Commercial Grape Production in Kansas

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Kansas has potential for successful commercial grape production. Kansas has several factors that encourage grape production, including soils that are adapted to grape culture, water available for irrigation, and abundant sunshine. Grape acreage in Kansas has steadily increased since the first commercial wineries opened in 1988. Demand for Kansas-grown grapes also has increased because the wine industry has outgrown the capabilities of expanding vineyards.

Developing a Vineyard

To develop a successful vineyard and marketing program, objectively evaluate the following factors to determine if developing and operating a vineyard is within your goals and resources.

Capital investment. The cost to establish a vineyard to bring vines into bearing can be as much as $5,000 per acre. The vineyard will reach full production in the fifth year and may be 4 to 6 tons per acre.

Labor. There is a high labor requirement that generally exceeds 100 hours per acre per year. A large part of that requirement is manual labor for pruning and harvesting.

Market. Wine and grape production requires specific cultivars, so the market should be evaluated for demand.

Developing a Marketing Plan

1. Identify target market(s)

Table or dessert grapes (consumed fresh)

- Grapes are sold "pick your own" to local customers within a 20-mile radius of the farm.
- Grapes are sold at roadside stands or farmer's markets.
- Growers pack and deliver grapes to local supermarkets.

Processing grapes for wines, juices and jellies

- Grapes are sold "pick your own" for home use.
- Grapes are sold to clubs or to area wine-making supply stores for home wine-making.
- Grapes are sold to commercial wineries.

Each option involves a specific marketing plan with proper cultivar selection, cultural practices and harvest parameters.

2. After identifying a target market, consider the 4 Ps of marketing:

- Product – Grapes are the product, but remember the buyer's perspective. Grapes are the raw material, but the quality of the grapes determines the value.
- Place – Know where customers are located and have a good site to grow quality grapes.
- Price – The main consideration is how much customers are willing to pay. First, establish the price you are likely to receive based on past prices by talking to customers and establishing a price for grapes you will have available. Compare expected prices with projected costs before planting.
- Promotion – The earlier you start promotions, the more time and less money you have to spend to let people know you are in business. Tell potential customers when you will have grapes available for sale. When your first crop is harvested, take samples to prospective customers. Build connections by becoming active in grape-grower groups, wine groups and community groups. It is hard to sell a high-quality product without a market, and it is hard to develop a market without a high-quality product. Product quality and marketing go together.

Grapevine Morphology

Grape is a perennial plant. It produces shoots that harden in the fall and become canes. The canes go into dormancy before severe cold weather. Because it is a perennial, it develops flower clusters for the next crop while flowering and maturing its current crop. A grapevine always carries two crops: current and future. The green shoots that produce the current season's crop eventually turn brown and contain the buds for next year's crop. Healthy vines will produce for 25 years or longer. Many commercial vineyards have produced for more than 50 years.

Grape growth is similar in many ways to other fruit crops. However, it is different enough to require special study to understand the application of many cultural practices.

Grapevine development. The chilling requirement, or the rest, for grapevines is usually satisfied by late December or early January in Kansas. As soon as temperatures reach a daily average of 47 to 75° F, buds from the previous year are ready to start growing. Metabolism starts to occur in dormant buds in March, and bud growth occurs by mid-April. The flower clusters that developed last growing season develop individual flowers by late April. Flower development reaches the bloom stage in early June in northern Kansas and slightly earlier in southern Kansas. Under favorable conditions, pollination occurs within a couple of days and fruit set occurs about one week after bloom (mid-June). Unpollinated ovaries drop from the cluster. Unfavorable conditions during pollination reduce fruit set and increase fruit drop. Flower cluster initiation for next year's crop starts about a week before bloom and continues until just before harvest in late August to mid-September. Leaf fall is in mid-November, but it can be earlier, depending on the first hard frost, which causes the leaves to drop.

Fruit growth and development. Grape flowers and fruit clusters are borne only on new shoots from dormant buds. These buds were formed in the axils of leaves the previous season. Grape buds are compound buds that contain three separate, smaller buds: primary (central bud), secondary and tertiary (Figure 1). In the spring, the primary bud breaks dormancy and produces the fruiting shoot. Most of these shoots on young vines remain vegetative and do not produce fruit.

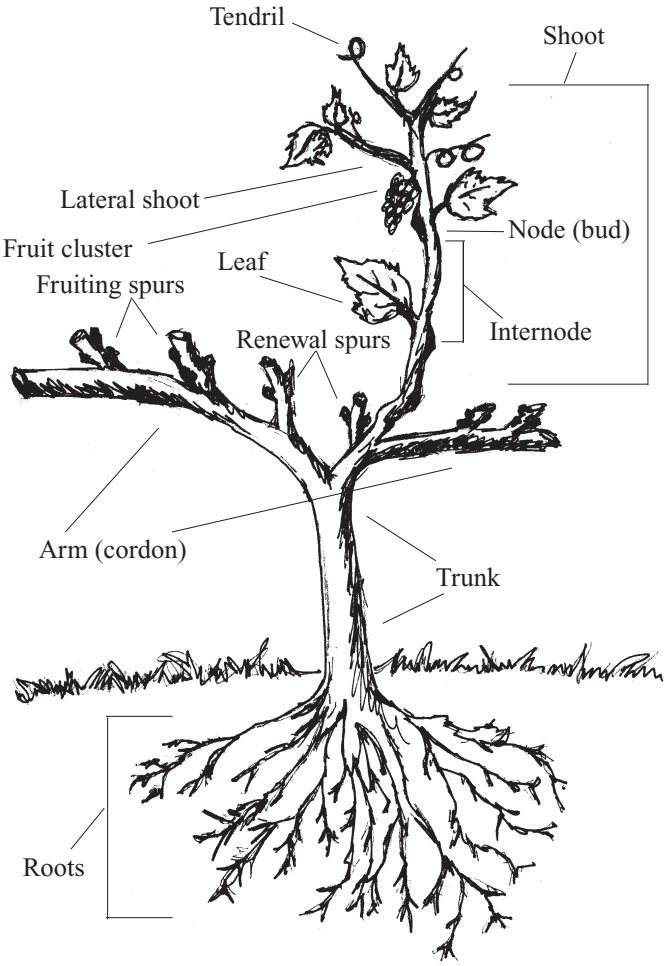


Figure 1. Anatomy of the vine.

Spring frosts occasionally kill the tender primary bud in the early stages of growth. In this case, the secondary bud develops a shoot that may or may not bear fruit. The secondary bud is less vigorous and productive than the primary bud. This characteristic of the grape, however, does allow a partial crop even when the primary buds are lost. Severe spring frosts may kill both the primary and the secondary buds in the "eye." In such cases, fruit production is lost for that season, and the remaining shoot growth may be vigorous.

Flower clusters. As the new primary shoot develops, flower clusters form opposite a leaf. Where a flower cluster does not develop, a tendril may grow opposite the leaf. Each grape species has a definite number of flower clusters per shoot. Location of these clusters on the shoot is also specific. The American grape (*Vitis labrusca*) characteristically forms two to four flower clusters per shoot. These are usually at nodes two, three, four and five from the base of the shoot. French hybrids flower prolifically, sometimes having five or more clusters per shoot.

Cluster position on cane. The location and number of flowers or fruit clusters on the shoot are factors to consider in determining a vine training and pruning system. One reason for leaving longer but fewer canes on American grapes than on European grapes is because fewer flower clusters are born on each shoot on American vines. French hybrids have more clusters on the first two or three shoots and will have more canes that are shorter after pruning.

Grape fruit cluster. The grape fruit cluster is a modified tendril. Whether a tendril or a flower cluster develops is determined by the genetic code of the vine. The number of flower clusters that develop from a single dormant bud and the number of mature fruits is determined mostly by vine vigor and growing conditions the previous season.

Cane growth. During the growing season, new buds develop in leaf axils. These become the dormant buds from which the shoots develop. Frequently during the summer, a lateral shoot is produced on the axil of the leaf adjacent to the bud. After the leaves fall, the shoot is called a cane. It is from the canes that next year's fruiting wood is selected at pruning time and from which propagation wood is taken.

Vine support. Grapevine support is necessary for commercial production. This support is a wire trellis constructed according to the training system of the vines. The trellis holds up the vine so it can be managed and cared for properly and efficiently. It also exposes the foliage to sunlight, which increases the bearing area. Even with the use of supports, do not neglect pruning or vines will become unmanageable and unproductive. Yield and berry quality can be improved with proper training systems that increase sunlight exposure. The goal is to intercept as much light as possible within each acre without too many layers of leaves. Growers can improve light interception by using a north-south row orientation, choosing a specific training system, applying shoot positioning, and practicing shoot and cluster thinning during the growing season.

The cultural practices discussed in this guide are used to attain a balance in the vine. The key to good yield and quality grapes is a balance between vegetative growth and fruit production. Apply the proper cultural practices such as balanced pruning, proper nitrogen fertilization, irrigation, and shoot and cluster thinning so the environment has little detrimental effect on yield and berry quality.

Grapevine Glossary

Arm: a major branch of the trunk. Can be a cane or a cordon, depending on the training system.

Balanced pruning: pruning method that uses cultivar-specific formulas to adjust the extent of pruning (number of fruiting buds retained) based on the weight of wood pruned away.

Basal bud: a small bud positioned at the base of a cane or spur that is usually non-fruitful.

Bud: a compressed (non-elongated) shoot. Buds develop in the axil of each leaf and overwinter. These buds are compounds and contain primary, secondary and tertiary buds.

Count bud: fruitful buds on canes or spurs (excluding basal buds).

Cane: a mature (woody) shoot that has grown for one season.

Canopy: the entire foliage of a grapevine as it is positioned on the trellis.

Cordon: a semi-permanent extension of the trunk; an arm, usually horizontal and trained to a trellis wire.

Fruiting wood: 1-year-old wood that produces the current season's crop.

