

Grapes

GENERAL INFORMATION

Recent trends indicate a rapidly increasing interest in production of both wine and table grapes. The European grapes, *Vitis vinifera*, are very sensitive to cold temperatures. Over most of New England, special cultural care must be taken to overwinter *V. vinifera* varieties. *V. labrusca*, which includes Concord and Niagara, is hardier and more resistant to endemic disease problems.

Grapes will do best on a well drained loam soil with a pH of 5.5 to 6.5. Potash, manganese, and iron deficiency problems may develop if soil is limed to raise pH above 6.5. Site selection is critical to success. The ideal site will seldom experience winter temperatures below $-5\frac{1}{2}^{\circ}\text{F}$, provides freedom from late spring frosts, and offers a frost-free growing season of at least 165 to 180 days.

There are many training system options for grapes; but whatever system is used, the selection of canes well exposed to light and the proper severity of pruning (generally determined using the balanced pruning formula for each specific variety) are the keys to productivity and fruit quality.

The use of multiple trunks (and systematic trunk renewal) is highly recommended in New England to minimize the risk of severe low temperature injury and the development of eutypa dieback disease and crown gall. Overcropping will also significantly increase the risk of winter injury.

Table 40. Recommended optimal soil characteristics for growing grapes.

Soil Characteristic	Desirable Range*
pH	5.5-6.5
Organic matter	4 to 6 %
Phosphorus	20-50 ppm
Potassium	120- 150 ppm Base Saturation >3.0
Magnesium	100-150 ppm Base Saturation >5.0
Calcium	1000 - 1500 ppm Base Saturation >50.0

*Desirable range will vary with soil type (sand, silt, or clay), soil organic matter, and pH.

Table 41. Critical nutrient values for grape petiole analysis.

Element	Deficient	Below Normal	Normal	Above Normal	Excessive
N (%)	1.80	2.00	2.50	3.00	>3.00
P (%)	0.24	0.25	0.35	0.40	>0.40
K (%)	1.45	1.50	2.00	2.50	>2.50
Ca (%)	0.59	0.60	1.70	2.50	>2.50
Mg (%)	0.29	0.30	0.70	0.90	>0.90
Mn (ppm)	45	50	150	200	>200
Fe (ppm)	48	50	150	200	>200
Cu (ppm)	6	7	30	50	>50
B (ppm)	24	25	40	50	>50
Zn (ppm)	18	20	35	50	>50

Source: Cornell University

DISEASES

Fruit Rots

Black Rot (*Guignardia bidwellii*): This is probably the most damaging grape disease in New England. Most loss is caused by damage to the berries, though leaves, tendrils and new shoots are also damaged. The fruit is susceptible from fruit set until veraison; resistance increases from pea-size to veraison.

This disease is caused by a fungus which overwinters in mummified berries and stem lesions. Mummies on the soil surface release spores when rain soaks them in the spring. There is a continuous production of spores throughout the spring and summer. These are carried to new plants by wind. Young tissue is infected in less than 12 hours between 60½ - 90½F. Spores grow into mycelium producing symptoms in 8 to 25 days, depending on the weather. New leaves and half-grown berries are most susceptible. Secondary infections occur when new spores are produced on the current year's infections. Secondary spores are produced into August, and are spread by splashing rain.

On leaves, infections appear as yellowish-tan spots in late spring. These spots enlarge, become reddish-brown with a dark outline. Lesions are roughly circular in shape. Shoots develop sunken, elliptical lesions, black in color up to 2 cm in length. On the berry, symptoms do not appear until the fruit is half grown. Lesions start as a small whitish dot and quickly engulf the whole berry. The infected area develops a reddish brown color. The berry wrinkles and blackens completely within a few days. These fruit become mummies that are very hard and stony, and supply inoculum for the following year.

Management: Sanitation is important. Destroy mummies and canes with lesions. Remove infected tendrils from vines. Plant grapes in locations having good air circulation, taking advantage of prevailing winds and sun. Black rot is more likely to occur near woodland borders. It occurs much more severely in wet years than in dry years. Protectant fungicides offer good control when they are applied initially when the shoots are 10-16 cm long and continued until the berries contain approximately 5% sugar. Bayleton, Abound and Nova are excellent eradicant materials; Bayleton is weaker as a protectant. Varietal resistance is another control option. See pest management schedule for recommended materials and timing.

Table 42. Grape black rot leaf wetness duration-temperature combinations necessary for grape foliar infection by black rot.

Temperature (½F)	Minimum leaf wetness duration for light infection (hr)
50	24
55	12
60	9
65	8
70	7
75	7
80	6
85	9
90	12

Bitter Rot (*Greeneria uvicola*): Bitter rot, while most common in southern grape regions, may infect grapes in New England. If 10% of the berries in a wine pressing are infected with bitter rot, the wine can be undrinkable. Bitter rot may be easily confused with black rot. Infected berries first develop brownish, water-soaked lesions. The bitter rot fungus infects ripe grapes, and unlike the black rot fungus, does not infect green berries. Bitter rot susceptibility increases right at veraison. Lesions often have concentric rings. Berries turn brown but retain their shape. In 3 or 4 days black pustules erupt on the berry. If overripe berries become infected, they are not easily detected, because pustules do not form. These berries are the most bitter, and the most likely to be mistakenly harvested.

Warm, humid weather at the time berries ripen favors the disease. The fungus grows rapidly, and can rot berries in 5 to 7 days. Wounding promotes fungal growth.

Management: Good air circulation for good drying in the vineyard. Fungicides used for the control of some of the previously discussed diseases usually will also control bitter rot. If conditions are right for infection, late season sprays should not be omitted. Most varieties have some degree of resistance to the fungus.

Botrytis Bunch Rot (*Botrytis cinerea*): Botrytis rot can cause serious losses in susceptible varieties. While some rot is acceptable in wine grapes, and may even be desirable, the disease can get out of control. The fungus which causes the disease is present in grape mummies, debris on the vineyard floor and in organic matter around the planting. Spores are released in

moist, warm weather in spring, and then throughout the growing season. These first spores infect blossoms at the end of bloom. A second infection occurs at berry maturity. The fungus uses senescing or dead material as a base to spread into healthy tissue. Botrytis-infected berries are at first soft and watery. The berries usually become covered with gray, fuzzy fungal mycelium within a few days. Rotted berries shrivel, then drop to the ground to eventually become mummies.

