COOPERATIVE EXTENSION SERVICE
UNIVERSITY OF KENTUCKY • COLLEGE OF AGRICULTURE

Growing Grapes in Kentucky

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Kentucky has a long record of good grape production. As a home fruit crop or commercial crop, grapes have many benefits. Grapevines are relatively inexpensive and easy to propagate. They reach full bearing potential in four years and bear annually. The many varieties of grapes can be consumed fresh or used to make grape juice, jams, jellies, and wine. Grapes are also easy to manage. Vines are trained on trellises or arbors and easily can be sprayed using small equipment for control of insects and diseases.

Planning Your Commercial Grape Vineyard

Establishing a new vineyard requires considerable investigative work, and planning ahead is vital, especially for beginning growers. Using a thoughtful approach can prevent or minimize future problems. A seven-minute VHS tape titled *Planning for a Commercial Table Grape Operation* is available through your local Cooperative Extension Service office.

Before planting a vineyard, consider your physical, mental, and financial abilities as well as your experience with the crop. You should also ask yourself the following three questions.

Will growing grapes be economically viable? When assessing the economic feasibility of growing grapes, explore the market potential for grapes to determine where and how they can be sold profitably. To gain insight about potential returns, consult information sources and determine:

- the average cost of vineyard establishment;
- yearly production costs;
- anticipated short- and long-term returns;
- labor costs or inputs;
- which varieties meet market demands.

A marketing system for Kentucky's table grapes does not exist. Marketing will be your own responsibility. Kentucky has two types of winery licenses, determined by production volume: the Farm Winery license and the Small Winery license. Several wineries operating in the state are interested in purchasing certain cultivars of high-quality, Kentucky-grown grapes. *If you are considering growing for a winery, consult the winery prior to planting to find out which cultivars are needed.* The Kentucky Vineyard Society helps bring together buyers and growers of table grapes. The Cooperative Extension Service also has useful information concerning marketing of fresh produce. As information on potential markets and marketing strategies develops, it will be available through your local county agricultural Extension agent.

Is the climate suitable for sustained production? Grapes can be grown successfully in a variety of climates. They require about 200 frost-free growing days. You should know about minimum winter temperatures and spring frosts in your area and in the microclimate of the site where you intend to grow the grapes. When you have decided which varieties you want to plant, look up information about those varieties to make sure they are suited to the climate (precipitation, heat, drought, cold) in your area. Find out if anyone has successfully grown those varieties in your area. You can obtain variety performance data from the University of Kentucky.

Will the site support a healthy, long-term vineyard? The best locations for grapes have plenty of bright sunshine, warmth, good air circulation, freedom from frost, and well-drained soil (soil with good internal drainage is more important than very fertile soil). Because cold air settles in low spots, late spring frosts often damage new spring growth in low areas. The best site is above the level of adjoining land, so that cold air drains away from the planting. Disease control is easier on these higher sites since better air circulation dries off the foliage sooner on dewy mornings and after rains. Steep hillsides with well-stabilized soil are satisfactory for growing grapes; however, cultural operations are easier on level or gently sloping sites.

In identifying a suitable site, the first step is to obtain a *soil survey* of the intended planting site from your local Natural Recources Conservation Services office. Then dig several backhoe pits to verify the

accuracy of the survey. Examine the survey results, paying particular attention to the depth of root-restrictive layers (hard pan, rock, plow soles, high water levels, etc.) and the rooting depth of existing vegetation. Observation of crops growing nearby also can give clues to potential problems. If the site seems suitable, determine whether soil modification is necessary or possible by sending a *soil sample* for analysis (pH, Ca, Mg, B, P, K).

You should also determine if the site has adequate water for irrigation. Supplemental water during the growing season can often improve grape yield and quality. Peak usage is from June to September. Is a suitable water source available at the site? Is frost protection needed?

Also before planting, investigate the site's potential biological problems, such as perennial weeds, disease organisms, insects, and birds, and devise control strategies for these problems.

Which Grapes to Grow

There are many grape varieties (cultivars) from which to choose (Table 1). Each category of grapes has its own characteristics, and each cultivar within the categories has advantages and disadvantages. While the traits attributed to American grapes, American-French hybrids, and European (vinifera) grapes are generally true, there is great variation among the cultivars. When selecting cultivars, obtain local recommendations if possible. Relative disease susceptibility of various cultivars is presented in Table 2.

All species of grapes can be used to make wine. Wine quality is influenced by cultivar, fruit quality, and ability of the vintner. Vinifera types have the potential to make the best quality wine. In Kentucky's environment, however, American types are the easiest to grow and vinifera are the most difficult.

American bunch grapes (*Vitis labrusca*) are derived from native American species. They are characterized by their hardiness and insect and disease resistance and are generally well-adapted to Kentucky growing conditions. American grapes have slip skins (the skin readily separates from the flesh) and tend to be more acidic toward the center of the grape berry. Concord is the most important commercial and home grape cultivar grown in the eastern United States. A wide selection of other varieties is also available to extend the ripening season and to give diversity in flavor and color.

American-French hybrid grapes are crosses between European grapes and, primarily, the native American grapes *Vitis ruprestris* and *Vitis lincecuni*. These varieties are considered to be more suitable than American grapes for wine because they produce a flavor more like European grapes and lack the "foxiness" unique to American grapes. (Foxiness is the taste that comes to mind when you think of grape juice or grape-flavored Kool-Aid.)

European grapes (*Vitis vinifera*) are the primary grapes grown in the western United States and Europe. These varieties are characterized by the adherence of the skin to the berry flesh and are sweet throughout the grape. They are known for making the highest quality wines. European grapes are difficult to grow in Kentucky and are generally not recommended. They are generally susceptible to downy mildew, powdery mildew, and crown gall, and they are all susceptible to winter injury. Only the hardiest cultivars can be grown—with difficulty—using the best cultural techniques on the very best sites.

Table 1. Grape cultivars for Kentucky.

Cultivars	Color	Maturity[a]	Cropping history in Kentucky	Hardiness to winter injury	Comments
AMERICAN (all varieties are seeded)					
Buffalo	blue / black	August	good	above average	Concord-type. Medium berry, medium to large, well-filled, sometimes shouldered clusters. Heavy, regular bearer. Disease-resistant; slip skin. Spicy-sweet, vinous, non-foxy flavor. Marvelous grape aroma. Excellent for table use, jam, juice, or wine.
Fredonia	blue / black	August	good	very hardy	Formerly a leading early blue variety. For fresh use, jelly, and roadside marketing.
Alden	blue / black	August	planted somewhat	average	Heavy bearing with large clusters; hence, needs heavy pruning. Non-slip skin. Fine eating quality; for fresh use as a dessert grape.
Niagara	white	August	good	above average	Most widely grown white grape in Kentucky. Large berries and clusters and good yields. Good fruity flavor. Used for fresh fruit and wine.
Steuben	blue / black	August	good	above average	Concord type. Heavy producer. Vines have good vigor. Sweet. Excellent flavor. For general use and home and roadside markets.
Delaware	red	August	planted somewhat	above average	High quality American bunch grape. Small grapes with small, compact clusters. Vines are slow growing and never get large and should be set closer together than other varieties. Requires heavy pruning. Yields less than Concord.
Elvira	white	August	planted somewhat	very hardy	Compact clusters. Vines are vigorous.
			Cropping	**Hardiness**	

[a]Arranged in order of maturity within each category, per trials at Princeton, Kentucky.

Cultivars	Color	Maturity	history in Kentucky	to winter injury	Comments
Concord	blue/black	September	good	very hardy	Leading eastern American bunch grape. Vines are vigorous, productive, and easy to train. Tendency toward uneven ripening, especially farther south where uneven ripening is a serious problem. Bath or Steuben varieties could be substitutes. Fruit is good quality for fresh use and excels for fresh juice and jelly with its foxy flavor.
Catawba	red	September	good	above average	Pleasing flavor. Valued for wine, fresh fruit, and fresh juice.
Cynthiana	blue/black	September	planted somewhat	very hardy	Small to medium-sized clusters. Vines are vigorous. Used almost strictly for wine.
Norton	blue/black	September	planted somewhat	very hardy	Comparable to Cynthiana in growth habit, but has a different maturity date and wine flavor.
AMERICAN-FRENCH HYBRID					
Seedless Table Grapes					
Himrod	white	July	planted somewhat	slightly susceptible	Clusters are large and loose; berries are medium-sized, oval, yellow, and sweet. Excellent dessert grape.
Venus	blue/black	August	good	slightly susceptible	Good berry size with a flavor that is a combination of muscat and *Vitis labrusca*. Worthy of trial in western Kentucky.
Reliance	red	August	good	above average	Reddish pink. Very thin skin results in some raisin-like fruits, which are unattractive and should be removed from the clusters before sale. Problems include shriveling, obtaining a consistent pink color, and berry shatter (separation from the cluster) during shipping and handling. Excellent flavor, like a delicate Delaware. Shows excellent potential for roadside market sales.
			Cropping	**Hardiness**	

Cultivars	Color	Maturity	history in Kentucky	to winter injury	Comments
Einset Seedless	red	August	recommended for trial only due to limited experience	average	Bright red. Cluster is medium-small, shouldered. Vines are vigorous. Fruit is medium-sized and oval. Adherent skin is resistant to cracking—good storage potential. Flesh is tender to firm. Flavor is fruity, mildly strawberry.
Vanessa	red	August	recommended for trial only due to limited experience	average	Bright red. Clusters are medium in size. Vines are hardier than standard eastern varieties. Spherical berry is larger than eastern varieties with crisp, sweet flesh.
Glenora	blue/black	August	planted somewhat	slightly susceptible	Non-slip skin. Delicate flavor.
Canadice	red	August	planted somewhat	average	Stores well. Flavor is similar to Delaware.
Mars	blue/black	August	good	above average	One of the hardiest seedless grapes. Resists cracking. Some resistance to black rot. Good quality.
White Wine Grapes					
Vignoles (Ravat 51)	white	August	planted somewhat	very hardy	Tight clusters. Vine is medium productive. Wine is high in acid, German-style.
Seyval Blanc (Seibel 5276)	white	August	good	above average	Yellowish white. Large, compact clusters of medium-sized berries. Above-average vigor. Spur pruning recommended. Wine of superior quality.
La Crosse	white	August	recommended for trial only due to limited experience	very hardy	Medium-sized clusters. Vines are prolific.
Cayuga White	white	August	good	above average	Large clusters. Vine is vigorous and productive.
Vidal Blanc (Vidal 256)	white	September	good	above average	Yellowish white. Large, compact clusters of large berries. Spur pruning recommended; may also need cluster thinning. Wine rated very good.
Villard Blanc (SV 12-375)	white	September	good	average	Large, loose clusters. Requires spur pruning. Medium disease resistance. Makes an excellent white wine.