Fruiting spur: a short cane retaining two to six fruitful buds.

Lateral (summer lateral): a side branch of a main shoot.

Node: thick part of the shoot or cane where the leaf and its compound bud attach.

Renewal spur: a short cane retaining one or two buds. A shoot from a renewal spur will be selected to provide fruiting canes or spurs one year hence.

Rootstock: the lower portion of a grafted plant that comprises the root system and a small part of the trunk.

Shoot: current season's succulent and green stem growth. A shoot becomes a cane when more than half its length becomes woody.

Shoot positioning (combining): positioning shoots during the growing season to hang down. Used in single curtain and double curtain training systems.

Spur: a short cane pruned back to retain one to six buds.

Sucker: shoot arising at or below ground level.

Tendril: slender, twining organ on a shoot opposite a leaf; can coil around an object for support.

Thinning: removing flower clusters or young fruit clusters to reduce the vine's crop load.

Trellis: permanent vine support system, usually consisting of fenceposts and wires.

Trunk: the main stem or body of a vine between the roots and the top of the vine.

Vineyard Location

A vineyard is a huge venture. It requires a lot of capital and it will exist for many years. Be sure to provide the best environment for the vines to grow. The main characteristic of a good grape planting site is good internal soil drainage. At least 30 inches of unobstructed soil depth is desirable. Choose a location that is higher than the surrounding area and can be irrigated.

Evaluating the site. After planting grapes, it is difficult to improve the physical properties of the soil at that site. Before planting, use a backhoe to dig 6-foot pits in several places on the site. Select areas where current vegetation is vigorous and other areas where growth is poor. Use these pits to evaluate drainage, transition layers, vegetation growth and rooting, and soil texture. Contact the USDA Soil Conservation Service for a map of the areas where you want to establish a vineyard.

Soil drainage. Good soil drainage means that rain water does not displace oxygen surrounding the root system for more than a day. In poorly drained soil, vines will not be vigorous and productive, and probably won't live. Bright, uniformly yellowish-brown or brown subsoil indicates good internal drainage. Subsoils that are mottled or dark gray have poor drainage. If the general topography (elevation, slope, etc.) is favorable but drainage is poor, install tile drains.

Transition layers. A transition layer is where the soil texture changes dramatically, such as a layer that is all sand or all clay. Roots won't penetrate these layers. Break through these layers and mix them before planting, or plant in another location without transition layers. Reduce the effects of a transition layer by ripping through a layer in two directions. Rip the soil 3 or 4 feet deep on 3-foot centers to improve rooting depth and soil drainage.

Current vegetation. Current vegetation growth helps determine soil productivity. Perennial weeds and grasses perform well on good sites. Check the rooting depth of these plants.

Soil texture. The percentages of sand, silt and clay create the soil texture. Sand makes a soil look and feel grainy, and clay causes soil particles to stick together. Sand is important for drainage, and clay is important for water and nutrient retention. Knowing the soil texture can help you plan the irrigation and fertilization practices. With proper management and good internal drainage, vineyards can produce well in soil textures ranging from sandy loams to heavy clay and silty-clay loams.

Soil testing. A naturally fertile soil is not as important as drainage and soil depth because chemical fertilizers can help manage vigor and production. Use soil tests to provide information on soil texture, soil pH and nutrient levels. Use soil survey maps to determine the soil type in the vineyard. Any areas of the field that differ should be sampled separately. At each sampling site, collect soil samples at two different depths (6 to 12 inches and 18 to 24 inches) and submit them separately for testing. Visit your local K-State Research and Extension office for instructions on collecting soil samples and for envelopes or boxes for the samples. If crop or sod growth indicates a uniform site, one sample is adequate. Send a sample of six to 10 subsamples from different spots. If there are differences, these spots should be sampled separately.

A basic soil test and textural analysis is done once for the life of the vineyard. It should be run on each composite of six to 10 subsamples. A basic soil test gives information on base saturation percentages, pH and concentrations of Ca, Mg, K and Na in parts per million (ppm). Base saturations should be 65 to 75 percent Ca, 10 to 15 percent Mg, 3 to 5 percent K and less than 2 percent Na. The best ratio of Ca to Mg concentration is 4 Ca: l Mg, but a 3:1 ratio is also manageable. Sodium is a problem in concentrations of 690 ppm or higher. Chloride is a problem at 350 ppm or higher. A satisfactory pH range for grape is 5.5 to 6.5. Soil pH can be increased with lime and decreased with sulfur.

Irrigation. Irrigation will pay for itself in the early years of a well-managed vineyard. Supplemental irrigation increases plant survival in the first two years. Mature

vines need consistent moisture through the summer for fruit growth and quality, as well as for fruit bud development for next year's crop.

Water quantity and quality. Grapes need a minimum of 5 gallons of water per plant per day. A drip or subsurface irrigation system is designed to supply 10 gallons per plant per day and would provide adequate water even during high stress. Determine water quality by testing a water sample for pH, salinity (total dissolved salts), Na and Cl. An acceptable pH range is 5.5 to 7.5. Salinity in irrigation water is not a problem if concentrations are below 640 ppm. Sodium and chloride levels need to be below 460 and 142 ppm, respectively, to avoid toxicity problems. Salinity is measured and reported in electrical conductivity (EC) in milli mhos per centimeter. Convert EC to ppm by multiplying by 640 ppm.

Air drainage. Vineyards planted on slopes of 2 to 3 percent will escape spring frost damage to fruit buds, blossoms and small fruits after bloom. Cold air moves down, drawing warmer air from higher layers. A vineyard planted in a low site, such as along a creek or at the bottom of a hill, is more susceptible to low temperature injury than a site in a higher area.

Avoid soil erosion. Steep slopes in the site will create more soil erosion and make it more difficult to operate equipment for cultural practices. Cool temperatures on slopes to the north may delay vine growth enough in the spring to avoid frost damage. On a southern slope, there may be earlier spring growth and increased risk of frost injury.

Windbreak beneficial. Protection from southwest winds can reduce vine damage and increase pest control. It is beneficial to begin a windbreak at least a year before planting in areas with full exposure to summer winds.

Grape Cultivars

Cultivar selection is one of the most important decisions in the planning process for a market vineyard. Consider the target market or use for the grapes and the cultivar's adaptation to the region. Only cultivars with definite market demand should be grown.

Adapted types. Severity of winter temperatures is the main factor for selecting a grape variety that is adapted to the Kansas climate. Kansas is in USDA hardiness zones 5 and 6. In zone 5 (northern Kansas), the average minimum winter temperatures are -10° to -20°F and in zone 6 (southern Kansas), the average minimum winter temperatures are 0 to -10°F. *Vitis vinefera* cultivars (the European grape) are not recommended for production in Kansas because they cannot survive below -5°F. The most reliable grape cultivars for Kansas are American types (Cynthiana, Catawba, Steuben, etc.) and French-American hybrids (Vidal, Seyval, Vignoles, etc.). Grape cultivars range in hardiness, but most common French-American hybrids will tolerate -10 to -15°F with minimal damage. Most American hybrid types tolerate temperatures just below -15°F.

The wine grape cultivars with the highest market demand in Kansas are Cynthiana, Vignoles, Seyval, Vidal, Chambourcin, Foch and Catawba. Seedless table grapes that could develop high market demand are Mars, Canadice and Reliance.

There are many grape cultivars that can be grown in Kansas. Research has identified a number of cultivars adapted to Kansas conditions that have high fruit quality and marketability. A list of recommended cultivars is given in Table 1. Table 2 lists cultivars that could be considered for trial plantings.

Table 1. Recommended grape cultivars for use in Kansas.

Northern Kansas (zone 5)

Seedless Table Grapes	Multipurpose[1]
Canadice	Catawba
Mars	Concord
Reliance	Niagra
Sunbelt	Steuben

Red/Blush Wine	White Wine
Catawba	Blanc
Cynthiana (Norton)	Cayuga White
Chancellor	Seyval Blanc
DeChanunac	Ventura
Foch	Vignoles
Steuben	

Southern Kansas (zone 6)

Seedless Table Grapes	Multipurpose[1]
Same as above	Same as above

Red/Blush Wine	White Wine
Baco Noir	Same as above
Catawba	
Chambourcin	
Chancellor	
DeChanunac	
Steuben	

[1]For dessert, juice, jelly or wine-making.

Table 2. Grape cultivars to consider for trial planting.

Northern Kansas (zone 5)

Seedless Table Grapes	Multipurpose[1]
Himrod	St. Croix
Red/Blush Wine	**White Wine**
Frontenac[2]	Chardonel[2]
St. Croix	Esprit
	LaCrosse

Southern Kansas (zone 6)

Seedless Table Grapes	Multipurpose[1]
Himrod	St.Croix
Marquis	
Red/Blush Wine	**White Wine**
Frontenac[2]	Burden 4672
St. Croix	Chardonel[2]
	Esprit
	Siegfried
	Traminette

Cultivar Descriptions

Seedless Table Grapes

Canadice – red, small-medium berry size, medium-large clusters, compact cluster, thin adherent skin, melting flesh, excellent flavor, early ripening, good cold hardiness. Fruit rot is a problem in wet years because the clusters are excessively compact.

Himrod – white, medium berry size, small-medium clusters, loosen cluster, melting flesh, excellent honey-like flavor, good cold hardiness.

Marquis – white, large round berries, very large attractive clusters, melting flesh, very flavorful, mild American flavor, moderately hardy. The vine has medium vigor and is productive.

Mars – blue, medium-sized berries, small to medium clusters, good flavor (mild Concord-like), nonadherent skin, ripens early. Vine is vigorous and cold hardy (hardiest of the seedless types), and fairly resistant to black rot, anthracnose and mildews.