Management: Good air circulation and vineyard sanitation are helpful. Leaf removal around the clusters has shown excellent control of the disease in California. Protective fungicides should be used when wet weather occurs near bloom and berry ripening. See pest management schedule for recommended materials and timing.

Foliage and Cane Diseases

Downy Mildew (*Plasmopara viticola*): This disease causes damage primarily by attacking the vine, though all parts of the plant are susceptible to injury. The optimum conditions for the disease are cool to moderate temperatures, and wet weather. The disease is caused by a fungus which needs living tissue as a host. In spring, spores of the fungus come from dead tissue on the ground. Free water is required for infection, and infections may occur during high humidity throughout the season. Splashing water or handling wet plants may readily spread the spores. The spores grow into cottony masses, producing many new spores which can spread the infection. As tissue dies, it falls to the ground where the fungus overwinters.

On leaves, new infections are difficult to see. They appear first as generally angular, pale-yellow spots delimited by veins which later become brown. On the underside of the leaf the cotton-like 'downy' growth appears. Fruit infection occurs at two times. First, when the berries are the size of small peas, infections will cause berries to turn light brown and soft. Berries will shatter easily. Sometimes the downy growth covers the berries. During the heat of the summer, little fruit infection occurs. The second infections occur in the late summer or early autumn. Berries infected then do not turn soft or develop downy growth. The berries turn dull green, then purplish-brown. Shoots and tendrils develop water-soaked lesions, become stunted and distorted, and may die.

Management: Remove debris from the vineyard floor. Maximize air circulation to improve drying.

European grapes are generally more susceptible than American grapes. The most serious epidemics occur when a wet winter is followed by a wet spring and a warm summer with frequent precipitation. Fungicides should be applied when disease pressure is high. Apply just before bloom; 7-10 days later; 10-14 days later; 3 weeks later. See pest management schedule for recommended materials and timing.

Powdery Mildew (*Uncinula necator*): Powdery mildew causes loss by infecting leaves and berries. It is primarily a problem on European grape varieties, although American varieties may be damaged. It may be confused with downy mildew. (See above description.) Losses are not generally heavy from the disease, although it can build up over several years.

The fungal pathogen overwinters in specialized structures on or in living tissue. In spring, spores are released which attack new tissue. Rain and free moisture are not important to the spread of powdery mildew, unlike other grape diseases. Wind carries spores from infected areas into new locations. Dry conditions with low relative humidity favor this disease. Infected tissue, especially on leaves, looks as though a white powder were on the surface. Severely infected leaves curl. Leaves of American varieties like Niagara and Concord are very susceptible. Young fruit and blossoms may be misshapen by infections; mature fruit is immune.

Management: Use fungicides where infections are known to occur. Copper and lime sulfur dormant applications provide good early season control. However, there are label restrictions. Check with your state Extension Specialist for recommendations. Some varieties are sensitive to sulfur and it should always be applied at cooler temperatures (<85½F) Nova and Bayleton are also effective; see pest management schedule for recommended materials and timing.

Cultural practices can help reduce disease incidence. Planting in sites with good air circulation and sun exposure and the use of appropriate training systems which allow for good air movement are highly advisable.

Eutypa Dieback (*Eutypa armeniaca*): This disease also has been known as "dead arm." It causes limbs to die back and forms cankers. Recently, it was shown to occur in conjunction with Phomopsis, causing the dead arm symptoms. Cankers are frequently found around old pruning cuts. They are usually under the bark, and show only as a flattened

area on the surface. The cankers run lengthwise along the limb. Infections occur on pruning cuts in early spring. Over several years, the infection increases, causing new leaves to emerge small and yellowed. New shoot growth has shortened internodes, leaves are small and cupped and all growth is chlorotic. Eventually the cane dies. After about 5 years, the bark sloughs off. This is seldom seen in vineyards less than 8 years old.

Management: Infected material should be removed early in the season when symptoms are obvious. Make cuts well below cankers. Destroy all prunings. Paint all pruning wounds on wood 2 years or older with Benlate. It may be necessary to remove the whole plant. Multiple trunk systems are recommended on an 8 to 10 year cycle. This helps with both *Eutypa* dieback and crown gall.

Phomopsis cane and leaf spot (*Phomopsis viticola*): This is a fungal disease which causes reddish-brown lesions on canes, leaf spots and fruit rot. Small black spots at the base of developing shoots are the first sign of infection. These areas may crack, and late in the season may appear bleached. Leaf infections appear as small, dark lesions with yellow margins. Usually the lower leaves are affected first. Berry infections are rare, and symptoms are similar to black rot symptoms. The fungus overwinters in lesions in wood. In spring, spores are released and spread by rain. Cool, wet weather promotes spread of the disease.

Management: Prune and destroy infected canes. Late dormant sprays help to kill the overwintering fungal fruiting bodies on the surface of the vine. Two applications of Captan (at 1" and at 6" shoots) provide good management under normal conditions. Protectant fungicides are helpful at preventing infection if they are less susceptible to the fungus. See pest management schedule for recommended materials and timing. Concord, Catawba, Chelois, Delaware, Niagara, and Rougeon are the most susceptible varieties.

Anthracnose: This disease, like several of the others discussed, is worst during those growing seasons which are warm, humid and rainy. It reduces the quantity and quality of the berries. Circular "birds-eye" lesions are produced on the leaves with brown to black angular-shaped margins. If infection is severe, numerous lesions may coalesce, making large areas of the leaf necrotic. Often lesions will be concentrated on the veins. Necrotic tissue may drop out, leaving a "shot hole." Youngest leaves are the most susceptible.

Lesions on the stems and shoots may also be numerous; coalescing lesions will split open the tissue into the pith. Margins will be raised and purplish to brown in color. Lesions on the rachis and pedicels of the fruit cluster are similar to the stem lesions. If infections are numerous, berries may drop off entirely, or they may develop cracking. Numerous spores are released from overwintering lesions on stems or berries and are dispersed by rainfall. Spores are infectious over a wide temperature range, but need water in order to penetrate susceptible tissue. Hail injury may especially favor infection by this fungus.

