mildew, leaf blight, phomopsis cane and leaf spot, powdery mildew, ripe rot, and Cladisporium spp. of bunch rot, suppression of botrytis gray mold.

Frequency and Rate: contains 0.008 lbs of pyraclostrobin in 1 oz of formulation and contains 0.0158 lbs of boscalid in 1 oz of formulation. Applied at the rate of 8 to 12.5 oz. no more than 23 oz per acre.

REI: 5-day

PHI: 14-day

Comments: Maximum rate per acre per season is 69 oz. Maximum number of applications per acre per season is 3. It is in Group 7 and Group 11 of the fungicides. Varieties such as Concord, Niagara, Fredonia, Worden and related varieties are highly sensitive to this product. Generally, these modes of action have a high risk of resistance development within the fungal population.

Estimated cost: ranges from \$18.08 to \$28.25 per acre per application.

Mefenoxam + copper hydroxide (Ridomil Gold Copper): has Danger as the signal word. Is a phenylamide fungicide with a copper included. Product include 5% mefenoxan and 60% copper hydroxide per pound of active ingredient.

Targeted pest: downy mildew

Frequency and rate: up to 4 applications per season. Applied at post-bloom at the formulation rate of 2 lbs per acre or 0.1 lbs mefenoxam and 1.2 lbs copper hydroxide per acre.

REI: 48-hr

PHI: 42-day

Comments: No more than 0.4 lbs ai per acre per season. Some varieties are sensitive to this product.

Estimated cost: \$27.02 per acre per application.

Mefenoxam + Mancozeb (Ridomil Gold MZ): has Caution listed as the signal word. Composed of 4% mefenoxam and 64% mancozeb. This product is a phenylamide fungicide with a dithiocarboximate fungicide included.

Targeted Pests: downy mildew.

Frequency and rate: applied at the rate of 2 lbs formulation per acre. Applications are made prior to bloom.

REI: 48-hr

PHI: 66-days

Comments: Up to 4 applications per season. Should not exceed the rate of 3.2lbs of mancozeb per acre. Applied only by ground equipment. Possible resistance issues with downy mildew, if more than two applications per season are used.

Estimated cost: \$27.60 per acre per application.

Carboxamide Fungicides:

Boscalid (Endura) has Warning listed as the signal word.

Targeted pests: powdery mildew and botrytis.

Frequency and rate: applied at the rate of 4.5 to 8 oz. per acre with a seasonal maximum of 25 oz. and 3 application per acre per season.

REI: 12-hrs

PHI: 14-days

Estimated cost: ranges from \$24.56 - \$43.67 per acre per application.

Salt fungicides:

Potassium salts of fatty acids (M-Pede) has Warning listed as the signal word.

Targeted Pests: powdery mildew, aphids and leaf hoppers.

Frequency and rate: 1 to 2% v/v solution. Sprays initiated at bud break.

REI: 12-hrs

PHI: 0-day

Comments: product should not be applied to Calmeria or Italia varieties of grapes.

Should not be used within 3 days of a sulfur application. Less effective for insect control in late season applications. Product should not be applied after veraison.

Estimated cost: ranges from \$23.80 to \$47.60 per acre per application.

Weeds

Weeds compete with vines for moisture and nutrients. They can be alternate hosts for pests that can damage the vines and/or the crop. They also can reduce air flow throughout the vineyard resulting in increased potential for spring frost damage and diseases. The presence of weeds can make management of the vineyard more difficult. Vineyard weed control starts a year or more prior to planting. At this time, noxious weeds can be eliminated from the site using cultural or chemical methods that would be difficult to impossible to utilize following planting. If herbicides are used, it is important to select products which would not leave a persistent residue that could damage young vines. Weeds and grasses compete more successfully than young grapevines for moisture and nutrients. Shading of the vines by weeds may also be a problem. Their control includes mechanical methods since the number of herbicides labeled for young vines are limited. Several herbicides are labeled for bearing vineyards. Care must be taken in their application to avoid drift onto grape leaves and fruit. Label directions concerning the age of vines and the rate and timing of application must be followed. Most herbicide programs involve the use of postemergence materials to control vegetation already growing and preemergence herbicides to control newly germinating weeds. A tank mix involves combining two or more herbicides in the same application. Often a postemergent herbicide and one or more preemergent herbicides may be applied at the same time. Advantages of a tank mix include control of a broader range of weed and grass species and the ability to achieve control at lower rates of each material. In most vineyards, annual grasses, broadleaf weeds and perennial weeds may all be problems.