Cultivars	Color	Maturity	Cropping history in Kentucky	Hardiness to winter injury	Comments
Red Wine Grapes					
Foch (Kuhlmann 188-2)	blue/black	July	good	above average	Small clusters of small berries. Moderately vigorous. Requires long-cane pruning. Makes an excellent red wine.
Baco Noir (Baco #1)	blue/black	August	good	slightly susceptible	Vine very vigorous; grows well in unfavorable soils. Requires long-cane pruning. Makes a good red wine that responds well to aging.
De Chaunac (Seibel 9549)	blue/black	August	good	very hardy	Spur prune. Makes an excellent red wine.
Chancellor (Seibel 7053)	blue/black	August	good	above average	Medium to large, loose clusters of medium-sized berries. Vines are vigorous. Spur prune. Highly susceptible to downy mildew and moderately susceptible to powdery mildew—mildew must be controlled. Makes an excellent red wine.
Villard Noir (SV 18-315)	blue/black	September	planted somewhat	average	Most widely grown red wine hybrid in southern France. Bluish black. Vine has low vigor but is a heavy producer and is disease-resistant. Heavy-bodied, sound, neutral, very good red wine.
EUROPEAN					
Chardonnay	blue/black	September	difficult to grow	susceptible	Vines are vigorous. Excellent quality grape used in making Chablis- to Burgundy-type, dry white wines.
White Riesling	white	September	difficult to grow	susceptible	An international favorite from Germany. One of the hardiest vinifera grapes. Small, round, greenish yellow speckled fruit with lively aroma. Makes a classic, flowery, semisweet to sweet white wine.
Cabernet Franc	blue/black	September	difficult to grow	susceptible	Similar to Cabernet Sauvignon (a popular West Coast grape), but is more cold-hardy and ripens earlier.

Cultivars	Color	Maturity	Cropping history in Kentucky	Hardiness to winter injury	Comments
Pinot Noir	blue/black	September	difficult to grow	susceptible	The wine grape of Burgundy, France. Small, dark blue fruit with a distinctive scent. It does best in cooler areas. Produces a dry, delicate, pinkish red wine.
Cabernet Sauvignon	blue/black	September	difficult to grow	susceptible	Requires the very best sites.

Table 2. Relative disease susceptibility and sulfur, karathane, and copper sensitivity among grape cultivars.

The relative ratings in this chart apply to an average growing season under conditions usually favorable for disease development. Any given variety may be more severely affected.

	Susceptibility or sensitivity to:										
Variety	BR	DM	PM	Bot	Phom	Eu	CG	ALS	S[a]	K[a]	C[b]
Baco Noir	H	L	M	M	L	M	H	M	No	M	?
Cabernet Franc	H	H	H	L	?	?	H	?	No	?	L
Cabernet Sauvignon	H	H	H	L	H	H	H	?	No	?	L
Canadice	H	M	L	M	?	?	M	M	?	?	?
Catawba	H	H	M	L	H	L	L	L	No	No	M
Cayuga White	L	M	L	L	L	L	M	M	No	M	L
Chancellor	L	H	H	L	H	L	H	H	Yes	L	H
Chardonnay	M	H	H	H	H	M	H	M	No	H	L
Concord	H	L	M	L	H	H	L	L	Yes	L	L
DeChaunac	L	M	M	L	H	H	M	H	Yes	L	L
Delaware	M	H[c]	M	L	H	L	L	L	No	H	L
Elvira	L	M	M	H	L	L	M	M	No	No	M
Einset Seedless	H	M	H	L	?	?	L	?	?	?	?
Foch	M	L	M	L	?	H	L	L	Yes	M	?
Fredonia	M	H	M	L	M	?	L	L	No	?	?
Himrod	M	L	M	L	?	?	?	L	No	?	?
Niagara	H	H	M	L	H	L	M	L	No	No	L
Pinot Noir	H	H	H	H	?	?	H	L	No	M	L
White Riesling	H	H	H	H	M	M	H	L	No	M	L
Seyval Blanc	M	M	H	H	M	L	M	M	No	L	L
Steuben	M	L	L	L	?	?	L	M	No	?	?
Vanessa	H	M	M	L	L	?	L	?	?	?	?
Vidal Blanc	L	M	H	L	L	L	M	L	No	H	?
Vignoles	L	M	H	H	M	M	M	M	No	M	?

Key to diseases and elements: BR = black rot, DM = downy mildew, PM = powdery mildew, Bot = botrytis, Phom = phomopsis, Eu = eutypa, CG = crown gall, ALS = angular leaf scorch, S = sulfur, K = karathane, C = copper.

Key to ratings: L = low susceptibility or sensitivity, M = moderate susceptibility or sensitivity, H = high susceptibility or sensitivity; No = not sensitive, Yes = sensitive; ? = relative susceptibility or sensitivity not established.

[a]Slight to moderate sulfur and karathane injury may occur even on tolerant varieties when temperatures are 85 degrees F or higher during or immediately following the application.
[b]Copper applied under cool, slow-drying conditions is likely to cause injury.
[c]Berries not susceptible.

We wish to thank the New York Cooperative Extension Service for the use of this table.

Grape Cultivar Research

University of Kentucky researchers, in cooperation with the Tennessee Valley Authority (TVA), established a table grape cultivar planting in 1983 at the UK Research and Extension Center in Princeton, Kentucky. The planting utilized trickle irrigation and "balanced pruning" (a method explained in the "Managing Your Vineyard" section of this publication). The research resulted in data pertaining to winter injury, rates of regrowth, and yields.

Lower than normal winter temperatures during the first two years after establishment provided the opportunity to rate the grape cultivars for susceptibility to winter injury. Researchers considered both the initial damage and the rate of recovery from winter injury. The research indicated that table grape cultivars vary considerably in susceptibility to winter injury (Table 3). The susceptibility to winter injury observed in the Kentucky research differs from that reported by more northern states but is similar to that found by other investigators in the upper south. As with most perennials, grapes' hardiness is influenced by previous weather events. Warmer temperatures start biological activity and when followed by cold increase the plants susceptibility to winter injury. Kentucky's fluctuating winter temperatures often result in dehardening of some grape cultivars.

The cultivars not only differed in amounts of winter injury, but the rates of regrowth of different cultivars with the same amount of winter injury also varied (Figure 1). In selecting table grape cultivars, choose varieties that experience less winter injury and/or greater regrowth.

Average annual yields for vines trained to the Geneva double curtain style of trellis (explained in the "Managing Your Vineyard" section of this publication)—of those cultivars with commercially acceptable fruit quality and yields—are reported in Figure 2. Soluble solids, cluster weight, and harvest date are listed in Table 4.

Based on the results of these studies, 'Reliance' is the hardiest seedless cultivar for Kentucky, and 'Moored,' 'Niagara,' 'Concord,' and 'Captivator' are the hardiest and most productive seeded cultivars.

Figure 1. Table grape regrowth rating, 1983-1984

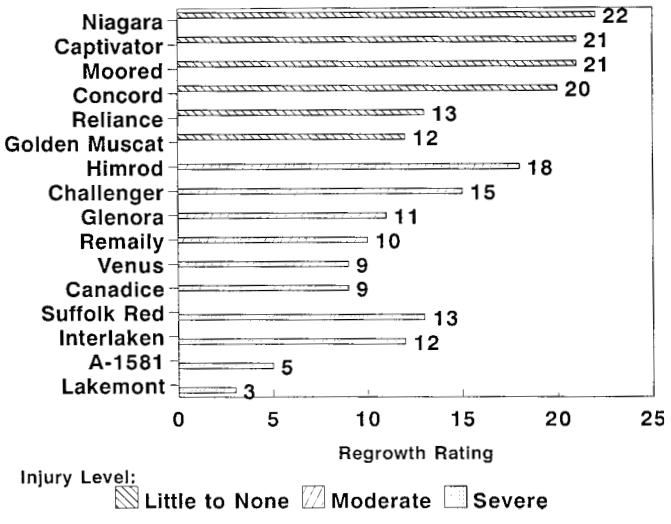
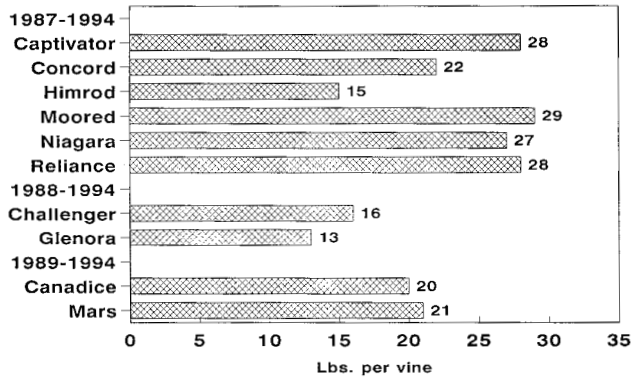


Table 3. Average winter injury ratings (1983-1984), Princeton, Kentucky.

Cultivar	Injury rating[a]
Niagara	6.75
Concord	6.75
Moored	6.25
Golden Muscat	5.75
Reliance	5.75
Captivator	5.42
Challenger	4.25
Himrod	3.92
Romulus	3.92
Canadice	3.83
Venus	3.50
Glenora	3.33
Suffolk Red	1.58
A-1581	1.42
Interlaken	1.00
Lakemont	0.25

[a]Winter Injury Rating System:
0 = apparently dead
1 = new growth near ground level
2 = new growth on less than 20% of last year's wood (LYW)
3 = new growth on 20%-40% LYW
4 = new growth on 40%-60% LYW
5 = new growth on 60%-80% LYW
6 = new growth on 80%-100% LYW
7 = no apparent damage

Figure 2. Average annual yield per vine through 1994 for the UK/TVA vineyard planted in 1983 at UK REC, Princeton, KY.