Reliance – red, small-medium berry size, medium to large clusters, compact cluster, thin adherent skin, melting flesh, excellent flavor, high sugar content, early ripening, good cold hardiness. Full red color inhibited by overcropping and/or high temperatures during ripening. Fruit will crack in high-moisture conditions.

Multipurpose

Catawba – red, medium berry size, medium clusters. Good flavor, good for juice and blush wine (sparkling wine is popular). Vine is productive, moderately vigorous and cold hardy.

Concord – blue-black, medium-large berries, medium clusters, the quality standard for juice, jam and jelly, also used for sweet wines. Uneven fruit ripening is most common problem due to overcropping and high temperatures during ripening. Vine vigor is moderate-high, good productivity and cold hardiness.

Niagara – white, large berries, large clusters, distinctive American grape flavor, good for juice and jelly. Vine is vigorous, productive, and cold hardy.

Steuben – blue-black, medium-large berries, large clusters, good flavor (Concord-type), nonadherent skin, good dessert quality (seeded) and good for juice, jelly, and Concord-style wine. Vine vigor is medium, productivity is good, cold hardiness is good if the vine is not overcropped.

St. Croix – blue, medium-sized berries, medium clusters, very hardy. The vine is vigorous and will fruit heavily a year after planting.

Sunbelt – blue-black, medium-large berries, medium cluster. Fruit is nearly identical to Concord but ripens more evenly. Excellent fruit quality for juice, jam or jelly; also can be used for sweet wines. Vine is vigorous, productive, and cold hardy. Fruit is highly susceptible to black rot, moderately susceptible to downy mildew, but only slightly susceptible to powdery mildew and anthracnose.

Red/blush Wines

Baco Noir – blue-black, small berries, medium clusters, early ripening, good wine quality. Vine is vigorous, but may be cold injured, particularly if overcropped or if excessive vigor is encouraged. Better adapted to southern Kansas.

Chambourcin – blue, medium-sized berries, large, moderately loose clusters, late ripening, moderately hardy. The vine is very productive and it requires a long growing season and a site less subject to low winter temperatures.

Chancellor – blue-black, medium berries, medium-large clusters, very good wine quality. Vine is moderately vigorous, productive and requires cluster thinning. It is moderately cold hardy, better adapted to southern Kansas.

Cynthiana – probably synonymous with Norton. Blue-black, small berries, small clusters, outstanding wine quality, usually produced in claret style. Vine is vigorous, productivity is low but can be increased by training to Geneva Double Curtain. Good cold hardiness and resistance to most diseases.

DeChaunac – blue-black, medium berries, medium-large clusters, good wine quality. Vine is moderately vigorous, productive, requires cluster thinning. It is moderately cold hardy, better adapted to southern Kansas.

Foch – blue-black, small berries, small clusters, good wine quality, early ripening. Vine has moderate-high vigor,

is productive, cold hardiness is very good if not over cropped. Requires cluster thinning for crop control.

Frontenac – blue, medium clusters, moderate to late budbreak, midseason maturity, good productivity, easy to manage, good fruit character, moderately susceptible to powdery mildew, very cold hardy.

White Wine

Burden 4672 – white, moderately hardy, very late budbreak, midseason maturity, susceptible to powdery mildew and phylloxera (leaf form), and wines are fragrant and delicate.

Cayuga White – white, medium berries, large clusters, good wine quality. Vine is vigorous and productive, but may be only moderately cold hardy. Fruit ripens just before Concord. Very susceptible to black rot and anthracnose, moderately susceptible to both mildews.

Chardonel – white, moderate to good hardiness, moderate to late maturity, productive. It was a selection from the cross Seyval X Chardonnay. During good years fruit quality is similar to Chardonnay and in poor years it is similar to Seyval. Its potential for sparkling wine production seems to be good.

Esprit – white, large berries, large clusters, very productive, good cold hardiness.

LaCrosse – white, small tight clusters, moderate to late budbreak, mid to late maturity, productive, very cold hardy, very susceptible to leaf phylloxera.

Seyval blanc – yellow, medium berry size, large clusters, good wine quality. Medium-high vigor, productive, requires cluster thinning. It has fairly good cold hardiness if vine is not grown with excessive vigor, overcropped, or otherwise stressed.

Siegfried – white, tight, small to medium clusters, moderately hardy, moderately early budbreak, mid-season maturity, very sensitive to 2,4-D. It is a French-American hybrid that has Riesling as one of it's parents, wine has a Riesling character.

Traminette – white, large loose clusters, mid-season maturity, moderately hardy, moderately productive. It is a French-American hybrid that has Gewurztraminer as one of it's parents, wines are reminiscent of Gewurztraminer.

Ventura – yellow, medium-large berry size, medium clusters, good neutral or blending wine. Medium-high vigor and productive. Vine has very good cold hardiness.

Vidal blanc – yellow, large berry size, large clusters, excellent wine quality. Vine is vigorous and productive, requires cluster thinning. It has fairly good cold hardiness if vine is not overcropped or otherwise stressed.

Vignoles – yellow, small-medium berry size, small clusters, very good wine quality. Medium-high vigor, productive. It has fairly good cold hardiness if vine is not grown with excessive vigor, overcropped, or otherwise stressed.

Plant Materials

Orders for vines should be placed with nurseries at least 6 months to a year before planting to ensure delivery. Nurseries that specialize in grape plants and grow the desired cultivars are the most suitable sources. One-year-old plants are best. These are dormant, rooted cuttings that were grown in a nursery the previous summer. The grades or size may vary by nursery, but 1-year-old, extra heavy, or number one dormant rooted cuttings are best.

When the planting stock arrives, open the bundles immediately and check the roots for moisture. Moisten if roots are dry. If planting must be delayed, keep the plants in a humid location at 35° to 40°F and cover with moist sawdust, or line them in a trench with soil covering the roots.

Planting in mid- to late March gives the plant time to get well-established and grow new roots before temperatures and water requirements increase. Fall plantings can be made if nursery plants are available. However, plants that grow in the vineyard and harden off generally survive winter temperatures with less plant loss than fall newly set plants.

Establishing the Vineyard

Site preparation should begin at least one year before planting. The site should be completely prepared for optimum plant growth because the vineyard will last a long time and the investment is high.

Kansas vineyards can be established on hilly and flat sites. Site preparation is similar for both, but prevention of soil erosion should be part of the site development in hilly areas. Areas where cultivated crops have been growing require less preparation than sites with with sod.

Plant a windbreak where there is full exposure to summer winds. Southwest winds can cause vine damage and increase desiccation during the summer. In flat areas, low spots should be filled in to avoid water accumulation around vines. There should be sufficient slope for water to drain off the vineyard site. The leveling may be accomplished with a land plane or earth-moving equipment. Contact the County Soil Conservation Service for assistance in determining field elevations. The soil-fill in low spots will settle after rains or irrigation. If the spots are still low after settling, additional leveling will be needed. Use a subsoiler to rip the soil in two directions, the deeper the better.

Grapes should not be planted before a weed control program is completed. Perennial weeds should be eradicated more than one year before planting grapes. K-State Research and Extension can provide recommendations for an eradication program.

Grapes cannot compete in sod, so if the selected vineyard site is in sod, it should be deep plowed. This can be done the fall before planting or a year before planting with a cultivated or green manure crop planted in late August. Hairy vetch at 40 lbs. per acre, Austrian winter pea at 78 lbs. per acre or sweet clover at 18 lbs. per acre are recommended.

If the vineyard is going to be planted on hilly ground where sod is growing, spray a 3- to 4-foot strip of sod with herbicide and plow it. This requires planning so the exact locations of the grape rows are identified then sprayed. An herbicide that is translocated to the grass (Roundup, Poast or Fusilade) will be more effective and prevent regrowth after plowing than an herbicide that is not translocated. Grass strip middles (6 foot) should be established using either tall fescue or buffalo grass.

Irrigation

Drip irrigation is the most efficient way to supply supplemental moisture to grape vines. The moisture is confined to the row area with lateral line tubes on a wire about 3 feet above the soil with one or two emitters per plant.

Plan the irrigation system a year before planting so it is available throughout the first year. Insufficient moisture and poor weed control during the first summer account for a lot of vine loss. Plants should develop a strong root system and vine growth during the first year or bearing will be delayed one or two years if plants survive. If a drip system is used, everything except the in-row laterals need to be established the year or fall before planting. A subsurface system needs to be in place and working the summer before planting. It takes at least one year for a subsurface system to work properly.

Well water or surface water can be used for irrigation. If surface water is used through the drip system, a filtering system will be necessary to prevent the line from plugging and to maintain even water distribution.

The volume of water should supply a minimum of 5 gallons per plant per day. However, a system designed to supply 10 gallons per plant per day would ensure adequate water during high stress periods during crop development.

An engineer with expertise in irrigation should design the irrigation system layout. Request assistance from a K-State irrigation engineer through your local K-State Research and Extension office, or irrigation equipment supply companies may have staff members to help design a system.

Planting the Vineyard

Plant rows in a north-south direction. This results in more sunlight exposure than east-west planting. On sloping ground where soil erosion is a problem, generally the rows are developed on the contour to control water runoff and prevent erosion.

Determine total plant density by considering the selected cultivars and size of equipment. The highest yields have been obtained from vineyards with 600 or more vines per acre. As the space between rows increase, yields per acre decrease. Generally, 10-foot row spacing is necessary for other field crops where tractors and implements are used. If rows are too close, plants can be damaged, especially if vine trunks curve into the row. If the equipment is not used in the vineyard or in confined areas, an 8-foot spacing is adequate area.

Eight-foot or 6-foot row spacing intervals help ensure a full trellis. However, the vigorous plants could be spaced at least 10 feet apart. American-type vines grown on a single cordon trellis will require more space per plant than French-American hybrids. The single curtain trellis system requires more space per plant than the Geneva Double Curtain system.