Non-chemical weed control:

Mechanical weed control through the use of grape hoes or other methods of shallow cultivation are not widely used. They are more expensive than chemical weed control and are more apt to damage vines. Mulches have been used in some vineyards. They do suppress weed growth and moderate both temperature and moisture levels in the soil. Mulches can harbor pests or provide areas for pests to exist where they are much more difficult to control. The expense of establishing and maintaining a much cover is more than the cost of chemical weed control and therefore usually not utilized. Mowing is often done between rows to reduce weed growth.

Chemical control of weeds:

Approximately 90 percent of commercial vineyards in Tennessee are treated with herbicides for broadleaf weed and grass control. The most commonly used herbicide includes the active ingredient glyphosate. Table 4, lists an estimate of herbicide products used during the 2007 growing season. Not all products listed within Table 4, or within the weed control section listed below were used by producers during 2007, however products are provided to give the reader an idea of possible weed control options.

Nonbearing vines:

Nonbearing vines are typically less than 3 years old and not yet producing fruit at their full potential.

Postemergence Weed Control Products:

Glycine herbicides:

Glyphosate (Roundup 4L, WeatherMax 5.5SL, others): has Caution listed as the signal word.

Target weeds: most grasses and broadleaves.

Application rate and frequency: 1-5 qt/acre of 4L formulation in 10-40 gal water/acre.

Applied as preemergence broadcast application, directed spray, or wiper application, directed to growing weeds. Generally, no more than 3 applications per year.

REI: 12 hours.

PHI: 14 days.

Comments: Avoid contact with vines or severe damage will occur. Applied 30 days prior to planting. Often applied in strips through the vineyard prior to planting.

Estimated cost: depending on method of application and formulation may vary in cost from \$12.00 to 30.00 per acre per application.

Glyphosate (Touchdown 4.17): has Caution listed as the signal word.

Target weeds: grasses and broadleaves-jimsonweed, mustard, annual morningglory, ragweed, smartweed, velvetleaf

Application: 5.33 pt (maximum) in 10-30 gal water/acre/year. Requires a surfactant or wetting agent. Applied as spot treatment or as a wiper application. Materials are directed to targeted weeds. Generally, no more than three applications per year.

REI: 12 hours.

PHI = 14-days.

Comments: Do not use within 12 months of first harvest. Avoid contact with vines or severe damage will occur. Applied 30 days prior to planting. Often applied in strips through the vineyard prior to planting.

Estimated cost: depending on method of application, may vary in cost from \$15.00 to \$30.00 per acre per application.

Bipyridylum herbicides

Paraquat (Gramoxone Inteon 2E): has Danger listed as the signal word and is a Restricted Use Pesticide.

Target weeds: most grasses and broadleaves

Application: 2-3 pints or 0.5 to 0.75 lbs active ingredient per acre in 30-100 gal water.

Sprayed directly on emerged weeds.

REI: 12 hours

Comments: Restricted-use pesticide. Avoid contact with young shoots, foliage, and fruit. Requires a wetting agent which may increase cost slightly.

Estimated cost: ranges from \$8.23 to \$12.34 per acre per application.

Phosphinic acid herbicide

Glufosinate (Rely 1L): has Warning listed as the signal word.

Target weeds: barnyard grass, foxtail, jimsonweed, sheperdspurse, smartweed
Application rate and frequency: 1 lb formula at 3-6 qt in a minimum of 20 gal of water/acre sprayed directly on emerged weeds.

REI: 12 hours

Comments: Maximum application of 18 qts/acre/year.

Estimated cost: if available, would cost around \$16.52 per acre. Product has been difficult to obtain.

Aryloxyphenoxypropionate herbicide

Fluazifop (Fusilade 2 DX): has Caution listed as the signal word.

Target weeds: grasses.

Application: 1-1.5 quarts formulation per acre plus a crop oil concentrate at 1 qt or spreader at 1 pint in 25 gal water/acre. Applied to actively growing grass.

REI: 12 hours.

PHI: NA

Comments: Do not apply within 12 months of first harvest. Crop oils commonly mixed with this product can severely burn young vines. Sequential treatments are normally needed for perennial grass control.

Estimated cost: Ranges from \$43.50 to \$65.25 per acre, however may cost less, if areas are spot sprayed.