UK, 1995

Table 4. Fruit characteristics, UK-TVA planting, Princeton, Kentucky.[a]

Cultivar	Grams/cluster	Average harvest date	% soluble solids
Moored	161	14 Aug	17.3
Golden Muscat	280	17 Sept	18.8
Venus	201	7 Aug	17.7
A-1581	279	11 Aug	16.2
Niagara	156	21 Aug	16.8
Interlaken Seedless	269	11 Aug	16.9
Concord	121	2 Sept	17.5
Captivator	75	18 Aug	17.5
Suffolk Red	183	11 Aug	19.4
Reliance	152	3 Aug	21.0
Remaily Seedless	210	2 Aug	19.7
Glenora	122	8 Aug	19.0
Himrod	181	23 July	19.0
Challenger	151	11 Aug	18.6
Romulus	131	8 Aug	18.5
Canadice	129	9 Aug	21.3

[a]No significant differences in these characteristics were observed for the two training systems (Geneva double curtain and four-cane Kniffin).

Planting Grapes

Vines can be bought at reasonable prices, and good, true-to-name nursery stock is the best investment. Many feel that top-grade, 1-year-old plants are the best. Smaller, sometimes weaker, 1-year-old plants are often held over by the nursery to grow another year and are then sold as 2-year-old stock. Obtain certified virus-free stock when possible.

Where established vines are available, additional vines easily can be started by the layering process or by using hardwood cuttings. These practices are described below. Please note that if plant material is patented, it is a violation of the law to propagate the material without permission of the owner of the patent.

Layering. In the spring, an easy way to propagate a new vine from an old vine is to bend a cane to the ground and cover a 10-inch section with soil in a shallow trench, leaving the growing tip end extending out above the soil. Roots form at the joints (nodes) of the covered section and make a new plant. The following spring, the new plant can be separated from the mother vine where it enters the soil and carefully dug to be planted at a new location. Layering is useful in introducing a new vine to replace missing vines in an established planting; it is often difficult to develop a new plant in such a vacant space by transplanting a rooted vine or planting cuttings.

Hardwood cuttings. If you need a large number of vines, use hardwood cuttings taken in December from healthy mature vines. Cut pencil-width, mature canes into sections 8 to 12 inches long with three or four buds each. The lower cut should be just below the lowest bud and the upper cut an inch or two above the top bud. This way, it is easy to identify the bottom and top of the cuttings at planting time. (When cuttings are made from canes already pruned and removed from the vines, the lower—basal—ends usually are larger. In addition, there is a leaf scar where the leaf dropped off in the fall just below each bud.) Tie the cuttings in bundles of 25 or more, with tops at one end. Then bury the bundles in damp moss or sand or wrap well in moist burlap bags, and cover tightly with plastic. Leave them in a cool cellar until ready to plant. You may also place bundles under a mound of soil in a well-drained place. Firmly pack the earth around each bundle, and cover all the bundles with at least 6 inches of soil.

Dig up the bundles in late March or early April, before the buds start growing, and plant the cuttings 6 to 8 inches apart, with the second bud from the top at the surface of the soil, in straight rows 3 feet apart. Set cuttings with the basal ends down. Pack the soil well around the base of the cuttings to encourage root formation. Cultivate and water the young vines frequently. They may be transplanted to their permanent locations after one or two seasons in the nursery row.

Soil Preparation

Take a soil test, and follow test recommendations prior to planting. Grape growth in Kentucky is normally limited by nitrogen, potassium, and phosphorus. In most cases, nitrogen is the most important element needed. Use of green manure crops before planting

increases organic matter and reduces native weed populations. Manure, if available, can provide potash (potassium) and phosphorus.

Grapes can be grown successfully over a wide range of soil pH conditions. They perform best where soil pH is between 5.0 and 6.0. At planting, adjust the soil pH to 6.5; then let the soil pH drop to between 5.0 and 6.0 over time. Apply lime only when the soil test indicates a need. If the pH is raised above 7.0, manganese can become unavailable, leading to a deficiency. Dolomitic lime supplies magnesium; it also can be used to reduce available potassium if potassium is too high.

Vine Spacing and Planting

Vine spacing (Table 5) depends on the type of cultivation, vigor of the vines, soil fertility, and type of training system. An 8- to 10-foot spacing within rows is suggested, with a 10- to 12-foot spacing between rows. This row spacing is wide enough for most disk and tractor cultivation. But be sure to determine the width of any cultivation tools before deciding on row widths. Using a stake to mark planting holes or a line stretched tight to set plants by helps keep vines straight in the row.

Table 5. Relationship between vine spacing and number of vines per acre.

Spacings	Vines per acre
6 × 8 feet	907
6 × 10 feet	722
8 × 8 feet	680
8 × 10 feet	542
10 × 10 feet	435
10 × 12 feet	363
12 × 12 feet	302

Details of planting are simple but important. For small plantings, make the hole large enough with a shovel or auger to avoid crowding the roots—usually about 18 inches across and 15 inches deep. Place some topsoil in the bottom of the hole, and put the plant in place at the same depth it grew originally, after removing any split roots or broken ends. Cut back all long roots to 10 to 15 inches. Spread roots out, working the soil well between roots to avoid air pockets. Cover with soil, and tramp down firmly. Finally, fill the hole to ground level. For larger plantings, plow a furrow and set grapes using a shovel or tree planter.

You may plant vines in either spring or fall. If you plant them in the fall, mound the soil above the surface in the root zone and then remove the extra soil in the spring. If you are planting in spring, order nursery vines early enough to plant them while they are still dormant. If the weather is dry, water the vines weekly after growth starts. Some growers prefer rows to run north and south so the morning sun shines on one side of the row and the afternoon sun shines on the other side, though this is not of great importance.

Grape Trellis Construction

A trellis for vine support is designed and constructed to be strong and long-lived and to require low maintenance. It is a major long-term vineyard investment (Table 6) and should last 20 years or more. The trellis may or may not be in place prior to the first growing season but should be completed by the start of the second growing season. If it is not in place, use a stake the first year to train the vine. The straighter the trunk(s), the more winter hardy and productive the grape plant will be. It is also easier to work in the vineyard if the trunks are straight.

Trellises for most grape training systems are fairly standard. A single curtain cordon (SC) trellis usually consists of two tightly stretched wires, one above the other, about 3½ and 6 feet above the soil surface. Line posts should not be more than 24 feet apart in order to provide vertical support. They may be of wood, concrete, or steel. Pine posts pressure-treated with CCA (chromated copper arsenate), black locust, Osage orange, red cedar, and white oak are the most commonly used long-lasting materials. Line posts should be 3 to 4 inches in diameter and 8 to 9 feet long, with 2 feet below ground and 6 feet above ground. End posts that support and position the wire tensioning must be larger (10 to 11 feet with 3 to 4 feet below ground) and a minimum diameter of 4 to 6 inches. Failure of either end post results in failure of the entire trellis. Use slightly larger end posts for a Geneva double curtain (GDC) trellis.

Growers must maintain proper wire tension. Wires sag with time due to weather and plant weight. The end posts should be well-braced because they carry most of the pull of the trellis load. Two to three vines are usually set between each pair of posts. Failure to keep lines tight results in crooked trunks and sagging cordons. End posts should be braced or anchored. Anchors (4 to 6 inches in diameter) provide the best support if space is available. Use wider diameter and larger shanks on augers in sandy soil. Install anchors in the fall, but attach them the following spring. You can periodically tighten the anchors by using a turn buckle. Some people angle the end posts at 60° from horizontal, i.e., 30° off vertical. The GDC trellis requires one trunk support wire 3½ feet above the ground plus two horizontal, parallel cordon support wires positioned 2

to 4 feet apart and 6 feet above the ground (Figures 3a and b). Crossarms are made of either wood or metal. Many growers loosen the wire in the fall to reduce strain on the trellis due to metal contraction in cold weather.

Attaching the wires on the windward side of the trellis helps make the trellis more weatherproof. The wires should be durable and retain correct tension. Wire such as No. 11 or No. 12 crimped, high-tensile (210,000 psi) steel wire with class III galvanizing works well. The bottom wire need not be as strong or heavy as the top wires; ordinary No. 9 galvanized wire can be used here. Wires may be loosely stapled to the tops of line posts or crossarms with 1¼- to 1½-inch fence staples on the *windward* side of the posts. Some growers bore holes through the post at the appropriate height, and the wire is passed through these. However, this is difficult for long stretches of wire. High-tensile wire should be tensioned at 250 to 300 pounds to eliminate problems. An inline tensioner and cranks are used to tighten the wires properly.

Re-tension the wires in the spring after pruning. Avoid curved rows because the wire will tend to pull middle posts to one side. Wire and tighteners are available from fencing supply stores, and you can get posts from sawmills, lumber yards, and power companies. Leave 30 to 40 feet beyond the last post on each row end for turning equipment.

Table 6. Single curtain cordon trellis construction costs.

Trellis costs per acre		
Materials and labor	**Calculations**	**Cost**
digging post holes	30 hours × $6.00 per hour	$ 180.00
setting posts	27 hours × $6.00 per hour	$ 162.00
stringing wire	5 hours × $6.00 per hour	$ 30.00
bracing posts	5 hours × $6.00 per hour	$ 30.00
posts for trellis	182 posts × $4.50 per post	$ 819.00
wire for a 2-wire trellis	8,715 ft × $.02/ft of wire	$ 174.30
		$1,395.30

Managing Your Vineyard

Postplant Fertilization

Plants should not need additional fertilizer the first year if the soil is brought up to soil test recommendations prior to planting. During subsequent years, apply fertilizer in late winter or early spring. This promotes early spring growth and reduces available nitrogen levels in late summer and early fall. A low nitrogen level late in the season slows growth and helps develop winter hardiness. Base subsequent fertilizer recommendations on the amount of vegetative growth. About two pounds of prunings per vine is considered normal. If vegetative growth is excessive, reduce or stop nitrogen application. If leaves have poor color and pruning weights are low, increase fertilizer application. Poor leaf color, weak spindly growth, and early defoliation in the fall indicate a poor nutritional status.