Management: Do not plant highly susceptible varieties in heavy soils with poor drainage. Dormant fungicide sprays help to reduce inoculum of the pathogen. Protectant sprays beginning when shoots are 5-10 cm long and continuing at 2-week intervals are recommended. A fungicide should be applied 24 hours after hail injury.

Angular Leaf Scorch: This is a relatively new disease on the scene and was especially widespread in New York in 1986 which was an unusually wet growing season. Symptoms on the leaves are characterized by angular, red-brown necrotic lesions delimited by the major veins. A yellowish margin usually separates the infected tissue from the healthy green tissue. Significant defoliation was noted on plantings of Aurora, DeChaunac, Rougeon, and Ventura in New York in 1986. The fungus overwinters on the ground in infected leaf litter.

Management: Destruction of the overwintering leaves should help eliminate inoculum of the fungus. Prebloom sprays of mancozeb starting when shoots have three unfolded leaves and continuing on a regular black rot/downy mildew control schedule also offer disease control. Mancozeb has a 66 day pre-harvest interval.

Root and Trunk or Crown Diseases

Crown Gall (*Agrobacterium tumefaciens*): Crown gall is a bacterial disease that infects more than 2,000 species of plants (including brambles). Crown gall of grape is a major problem in cold climate regions. Wounds are necessary for infection to occur. Observations suggest that freeze injury wounds are highly conducive to infection. The disease is particularly severe following winters that result in freeze injury on cold-sensitive cultivars, such as those of *Vitis*

Table 43. Effectiveness of fungicides on grape diseases.

Fungicide	Phomopsis Cane and Leaf Spot	Black Rot	Downy Mildew	Powdery Mildew	Botrytis Rot
Abound	++++	++++	++++	++++	-
Bayleton (triadimefon)	-	++++	-	++++	-
Benlate ^a (benomyl)	+++	+	-	+++	++
Captan	+++	+	+++	-	+
Copper & lime	+	+	+++	++	+
Ferbam	++	+++	++	-	-
JMS Stylet Oil	-	-	-	+++	-
Mancozeb	+++	+++	+++	-	-
Nova (myclobutanil)	+	++++	-	++++	-
Procure	-	++	-	++++	-
Ridomil Gold MZ	-	+	++++	-	-
Ridomil/Copper	+	+	++++	++	+
Rovral (iprodione)	-	-	-	-	+++
Rubigan (fenarimol)	-	++	-	++++	-
Sulfur ^b	+	-	-	+++	-
Ziram	++	+++	++	-	-

++++=excellent, +++=good, ++=moderate, +=slight, -=not effective.

^a Benomyl-resistant strains of the powdery mildew and Botrytis fungi have been detected. When resistant strains are present, benomyl will be ineffective and should not be used.

^b Sulfur may cause damage to sensitive varieties, it should always be used under cool temperatures.

vinifera. Crown gall is characterized by galls or overgrowths that usually form at the base of the trunk. Galls form as high as 3 feet or more up the trunk (aerial galls). Galls generally do not form on roots. The disease affects all grape cultivars. Vines with galls at their crowns or on their major roots grow poorly and have reduced yields. Severe economic losses result in vineyards where a high percentage of vines become galled within a few years of planting.

The disease first appears as small overgrowth or galls on the trunk, particularly near the soil line. Early in their development, the galls are more or less spherical, white or flesh-colored, and soft. Because they originate in a wound, the galls at first cannot be distinguished from callus. However, they usually develop more rapidly than callus tissue. As galls age, they become dark brown, knotty, and rough.

Management: Control procedures include: (1) planting only nursery stock which is free of any obvious galls on crowns or roots; (2) not planting into a field where crown gall has occurred previously, unless a non-host crop, such as strawberries or most vegetables, is grown for two or more years before replanting; and (3) minimizing winter injury to root and crown systems.

In addition to be above procedures, a nonpathogenic bacterium, *Agrobacterium radiobacter*, strain K-84, is commercially available for biological control of grown gall. The biocontrol agent may be applied to roots of healthy plants when they are first set out. After planting, the control becomes established in the soil around the root zone and prevents crown gall bacterium from entering this region. However, the biocontrol agent will not cure plants which are already infected before its application.

INSECTS

Fruit Pests

Grape Berry Moth (*Paralibesia viteana*): The moth is about 3/8 - 1/4" long and has a broad gray band across the middle of its wings. The larva is grayish-green and about 3/8" long when full grown. Larvae are found in the blossoms, young fruit clusters, and newly-formed berries; later they are found in green and ripening berries. Larvae feeding in the green and ripening berries cause most losses. Green berries will be seen to have a maroon coloration on one side, espe-

cially where the berry comes closest to or contacts a nearby berry in the same cluster. Such coloration indicates that a larva has fed on one berry, burrowed into another, and connected them with webbing. Ripening berries infested with larvae are detected by the wrinkled, shrunken appearance of the fruit.

Management: Remove wild grape plants from areas adjoining the vineyard. Till between rows to bury overwintering larvae. Pheromone traps are available to monitor onset of activity and pressure. Traps should be placed in the vineyard prior to the onset of GBM activity, usually around bloom. Threshold numbers for these traps have not been verified for New England, but they are useful to determine the onset of GBM activity. Mating disruption is being used successfully in some vineyards with the application of Isomate™ pheromone ties. These ties emit GBM pheromones slowly over time and when dispersed throughout the vineyard, make it difficult or impossible for male and female GBM moths to find one another and mate. These ties are recommended for vineyards 5 acres in size or larger. They are available from Pacific Biocontrol in Davis, California and Micro Flo in Lakeland, Florida. Contact your local Extension Specialist for help getting Isomate™ ties.

When damage is seen, it is too late to treat. It may be necessary to treat with insecticide the following season. See pest management schedule for recommended materials and timing. Applications should be made post-bloom, 10 days later and again in late July or early August.