Cross alleys. Long rows make vineyard operations more efficient than short rows. However, for cross travel, cross alleys at 300- to 400-foot intervals make travel easier during harvesting. Cross alleys between rows should be wide enough to allow tractors or other equipment to turn into adjacent rows. There should be about 25 to 30 feet of space at the ends of the rows and at least a 12- to 15-foot-wide drive along the outside rows to operate equipment.

Staking rows. Accurate measurements of the planting are necessary where trellis structures run parallel at specific intervals for the vineyard rows. Lay out straight, equally spaced rows by driving a long white (or very visible) stake at each end of an outside row. Drive additional stakes to mark rows at intervals across each end of the field perpendicular to the initial outside row.

Baseline measuring. There is a simple procedure to establish a perpendicular baseline at each end of the row (*Figure* 2). Set a stake on the baseline 30 feet from the end. Place a stake 40 feet from the end of the baseline on the assumed perpendicular line. Measure the angular distance between the 30- and 40-foot stakes. If the distance is 50 feet, the assumed line is correct and can be extended by sighting. If it is not, move the 30-foot marker (not the 40-foot) until there are 50 feet between the two stakes. Stakes can be driven on this second base at the proper intervals to indicate the row ends.

Trellis construction. A trellis is necessary to manage and support vines for maximum exposure to sunlight. Trellises should be in place before or shortly after planting so growing vines are trained correctly. Trellis construction is similar to building a farm fence. Trellises have line posts along the grape row, one or two wires to support the vines, and braces on end posts to keep the posts from being pulled out of the ground by a heavy load on the trellis wire.

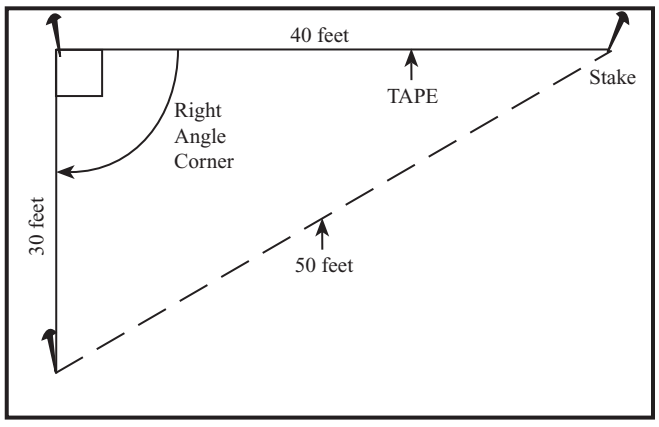


Figure 2. Three, four, five right-triangle method for laying out a square corner baseline.

The standard single curtain trellis is a one- or two-wire vertical trellis with posts set 16 to 24 feet apart, depending on vine spacing and training system. Eight- or 9-foot posts, 3 inches in diameter, are set 2 to 2½ feet in the ground. The posts support one or two wires. The top wire is supported at 5½ to 6 feet above the ground and the optional lower wire about 2½ to 3 feet above the ground. Posts can be 16 or 24 feet apart with two or three vines between posts.

End posts need to be at least 5 inches in diameter. Railroad ties can also be used. They should be at least 9 feet long and set about 3 feet below the soil surface in a foot of concrete.

Wood end posts and line posts should be commercially pressure-treated with a preservative so they will not rot. Use chromated copper arsenate (CCA) or pentacholorophenol. Dry the posts before treatment or the preservatives will not penetrate into the wood. Penta-treated posts should dry for six months before placed near vines, or vines should be at least 12 inches from the posts to avoid injury to the vines. Rust-resistant metal posts can also be used.

Bracing end posts. Brace the end post so it stays in place by setting an extra line post within a few feet of the end post on the row side (*Figure 3*). Use a heavy piece of lumber (2 x 4 inches or larger) as a brace from the top of the end post to the bottom of the line post. Cut the brace so that the upper end rests in a notch about two-thirds up on the end post and the lower end against the base of the line post. The angle should be greater than 34 degrees between the brace and the end post to prevent the end post from lifting out of the ground when the wires are tightened. Heavy wire can be looped from the top of the line post to the bottom of the end post then twisted to stabilize the end post. An advantage of this bracing method is that wires do not extend beyond the end posts.

Another brace method uses a base wire from the top of the end post to an anchor in the ground on the side opposite the row. A disadvantage to this method is that the wire to the anchor extends beyond the end post and may interfere with activities such as mowing along the end posts.

The wire for support must be strong enough to support the weight of the vine and fruit. A new lightweight wire has recently been developed for vineyards. It is number 11 size, crimped, high-tensile strength steel wire with class III galvanizing. Regular wire stretches with heat and crop load, then shrinks in the winter, causing posts to loosen in the soil. The new wire retains its tension without annual tightening. Number 9, black annealed wire can also be used for the top wire and stapled to the top or near the top of the post. Sometimes a lower wire is used as a training wire and to support the trunk. It is also used to support the irrigation tube for a trickle irrigation system. Straight galvanized number 11 or 12 fence wire is used at the lower level.

Table 3. Wire sizes and approximate feet of wire in a 100 lb. roll.

Size of wire	Approximate feet/100 lbs.
12 straight	3,436
11 straight	2,632
11 crimped	2,584
10 straight	2,079
10 crimped	2,000
9 straight	1,730
8 straight	1,443

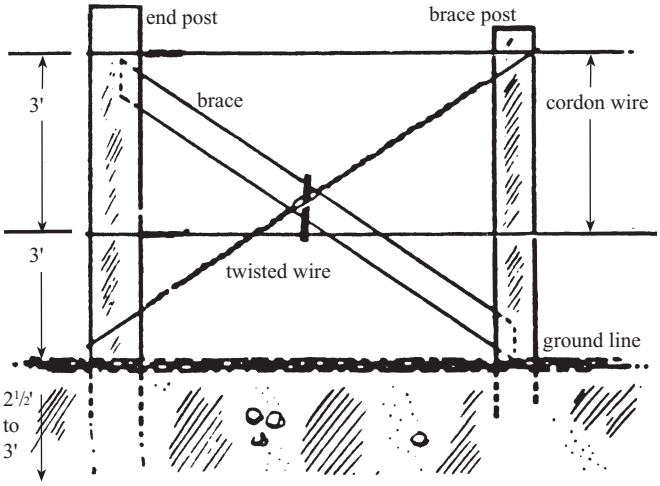


Figure 3. End post braced to line post; avoids use of wires beyond end post.

The amount of wire needed per acre depends on the number of rows and the type of training system. Ten-foot row spacing would need about 4,400 feet of wire for the top and bottom.

The wire attachment to end posts should allow for adjusting tension. Devices such as ratchet tighteners and crank tighteners eliminate the removal of wires from end posts when tightening. Wires are fastened to line posts with fence staples or through holes that are drilled through the posts. The staples should be driven into the post far enough to support the wire close to the post with enough space left for the wire to slip through when tightening. If steel posts are used in the grape row, use regular wire fence fasteners to support trellis wires. Hang trellis wires on the windward or uphill side of the posts so staples are less likely to be pulled out from pressure on the wire.

Loosen in the fall. The trellis wires should be slack in the fall. The wires will stretch sufficiently from the weight of the fruit in the summer, so loosening is not necessary. The wires contract during cold weather and if they are tight, the trellis line may be damaged.

Tighten in the spring. The wires should be tightened again in the spring. The most appropriate time for tightening is after pruning but before new growth to prevent damage.

Planting Vines

Till the soil for planting when the soil is dry enough to work without developing mud chunks or puddling. The plant-

ing area should be prepared similar to a seedbed. The following practices are recommended during planting:

1. Keep the roots moist to avoid root drying.
2. Prune damaged part of the roots.
3. Long roots may need pruning so they spread out in the planting hole; but as good roots are pruned off, the food reserves for the plant are reduced.
4. Set plants 10 to 12 inches deep and pack the soil firmly around the roots.
5. Add water to increase soil-root contact and ensure moisture availability.
6. The strongest cane should be cut back after planting to three strong buds. Remove all other canes.

Planting holes. For small plantings, dig plant holes with a shovel. For larger areas, use a short, 6-inch diameter, tractor-powered, posthole auger. In heavy soils, the auger edges may compact or glaze the sides of the hole. This can prevent roots from growing through the glazed soil and permanently retard plant growth. The glazing should be chipped off with a shovel so roots can penetrate the surrounding soil.

Plant in furrow. Another planting method is to make a straight furrow 10 to 12 inches deep in the row. This can be done with a lister. Spread roots well, cover with a few inches of topsoil and tamp firmly. Finish filling the furrow with discs or coulters.

Plant in polyethylene. A cultural program for weed control in new plants is to lay strips of polyethylene on the row before planting. The sides are covered with soil to hold it in place. New plants are planted through a cut in the polyethylene. This requires special equipment to lay the polyethylene, but it reduces first-year weed control problems.

Care After Planting

Weed control. The most critical factor in establishing successful grapevines is weed control. Hand hoeing, cultivation, herbicides and mulches can be used for weed control. Careful cultivation will control many weeds in the row. Certain herbicides, when used properly, are safe for young vines and will help control weed growth (refer to Kansas Commercial Spray Schedule for Small Fruits and Grapes). A heavy surface mulch will reduce weed growth and help hold soil moisture. Some hand-hoeing, especially around the new plant, may be necessary.

Rabbit control. Spray plants with repellents or surround young plants with a barrier to control rabbits. Cardboard milk cartons prevent rabbits from chewing on trunks. It allows the use of contact herbicides for weed control near the plant; but the applicator must be certain there is no herbicide drift on the plant.

Growth tubes. Growth tubes can be placed around plants shortly after planting. Growth tubes force shoots to grow rapidly and straight. The tubes also protect young vines from contact herbicides that might be needed for weed control. The tubes also will prevent rabbits from chewing on trunks. Growth tubes should be removed from the vines on or before the first week of September to harden the vine and reduce injury to the new trunk.