As a general guideline, apply ½ pound of complete fertilizer (10-10-10 or 12-12-12) or 2 to 4 ounces of ammonium nitrate to the soil surface extending from 4 to 6 feet around each vine during the second season. Avoid concentrating the fertilizer at the base of the vines or allowing the fertilizer to contact the trunks. You can double the rate for the third season. For the fourth and subsequent seasons, apply about ½ pound of ammonium nitrate or 2 pounds of 10-10-10 per vine. Commercial growers should base their fertilizer recommendations on petiole analysis. Leaf petiole samples should be taken between four and eight weeks after peak bloom. Analysis kits and directions for sampling are available from your local county Extension office.

Cultivation

Grapes, like other fruit, benefit from regular shallow cultivation, particularly in the early part of the growing season. If cultivation is not practical, you may use chemical weed control or a mulch of grass clippings, straw, straw and manure, or hay. Most growers use chemical weed control around vines under trellises and use a rotary mower to control growth between rows. On steep slopes, a good, thick sod eliminates the need for cultivation and helps reduce soil erosion. Where grapes are planted in contoured rows on hillsides, plowing the soil toward the plant row from above for two or three years establishes terraces to retain moisture and prevent erosion.

Cover Crops and Mulches

Sowing a cover crop in August prevents winter soil erosion, makes winter pruning easier, and provides humus when the cover crop is mowed in the spring. Wheat, rye, barley, or oats are often used, sometimes with winter vetch. Where soil erosion is a danger on steep slopes, make fall seedings by using the no-till method or by broadcasting on the surface in each row middle. If vines are mulched, or if middles are mowed, no cover crop is needed unless vegetation is very sparse in early fall. Sod cover between rows with herbicide treatment in rows is a practical and popular technique, especially on slopes.

Figure 3a. Systematic Development of A Single Curtain Cordon System. Years 1-5

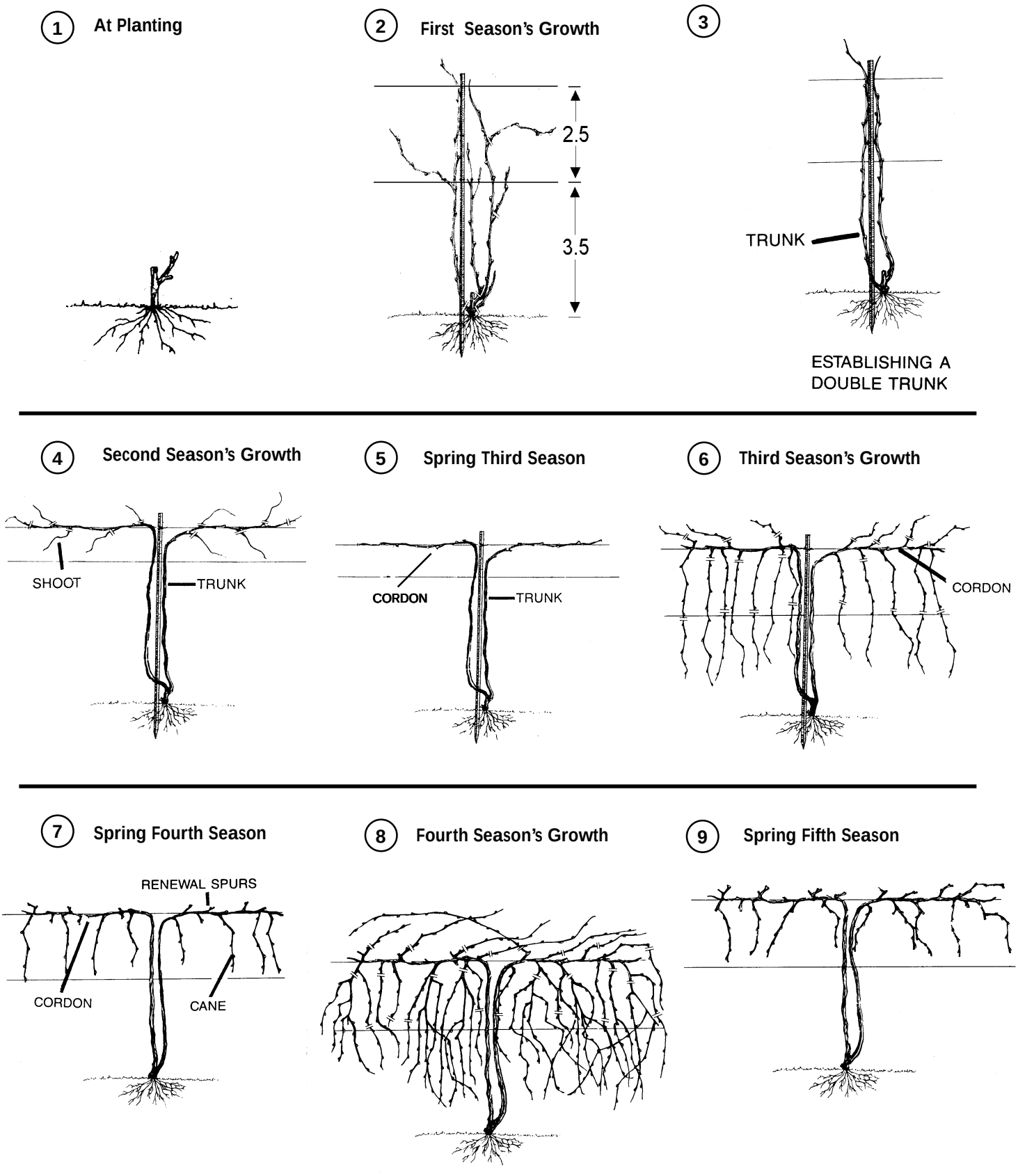
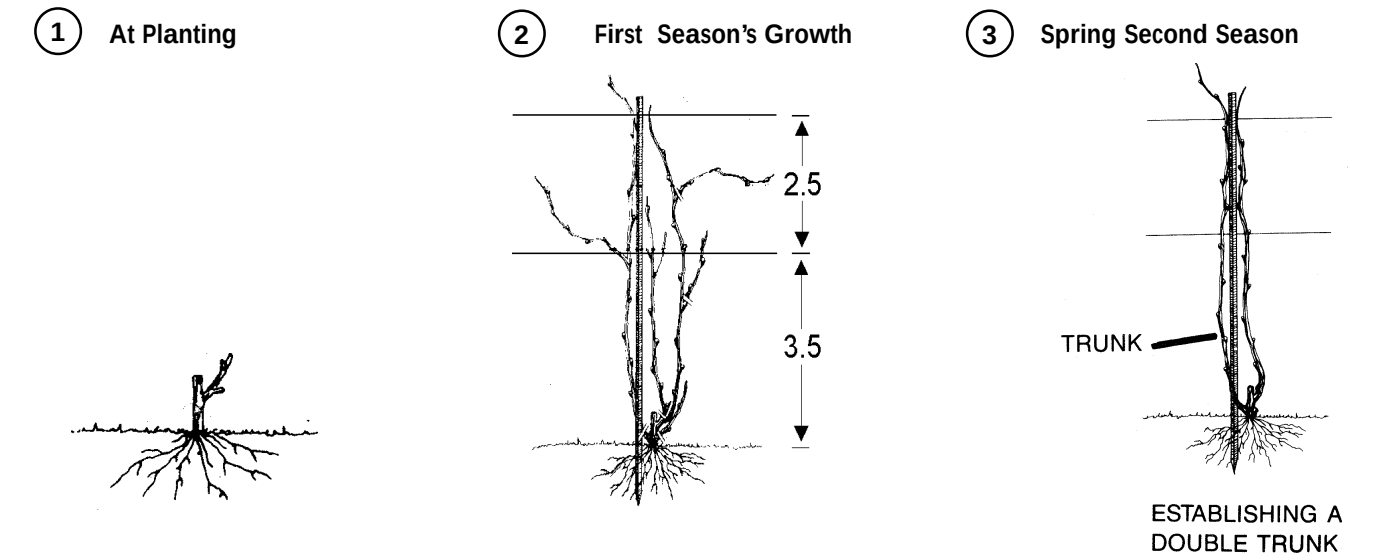
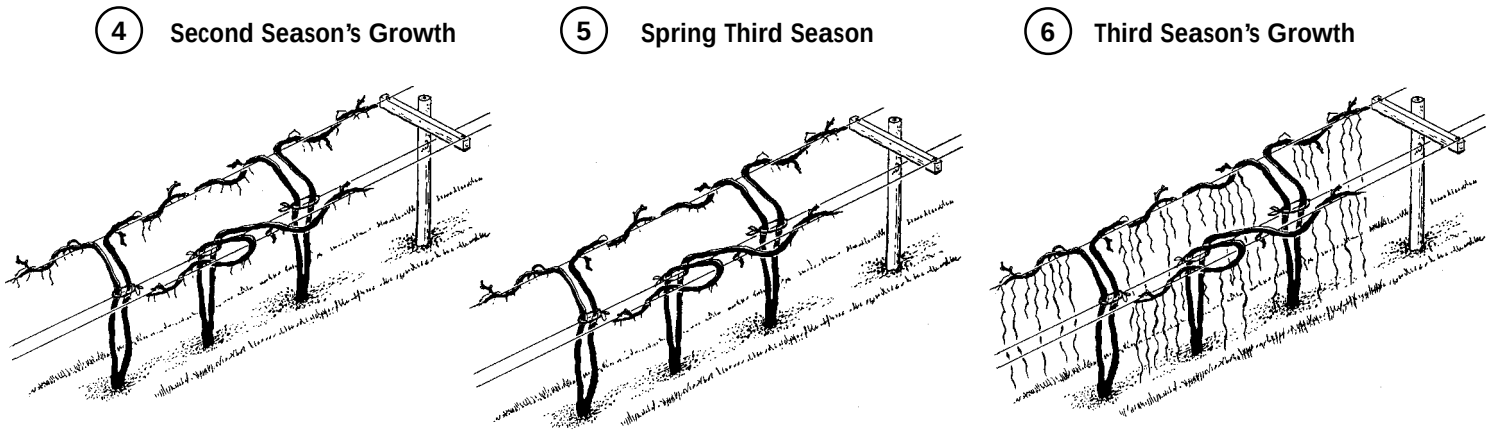
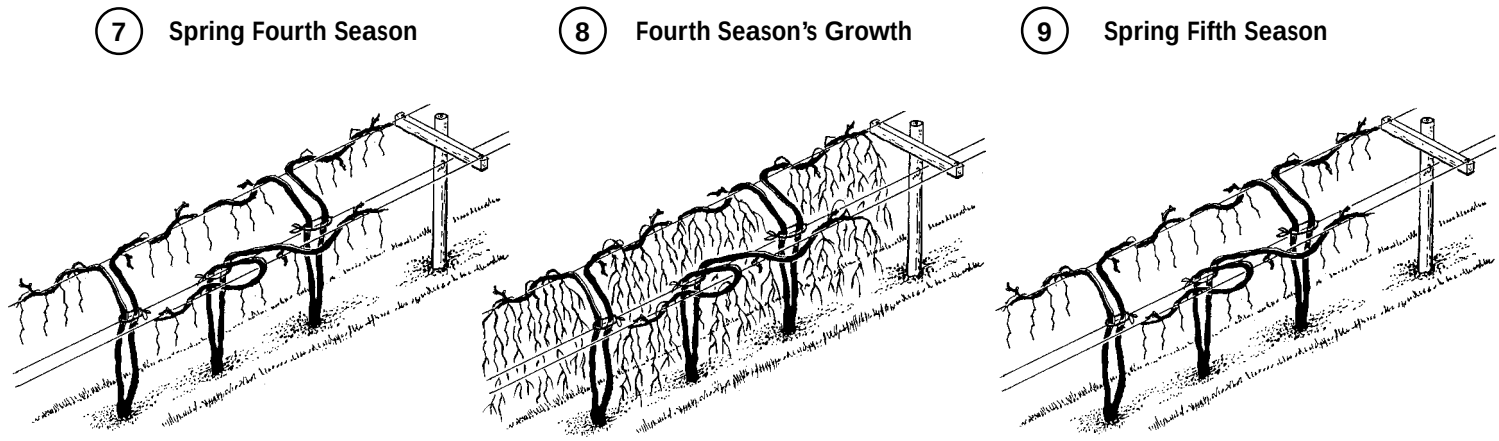