Foliage and Cane Pests

Grape flea beetle (*Altica chalybea*): This is a metallic blue beetle about 3/16 - 1/4" long that jumps when disturbed. It is found on swelling buds during the spring. The flea beetles overwinter as adults and emerge during April. They chew holes in the ends and sides of buds that are beginning to swell. Such damage destroys the capacity of a bud to develop a primary or secondary shoot. Once the buds have grown to a length of 1/2" or more, the beetles cannot cause significant injury.

Management: See pest management schedule for recommended materials and timing.

Grape Phylloxera (*Phylloxera vitifoliae*): The presence of this soft-bodied insect (about 1/16" or less in length) is indicated by galls or knob-like protrusions on the underside of leaves. It is found primarily on

leaves of vinifera varieties, especially after bloom. The damage results from new leaves remaining curled and unproductive on the vine.

Management: Plant resistant rootstocks. Remove infected leaves. Spray applications should be made immediately after bloom and again 10 days later. See pest management schedule for recommended materials and timing.

Grape Leafhopper (*Erythroneura comes*) and **Potato Leafhopper** (*Empoasca fabae*): These soft-bodied, elongated insects about 1/8" in length, walk quickly when disturbed and hop when touched. The grape leafhoppers are yellow and white or red and white. The potato leafhopper is light green and has a distinctive side-ways walk. Leafhoppers appear primarily in mid-summer and are found on the underside of leaves, especially young ones. Feeding activity causes white blotches on leaves, leaf curling, and eventual leaf drop.

Management: When leafhoppers number 3 or more per leaf, apply an insecticide (preferably when most of the nymphs have hatched). See pest management schedule for recommended materials and timing.

Japanese Beetle (*Popillia japonica*) and **Rose Chafer** (*Macroductulus subspinosus*): These clumsy, large beetles can feed heavily on the foliage of many different plants. Japanese beetles are a shiny copper color, almost round in shape with legs that tend to stick out. They will play dead when disturbed, dropping to the ground. Rose chafers are very similar behaviorally but dull green in color and more oval in shape. They can be found on both leaves and fruit. The feeding damage to leaves results in skeletonizing of the leaves with only the veins left; injured fruit is unsalable. Japanese beetles are about 1/2" long and copper-colored, with metallic green markings. They feed on grape foliage, skeletonizing the leaves during the mid and late summer. The larvae, or grubs, live in the soil, feeding on roots of grasses.

Management: The beetles can be controlled with sprays of Sevin or malathion. Traps are also available which use a sex and/or feeding attractant to capture the adults in a can or plastic bag, but such traps may not provide adequate control. Place traps near, but not in the planting, as traps within a planting may suffer increased localized damage from beetles which are attracted, but do not fall into the trap. See pest management schedule for recommended materials and timing.

Table 44. Effectiveness of insecticides for management of grape insects.

Material	PESTS								
	GBM	LH	GP	GCGL, JB	GCGR	GFB, CW	RBLR	M	RC
*azinphos-methyl [Guthion]	+++	+	?	++	+++	++	+++	0	++
Bt [Dipel 2X]	++	0	0	0	0	0	0	0	0
carbaryl [Sevin]	+++	+++	0	+++	0	+++	+	0	+++
diazinon [Diazinon]	0	++	0	0	0	0	0	0	0
dicofol [Kelthane]	0	0	0	0	0	0	0	+++	0
endosulfan [Thiodan]	?	++	+++	?	?	?	?	0	?
fenbutatin-oxide [Vendex]	0	0	0	0	0	0	0	+++	0
insecticidal soap [M-PEDE]	0	++	0	0	0	0	0	?	0
imidacloprid [Provado]	?	+++	?	?	?	?	?	?	?
*methomyl [Lannate]	++	++	?	?	?	?	?	?	?
phosmet [Imidan]	++	+	?	+	++	?	++	0	+

+++ = highly effective; ++ = moderately effective; + = slightly effective; 0 = not effective/not labeled; ? = effectiveness unknown
 Key to pests: GBM = grape berry moth; LH = leafhoppers; GP = grape phylloxera; GCGL = grape cane gallmaker; JB = Japanese beetle; GCGR = grape cane girdler; GFB = grape flea beetle; CW = cutworm; RBLR = red banded leafroller; M = mites; RC = rose chafer.

*restricted use pesticides

Two-spotted spider mite (*Tetranychus urticae*): Spider mites are very small (1/50"), insect-like creatures that feed on grape foliage, sucking out plant juices and causing a white stippling or bronzing of the leaves. Under heavy infestations, leaves will turn brown and be covered in a fine webbing. Adults may also move onto the fruit, reducing consumer appeal by their presence. There is currently little available for chemical control of this pest. Foliar sprays of diazinon may suppress populations of spider mites, but this chemical may also reduce populations of natural predators which feed on the spider mites.

Management: There have been some reports that soaking sprays of water applied at relatively high pressure may temporarily suppress mite populations. Several companies now commercially produce predatory mites which feed on spider mites. These predators can be released in grape plantings and may provide some control of spider mites, but research is needed to determine appropriate release rates and timing. It is important, however, to encourage natural enemies of spider mites by reducing the use of pesticides which may harm natural enemies. Contact your local Extension Specialist or call (916) 324-4100 for a copy of Suppliers of Beneficial Organisms in North America, an excellent sourcebook for natural enemies such as predatory mites. This reference is also available via the Internet at <http://www.cdpr.ca.gov/docs/ipminov/bensuppl.htm>.

Grapevine Aphid: These aphids are dark brown and about 1/32 - 1/16" in length. They appear on young shoots and leaves during summer months. When abundant, aphids prevent proper extension of shoots, expansion of leaves, and development of fruit.

Management: When present, an overhead irrigation system can be used to reduce aphid numbers on the vines. This is not a "tested" method but has been recommended anecdotally. Similarly, spraying with water at high pressure can have the same result: washing the aphids off the vine.

Vertebrate Pests

Birds: Birds are a major pest problem in grapes. Left unchecked, they can destroy enough of the crop to ruin the profitability of a vineyard. The loss of chemical deterrents has made bird control a more difficult task in recent times, but effective means are still available.

Netting is the most effective way to keep birds out of the vineyard. Although initial costs can be high, most netting will last for many years if cared for properly. Netting should be hung over some sort of support structure built around the vineyard. Usually posts are set nine feet above the ground around the perimeter of the vineyard, and wire is run from pole to pole to form a grid over the planting. The netting is hung over this grid when the fruit begins to turn color.