Training Systems. There are many training systems to choose from and some are more complicated and expensive than others. If you are just beginning to learn how to train and manage grapes, the single curtain bilateral cordon (SCBC) system is the best.

Single curtain. The SCBC system requires one top wire. Pruning is simple, shoot positioning is not usually required, disease control is easier than other systems and vines are productive and easily hand harvested. In a SCBC system, the trunk is attached to the top horizontal wire 5½ to 6 feet above the ground. Two horizontal cordons are developed from the top of the trunk and extended 3 or 4 feet in each direction. The cordons are secured to the top wire by plastic ties or similar material. Cultivars that are low or moderately hardy (Chardonel, Chambourcin, Traminette, Siegfried, etc.) should be established with two trunks. Each trunk would then produce one 3 or 4 foot cordon. (*Figure 4*)

Geneva double curtain (GDC). The GDC system is more complicated and expensive than the SCBC system (*Figure 4*). Disease control is more difficult with a GDC system and two distinct curtains of vines must be maintained or the system will not be productive. Shoot positioning is mandatory. GDC is intended to accommodate high-vigor vines and efficiently use the entire vineyard area. Research has shown that this system can increase vine productivity and maintain or improve fruit and vine maturation because leaves on the

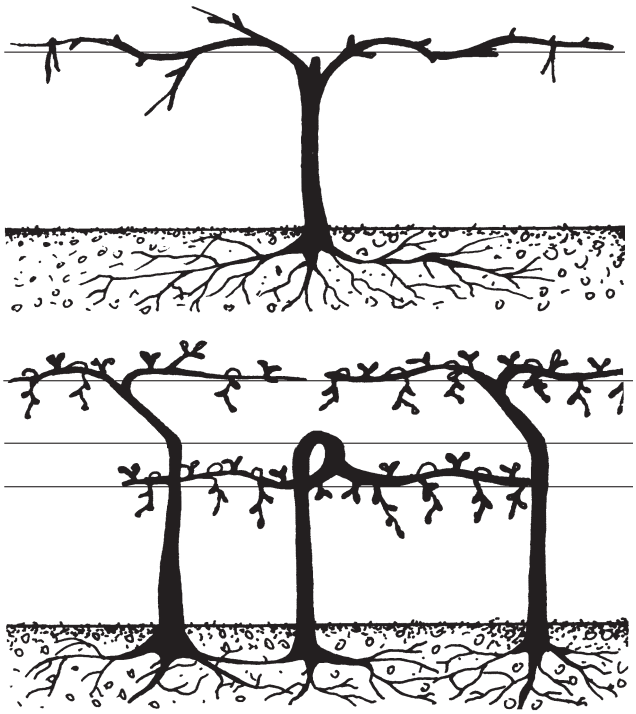
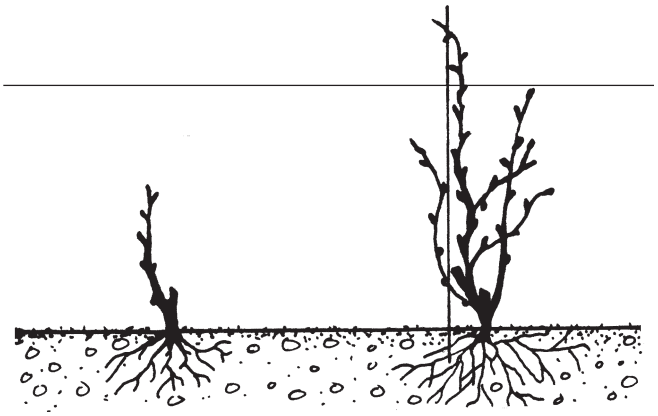
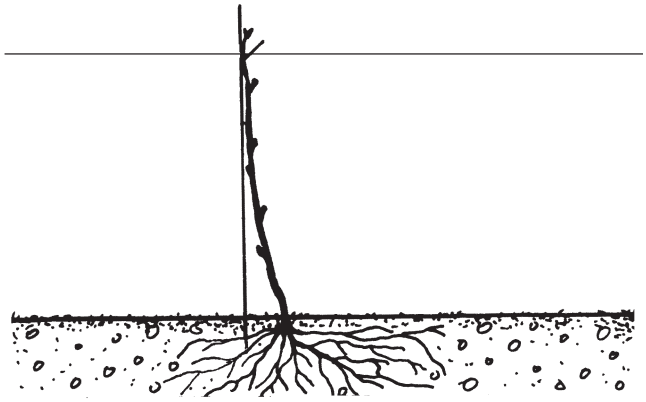


Figure 4. Pruning and training systems: SCBC, top, and GDC, bottom.

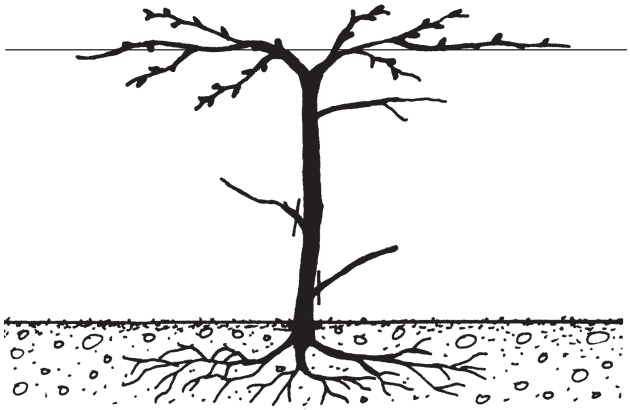
Figure 5. Pruning grapevines.



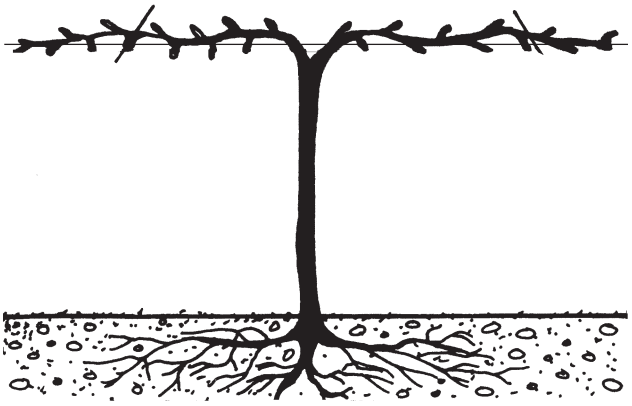
At planting First season's growth



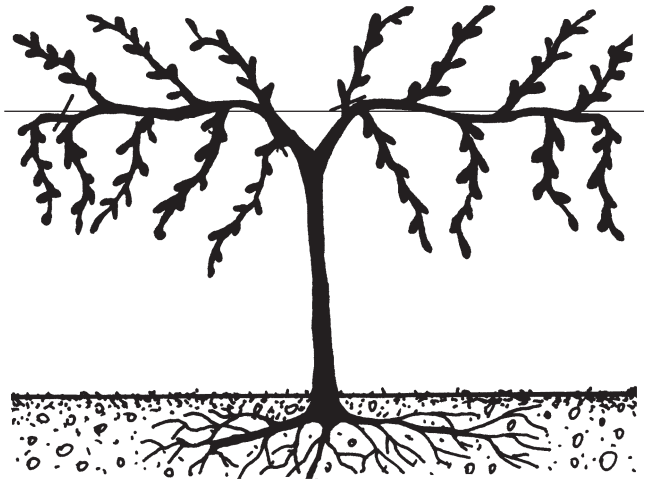
Spring, second season



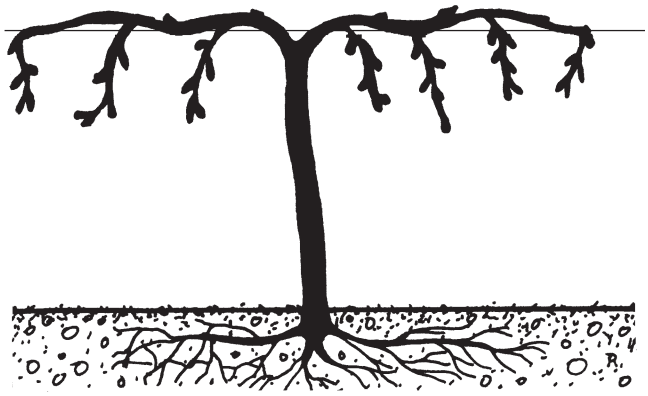
Winter, second season



Spring, third season



Winter, third and following seasons



Spring, fourth and following seasons

basal half of the shoot have better sunlight exposure. This system should not be used for cultivars that are susceptible to downy or powdery mildew, or not cold hardy.

The system has two horizontal cordon wires that are 4-feet apart and 5½ to 6 feet above the ground. Metal supports attached to each post hold the wires in place.

Cordons are positioned in a vertical curtain 2 feet from the trunks and posts of the row. One or two main trunks are developed for each vine and should be extended 5½ or 6 feet high, then horizontally to the cordon wire. Cordon canes extend 6 to 8 feet along the cordon wire in each direction. The vines in the row are alternated to the left or right cordon wire to give the double curtain effect.

Training and Pruning

First year. After planting, cut back the strongest cane to three strong buds and remove the others. If growth tubes are being used, drive a 5 or 6-foot high stake into the soil near each vine. After the vine emerges from the tube, it can be trained to the stake. Tie shoots loosely or with plastic tape to avoid girdling. If the lead vine grows higher than the stake the first year, use a piece of twine to connect the stake to the top wire. Stakes should be used if the trellis cannot be built the first growing season. If the trellis is in place and growth tubes are not used, attach a piece of twine to the top wire and loosely tie it to the base of the newly planted vine. Secure the twine to the top wire with just enough force to keep the twine straight. Shoots can be attached to the twine as they develop.