Figure 3b. Systematic Development of the Geneva Double Curtain System. Years 1-5







Chemical Weed Control

Many commercial growers use herbicides to maintain a weed-free band 24 to 30 inches wide beneath trellises. Unfortunately, few chemicals are available that can be used on young vines. Thus, many growers use mechanical cultivation or a black plastic mulch beneath vines for the first three years of growth. See Extension publication, *Kentucky Commercial Small Fruit and Grape Spray Guide* (ID-94).

2,4-D and Dicamba CAUTION—Most grape varieties are easily damaged by the vapor or drift of either 2,4-D or Dicamba. Therefore, do not spray nearby fence rows or ditch banks with products containing these compounds. Also, do not spray grapes using spray machines that have been used to apply these materials. Grape leaves injured by these chemicals become elongated with whitish and light green streaked surfaces. Delayed ripening, small berries, and death of the vines is possible. Symptoms often remain for several years.

Thinning

Thinning involves hand removal of flower clusters before bloom and of immature clusters after fruit has set. This procedure strengthens the vine and improves grape quality by increasing the ratio of leaves to fruit. Thinning complements pruning because it enables the grower to further adjust the ratio of leaves to fruit and improve grape quality. Most growers who thin do it to increase cluster size or to prevent young vines from overbearing.

Flower-cluster thinning is done between leafing out and bloom. This increases the supply of food materials to remaining flowers, berry set, and percentage of normal berries per cluster. Thus, cluster weight and length are increased. Remove flower clusters by pinching them between your thumb and fingernail at stages when they are visible above the foliage.

Cluster thinning involves removal of entire clusters after berries have set. This does not influence the set of normal berries or cluster length. The procedure removes undersized and misshapen clusters and provides more favorable growing conditions for remaining clusters, resulting in increased berry size. Cluster thinning is a time-consuming and expensive operation and is primarily done on fresh-market grapes. Evaluate your market to determine if your grapes can be economically thinned.

Gibberellin on Seedless Grapes

Gibberellin increases the size of grape berries and lengthens clusters on seedless grapes when used according to the label. In fact, berry size can increase up to 50 percent. Apply gibberellin at the shatter stage (when unfertilized berries drop off), taking care to cover individual branches.

Training Young Vines

At the end of the first season, select the strongest cane, and remove all other canes from the vine. If the vine was planted in the fall, do not cut it back until early spring or after the severest winter weather has passed. After new growth from the two buds is a foot or so long, tie the most upright vine loosely to a 6-foot stake or to twine hung from the top trellis wire and remove the other shoot or retain the second shoot if training using two trunks. Repeat, tying every 12 to 18 inches of new growth to help develop a straight trunk. When the shoot reaches the top wire, pinch out the tip to encourage branching if training to a single trunk. If vines are not cut back and summer-trained as described here, new growth will be scattered with little or no trunk development.

In Kentucky, many grape growers prefer to develop vines that have two trunks of different ages, each arising from ground level. This enables the removal of one trunk if it is winter-injured without the loss of a crop for that year. In addition, by maintaining one older and one younger trunk, trunk renewal is facilitated. Under Kentucky growing conditions it is not recommended that old trunks be maintained for long periods of time, as accumulated winter injury reduces vine vigor and yield. Vines with old trunks are also less prone to initiate new trunks from the base. Plan to replace old trunks about every five years.

At the end of the second season, if there is more than one cane, select the biggest one for the trunk (or biggest two if you are training with two trunks) and remove all other canes. Remove any tissue that was winter-killed. Then handle the cane as described above until it reaches the top wire.

The remaining upright cane should reach the top wire during the first or second season and be topped at that height to promote side growth. After this, buds on the cane will grow. Permit two to four buds to grow at the top wire; rub off all other small shoots from buds between the wires and below the bottom wire. Always remove suckers (unwanted new shoots) and laterals developing below the bottom wire as they appear.

If vines bloom heavily the second year, remove most of the flower clusters since heavy production at this time results in weak shoot growth. Most vines should produce a fair crop the third year, after which they may be treated as mature vines.

Training Mature Vines

Many cordon systems are well suited to spur pruning (pruning one- to three-bud stubs), as exemplified by one-wire, two-wire, or three-wire cordons. The Geneva double curtain and the single curtain cordon training systems are well suited for Kentucky, although there are many other acceptable training systems. At the UK Research and Education Center in Princeton, vines trained to the GDC averaged 4 pounds more fruit per vine than vines trained to the four-cane Kniffin system. In 1993, vines trained to the four-cane Kniffin were converted to the SC. For 1993 and 1994, vines trained to the GDC have averaged slightly less than 4 pounds more per vine than those converted to the SC system.

Single curtain cordon. The SC training system has several advantages over the Kniffin system. Pruning is easier and quicker, and hand-harvesting is simplified because the fruit is all in one area of the vine and easily accessible. Training is similar to that of the GDC system except the vines are trained on a two-wire trellis and there is one curtain of foliage. The SC system is recommended for low- to medium-vigor cultivars and vineyards, while the GDC system is recommended for high-vigor cultivars and vineyards.

In the SC system, train one or two trunks up to the top wire to a height of about 6 feet and train two cordons in opposite directions along the top wire. These cordons extend 4 feet in each direction if the vines are spaced 8 feet apart, and they are attached to the top wire by plastic ties or similar material. Tie the trunks to the lower wire at a height of 3½ feet to support and maintain straight trunks. These ties must be inspected and adjusted annually to avoid girdling the trunks and cordons as they expand. Short five-bud canes and one-bud renewal spurs that grew the previous season are selected along the entire cordon. These should be positioned approximately 8 to 12 inches apart along the cordons and have a downward orientation if possible. Position shoots arising from these canes and spurs downward early in the season to optimize sunlight exposure during the growing season and to facilitate pruning.

Geneva double curtain. The GDC system results in increased leaf and shoot exposure to the sun and in higher yields of better quality fruit with no delay in maturity for vigorous cultivars. This training system is well-adapted to mechanized harvesting, which is used on large plantings in other states. The system also may be adapted for use on vigorous wine grapes.

The trellis for the GDC system (Figures 3a and b) has two top cordon wires 4 feet apart and about 6 feet high. They are supported on posts by crossarms that are 4 feet long. Alternate vines along the row are tied to and trained along the opposite top (cordon) wires. Allow cordons or long arms to develop to 6 to 8 feet long in each direction along the cordon wires. With vines extending 14 to 16 feet along each wire, trellis space per vine is about double that of other training systems. Each year, retain a number of five-bud fruiting canes and a few one-bud renewal spurs on each cordon. The total number of five-bud canes and one-bud spurs left per vine should add up to the correct total for the vine according to the balanced pruning guide. This system is suggested for vineyards of above-average vigor that are producing 3 pounds or more of pruned canes per vine.

The lower wire, at a height of 3½ feet in the center of the trellis, is important. Tie vine trunks to it to keep them upright and free from injury from machinery. Above the center wire, slant the vines over to the cordon wires, which are about 2 feet higher and positioned 2 feet out on either side.

Shoot positioning. SC and GDC training require that vines be combed to orient them to sunlight. Lower leaves in dense, multi-level leaf canopies show significant reductions in photosynthesis and do not function at appropriate levels. Conversely, vines with thin, open canopies, where leaves are well-exposed to sunlight, often do not have enough leaves to mature a good crop. The ideal grape canopy has a large number of leaves with maximum sunlight exposure. This maximizes fruit yield and quality.

Leaf light exposure also affects the next year's production. Leaves that receive maximum light exposure and are attached to nodes that will be retained for the next year produce more and larger fruit clusters. Thus, it is important to position shoots and leaves for at least the first five nodes, which will produce the next year's crop. Without shoot positioning, nodes six to 12 usually receive the highest sunlight exposure and are removed in the SC and GDC training systems.

Position shoots by physically moving the shoots into a vertical downward orientation. Do this on both sides of the canopy row for single curtain cordons and both sides of both curtains on a Geneva double curtain system. Do the first shoot positioning before bloom and the second two to three weeks later. There are mechanical devices to do this on larger vineyards.

Pruning

Pruning has more effect on the vine than any other practice. If a vine is not pruned enough, it will bear too large a crop and weaken. If this happens year after year, the vine soon becomes relatively unproductive and produces low-quality fruit. If the vine is pruned

too much, the result is excessive vegetative growth and, again, lowered production and low-quality fruit. Therefore, pruning is adjusted to produce large crops of high-quality fruit and keep the vines healthy. This is called *balanced pruning*. Practice balanced pruning regardless of which training system you use.