Some temporary nine foot poles may be placed within the vineyard at intersections of the grid to keep the netting from drooping. Bury the edges of the netting or anchor it to the ground to keep birds from crawling underneath. Remove the netting when the harvest is complete, and store in a cool, dry place.

Visual scare devices have variable effectiveness on birds. Scarecrows, balloons, kites, or stuffed owls may work on certain bird species in certain areas, but none seem to have widespread dependability. When using scarecrows, “scare eye” balloons, stuffed owls, or snakes, put them in the vineyard only when the fruit begins to ripen, and move them regularly, at least once a day. Six scare-eye balloons per acre are recommended. Take them out of the field as soon as harvest is over. This will reduce the chance of birds becoming accustomed to the devices, and increase the longevity of their effectiveness. Kites and helium-filled balloons positioned high above the planting with a silhouette of a hawk hanging from them have provided good results in some areas.

Noise deterrents, such as propane cannons, alarms and recorded distress calls seem to have the least effect on birds in vineyards, but may greatly annoy neighbors. A combination of noise and visuals may be effective, however. Several operations have hired people to regularly drive motorcycles and/or ATVs through the vineyard when the fruit is ripe, and this seems to keep birds away quite well. Be sure to make drivers aware of where pickers are however, to avoid possible accidents.

Bird Shield™, a new repellent formulated from methyl anthranilate, is currently being registered for use on blueberries, cherries, and grapes. Methyl anthranilate is commonly used as a grape flavoring in human food preparations. Bird avoidance is based on odor quality and irritation. To humans, this chemical has a grape-like or fruit odor and a slightly bitter, pungent taste. Unfortunately, efficacy data do not support recommending this material at this time.

Table 45. Grape pest management schedule†.

Dormant			
Pest	Spray Material, Rate/A (pre-harvest interval)	Cultural Practices and Scouting Notes	Comments
Anthracnose	Lime sulfur solution, 5-10 gal (0)		This dormant application is aimed at reducing overwintering inoculum on canes.
Bud swell (before buds show green)			
Eutypa dieback	Benlate 50WP, 3.2 oz/gal, (50)	Prune out infected wood early in the season; make cuts well below cankers. Renew trunks every 8-10 years.	Paint or spray on immediately after pruning, before rain, dew, and spores some in contact with fresh wood. See pest management schedules for other fruits for PYO restriction for Benlate.
European red mite and/or scale insects	Superior oil, 2 gal (70-second viscosity) Cythion 8EC, 1 pt (3)	Vinifera and French Hybrids are more susceptible to mites; scout for mites from bud break to 10-inch shoot.	Do not exceed a maximum of 2-3/4 pt of Cythion per acre per year.
Flea beetle	Imidan 70W, 1-1/3 to 2-1/8 lb (14) Sevin 50WP, 2-4 lb (7)		Scout planting for presence of flea beetle before spraying to avoid unnecessary sprays.

Bud break to pre-bloom (after 1/2 inch new shoot growth)

Pest	Spray Material, Rate/A (pre-harvest interval)	Cultural Practices and Scouting Notes	Comments
Black rot Phomopsis cane and leaf spot Downy mildew	*Penncozeb 75 DF, 1.5 – 4 lb (66) Abound, 11.0-15.4 oz (14) Rubigan EC, 2-3 oz (30) Captan 50WP, 1.5 lb (0) Captan 4L, 0.75 – 1 qt (0) Nu-Cop 50DF, 2 lb (1)		Early sprays for black rot are important where this disease has been a problem in the past. *Penncozeb not labeled against Phomopsis Abound: see label for comments on resistance management. Rubigan note: total of 19 oz allowed seasonally. Nu-Cop may cause slight to severe foliar injury on certain varieties. See label for other restrictions.
Powdery mildew	Bayelton 50WP, 2-6 oz () Nova 40W, 3-5 oz (14) Rubigan IEC, 3 oz ()		This early spray is needed on varieties that are highly susceptible to powdery mildew.
Grape Cane Gall-Maker	Imidan 70 WSB, 1.3 – 2 lb (1)		Imidan will also control grape cane borer at this time if present – read label.
Flea beetle	Same as budswell		Scout planting for presence of flea beetle before spraying to avoid unnecessary sprays.
Ten-inch shoot (when new shoots are about 10 inches long)			
Redbanded leafroller Rose chafer	Imidan 70W, 1 1/3-2 1/8 lb (14) Sevin 50WP, 2 -4 lb (7) °*Sniper 2E, 1-2 pt (0-28)	Pheromone traps available for red banded leafroller and grape berry moth to monitor populations in the vineyard and determine the need for spray.	*Pre-harvest interval for Sniper depends on rate applied. Higher rate requires longer PHI. Read the label. Redbanded leafroller, and rose chafer infestations may occur starting at 4 inch shoot growth.
Grape cane girdler	Gution solupak, 1.5 lb (7)		
European red mite Two-spotted spider mite	Vendex 50WP, 0.5-1 lb (28) Kelthane 35 WP, 1-1.5 lb (1) M-Pede, 1-2% (0)	Mite predators may be effective in controlling European red mites. Contact your local Extension Specialist or call (916) 324-4100 for a copy of Suppliers of Beneficial Organisms in North America, an excellent sourcebook for natural enemies such as predatory mites.	M-Pede may be tank-mixed with Vendex or Kelthane. Note: the use of mancozeb fungicides can reduce predatory mite populations.
Flea beetle larvae	Same as bud swell		Flea beetle larvae infestations may occur starting at 4 inch shoot growth.

Table 45 continued. Grape pest management schedule.