Cyclohexanedione herbicide

Clethodim (Prism 0.94 lb, Arrow 2EC, Select): Prism has Warning where Arrow has Caution listed as the signal word.

Target weeds: grasses

Frequency and rate: for the 0.94 lbs formulation use 13 to 17 fl.oz. per acre and the 2EC formulation use 6 to 8 fl oz/acre. Both recommend using with crop oil. May be used as spot treatment.

REI: 12 hours

PHI: 12 months of harvest

Comments: Do not apply more than 68 fl oz /acre/year. Commonly mixed with crop oils and can severely burn young vines. Sequential treatments are normally needed for perennial grass control.

Estimated cost: ranges from \$6.09 to \$8.13 per acre per application.

Sethoxydim (Poast): has Warning listed as the signal word.

Target weeds: grasses

Application: 1.5-2.5 pt plus 2 pt crop oil in 10-20 gal water/acre Applied as directed spray when grass is actively growing.

REI: 12 hours

PHI: 50-days

Comments: Maximum application of 2.5 pts / application or 5 pts / season. Crop oils commonly added to this material can severely burn young vines. Sequential treatments are normally needed for perennial grass control.

Estimated cost: ranges from \$14.29 to \$23.81 per acre per application. However, cost may be less if spot sprayed.

Preemergence Control Herbicides:

Benzamide herbicides

Isoxaben (Gallery 75DF): has Caution listed as the signal word.

Target weeds: broadleaves-dandelion, lambsquarter, mustard, night-shade, ragweed, smartweed, velvetleaf

Application rate and frequency: 0.66-1.33 lb formulation /acre in 10 gal of water applied late summer/early fall or spring prior to weed germination.

REI: 12 hours

PHI: 12 months.

Comments: Do not apply within 12 months of first harvest. For non-bearing vineyards only.

Estimated cost: ranges from \$72.67 to \$144.97 per acre per treatment.

Isoxaben and oryzalin (Snapshot 80 DF, 2.5G) most used formulation and is a combination of a benzamide and dinitroaniline herbicide.

Target weeds: broadspectrum of grass and broadleaf control

Application: 2.5-5 lb/acre for the 80DF formulation and 150 lbs for the 2.5G formulation.

REI: 12 hours

Comments: Do not use within 12 months of first harvest.

Estimated cost: \$ 298.50 for the 2.5 G formulation.

Dinitroaniline herbicides

Oryzalin (Surflan 4AS): has Caution listed as the signal word.

Target weeds: grasses and broadleaves-lambsquarter, mustards, pigweed, and purslane.

Application: 2-4 qt/acre in 20-40 gal water/acre band-sprayed.

REI: 12 hours

PHI: NA

Comments:

Estimated cost: ranges from \$37.00 to \$74.00 per acre per application.

Pendimethalin (Prowl 3.3EC, H₂O): has Caution listed as the signal word.

Target weeds: grasses and broadleaves-lambsquarter, pigweed, purslane

Frequency and rate: 2-4 qt in 20 gal water.

REI: 24-hours

PHI:

Comments: Applied only to dormant, nonbearing vines. Should not be applied after the bud has swelled. Product is often mixed with paraquat, glyphosate, or Rely for postemergence weed control.

Estimated cost: ranges from \$17.15 to \$34.30 per acre per application.

Acetamide herbicide:

Napropamide (Devrinol 50DF): has Warning listed as the signal word.

Target weeds: grasses and broadleaves-mustards, purslane, pigweed

Application rate and frequency: 8 lb in 20 gal water/acre

REI: 12 hours

Comments: Do not allow spray to contact fruit or leaves.

Estimated cost: \$72.40 per acre per application.

Nitrile herbicide:

Dichlobenil (Casoron 4G or Norosac): has Caution listed as the signal word.

Target weeds: grasses and broadleaves-jimsonweed, chickweed, lambsquarter, pigweed, ragweed, smartweed, velvetleaf

Application: 100-150 lb/acre soil surface applied Nov.-Feb. Overhead irrigation may be needed to activate in the spring.

REI: 12 hours

Comments: Can be applied 4 weeks after transplanting. Increased temperatures increase volatilization of product.

Estimated cost: ranges from \$223 to \$334.50 per acre per application. Generally, only one application is needed to provide control for 3 or more years.

Bearing vines:

Preemergence herbicides:

Triazine herbicide:

Simazine (Princep 4L, 90): has Caution listed as the signal word.