A general rule for the balanced pruning of most American varieties is "30 + 10." This means you leave 30 buds on the vine to balance the first pound of annual wood you prune from it and 10 more buds for each additional pound of prunings you remove. (Weigh the prunings from the first few vines; after that, you should be able to prune by estimating the amount of wood to be removed.) Since American-French hybrids tend to overbear, they are pruned somewhat more rigorously. A general formula for these is "20 + 10." Both formulas can be adjusted for different varieties according to vigor and productivity (Table 7). As you become more familiar with the performance of your own varieties, you may wish to vary the formulas accordingly.

Table 7. Suggested pruning levels for mature, vigorous vines of some varieties.

Grape variety	Number of nodes to retain: First pound of cane prunings	Number of nodes to retain: Each additional pound of cane prunings
AMERICAN VARIETIES		
Concord	30	10
Fredonia	40	10
Niagara, Delaware, Catawba	25	10
Elvira	20	10
AMERICAN-FRENCH VARIETIES (require removal of severe suckers along the trunk, head, and cordons during spring and early summer)		
Small-clustered varieties, such as Foch and Leon Millot	20	10
Medium-clustered varieties, such as Aurore, Cascade, Chelois	10	10 (weak vines need flower-cluster thinning and careful suckering)
Large-clustered varieties, such as Seyval, De Chaunac, Chancellor	20	10 (must supplement with flower-cluster thinning and careful suckering)

Adopted from *Cultural Practices for Commercial Vineyards* by T. D. Jordan et al., Cornell University Miscellaneous Bulletin #111.

When to prune. You can prune your vineyard from late winter to early spring, after severe cold weather is past. Some large growers start pruning in late January. Do not prune while the wood is frozen because frozen canes are brittle and the vines can be damaged. "Bleeding" of clear sap occurs if pruning is done in late spring, but there is no evidence that such bleeding is harmful. Recent studies have shown that pruning when the vines have 4 inches of new terminal growth helps avoid late spring frost injury to buds near the base of canes left following pruning. Commercial growers who have a large number of vines often "rough prune" their vines during the winter and then finish them up when there is 4 inches of new terminal growth.

Pruning according to fruiting habit. Clusters of grapes develop from shoots growing from buds left on canes that grew the previous year. It is important when pruning to leave the proper number of buds (or nodes) to give the desired production.

The most fruitful buds of many French hybrid varieties are at the base of 1-year-old canes. They are usually spur pruned, leaving all canes with two to four buds (or nodes) each. Baco Noir and Foch are exceptions—longer canes are left on these plants.

Pruning according to winter injury. Grape flowers and shoots arise from a compound bud developed in each leaf axil the previous season. There are generally three buds in every compound bud on 1-year-old canes. The primary bud is the largest bud, and it begins growth in the spring. It produces a fruiting shoot containing flowers, leaves, and tendrils. Occasionally the primary bud is killed by low winter temperatures or late spring frosts. If this occurs, the secondary bud grows. A secondary bud produces less than half the crop that a primary bud would. If the secondary bud has been killed, the tertiary bud grows but does not produce fruit.

Another reason to wait until late spring to prune is to evaluate winter and spring frost injury and adjust

the crop load accordingly. You can leave additional buds to account for the loss of injured buds. For example, if the pruning weight for an American-French hybrid Seyval vine is 3 pounds, the formula of 20 + 10 indicates that 40 buds should be left to produce fruit. However, if 50 percent of the primary buds have been killed, leaving 40 buds on the vine would only produce half a crop. If 80 buds were left, the 50 percent bud loss would be accounted for and a full crop should be produced.

Pruning a neglected vine. Old, neglected vines (usually in small home plantings) often are not vigorous and have several crooked trunks and considerable amounts of old wood. New canes are scattered over the vine. Much of this old wood and some of the trunks and new canes probably should be removed. Keep the healthiest canes with wood and buds matured the previous season to bear fruit. These may be selected almost anywhere on the vines. To bring the vine under better control, save enough of the best canes near the base, or at least on a central trunk, and remove all other growths, both young and old.

When a new trunk is needed to replace a seriously deformed one, save and straighten a 1- or 2-year-old cane growing from the base of the plant and train it up a stake or to the trellis. After one or two additional years, remove the rest of the old, gnarled, neglected vine at ground level, leaving the new renewal trunk from which to develop a good vine.

Winter clean-up. After you have finished pruning and removed desired material for propagating new plants, haul out the remaining brush and burn it or pile it in row middles and chop it with a heavy-duty rotary mower.

Controlling Diseases and Insects

Each planting possesses a unique set of insect and disease control problems. Hence, experience is needed to determine if more or fewer sprays are required to give good results. Remember that fungicides will prevent disease infection but will not cure existing problems, so apply fungicides as a preventive measure before disease problems are visible. Further information can be found in Extension publications *Disease and Insect Control Program for Home-grown Fruit in Kentucky Including Organic Alternatives* (ID-21) and *Kentucky Small Fruit and Grape Spray Guide* (ID-94).

Grape Diseases

Black Rot

Black rot is the most important disease of grapes in Kentucky. Because much of the fungicide control program in Kentucky is directed at this disease, growers need to learn about the disease and how to best manage it.

The causal fungus, *Guignardia bidwellii*, overwinters in mummified fruit on the vines or on the ground. In spring, rain activates and moves the fungus as airborne ascospores and rain-splashed pycnidiospores. If temperatures are suitable and leaves are wet long enough (Table 8), primary inoculum causes infections of newly emerging growth. Mummies on the ground discharge almost all their ascospores by ten to 14 days past bloom, whereas mummies still on the vine produce these spores all season long. Infection by one ascospore causes one diseased spot, which yields thousands of secondary pycnidiospores, which, in turn, cause more disease. Thus, it is important to prevent the first infections.

Leaf and shoot symptoms appear as angular, tan spots with reddish brown margins one to two weeks after infection. Each spot includes many tiny black specks (pycnidia), signs of the disease, which produce spores that can start infections on new leaves and shoots and on fruits from bloom until the berries begin to ripen. Infected berries first appear light brown, then as the berry turns dark brown, tiny black pycnidia form on the surface. Infected berries turn into shriveled, hard, black mummies, which are the main means for overwintering of the fungus.

Cultural practices are critical for disease management. Sanitation—the removal and destruction of all overwintering mummies and diseased canes—is critical to black rot control. If thorough sanitation is used, there will be no overwintering inoculum, no primary or secondary inoculum, and no black rot. At the least, remove all mummies from the vines so that this source of season-long inoculum is removed. Pruning to improve ventilation and sunlight penetration into the grapevines may decrease leaf moisture and reduce disease. Because a single infection from

Table 8. Grape leaf wetness duration and temperature combinations needed for foliar infection by the black rot fungus.

Temperature (°F)	50	55	60	65	70	75	80	85	90
Minimum hours of leaf wetness	24	12	9	8	7	7	6	9	12

primary inoculum can produce thousands of potential new infections, it is important to prevent early-season primary infections. Fungicides are important in managing these primary infections.

Phomopsis Cane and Leaf Spot

It was once thought that cane and leaf spot was part of a disease known as "dead arm." The canker and shoot dieback part of the disease is now called Eutypa dieback and is a different disease from cane and leaf spot. Phomopsis cane and leaf spot is important in many parts of Kentucky and, under conditions of high disease pressure, can cause crop loss.

The causal fungus, *Phomopsis viticola*, overwinters in lesions, or spots, on canes infected the previous season. Rainfall and cool weather favor spore release and infection of developing shoots and leaves. After three to four weeks, these new infections, in turn, provide inoculum for secondary infections until the weather turns warm. Fruit and rachis (fruit cluster and stems) infections also occur during this time. This disease is most active during cool spring and fall periods, so disease prevention in spring is important.

Shoots develop dark, elliptical lesions which sometimes become cracked, and leaves have circular or irregular spots with dark centers. At first the infected small fruits appear normal, but they begin to rot when they ripen near harvest. Rotted fruits are light brown with pycnidia breaking through the berry skin, and the fruit soon shrivels. At this stage, Phomopsis fruit decay resembles black rot in appearance, but decay appears when fruits are mature whereas black rot decay occurs when fruits are immature. Phomopsis overwinters in infected fruit rachises and canes.

Cultural practices will help in disease management. Infected canes and rachises should be removed and destroyed by early spring, if possible. Pruning to improve ventilation and sunlight penetration into the grapevines may reduce disease. Fungicides are important in managing primary infections.

Powdery Mildew

Powdery mildew is an important disease of grapes in Kentucky. Susceptible varieties, such as the French hybrids which are more susceptible than their American counterparts, can suffer reduced growth, yield, quality, and winter hardiness.

The causal fungus, *Uncinula necator*, overwinters in bark crevices or on old leaves as cleistothecia (specialized fruiting structures), which release airborne ascospores as the primary inoculum for infections. Ascospores germinate on any green surface, and the fungus penetrates the plant. After about a week of growth, the fungus begins to produce conidia; these conidia and the mycelium (disease signs) on which they grow give a powdery or dusty appearance to the infected plant tissues. These conidia can also become airborne and land on other plant parts to serve as secondary inoculum for continued powdery mildew infection through the season. As the season progresses, infected leaves may become yellow or bronze, dry up, and die.

Infections occur at high relative humidity with temperatures ranging from 59 to 90°F. Low light intensity favors infection. Unlike most grape diseases, free moisture on the leaves is actually detrimental for powdery mildew. Thus, this disease can be a serious problem in drier growing seasons when it is too dry for other grape diseases, but humid enough for powdery mildew. At season's end, new cleistothecia are formed and overwinter on the canes.

Cultural practices may have limited effects on the disease. Pruning to improve ventilation in the grapevines may decrease relative humidity and reduce disease. The resultant increased light intensity on the leaves might also reduce powdery mildew. Because a single infection from primary inoculum can produce hundreds of thousands of conidia, each of which can cause infections, it is important to prevent early-season primary infections. Fungicides are important in managing these primary infections.

Downy Mildew

Downy mildew is an important disease of grapes in Kentucky. *Vitis vinifera* varieties are more susceptible than the French hybrids, which are more susceptible than their American counterparts. Infected vines can suffer reduced growth, yield, quality, and winter hardiness.