Spring – second year. One of the main training objectives for the second season is establishing one or two straight trunks. Growth tubes should be removed and the one or two straightest trunks should be cut back to the first live, strong bud at the top. All other canes and laterals from the remaining trunk(s) should be removed (*Figure 5*, spring, second season). After the dormant buds have developed into 2- to 6-inch shoots, remove the other shoots on the trunk(s) except the top two, which will develop two cordons. Remove flower clusters as they appear so the food reserve in the plant is used for vine growth. After the two shoots reach the top wire they can be trained in opposite directions along the top wire. If two trunks are developed, the shorter or weaker of the two shoots on each trunk should be removed and the remaining shoots trained in opposite directions.

Spring – third year. Establish trunk(s) and cordons by the spring of the third year (*Figure 5*, winter, second season and spring third season). During dormant pruning, remove all canes that develop on the trunk and prune back the laterals on the two cordons to two bud spurs. In addition, shorten the cordons to 3 or 4 feet from the trunk. If the vines are 8 feet apart, the cordons should be 4 feet long. If vine spacing is 6 feet apart, the cordons should be 3 feet long. All remaining buds should produce flower clusters and be allowed to fruit.

Forth year and older. Considerable wood should be removed from vigorous and productive grape vines during pruning. Too little pruning produces many fruit clusters with small berries, and too much pruning prevents maturity and produces weak fruiting wood for next year.

A mature vine will have several hundred buds before pruning (*Figure* 5, winter, third season). More than half of the buds are capable of producing fruiting shoots. A vine with 50 to 60 buds can produce 10 to 20 pounds of grapes, or the equivalent of 5 to 6 tons per acre. If the vine is not pruned and overproduces, crop will be reduced the following year. In contrast, if a vine is over pruned, it will be excessively vigorous and bear only a part of a crop.

Time to prune. Delayed pruning late in the dormant season holds back new growth that may be injured by spring frosts. However, pruning must start early enough to prune the entire vineyard. Harmless "bleeding" may occur on vines because of late pruning. Never prune grapes in the fall after they are dormant because grapes are susceptible to winter injury. Do not start pruning until February. Pruning modifies the size and form of the vine and helps the vine maintain vigor and sufficient fruiting wood. A deficiency or excess of good fruiting wood affects crop production more than any other factor.

Balanced dormant pruning. During pruning, more than 75 percent of last year's growth should be removed. However, even though 60 or more buds can be left on a vine, do not expect a crop of 6 tons or more per acre unless the vine has sufficient vigor to support such a fruit load. To determine the fruit capacity of a vine at pruning time, growers use the concept of balanced pruning. This should be practiced during February and March unless there are too many grapes and they cannot all be pruned before April. Balanced pruning balances between removed wood and produced wood, which creates a balance between crop load and foliage.

Pruning considerations. Decide how much time it will take to prune the entire vineyard and count back from April 1 to establish your starting date (budbreak usually occurs around mid-April). Wait as long as possible to prune grapes because late pruned vines have a delayed bud break and winter injury is more easily detected in the spring just before bud break. Delayed bud break could help the new shoots avoid a late frost. Evaluate the vigor of the vines you are pruning. This can be resolved by using the weight of the one-year pruned wood to determine vine vigor.

Consider the cultivar you are pruning. Prune the hardiest cultivars first, such as the American hybrids (Catawba, Concord, Cynthiana, etc.), then prune the French-American hybrids (Foch, Seyval, Vignoles, etc.). Use the suggested balanced pruning formula for each cultivar. If a cultivar does not have a formula in this guide (*Table* 4, page 12), then use a 30 + 10 formula for American hybrids and 15 + 15 formula for French-American hybrids.

Vine and wood characteristics. When pruning, keep in mind the characteristics of productive fruiting wood: wood grown the previous season (1 year old); canes pencil size to slightly larger between the fifth and sixth bud and nearly the same at the 10th bud (French-American hybrids tend to

Table 4. Suggested pruning formula for various grape cultivars.

Cultivar	Formula
Aurore	15 + 10
Baco Noir	30 + 10
Catawba	30 + 10
Chancellor	20 + 20
Chelois	10 + 10
Concord	30 + 10
Cynthiana (Norton)	20 + 15
DeChaunac	20 + 15
Delaware	20 + 10
Foch	30 + 10
Niagara	35 + 10
Seyval	15 + 10
Vidal	15 + 10
Vignoles	15 + 15

be slightly larger); canes with 4 to 8 inches between buds (closer for French-American hybrids); and canes that originate near the main trunk.

Evaluate the previous year's yield, maturity and quality, so each vine is pruned to its own capacity. It's not necessary to keep a record of each vine's yield. Examine cultivar records to determine yield, maturity and quality and adjust the number of buds you leave based on last year's performance. If last year's crop was large, the vine may not have produced enough growth to mature a similar amount of fruit. If there are many small berries per cluster, the vine may have been overloaded. Weighing pruned 1-year-old wood and using the correct formula for the cultivar will determine the vigor and yield potential of each vine in the vineyard.

Consider the position of the selected canes. The trellis should be full of vines, and shoots should be equally spaced along the cordon with a large number of the leaves exposed to sunlight. Excessive vigor leads to shaded leaves, which is associated with low fruit quality, low soluble solids and high acid content. Overloaded vines can have fruit with low soluble solids because the leaf-to-fruit ratio is inadequate and there are not enough carbohydrates to support fruit development and cane growth.

Pruning procedure. Use a simple procedure for pruning. First, size the vine and estimate the weight of one-year-old wood. Leave five to seven renewal spurs (two buds each) equally spaced on the cordon, select fruiting canes to retain and remove the rest. It is easier to make a more accurate weight estimate after pruning a few vines. Second, determine how many buds to leave. For the first few vines, weigh the prunings and use the correct formula for the cultivar (Catawba 30 + 10, Cynthiana 20 + 15, etc.). Weigh prunings from a vigorous vine and a weak vine to decide how many buds to leave. If too many buds remain after you weigh, then prune to the desired number of buds. Start the bud count for fruiting canes with the second or third bud because the first and sometimes the second bud produce unfruitful shoots. After you are able to accurately estimate the weight of the 1-year-old wood, only periodic weighing is necessary.

Using the pruning formulas. If the prunings weigh 1 pound when using a 30 + 10 formula, leave 30 buds not including renewal spurs (for a single curtain or Geneva double curtain system, this would mean six five-bud canes). If the prunings weigh 2 pounds, leave 30 + 10 or 40 buds. Leave 10 buds for each pound of prunings after the first pound (eight five-bud canes). If the prunings weigh 2.5 pounds you leave 30 + 15 or 45 buds (eight five-bud canes plus two extra two-bud spurs). If the prunings weigh 3 or more pounds, the maximum number of buds you should leave are 60 buds (10 six-bud canes). If the prunings weigh 3 pounds when using a 15 +15 formula, leave 15 buds + 30 buds or 45 buds.

Canopy Management

Shoot and cluster thinning and shoot positioning in the summer are required to produce quality grapes.

Shoot thinning. All grape cultivars benefit from shoot thinning. A good canopy exposes leaves to the maximum amount of light. The canopy should be minimal in American hybrid grapes and extensive in French-American hybrids because the latter produce more non-count shoots. Non-count shoots develop along the cordon or trunk of the vine where buds are not left during dormant pruning operation. Shoot thinning reduces canopy shading, improves leaf exposure to sunlight, improves pesticide spray coverage and makes harvest easier. Shoot thinning should start two to three weeks before bloom. Shoot thinning has a larger window than four weeks, but it is done simultaneously with cluster thinning that does have a four-week window. For French-American hybrid vines spaced 6 or 8 feet within the row, leave 56 or 42 shoots per vine, which is seven shoots per linear foot of cordon. Estimate shoots per vine by counting total shoots on a few vines. Remove weak shoots, overly vigorous shoots, or shoots with no clusters. Shoots on American hybrids should be equally spaced on the vine. American hybrid cultivars do not require shoot thinning.

Cluster thinning. Cluster thinning is important for seedless table grapes and French-American hybrids that produce large clusters. Cluster thinning removes undesirable, small and sparse clusters, increases berry size and cluster weight, directs the vine's capacity into the remaining clusters, and helps a vine balance foliage and fruit. Cluster thinning should start two to three weeks before bloom (four-week window), preferably no later than one week past bloom. The amount of cluster thinning is determined by cluster size and vigor. Most cultivars require no thinning, while others benefit from it. Leave one or two clusters per shoot, the basal (primary) cluster and maybe the secondary cluster should be retained.

No cluster thinning should be done for the following cultivars unless the vines are weak: Catawba, Cynthiana, Vignoiles, Foch, Steuben, Melody, Golden Muscat, Baco

Table 5. Grape herbicide management suggestions.

Pay particular attention to which herbicides are harmful to young nonbearing vines and which ones can only be used on nonbearing vines. Try to keep as much of the spray off the trunk of the vine as possible and avoid contact with any parts of the developing shoots.

First application for new vineyards or ones with weed problems – PRE-BUD BREAK
(late March to early April – maybe earlier or later depending on spring conditions and your particular site.)

If perennial weeds are a problem:

Apply broad-spectrum systemic herbicide and follow this two weeks later with a broad-spectrum contact herbicide mixed with pre-emergent herbicide.

If perennial weeds are not a problem:

Apply a broad-spectrum contact herbicide mixed with pre-emergent herbicide after the weeds start to grow.

First application for established vineyards with good weed control – BLOOM
(late May to early June when caps begin to fall)

If perennial weeds are not a problem:

Apply a broad-spectrum contact herbicide mixed with pre-emergent herbicide. If weeds are well developed, it would be best to start with a broad-spectrum systemic and, after the weeds start to die, follow it with the above mixture.

Second application for new vineyards or ones with weed problems – SHATTER
(mid- to late June when unfertilized berries fall from clusters; about 7 to 10 days after bloom)

If weeds are a major problem:

Apply a second application of a broad-spectrum contact herbicide mixed with pre-emergent herbicide. If weeds are well developed it would be best to start with a broad-spectrum systemic and, after the weeds start to die, follow it with the above mixture.