Target weeds: grasses and broadleaves-jimsonweed, annual morningglory, mustards, ragweed, smartweed, and velvetleaf.

Frequency and rate: for the 90 formulation use 2.2 lb/acre in light sandy soils; dark, heavy soils: use 5.3 lb/acre in a minimum of 20 gal of water. Band-sprayed under trellis before weed germination. Often tank mixed with oryzalin or norflurazon.

REI: 12 hours

PHI: none listed

Comments: Vines must be established 3 years.

Estimated cost: ranges from \$11.32 to \$27.18 per acre per application.

Pyridazinone herbicide:

Norflurazon (Solicam 80DF): has Caution listed as the signal word.

Target weeds: grasses and many broadleaves-dandelion, fall panicum, jimsonweed, mustards, ragweed, and velvetleaf.

Application rate and frequency: Sandy, light soils: 2.5 lb/acre; dark, heavy soils: 5 lb/acre in at least 20 gal of water

Band-sprayed below trellis before weed germination.

REI: 12 hours

PHI: none listed

Comments: Do not apply after bud break on sandy soils. Vines must be established 24 months.

Estimated cost: ranges from \$59.55 to \$119.10 depending on rate used.

Urea herbicide:

Diuron (Karmex 80DF or Direx 80DF): has Caution listed as the signal word.

Target weeds: broad spectrum grass and broadleaf control

Application: Sandy, light soils: 2 lb/acre; dark, heavy soils: 4 lb/acre in 25-40 gal water

Rotated with norflurazon as weed populations change. Band-sprayed under trellis before weed germination. No more than 8 qts of the 4L formulation per acre per crop season.

90 days should be allowed between applications.

REI: 12 hours

PHI: none listed

Comments: Vines must be established 3 years. Often applied with paraquat or glyphosate for postemergence control of weeds.

Estimated cost: ranges from \$5.57 to \$11.14 per acre per application.

Benzamide herbicide:

Pronamide (Kerb 50-W): has Caution listed as the signal word.

Targeted pests: cool season broad leaf weeds.

Frequency and rate: applied at the formulation rate of 4 lbs per acre per crop cycle with no more than 8 lbs formulation per acre per crop cycle. Usually applied in the fall after harvest for cool season broadleaf weed control when temperatures do not exceed 55F.

REI: 24-hours

PHI: NA

Comments: Plants must be established at least one year or spring transplants established at least 6 months.

Estimated cost: ranges from \$172 or greater depending on rate used.

Postemergence control products:

Glyphosate (Roundup): has Caution listed as the signal word.

Target weeds: most grasses and broadleaves

Application: 1-5 qt/acre in 10-40 gal water/acre applied as a broadcast application, directed spray or

wiper application to growing weeds

PHI: 14 days.

REI: 12 hours.

Comments: Avoid contact with any part of the grapevine except mature bark.

Estimated cost: listed above.

Paraquat (Gramoxone Extra, Gramoxone Inteon): has Danger listed as the signal word, is a Restricted Use Pesticide.

Target weeds: most grasses and broadleaves

Application: 2-3 pt/acre in 30-100 gal water/acre; use of a nonionic surfactant required.

Sprayed directly on emerged weeds. Applications repeated as needed.

REI: 12 hours

Comments: Restricted-use pesticide. Avoid contact with young shoots, foliage, fruit.

Product is a contact herbicide which burns area of contact, thorough coverage is needed for prolonged control.

Estimated cost: listed above.

Glufosinate (Rely 1): has Warning listed as the signal word.

Target weeds: barnyard grass, foxtail, jimson weed, sheperdspurse, smartweed

Application: 3-6 qt/acre in a minimum of 20 gal water/acre sprayed directly on emerged weeds.

Applications repeated as needed.

REI: 12 hours

PHI: 14-day.

Comments: Maximum application of 18 qt/acre in 12 months.

Estimated cost: if available, would cost around \$16.52 per acre. Product has been difficult to obtain.

N-Phenylphthalimide herbicide:

Flumioxazin (Chateau 51WDG): has Caution listed as the signal word.

Targeted weeds: annual broadleaf weeds and grass weeds.

Frequency and rate: applied at the rate of 6 to 12 oz. Should not apply more than 6 oz per acre rate in soil containing a sand base.