Pre-bloom			
Pest	Spray Material, Rate/A (pre-harvest interval)	Cultural Practices and Scouting Notes	Comments
Black rot	Captan 50WP, 2-4 lb (0) Captan 4L, 0.75 – 1 qt (0)		Do not delay sprays beyond this point. If using Nova or Bayleton for post-infection control of black rot, apply at the high label rates during bloom.
Downy mildew	Ridomil/Copper 70W, 1-2 lb (66) Ridomil MZ 58, 1.5-2.0 lb (66)		
Phomopsis cane and leaf spot	*Penncozeb 80WP, 1.5-4.0 lb (66) **Dithane DF, 1.5 – 4 lb (66) *Nova 40WP, 3-5 oz (14) *Bayleton 50WP, 2-3 oz (14) –protective schedule *Bayleton 50WP, 3-4 oz (14) –post infection		*Penncozeb, Nova, Dithane and Bayleton not labeled for Phomopsis. **Additional formulations of Dithane are labeled for this use.
Powdery mildew	Bayleton 50WP, 2-6 oz (14) Nova 40WP, 3-5 oz (14) Rubigan EC, 3 oz (30)		Refer to Rubigan label for further recommendations on rates.
Flea beetle larvae	same as 10 inch spray		
Red banded leafroller	Imidan 70W, 1 1/3-2 1/8 lb (14)	Pheromone traps available for red banded leafroller and grape berry moth to monitor populations in the vineyard and determine the need for spray.	*Pre-harvest interval for Sniper and Guthion depends on rate applied. Higher rate requires longer PHI. Read the label. Guthion and Sniper have 48 hr REI for mowing, irrigating, and scouting; and 4 day REI for all other activities.
Grape berry moth	Sevin 50WP, 2 -4 lb (7) *Guthion solupak, 1.5 – 2 lb (7)		
Rose chafer	*Sniper 2E, 1-2 pt (0-28) **Thiodan 50WP, 2-3 lb (7) **Phaser 50WP, 1 lb (7)	Isomate™ Grape berry moth mating disruption ties are recommended for vineyard blocks of 5 acres or larger. See information under grape fruit pests above for more details.	**Thiodan and Phaser not labeled for Red banded leaf roller and Grape berry moth.
Bloom			
Black rot	Penncozeb 80WP, 1.5-4.0 lb (66) Captan 4L, 0.75-1 qt (0)		If using Nova or Bayleton for post-infection control of black rot, apply at the high label rates during bloom.
Downy mildew	Captan 50WP, 2-4 lb (0) Procure 50WS, 4-6 oz (7)		
Powdery mildew	Bayleton 50DF, 3-4 oz (14) Nova 40WP, 4-5 oz (14)		Procure is primarily for use against the mildews. DO NOT use more than 32 oz. of Procure 50WS/acre/season. This is a complex label. Read it thoroughly before using.

Pre-bloom

Pest	Spray Material, Rate/A (pre-harvest interval)	Cultural Practices and Scouting Notes	Comments
Botrytis bunch rot	Benlate 50WP, 1 lb (50) Rovral 50WP, 1-2 lb (7) Vanguard WG, 10 oz (7) Elevate 50WDG, 1 lb (0)		<p>First Benlate application should be made no later than 5% bloom if weather is wet; repeat at 14 days if wet weather continues.</p> <p>Rovral should be applied no more than 4 times. See label for specifications.</p> <p>If tank mixing Vanguard with another fungicide, use 5-10 oz/acre. DO NOT apply more than 20 oz per acre per year.</p> <p>Do not apply more than 3 lbs of Elevate per acre per season.</p>
Grape phylloxera (leaf form)‡	Thiodan 50WP, 1 lb (7) Phaser 8EC, 1.5-2 qts (7)	Remove infected leaves.	<p>Apply first at bloom and repeat 10 to 14 days later.</p> <p>Since bees do not pollinate grapes, the danger to them is small unless vineyard is located close to another crop. Be careful.</p> <p>Read label carefully for Thiodan-sensitive cultivars such as Baco Noir, Concord, and Seibels.</p>
Petal-fall (immediately after bloom or 10 days after last spray)			
Black rot	Penncozeb 80WP, 1.5-4.0 lb (66) Captan 50WP, 1.5 lb (0)		
Downy mildew	Ridomil Gold/Copper , 2 lb (66) Ridomil MZ 58, 1.5-2.0 lb (66) Procure 50WS, 4-8 oz (7)		
Powdery mildew	Bayleton 50WP, 1 - 2 oz (14) Nova 40 WP, 4-5 oz (14)		
Botrytis bunch rot	same as bloom		
Grape berry moth	*Guthion Solupak, 1.5-2 lb (0-10) °*Sniper 2E, 1-2 pt (0-28)	Pheromone traps available for red banded leafroller and grape berry moth to monitor populations in the vineyard and determine the need for spray.	Berry moth emergence begins in late May and June. There are several generations in a year.
Redbanded leafroller	Sevin 50W, 2-4 lb (7) Methoxychlor 2E, 2-6 qts (14)		
Grape Leafhoppers			*Pre-harvest interval for Guthion and Sniper depends on rate applied. Higher rate requires longer PHI. Read the label.
Rose chafer		Examine underside of leaves for presence of leafhoppers.	Guthion and Sniper REI varies from 48 hrs to 21 days depending on activity; read the label.
			Methoxychlor not effective on leafroller.
Grape mealybug	Imidan 70W, 1 1/3-2 1/8 lb (14)		

Table 45 continued. Grape pest management schedule.