Final application for new vineyards or ones with weed problems – VERAISON (berry coloring)
to HARVEST (mid-July to mid-August)

If grasses are a major problem:

Apply a post-emergent herbicide specific for control of grasses. Repeat if necessary after harvest.

Noir and all American hybrid wine grapes. Retain two clusters per shoot for Mars, Aurora, Ventura, Rougeon and Vaneasa. Retain one basal cluster per shoot for Seyval, Vidal, DeChaunac, Chancellor, Chambourcin, Canadice and Reliance.

Shoot positioning. This reduces shading in the upper part of the canopy where next year's fruiting wood is developing. Node productivity (cluster size) is related to the amount of light the leaf supporting the node is exposed to. Enough sun exposure improves the fruitfulness of that node the following year. Shoot positioning increases fruit exposure to sun, wind and pesticide sprays that improve fruit quality and reduce disease problem. Shoot positioning involves separating the shoots and vertically positioning them in a downward or upward position. Positioning can be accomplished manually or mechanically. The best time to position shoots is one to two weeks post-bloom, because tendrils are soft enough to easily separate and shoots are strong enough to resist breakage.

Shoot positioning is important for American hybrid cultivars such as Catawba, Cynthiana, Concord, Niagara, etc. regardless of the training system, as shoots grow horizontally along the trellis and have large leaves. French-American hybrids trained to a single curtain system do not need shoot positioning. However, shoot positioning is critical for all GDC trained vines. A GDC system has two distinct curtains of shoots evenly arrayed in a downward position. No shoots should be growing on top of the cordon nor should any be allowed to bridge the curtains. When looking down a row between curtains of GDC vines, there should be two separate curtains and the support posts for the trellis.

Soil Management

The vineyard floor can be clean cultivation or grass sod establishment between the rows. The clean cultivation program should not be used on sloping ground or in situations with severe soil erosion, which causes loss of topsoil, washes gullies through the vineyard and may even wash out vines.

Sod established between rows is mowed several times during the growing season to reduce overgrowth. Following a heavy rain, equipment should enter the vineyard a day or two earlier than if the floor is clean cultivated.

Weed control. Weeds can be controlled by using cultivation or herbicides. A grape hoe is specifically designed to till around grape vines in the trellis row, although some hand hoeing close to the trunk may be necessary.

Several herbicides can be used for vineyard weed control. Apply herbicides cautiously and accurately to avoid injuring the vine. Read the herbicide label thoroughly and apply the chemical properly. Suggestions herbicide use are included in the Kansas State University publication "Commercial Spray Schedule for Small Fruits and Grapes." Follow the protocol in Table 5.

Mulches may also be used around vines to suppress weeds. Some potential mulching materials are baled hay, straw and wood chips. These materials may contain weed seeds, so it is important to know the source and contents of the mulch before it is applied. Mulches and shallow irrigation may reduce root development below the 4- to 6-inch level. This reduces the plant's ability to absorb moisture from lower levels during drought.

Fertilizing. Major soil fertility problems can be avoided through soil testing and incorporating nutrients and/or lime into the soil before planting. Some of the nutrients and lime do not move easily into the root zone, so work them into the soil the fall before planting.

Nitrogen is the most beneficial nutrient for grapevines. Generally, an annual application of 50 to 75 pounds of actual nitrogen per acre is suggested. Growth, productivity and tissue analysis determine if this rate should be increased or decreased. Nitrogen can be applied in mid-April (at bud break) or in two applications, with ½ to ⅔ applied in early March, and the rest in early to mid-May if a full crop is developing. If spring frosts reduce the crop, the rest of the nitrogen may not be needed. Several forms of nitrogen can be used, including ammonium nitrate or urea. Where the soil pH is above 7.0, ammonium sulfate is beneficial.

Potential deficiencies of required mineral elements should be corrected during vineyard preparation. Soil tests and leaf analysis should be used periodically to determine the levels of required soil nutrients. This is particularly important in soil where the pH is near 7.0. A deficiency of some nutrients, such as manganese, is more likely to occur at this pH level.

Establishment cultivar. Profile nitrogen recommendations in this guide should be used only as a place to start. Nitrogen rates should be changed according to soil type and vineyard microclimate. Application rates can be changed after profiles of the cultivars in the vineyard are established. Develop the nitrogen status of each cultivar by gathering the following information:

1. Overall soil test results and cultivar-specific petiole analysis (three to five years) results.
2. Pruning weight records of six to 10 vines per cultivar.
3. Dates when shoot growth ceases and the trellis is filled with foliage.
4. Record yield of vines and average cluster weight.
5. Record when fruit maturity occurs and the information on the quality of the fruit. Estimate nitrogen status by comparing vines to the descriptions below.

Adequate nitrogen:

1. Pruning weight is 0.3 to 0.4 lb. per foot of cordon.
2. Shoot growth is rapid and ceases in early fall.
3. Mature leaves are normal size and uniformly green.
4. Internodes are 4 to 6 inches long.
5. Trellis is filled with foliage by August 1.
6. Acceptable yield.
7. Fruit maturation is normal.
8. Fruit quality is good to high.

Deficient nitrogen:

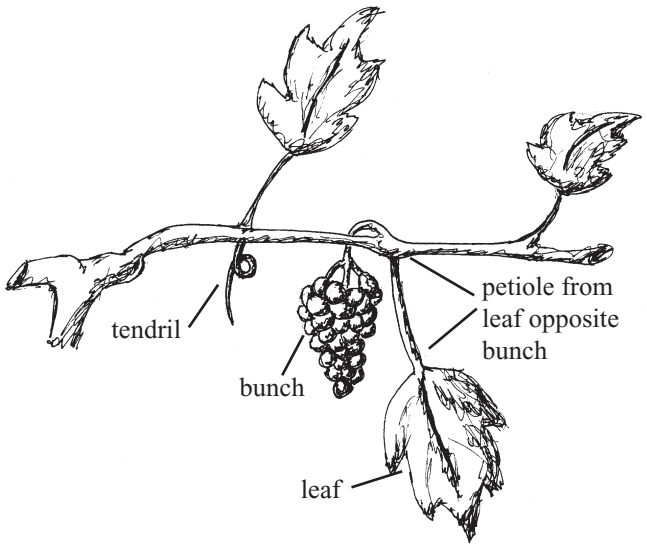
1. Pruning weight is less than 0.4 lb. per foot of cordon.
2. Shoot growth is slow and ceases in midsummer.
3. Mature leaves are small and light green or yellow.
4. Internodes are less than 3 inches long.
5. Trellis is not filled with foliage by August 1.
6. Yield is chronically low for the cultivar.
7. Fruit maturation is advanced.
8. Fruit quality is poor and variable.

Excessive nitrogen:

1. Pruning weight is greater than 0.4 lb. per foot of cordon.
2. Shoot growth is rapid and ceases in late fall.
3. Mature leaves are very large and deep green,
4. Internodes are greater than 6 inches.
5. Trellis is excessively filled with foliage by August 1.
6. Yield is low due to few and small clusters.
7. Fruit maturation is delayed.
8. Fruit quality is poor and variable.

Petiole (tissue) analysis. The grape petiole is the only part sampled. It is the slender stem connecting the leaf blade to the shoot. Petiole analysis is a valuable method to determine the nutrient status of a vineyard. Collect samples at the same time of the year for three to five years for determining nutrient status. Petiole analysis also can identify vine nutrient problems anytime during the growing season.

Figure 6. Petiole analysis.



Petiole analysis procedure.

1. Collect samples between July 1 and Aug. 15 and send to a private laboratory or to the KSU Soil Testing laboratory, Attn.: Dr. Sorkel Kadir, Kansas State University, Department of Horticulture, Forestry & Recreational Resources, 3734 Throckmorton Hall, Manhattan, KS 66506.
2. Inside the envelope include your name, address, phone number and e-mail address. Identify each sample as to cultivar, status of the vines (healthy or unhealthy) and vineyard location.
4. Each cultivar should be analyzed separately, cultivars on different soil types should also be analyzed separately, and large vineyards should be divided into sub-samples if there are obvious differences in growth within the vineyard. When trying to diagnosis a nutrient problem, send a healthy sample and a sample from vines showing the symptoms.
5. Save only the leaf petiole. The petiole is the slender stem connecting the leaf blade to the shoot. Remove the leaf blade from the petiole before submitting the sample. Place the petioles in a paper bag and allow them to dry in a hot, dry location for a day before shipping. Leave the bag open during drying.
6. Collect the leaf petiole from a bearing primary shoot. Select the youngest fully expanded leaf that is well exposed to the sun, unless diagnosing a nutrient problem. For nutrient problem diagnosis, collect petioles from leaves that are showing the symptoms and then collect healthy samples from leaves of a similar age and shoot position. Non-routine sampling to diagnose a nutrient problem can be done at any time during the growing season.
7. Eight petioles from 60 vines (total of 480 petioles) equally spaced throughout the vineyard represent a sample. Collect petioles from shoots that represent the vigor of the vine.

Each cultivar, soil type and soil difference within a vineyard should be sampled separately. If there are many cultivars in a small vineyard, sample a vigorous and a non-vigorous cultivar. If growing 1 acre or more of a particular cultivar, sample that cultivar and fine-tune the nutrient level. Some cultivars require less than 50 to 75 lbs. of nitrogen per acre to produce high quality grapes, but other cultivars will require more.

Herbicide Damage

The use of the phenoxy herbicides for weed control in pastures, wheat fields and other crops growing near vineyards is a potential hazard. Due to the volatility of 2,4-D compounds, vine injury can occur great distances from the point of application. A combination education-public relations program with neighboring farmers may encourage judicious herbicide use and reduce the risk of vine damage. For more information on herbicide drift and damage symptoms, see K-State Research and Extension publications S-142 *Preventing Hormonal-Type Herbicide Damage to Kansas Grapes*, and MF-2588 *Questions and Answers about Vineyard Injury from Herbicide Drift*.