The causal fungus, *Plasmopara viticola*, overwinters in leaf debris in the vineyard. In spring, the fungus produces specialized swimming spores (zoospores) when the leaves are wet. The zoospores, splashed by rain to green plant tissue, initiate infection of wet leaves, and the fungus invades the leaves. After about one to two weeks, the infections produce symptoms and more spores are produced to start secondary infections. Infections occur during wet periods all season long, especially at night when temperatures are around 70°F.

Symptoms appear on the top side of the leaves, often along the veins, as yellow to reddish brown spots. On the underside of these spots, signs of disease can be seen as delicate, dense, white, cottony growth of the fungus. Severely infected leaves drop. Infected shoot tips may thicken, curl, become white with

sporulation, then turn brown and die. Infected berries turn dull green to reddish purple and are easily dislodged from the bunch.

Cultural practices may help in disease management. Prune out diseased shoots which can harbor the fungus. Pruning to improve ventilation in the grapevines may decrease leaf wetness and reduce disease. Fungicides may be needed on susceptible grapes in some seasons.

Botrytis Bunch Rot

Botrytis bunch rot, also called gray mold, sometimes affects Kentucky grape production, especially in wet seasons. It is most commonly a problem on tight-clustered French hybrids and *Vitis vinifera* cultivars.

The causal fungus, *Botrytis cinerea*, overwinters on almost any kind of dead plant material in the vineyard. In spring, the fungus produces spores which can be disseminated by rain and wind. When buds, young shoots, and flowers are wet or exposed to greater than 90 percent humidity, the spores initiate infection. After a few weeks, the infections produce symptoms and more spores are produced to start secondary infections. Ripening berries are attacked by the fungus in late summer.

Affected tissues rot and turn brown. Berries show a soft, mushy decay, which may spread progressively to adjacent berries and eventually to the entire bunch.

Cultural practices may help in disease management. Removal of leaves around clusters before bunch-closing may reduce losses from Botrytis due to improved air circulation and improved spray penetration and coverage. Fungicides may be needed on susceptible grapes in some seasons.

Anthracnose

Leaf spots that drop out to form "shot holes" and a decaying spot and cracking of infected fruits are seen with this disease. Anthracnose, sometimes called bird's-eye rot, is usually controlled by use of fungicide sprays such as those employed for black rot or cane and leaf spot control.

Crown Gall

This disease is easily recognized by the characteristic tumors, or overgrowths, produced on the trunk near the soil line of infected plants. The bacterium that causes this disease enters through trunk or root injuries, often through wounds created by winter freezes. Provide good plant vigor and reduce powdery and downy mildews to prevent winter injury. Remove and destroy infected plants, and carefully inspect any new plants introduced into the vineyard so that the cause of disease can be excluded.

Eutypa Dieback

The progressive dieback of shoots and vines and cankering of the older wood and trunk are characteristic of this disease. Prune cankers from the grapevine, and remove plants with infected trunks from the vineyard.

Fungicides for Grape Diseases

Before choosing fungicides for grape disease control, be sure the disease has been correctly identified. Then know the properties of the fungicide chosen and when it should be applied. Achieve thorough coverage of all plant parts when spraying fungicides. If a postinfection or curative fungicide program is used (e.g., black rot management based on leaf wetness monitoring to determine when infections have occurred), be sure accurate weather monitoring capability is available. The number of days you must wait to harvest varies with the fungicide chosen and must be considered in grape disease management decisions. See Extension publication *Kentucky Commercial Small Fruit and Grape Spray Guide* (ID-94) for properties of fungicides and recommendations.

Insects

Grape Flea Beetle

These $^{3}/_{8}$-inch, blue-green beetles eat buds and unfolding leaves, causing leaves to be ragged and tattered. Larvae feed on flower clusters and skeletonize leaves in a manner similar to adult rootworm feeding. Adults overwinter in protected areas around vineyards and start feeding in early spring. Damage is often restricted to vineyard borders, particularly near wooded areas. Scheduled sprays for grape berry moth and leafhoppers provide effective control. Where flea beetles have been a problem, a spray timed at bud swell can provide control.

Grape Phylloxera

Grape phylloxera can be recognized by galls produced on the leaves or roots. The wingless forms of the insect are very small, yellow-brown, oval or pear-shaped, and aphid-like. Leaf galls are wart-like, about ¼ inch in diameter, and unsightly, but do little damage. Root galls, knot-like swellings on the rootlets, are difficult to control and can lead to decline of vines. Severe infestations can cause defoliation and reduce shoot growth. Root galls cause stunting and/or death of European varieties.

In spring, a female hatches from an egg that had been laid on the stem. She moves to a leaf and produces a gall. She fills the gall with eggs and dies soon afterward. Nymphs that hatch from these eggs escape

from the gall and wander to new leaves to make new galls and eggs. There may be six or seven generations of this form during the summer. In the fall, nymphs move to the roots. The following spring they become active again and produce root galls on susceptible varieties of grapes. Some of the root-inhabiting phylloxera develop into winged females that lay eggs of two sizes on the stems; the smaller eggs develop into males, and the larger eggs develop into females. Mating occurs, and the female then lays a single fertilized egg that overwinters on the grape stem. It is this egg that gives rise to leaf-inhabiting generations.

American varieties of grapes and European grapes on American rootstocks are tolerant to the root gall form of the insect. Graft European varieties of grapes onto American grape rootstocks. Foliar sprays to control phylloxera during their wandering stage are of limited value.

Grape Berry Moth

The larvae of this insect can cause serious damage to commercial vineyards by feeding on the blossoms and berries. Infested berries may appear shriveled with fine webbing. The grape berry moth overwinters as a pupa in leaf litter under vines. Adults begin to emerge in late May and lay eggs of the first generation singly on fruit stems just before blossom time. Larvae feed for about 21 days on the blossoms and young fruit. Larvae of the second and third generations enter berries and feed within, passing from one berry to another under protection of webbing. Clean up or bury leaf litter under vines in winter to eliminate overwintering pupae. Although larvae first appear when the grapes are in bloom, do not apply insecticides until the berries are the size of small peas so as not to destroy beneficial pollinators. Insecticidal control of the second generation is more difficult due to the extended flight period of the moths and the difficulty of getting adequate spray coverage inside the clusters as berry size increases. Mating disruption with synthetic pheromones is an effective alternative in large vineyards where there is no immigration of moths from outside sources.

Grape Leafhoppers

These small, white or pale yellow insects are more likely to be a problem in home plantings. They rest and feed (by sucking) on the lower leaf surface. Damage results in a stippled appearance to the leaves. Due to their small size, serious foliage damage is often done before their presence is noted.

Grape Root Borer

The larva feeds on roots of grapevines for a period of two years and is potentially the most destructive insect attacking grapes. Borer damage results in reduced vine growth, smaller leaves, reduced berry size, and fewer bunches of grapes. Because damage is restricted to below ground, problems often go unnoticed until vine decline is observed. Adults are brown moths with thin yellow bands on the abdomen, and they resemble some paper wasps. This insect problem is increasing in southeastern grape-growing areas.

Injury by root borers is often most severe in low, poorly drained areas of the vineyard. In mid summer, examine around the bases of vines out to a distance of 18 inches for empty pupal skins of grape root borer. If pupal skins are found beneath 5 percent of the vines, an insecticide application is recommended the next year underneath vines. It is best to apply the insecticide just as the adults are beginning to emerge, but the preharvest interval may make it necessary to spray after harvest. Insecticides are applied as a coarse spray to a 15-square-foot area surrounding the vine.

Japanese Beetle

The range of the Japanese beetle is increasing in Kentucky. They feed on a wide variety of plant material and show a preference toward grapevines. Large populations of these insects can rapidly skeletonize grapevine foliage. Repeated insecticide applications are necessary to control this insect during July and August when populations are high. Initial feeding on the foliage often attracts other beetles. Prompt control of early-season beetles may help to reduce beetle pressure during peak flight periods.

Grape Cane Gallmaker

Grape cane gallmaker is a common pest of grapes in Kentucky. 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.

General Insect Management Guidelines

You should use a number of cultural control practices to reduce insect problems. These include:

- Burying or removing leaves under the vines during the winter.
- Summer pruning vines to remove grape cane gallmaker and grape cane girdler before adult emergence.

- Using American rootstocks resistant to grape phylloxera.
- Maintaining good weed control during the season and eliminating weedy or trashy harborages around the vineyard that serve as overwintering sites for pests.
- Using systematic scouting of vineyards to monitor for grape insects on a regular basis. Pay particular attention to the ends of rows and rows bordering wooded areas. Insect problems may develop initially and with the greatest severity on these vines. Record and maintain notes of each visit to the vineyard.
- During mid summer, examining around the bases of vines for evidence of grape root borer emergence.

See Extension publication *Kentucky Commercial Small Fruit and Grape Spray Guide* (ID-94) for a complete grape spray schedule for both commercial and home plantings and a listing of the recommended insecticide sprays. Consult *Grape Insects* (Entfact 208) for additional information on grape insects.

Other Fruit Problems

Uneven or Delayed Grape Ripening

Concord is a variety that is susceptible to uneven ripening, and the condition becomes progressively worse in areas further south. Weather, certain pests, and cultural conditions increase the severity of the problem with Concord and other varieties.

The following are some causes of delayed or uneven ripening.

- Lack of fertilization and low vigor in poor locations with uncontrolled weeds and grass and heavy shade from trees or buildings.
- Failure to prune properly, causing vines to overbear and promote small, poorly formed clusters.
- Destruction or serious injury to foliage from insect or disease attacks or removal by man. Damaging attacks by the grape leafhopper often go virtually unnoticed. Through their sucking type injury, leafhoppers cause small white dots on leaf surfaces and give a dull, brownish cast to leaves. The grape leaf folder also causes serious leaf feeding injury where unchecked, destroying the usefulness of foliage. Serious foliage loss by black rot and other disease infections also retards or prevents normal ripening.
- Removal of large amounts of grape foliage to "permit grapes to get more sunshine and mature better." This is a mistake because grapes, like other fruit and nut crops, need a good supply of healthy, functioning foliage to mature the fruit crop. Regulate excessive foliage by adjusting fertility and pruning programs. Close to harvest, some growers remove leaves around the clusters to allow better air circulation, which reduces fruit decay.
- Sensitivity to volatile forms of 2,4-D, which can affect maturity for two or three years.