Petal-fall (immediately after bloom or 10 days after last spray)			
Pest	Spray Material, Rate/A (pre-harvest interval)	Cultural Practices and Scouting Notes	Comments
Mites	Vendex 50WP, 0.5 - 1 lb (28) Kelthane 35 WP, 1- 1.5 lb (1) M-Pede, 1-2% (0)	Conserve mite predators by avoiding use of carbamate or pyrethroid insecticides.	Vendex should not be used after this time due to pre-harvest interval limitation of 28 days. M-Pede should not be used after 6-7 mm berry size.
Mid-summer sprays: first cover to veraison (berry coloring)			
Black rot	Captan 50WP, 1.5 lb (0) Ferbam 76WP, 3-4 lb (7)	Kocide 101 is a fixed copper fungicide. Some grape varieties are sensitive to copper. Test for sensitivity or add the recommended amount of hydrated lime according to the label instructions.	Ferbam may be applied once in the midsummer if it was not used in the second post-bloom sprays. Ferbam can be used no more than three times during the season. Fixed copper fungicides should provide good control of downy mildew, but only moderate control of black rot and powdery mildew. These materials can cause damage to leaves and fruit, especially under cool temperatures and slow drying conditions.
Downy mildew	Ridomil/Copper 70W, 1-2 lb (66) Ridomil MZ 58, 1.5-2.0 lb (66) Procure 50WS, 4-8 oz (7) Kocide 101, 2 lbs		
Powdery mildew	Bayleton 50WP, 1 - 2 oz (14) Nova 40WP, 4-5 oz (14)		
Grape berry moth	Same petal fall; repeat as needed to harvest according to label instructions; check for harvest restrictions	See above	See above
Leafhopper			
Redbanded leafroller			
Rose chafer			
Grape mealybug			
Japanese beetle adults	Imidan 70W, 1 1/3-2 1/8 lb (14) Methoxychlor 2E, 2-6 qts (14) Sevin XLR Plus, 1-2 lb (7)		Repeat as needed to harvest according to label instructions. After beetles appear in early to mid-July, damage is mostly cosmetic if vine growth is vigorous.
Mites	Kelthane 35 WP, 1-1.5 lb (1)		
Veraison to harvest			
Drosophila fruit flies	°D·Z·N Diazinon, 6 oz (28)		Do not apply more than 10 lbs product per acre per season.

Veraison to harvest			
Pest	Spray Material, Rate/A (pre-harvest interval)	Cultural Practices and Scouting Notes	Comments
Powdery mildew	Bayleton 50WP, 1-3 oz (14) Sulfur 95 MFW, 2.5 oz (0) Nova 40WP, 1.5 - 2.5 oz (14) Rubigan I EC, 3 oz (30)		A maximum of 18 oz. of Bayleton may be used per acre per season. Sulfur may cause injury of certain grape cultivars, especially if temperatures exceed 85½F. Do not apply more than 1.5 lbs of Nova per acre per season. Do not apply more than 6 fl. oz. of Rubigan EC per acre per application or more than 19 fl. oz. per season. Read the label carefully.
Botrytis bunch rot	same as bloom		
Downy mildew	Captan 50WP, 1.5 lb (0) Fixed copper (consult label for use instructions)		Consult the label for harvest restrictions.
Black rot	As berries reach full size and sugar content starts to increase, they become resistant to infection by the black rot fungus. In general, berries are no longer susceptible to black rot after veraison (6-8% sugar content)		

‡ Root form controlled by using rootstocks derived from American grape.

†Where brand names for chemicals are used, it is for the reader's information. No endorsement is implied, nor is discrimination intended against products with similar ingredients. Please consult pesticide product labels for rates, application instructions and safety precautions. Users of these products assume all associated risks.

°Restricted use pesticide.

WEED MANAGEMENT

The primary goal of weed management is to optimize yields by minimizing competition between the weeds and the crop. Weeds reduce yields by competing with the crop for water, light, and nutrients. Weeds also harbor insects and diseases and encourage vertebrate pests. Timely cultivation, wise use of herbicides, and never permitting weeds to go to seed are integral parts of a good weed management system. Many of the weeds found in these fields are difficult-to-control perennial weeds that are not common in annual crop culture. New plantings usually have fewer perennial weed problems than older plantings. Annual and biennial weeds can also exist in these fields. Fields should be scouted at least twice a year (spring and fall) to determine specific weed problems. The selection of a weed management tool should be based on specific weeds present in each field. Several herbicides are labeled for use in this crop. A list of herbicides and their recommended uses is presented in Table 46 below.

Herbicides can be broadcast or applied as a directed spray to the base of the crop. With a band treatment, only 1 to 2 feet on either side of the rows is treated. The area between the crop rows is usually maintained with a mowed cover of sod, clover, weeds, or a combination of these. This cover is used primarily for erosion control and to improve trafficability in the field. With banding, less herbicide is needed in each acre. For example, a 3 foot band (1.5 feet on either side of the row) where rows are spaced 9 feet apart will require only one third the amount of herbicide normally required for a broadcast treatment.

Cultivation and mulching are sometimes used as weed management tools. All cultivations should be timely and shallow to minimize crop root injury, to minimize loss of soil moisture, and to avoid repositioning new weed seeds to the soil surface. Mulches that are free of weed seeds and placed thickly enough can be very effective at reducing or eliminating most annual weeds from the crop row. They are seldom effective on perennial weeds. If mulches are used in combination with herbicides, use the lowest recommended herbicide rate to avoid crop injury.

Table 46. Weed management in grapes during the planting year and in established vineyards[†].

TRANSPLANT YEAR			
Weed Problem	Herbicide	Rate/Acre	Comments and Limitations
PREEMERGENCE WEED CONTROL			
Annual grasses and small seeded broadleaf weeds	(napropamide) Devrinol 50WP	8 lb	Apply after transplanting to weed-free soil. Devrinol must be activated within 24 hrs by cultivation or enough water by irrigation or rainfall to wet the soil to a depth of 2 to 4 inches. The full rate may not be necessary at transplanting.
	Devrinol 50DF	8 lb	
	(oryzalin) Surflan 4AS	2 to 4 qt	
Broadleaf weeds, some grasses, and some perennial weeds	(pendimethalin) Prowl 4EC	2 to 4 qt	Apply to weed-free soil directly beneath vines. Do not apply if buds have started to swell. For non-bearing vines only.
	(dichlobenil) Casoron 4G	150 lb	Apply in late fall or winter for best results. Incorporate lightly for best results. The soil must be settled and the plants recovered from transplant shock before application. May cause injury in young plants or where vigor is not excellent.
POSTEMERGENCE WEED CONTROL			
Emerged annual and most perennial grasses	(fluazifop) Fusilade DX	16 to 24 oz	See label for best times to treat specific weeds. Will not control broadleaf weeds or sedges. Do not apply to crops to be harvested within 1 year of application. Do not apply if rainfall is expected within 1 hour or if grasses are under drought stress. Must be used with a crop oil concentrate or non-ionic surfactant.
	(sethoxydim) Poast	1 to 2.5 pt	See label for best times to treat specific weeds. Will not control broadleaf weeds or sedges. Do not apply to grasses under stress (e.g., drought). Crop oil concentrate must be added to the spray tank. Do not cultivate 5 days before or 7 days after application. Do not apply more than 5 pints per acre per season.
Emerged annual weeds and suppression of perennial weeds.	(pelargonic acid) Scythe	3-10% solution	Contact material for burn down only. See Scythe comments in Strawberry section. See label for complete instructions.
Emerged annual grasses and broadleaf weeds. Suppression of emerged perennial weeds	(paraquat) °Gramoxone Extra	2 to 3 pt	Contact herbicide. Use with a non-ionic surfactant. Apply as a coarse directed spray on a warm calm day to wet the weeds. Avoid application to foliage or green shoots. Use of a shield is highly recommended.
	(glufosinate) Rely	4 to 6 qt	Contact herbicide. Apply in at least 20 gallons of water per acre at no more than 30 psi. Apply as a coarse directed spray on a calm day to wet the weed foliage or green shoots. For spot sprays use 1.5 ounces per gallon of water. May also be used for sucker control. See label.