REI: 12-hr

PHI: 60-days

Comments: Should not be applied to grapes established less than two years, unless they are trellised at least 3 feet from soil surface. Applications after flowering in bearing vineyards must be made with hooded or shielded application equipment.

Estimated cost: pricing not available.

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Table 1. Cultivar Black Rot Susceptibility Ratings. ^{1,2}

Cultivar	Disease Reaction
Aurora	ES
Baco Noir	HS
Bath	HS
Cabernet Sauvignon	HS
Canada Muscat	HS
Canadice	HS
Cascade (Siebel 13053)	MR
Catawba	HS
Cayuga White	HS
Challenger	ES
Chambourcin	MR
Chancellor (Siebel 7053)	MS
Chardonnay	MS
Chelois (Siebel 10878)	MR
Concord	HS
DeChaunac (Siebel 9549)	MS
Delaware	HS
Dutchess	HS
Foch	MS
Fredonia	MR
Gewurtztraminer	HS
Glenora	HS
Himrod	MS
Interlaken	HS
Leon Millot	HS
Mars	R
Missouri Riesling	MR
Niagara	HS
Pinot Noir	HS
Reliance	HS
Remaily Seedless	MR
Riesling	HS
Rougeon (Siebel 5989)	MS
Seyval (Seyve-Villard 5-276)	HS
Steuben	MS
Vidal Blanc	MS
Vidal 256	MR

Vignoles (Ravat 51)	HS
Villard Blanc	HS
Vinered	HS

¹ *Disease ratings compiled from the Missouri and Cornell Grape Pest Control Guides.*

² *Disease ratings are for a "typical" black rot year. Significantly more or less disease pressure may modify the above. R = Resistant, MR = Moderately Resistant, MS = Moderately Susceptible, HS = Highly Susceptible, ES = Extremely Susceptible.*

Table 2. 2002 Estimated Potential of Tennessee Fruit Usage in Tennessee Wineries.

Variety of Fruit	Production Potential	Average Annual Volume
Concord	10	36,045 gal
Niagara	10	12,136 gal
Blackberries	10	28,500lbs/3,125 gal
Catawba	10	11,750 lbs
Strawberry	10	10,000 lbs/300 gal
Cynthiana	9	275 gal
Seyval	9	1,700 gal
Cayuga	9	1,650 gal
Chambourcin	9	2,250 gal
Foch	8	550 gal
Vignoles	8	825 gal
Leon Millot	8	1,000 gal
Chancellor	8	3,482 gal
Venus	8	2,500 gal
Baco	8	120 gal
Rougeon	8	150 gal
DeChauac	8	2,275 gal
Raspberry	7	12,700 gal

The fruit varieties in Tennessee were rated for their production possibility, on a scale of 1 (no potential) to 10 (perfectly suited for commercial production in Tennessee). Eighteen varieties were identified as scoring 7 or better. Factoring in their average annual volume, research suggests that Tennessee wineries represent a market for approximately 90 additional acres of annual fruit production. In 2002, represented an annual projected revenue of \$316,000 annually.

Table 3. Estimated Insecticide Usage in 2007 Grape Production.

Insecticide active ingredient	Trade name	% acreage treated
Chlorpyrifos	Lorsban 4E	5
Malathion	Malathion 25WP	trace
Pyrethrin and Rotenone	Pyrellin	trace
Carbaryl	Sevin	10
Dicofol	Kelthane	1
Pyridiben	Pyramite	0
Methomyl	Lannate	0
Fenpropathrin	Danitol	0
Sulfur*	Sulfur	20
Bifenthrin	various	Trace
Endosulfan	Thiodan	0
Bacillus thuringiensis	various	0
Spirodiclofen	Envidor	0
Imidachlopid	Provado, Admire Pro	0
Carbofuran	Furadan	0
Methoxyfenozide	Intrepid	0

Estimates provide by Frank Hale, University of Tennessee Extension Service. Reported levels for 2007, are not typical uses for grapes during more favorable growing seasons.

* Sulfur was primarily used for disease control.

Table 4. Estimated Herbicide Usage in 2007 Grape Production.