Protection by Sacking

Sacking clusters is practical in a small vineyard to protect grapes from diseases, insects, and birds. Use grocers' 2-pound paper sacks or 3-pound sacks for exceptionally large clusters. Put them on soon after bloom while grapes are about 1/8 to ¼ inch in diameter. Cut sacks from the top, 1½ inches down on each side. Pinch off the leaf attached opposite the cluster; draw a sack up over the cluster; fold it over the stem; and pin, clip, or staple it snugly above the fruit. Bunches develop splendidly within the sacks.

Bird Control

Birds can cause serious crop losses, and the pressure varies from year to year depending on wild food and water availability. Grapes with small, black berries tend to be the most desirable for birds, but they feed on all cultivars of grapes. Birds are intelligent and habituate to any bird scare tactic used. Consequently if you use scare techniques, vary them. *CAUTION: All songbirds are protected; killing them can result in a fine that far exceeds the value of the crop.*

Birds may begin feeding on grapes when the sugar content reaches 11 to 12 percent. Control becomes much more difficult once birds begin feeding. It is important to have bird control measures in place *before* the grapes become acceptable to the birds.

Netting and noisemakers are the two most common methods used. Netting is the most effective, particularly for small plantings. Netting can be purchased in large rolls and applied or removed by supporting the roll over the row with a tractor and rolling it over the row. Secure the netting to keep birds out. Avian alarms that broadcast bird distress calls at intervals and propane bird scare cannons also work well if neighbors do not live too close. The RAZZO is a visual and acoustic bird-scaring instrument in which a distress flap or optional butterfly is shot to the top of a 24-foot-high pole and falls down with a flapping action. This is best suited in areas where maximum effectiveness with a minimum of noise is required. Vary the site in the vineyard and/or the frequency of the distress calls at least once or twice during the harvest period to keep the birds from acclimating to these devices. "Scare-eye" balloons with large eyes painted on them; inflated hawks, snakes, and owls; and reflective tape suspended over the plantings give some relief, but they are less

effective if relied upon for a long time and if bird pressure is high.

Harvesting

Harvesting is the busiest and most labor intensive part of grape production. Planning ahead to avoid unnecessary delays is extremely important.

- Organize and train your picking crew before harvest.
- Arrange for cold storage. Grapes are best stored near 31°F and at 85 percent relative humidity.
- Be sure harvest equipment is in good repair.
- Make arrangements with your distributor well before harvest.
- Contact your distributor a month before harvest to make arrangements for advertising.

The optimum harvest time for grapes depends on the cultivar, growing season, and intended use of the fruit. Vines with heavy crops mature their fruit later than those with normal or light crops. Vines that are shoot positioned receive better sunlight exposure and mature their fruit earlier than vines that are not shoot positioned. Grapes mature faster on vines that do not have severe defoliation from insects or diseases. Less vigorous vines mature their fruit earlier than excessively vigorous vines.

Grape sugar content and color will not increase after the grapes are cut from the vine. If grapes are left on the vine too long, the grapes drop, fruit decay and cracking in some cultivars increases, and losses to wasps and yellow jackets reduce yields.

As grapes mature, berry pigment coloration increases, berry sugar content increases, and the acid content decreases. Harvest grapes in the morning after the dew has dried or postharvest diseases will be a severe problem. Keeping the vineyard mowed and controlling weeds speeds fruit drying. Rain dilutes the grape sugar content and reduces quality.

Harvesting for the Fresh Market

Order containers for packaging to be delivered at least a month before harvest, and assemble them at least a week before harvest. Pack fresh-market grapes into the retail container in the field. Eastern grapes are not as easily handled as western grapes and shatter (fall off the cluster) badly if rehandled. Pack grapes into 1-, 2-, or 4-quart containers. Then you can pack the small containers into over-packs or masters. You can also use vented plastic bags, which are preferred by some stores. Discuss packaging with the retailer, and pack into the type of unit he or she prefers. If the grapes will be stored, add sulfur pads to the containers before sealing them and shipping them to their destination.

Ideally you should harvest grapes for the fresh market when color and flavor are at their maximum. However, this may not be practical because of the fragile nature of these varieties as they reach optimum maturity. As the fruits approach maturity, use a hand refractometer to determine an acceptable sugar level for harvest (approximately 15 to 16 percent sugar). Tasting the fruit is helpful in determining when to harvest fresh-market grapes. Generally the last grapes to ripen in the cluster are those at the bottom tip of the cluster. Harvest vines more than once to maximize yield and quality. After the more ripe clusters are removed from the vine, the smaller, immature clusters will rapidly ripen and increase in sugar content.

Harvest fresh-market grapes by grasping the cluster by its stem and clipping the stem where it attaches to the cane. Try to avoid rubbing off the waxy "bloom" that gives the berries their attractive appearance. Hold the clusters by their stems and inspect for defective, decayed, shot (immature, small, and green), cracked, and damaged berries. Cut defective portions and/or berries off of the cluster by clipping off the berry stems. Avoid pulling off defective berries because this leaves the unattractive stem and a site for decay development. Careful handling is essential to avoid cracking the berry stem attachment and providing sites for disease development.

Pack the grapes into the market containers without crushing the berries but as tightly as possible to reduce bruising during transit. Fill the containers to at least 1 inch above the rim to account for settling.

It is important to avoid leaving visible spray residues on fresh-market grapes. Using wettable powder spray materials after the berries are ¼ inch in diameter contributes to spray residues at harvest. It is not practical or possible to wash these off once they are on the fruit. Maintain an excellent spray program up to the ¼-inch berry size. This significantly reduces disease pressure later in the season. After the ¼-inch berry diameter size is reached, use liquid spray formulations or materials that are applied at low rates per acre.

Harvesting for Wine Production

Many factors affect the quality of wine grapes, and the following guidelines are intended for hobbyists. A discussion of all factors influencing grape quality for wine is outside the scope of this publication. Grapes are harvested for wine based on percentage of sugar. A refractometer measures soluble solids, or percent sugar. The greater the grape sugar content, the higher

the alcohol content of the wine. This is true up to the alcohol concentration that kills the wine yeast. Grapes with low soluble solids are frequently amended with sugar to reach the desired sugar level. This increases cost and affects the wine quality.

The quandary for wine grape growers is determining when to harvest to achieve the maximum sugar content and acceptable acid level without losing the grapes to decay. Grapes are usually harvested between 17 and 21 percent sugar. A sugar level of 15 percent is considered the minimum by most. Risk of developing undesirable acids increases if the grapes are left to develop levels of 24 to 26 percent sugar.

Harvest wine grapes after the dew has dried off, and keep them out of bright sunlight until they are pressed or refrigerated. You can maintain grape quality without refrigeration in closed bins for 48 to 72 hours by adding sulfur dioxide.

Resources for Grape Production

University of Kentucky Publications

Available at your county Cooperative Extension Service office:

Farmer to Consumer Direct Marketing (AEC-38)
Planning for Marketing Fruits and Vegetables (AEC-40)
Management of Roadside Markets (AGR-41)
Lime and Fertilizer Recommendations (AGR-1)
Growing Grapes in Kentucky (HO-21)
The Japanese Beetle (ENT-5)
Black Rot of Grapes (PPA-27)
Kentucky Commercial Small Fruit Spray Guide (ID-94)
Disease and Insect Control Programs for Home-grown Fruit in Kentucky Including Organic Alternatives (ID-21)
Managing Rabbit and Vole Problems in Kentucky Orchards (FOR-43)

Publications from Other Universities

Estimated Budgets for Small Fruit Culture in Southern Illinois. C. C. Doll and E. D. Billingsley in: *1995 Illinois Small Fruit and Strawberry School Proceedings*, pp. 97-99. Write to: J. D. Kindhart, University of Illinois, Dixon Springs Agricultural Center, Route 1, Box 256, Simpson, IL 62985.

Planning Budgets for Fruits and Vegetables—EC 890. A supplement to the *Farm Planning Manual*. Agricultural Extension Service, University of Tennessee, Knoxville, TN 37901.

Texts and References

Pearson, R. C., and A. C. Goheen. 1988. *Compendium of Grape Diseases*, American Phytopathological Society, 3340 Pilot Knob Road, St. Paul, MN 55121, 93 pp.

Modern Fruit Science. 1995. Norman F. Childers, Horticultural Publications, 3906 N.W. 31 Place, Gainesville, FL 32606, 632 pp.

Small Fruit Crop Management. 1990. Ed. Gene J. Galletta, David G. Himelrick, Prentice Hall Inc., Englewood Cliffs, NJ 07632.

Fruit, Berry, and Nut Inventory: 2nd Edition. 1993. Edited by Kent Whealy and Steve Demuth, Seed Saver Publications, 3076 North Winn Road, Decorah, IA 52101.

Grape Vineyard Development Checklist

1. Determine market outlook and demand: profitability.
2. Determine appropriate varieties.
3. Select a suitable site.
   a. orientation
   b. avoid shade
   c. air movement
   d. temperature
4. Perform soil test.
5. Dig backhoe pits.
6. Determine water availability.
7. Prepare the site.
   a. subsoil when dry
   b. apply needed nutrients
   c. control perennial weeds
8. Survey the vineyard site.
   a. scale drawing of proposed planting
   b. direction of rows
   c. row and vine spacing
   d. row length—tractor turning space needed
   e. harvest time
   f. picking avenues and spray roadways
   g. irrigation delivery system
   h. drain system, if needed
9. Order cultivars from a reputable nursery at least six months before the month of intended planting.
10. Install any needed drainage.
11. Install any needed irrigation.
12. Plant cover crop.
13. Install deer fence, if needed.
14. Lay out and plant after danger of spring frost has passed.
15. If you are new to grape production, consider using a consultant for more technical aspects.

Correcting mistakes can be costly and time consuming. *Read, study, consult with good growers and Extension personnel, and think before you act!*

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Issued in furtherance of Cooperative Extension work, Acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture, C. Oran Little, Director of Cooperative Extension Service, University of Kentucky College of Agriculture, Lexington, and Kentucky State University, Frankfort.
Issued 7-97, 2000 copies.