Weed Problem	Herbicide	Rate/Acre	Comments and Limitations
POSTEMERGENCE WEED CONTROL			
Emerged annual and perennial weeds	(sulfosate) Touchdown	1 to 5 pt	NON-BEARING USE ONLY. Apply to actively growing weeds during site preparation prior to planting and no later than 1 year before harvest. Apply with a wiper or a shielded/directed spray. Do not allow the spray, spray drift, or mist to contact green foliage or green bark on the trunk, suckers, open wounds, or other green parts of the vine. Consult the label for rates for specific weeds and other precautions. Use with a surfactant or wetting agent.
ESTABLISHED PLANTINGS			
PREEMERGENCE WEED CONTROL			
Annual grasses and small seeded broadleaf weeds	(napropamide) Devrinol 50WP	8 lb	Apply in the early spring before seedling weeds emerge. Devrinol must be activated within 24 hours by shallow cultivation or with enough rainfall or irrigation to wet the soil to a depth of 2 to 4 inches.
	Devrinol 50DF	8 lb	
	(oryzalin) Surflan 4AS	2 to 6 qt	Apply to weed-free soil in the spring. Irrigation or 1 inch of rainfall is needed within 21 days of application. Do not make more than 1 application per year.
	(norflurazon) Solicam 80DF	1.25 to 5 lb	Apply in early spring when crop is dormant to clean and weed-free soil. Do not apply after budbreak. Do not apply to coarse soils. Do not use on nursery stock. VINES MUST BE TWO YEARS OLD BEFORE APPLICATION.
	(pronamide) °Kerb 50WP	2 to 8 lb	Apply in early spring for preemergence control of weeds or as a directed fall application after harvest but prior to leaf drop and soil freeze-up. Do not apply to vines less than 1 year old.
NOTE: For broad spectrum preemergence weed control, consider applying one of the above four "grass" herbicides (napropanide, oryzalin, norflurazon, or pronamide) in addition to one of the following "broadleaf" herbicides (simazine, diuron, oxyfluorfen, or dichlobenil). CHECK VINEYARD AGE RESTRICTION BEFORE USING ANY HERBICIDE.			
Broadleaf weeds, some grasses, and some perennial weeds	(simazine) Princep 80 WP	5 lb	VINEYARD MUST BE ESTABLISHED AT LEAST 3 YEARS. Do not replant to other crops for 2 years. Apply from late winter to early spring. Do not apply on gravelly, sandy, or loamy sand soils or injury may result.
	Caliber 90	4.4 lb	
	Princep 4L	4 qt	
	(diuron) Karmex 80 DF	2 to 6 lb	VINEYARD MUST BE ESTABLISHED AT LEAST 3 YEARS. Apply in Spring just prior to germination of annual weeds.
	(dichlobenil) Casoron 4G	100 to 150 lb	Use at temperatures below 40½F. May cause injury if plants are not well established. Apply in late fall or winter for best results. Effective on many perennial weeds.
	(oxyfluorfen) Goal 1.6E	2.5 to 10 pt	VINEYARD MUST BE ESTABLISHED AT LEAST 3 YEARS. Use a minimum of 40 gallons of water per acre, directed to the soil at the base of vines. Soil surface should be smooth and free of trash. Apply only to dormant vines. Do not apply to vines that are not staked or trellised.

Table 46 continued. Weed management in grapes during the planting year and in established vineyards[†].

ESTABLISHED PLANTINGS			
Weed Problem	Herbicide	Rate/Acre	Comments and Limitations
POSTEMERGENCE WEED CONTROL			
Emerged annual grasses and broadleaf weeds. Suppression of emerged perennial weeds.	(paraquat) °Gramoxone Extra	2 to 3 pt	Contact herbicide. Use with a non-ionic surfactant. Apply as a coarse directed spray on a warm calm day to wet the weeds. Avoid application to foliage or green shoots. Use of a shield is highly recommended.
	(glufosinate) Rely	4 to 6 qt	Contact herbicide. Apply in at least 20 gallons of water per acre at no more than 30 psi. Apply as a coarse directed spray on a calm day to wet the weed foliage or green shoots. For spot sprays use 1.5 ounces per gallon of water. May also be used for sucker control. See label.
Emerged annual and perennial broadleaf weeds and grasses	(glyphosate) Roundup Ultra	1 to 5 qt	Do not allow spray, drift, or mist, to contact green bark, suckers, or vines. Suckers within spray zone should be removed before application to reduce risk of crop damage. Use of a shield is highly recommended. Applications must be made prior to the end of bloom stage unless a wick applicator or shielded sprayer is used. Do not apply within 14 days before harvest.
Emerged annual weeds and suppression of perennial weeds.	(pelargonic acid) Scythe	3-10% solution	Contact material for burn down only. See Scythe comments in Strawberry section. See label for complete instructions.
Emerged annual and most perennial grasses	(sethoxydim) Poast	1 to 2.5 pt	Effective on actively growing grasses. Do not apply to grasses under stress (e.g., drought). Crop oil concentrate must be added to the tank. Do not cultivate 5 days before or 7 days after application. Do not apply within 50 days before harvest or exceed 5 pints per acre per year.

[†]Restricted use pesticide.