Herbicide active ingredient	Trade name	% acreage treated	Expected Season of Treatment*	Crop Stage
Glyphosate	Roundup	80	Su/F/W/Sp	NP/2/3
Oryzalin	Surflan		Sp / Su	NP
Pendimethalin	Prowl 3.3EC, H2O		Sp	NP
Pronamide	Kerb 50WP		F	2 ^a
Norflurazon	Solicam 80DF		F/W	2 ^a
Dichlobenil	Casoron 4G		W	NP/2/3
Isoxaben	Gallery		Sp	NP/2/3
Oxyfluorfen	Goal, Galigan, Oxiflo 2EC		F/W	NP/2/3
Diuron	Karmex 80DF		Sp/Su	2/3
Simazine	Princep 4L		F/Sp	3
Flumioxazin	Chateau 51WDG		W / Sp /Su	NP/2/3
Glufosinate	Rely 1L	1	Su /W	NP/2/3
Paraquat	Gramoxone Max 3SL	15	W / Sp / Su	NP/2/3
Clethodim	Select, Arrow 2EC	5	Su	NP/2/3
Fluazifop	Fusilade DX	8	Su	NP/2/3
Sethoxydim	Poast	5	Su	NP/2/3

* F= fall, W=winter, Sp = spring, Su=summer;

** NP= newly planted, 2=established 1 to 2 years, 3 = established 3 or more years.

^a vines must be established for 2 or more years

Table 5. Estimated Fungicide Usage in 2007 Grape Production.

Fungicide active ingredient	Trade name	% acreage treated
Azoxystrobin	Abound 2SC	5%
Boscalid + Paraclostrobin	Pristine 38WDG	1%
Boscalid	Endura 30WG	trace
Captan	Various 4L	10%
Cyprodinil	Vanguard 75WDG	0%
Fenhexamid	Elevate 50WDG	trace
Ferbam	Ferbam	0%
Fenarimol	Rubigan 1E	0%
Fixed Copper and Lime (Bordeaux mixture)	Various	20%
Iprodione	Rovral 50WP	0%
Kresoxim-methyl	Sovran 50WG	0%
Mancozeb	Dithane, Manzate	50%
Maneb	Maneb	2%
Mefenoxam + Copper	Ridomil Gold Copper	Trace
Mefenoxam + mancozeb	Ridomil Gold MZ	Trace
Myclobutanil	Nova 40W	20%
Sulfur	Various	20%
Tebuconazole	Elite 45DF	Trace
Thiophanate methyl	Topsin M	20%
Trifloxystrobin	Flint 50WG	0%
Triflumazole	Procure 50WS	1%
Ziram	Ziram	2%
Quinoxifen	Quintec 2SC	0%
Phosphoric acid	Phostrol, Prophyt	0%
Triadimefon	Bayleton	0%

Estimates provided by Steve Bost, University of Tennessee Extension Service.

Table 6. Efficacy of Selected Fungicides Against Diseases of Bunch Grapes

Fungicide	Disease					
	Black rot	Bitter rot	Botrytis rot	Downy mildew	Phomopsis cane and leaf spot	Powdery mildew
Azoxystrobin	+++++ ^a	+++++	+++	+++++	+++	+++++
Boscalid + Paraclostrobin	+++++	+++++	+++++	+++++	+++++	+++++
Captan	+++	+++++	++	++++	+++++	+++++
Cyprodinil	NA	NA	+++++	NA	NA	++
Fenhexamid	NA	NA	+++++	NA	NA	NA
Ferbam	+++++	+++	NA	++	++	NA
Finarimol	++	NA	NA	NA	NA	+++++
Fixed Copper and Lime (Bordeaux mixture)	+++	++	+++	++++	++	+++
Iprodione	NA	NA	+++	NA	NA	NA
Kresoxim-methyl	+++++	+++++	++	+++	+++	+++++
Mancozeb, maneb	+++++	+++++	NA	+++++	+++++	NA
Mefenoxam + Copper	++	++	++	+++++	++	+++
Mefenoxam + mancozeb	+++++	+++++	NA	+++++	+++++	NA
Myclobutanil	+++++	++	NA	NA	NA	+++++
Sulfur	NA	NA	NA	NA	++	+++++
Tebuconazole	+++++	NA	NA	NA	NA	+++++
Thiophanate methyl	++	+++	+++	NA	+++	+++++
Trifloxystrobin	+++++	+++++	++++	+++	++	+++++
Triflumazole	+++	NA	NA	NA	NA	+++++
Ziram	+++++	NA	++	++++	+++	NA

^aNA = no significant activity, + = very limited activity, ++ = limited activity, +++ = moderate activity, ++++ = good activity, +++++ = excellent activity.

^bSulfur will cause burn on sensitive varieties, especially on hot days.