Harvesting

The proper time to harvest depends on the cultivar, nature of the growing season and the intended use of the fruit. Degree of maturity is the best way to determine the exact time to harvest. Fruit maturity rate and time of ripening are governed by several factors:

1. Growing season temperatures: An average temperature of 70°F during the growing season is necessary for fruits and vines to mature.
2. Crop load: Fruit matures earlier on vines with normal to less than normal crop loads than those with heavy crops.

Table 6. Expected yield and crop values for major grape cultivars in Kansas.

Cultivar	Expected Yield (tons per acre)[1]	Value per Ton[2] $
Catawba	5-6	325-375
Cayuga White	4-7	450-550
Chambourcin	4-6	450-550
Concord	4-8	300-350
Cynthiana/Norton	2-6	600-900
Foch	5-6	300-450
Seyval Blanc	4-8	450-600
Vidal Blanc	4-8	450-550
Vignoles	2-5	550-700
Mars	4-8	900-10,003
Reliance	5-8	900-10,003

[1] Productivity depends on seasonal weather and vineyard management.
[2] Range of values reflects variable fruit quality and local supply and demand.

3. Light exposure: Fruit matures earlier on vines with leaves exposed to more sunlight, especially near the base of the canes.
4. Healthy foliage: Leaves free from insect, disease or herbicide injury or nutrient deficiencies encourage normal maturity.
5. Vine vigor: Overly vigorous vines delay fruit and wood maturity compared to low vigor vines.

Indices for Harvest

Table grapes. There are several indices that should be considered in determining berry maturity. The size, color and taste of the berry, as well as its soluble solids content or refractometer value are the major considerations. Most grape cultivars change color before they are mature enough for harvesting. Thus, grapes picked by color alone may be harvested before peak by flavor, size and soluble solids content.

Color and sugar content does not improve after grapes are removed from the vine. On the other hand, if the grapes are left on the vine too long, berries may shatter off and reduce yields. Grapes should be picked when color and flavor have peaked. The average length of time between bloom and optimum harvest date for a cultivar help determine the time of harvest, but it may vary from year to year.

Processing grapes. Grapes for wine, juice or jelly are harvested at the stage of maturity desired by the processor. Wineries have specific requirements for fruit quality and will pay varying prices to the grower based on specific measurements of quality. The important fruit chemistry parameters for the winery are sugar content (measured in degrees brix with a refractometer), pH, and titratable acidity (TA). For a cultivar, a winery specifies a range of acceptable values for each parameter. For example, sugar 19 - 22 Brix, 3.0 – 3.4 pH, 0.7 – 1.0 g/100 ml TA. Most wineries consider pH value the most critical factor because it is difficult to correct pH in the wine-making process, while sugar content and acidity are relatively easy to adjust. Grape growers should be aware that management practices greatly affect these fruit chemistry parameters. Good fruit quality only comes about through good vineyard management.

Even though fruit quality may be highest by harvesting only fully ripened clusters, it is sometimes necessary to harvest before all the fruit is mature. There is always danger of loss if harvesting is delayed until all fruit matures on the vines. Some varieties crack after maturity, and rain increases this tendency. Fruit rots on susceptible varieties spread rapidly during rainy weather.

Picking procedures. For fresh market, the clusters are harvested selectively according to the degree of maturity. Pickers place their hands under the cluster, then use a small pair of shears to clip the cluster from the vine before placing it carefully in a container. Grapes for fresh market are most frequently placed into 8- or 12-quart baskets. Grapes going to the processor are placed in lugs, or boxes of various sizes. The most common ones hold from l5 to 20 pounds. Specially made, lightweight nesting plastic lugs are now widely used in commercial vineyards. A small lightweight portable picking stand is a convenient way to hold the picking containers and for moving along the row. An experienced picker in good grapes can pick between 40 and 50 lugs per day.

Grapes for fresh market use should be picked and handled carefully. It is often desirable to harvest a vine more than once. The first picking harvest exposed clusters that are most mature and usually of the highest grade and quality. A second picking in one or two weeks is usually needed for completing the harvest of the remaining fruit.

Handling

Remove the fruit from the vineyard and place it in a shady or cool area to minimize sun exposure. Harvest usually occurs when daytime high temperatures are in the mid-80s to high 90s. Harvest should begin at sunrise and stop around 11 a.m. for wine grapes. The time between harvest and crush should be less than an hour if possible. Fruit should be moved as rapidly and as directly as possible to the consumer or to the processor. If fruit must be held before being sold or used, keep it in refrigerated storage. Some varieties can be held for as long as two months. Red cultivars generally store for as long as two months, which is longer than blue-black or white cultivars.

Ideal storage conditions for keeping grapes are a temperature of 30° to 33°F and a relative humidity of 85 to 90 percent. For storage periods of only a few days, temperatures between 35° and 45°F may be satisfactory.

Bird Control

Several species of birds, including the robin, starling, and blackbird, are common pests of grapes. These birds damage fruit by plucking entire berries from the cluster or pecking holes in the berries. Birds typically begin to feed on grapes when they develop color, which is before maturity. Regardless of the method, control efforts should begin as soon as the berries develop color.

The effectiveness and cost of bird control methods vary. The most effective and costly method is covering the vines with plastic or nylon netting. The initial cost is quite high, although the nets may be usable for three to six years with careful handling. Another option is to purchase a light-weight plastic net for one season.

Visual or auditory frightening devices are relatively inexpensive, but only moderately effective. This includes propane cannons, recordings of bird distress calls, high frequency sound emitters, hawk-mimicking kites and balloons, and brightly colored reflective streamers. Birds become accustomed to frightening devices quickly. Long-term effectiveness of frightening devices requires that the location of the device be changed every few days to prevent birds from becoming accustomed to the devices. Control is enhanced when visual and auditory devices are used simultaneously.

Currently, there are no chemical bird-repellents labeled for use on wine grapes in Kansas.

Insects, Diseases and Their Control

Insects

Although several insect types can damage grape vines or fruit, most only occasionally cause serious injury. The key to controlling grape insect pests is to frequently examine plants for signs of pest activity and apply controls before the grape vine, leaves or fruit are seriously injured.

Grape berry moth. The grape berry moth, especially at the larval stage, is the most important grape pest. The larva are about 3/8 inch long and are green to purple. The insect overwinters on the ground in cocoons. In late May or early June, mottled-brown adult moths, 1/4 to 3/8 inch long, lay eggs on the flower clusters or small fruit. The larvae spin webbing on the flower or fruit cluster where they are feeding. In July, the mature larva forms a small leaf flap that it folds around its body. These cocoons may remain on the leaves or fall to the ground. One or two additional generations in the summer feed by tunneling through the fruit. Each larva can feed on three or more berries and cause them to shrivel or fall to the ground. The last generation larvae fall to the ground and form overwintering cocoons from leaf debris under the vines.

Where grape berry moth has been a problem, examine flower clusters for webbing and small larvae, starting about five days before first bloom. If larvae are found, apply an approved insecticide. Immediately after bloom, inspect fruit clusters for webbing, damaged berries and larvae. Begin weekly inspections for summer generation injury in early August. Pheromone traps can help monitor flight and egg-laying periods.

Grape leafhopper. Several species of leafhopper attack grape foliage. Adults are active, wedge-shaped insects, about 1/8 inch long. Leafhoppers are white to yellow with yellow or orange markings. Both adult and immature stages feed by sucking juices from leaves. They usually feed from the lower leaf surface on younger foliage. Leaves first become speckled white, then turn pale and blotchy. If infestations are large, the leaves turn brown and fall. Leaf injury will reduce vine growth and interfere with berry ripening. To monitor for leafhoppers, examine the undersides of leaves for their white cast skins.

Adult leafhoppers overwinter under leaves on the ground or in protected locations such as brush piles or fence rows. They return to vines in the spring to feed and lay eggs. The population is continuous through the growing season, with two generations per year.

Take control measures if leafhopper populations are large enough to discolor leaves. The first application may be as early as post-bloom. Otherwise, control as needed during the summer.

Grape phylloxera. Phylloxera is a small, aphid-like insect that has a complex life cycle that involves a root and foliar form of the pest. It survives on the roots of susceptible cultivars throughout the year and on the leaves during the growing season. In Kansas, only the foliar form causes problems because American and French-American hybrids are resistant to the root form of the insect.

The foliar form survives the winter as an egg under the bark of the vine. In the spring during bloom, asexual, wingless nymphs crawl onto the surface of immature leaves and cause knobby galls to form on the lower leaf surface. The nymphs complete development within the leaf gall. Mature females then deposit eggs in the gall. After the second generation of nymphs hatch from the eggs, they crawl to new leaves at shoot tips and create new galls.

If leaves become heavily infested with phylloxera, premature defoliation and reduced shoot growth can occur. Vine vigor and yield can be severely reduced after a couple of years of heavy infestations. Insecticides are available to control the foliar forms of this pest. However, insecticides are effective only if used when nymphs are crawling on the outside of the leaf. The best window for control is during the bloom-vine stage.

Cutworms. Cutworms occasionally cause serious damage early in the season by cutting off the developing canes. Damage is common in weedy areas, and weed control reduces the likelihood of cutworm injury. If cutworms are a problem, use an approved cutworm bait.

Diseases

Black rot. Black rot is the most common disease of grapes in Kansas. The disease may affect the leaves, young canes, tendrils and fruit. Only the youngest tissues are susceptible, although the fruit may become infected any time before full maturity. Fruit symptoms do not appear until after the berries are half grown. Black rot generally is not the cause of fruit rot after the cluster has begun to color.

Symptoms begin to appear two weeks after infection. Although the leaves and vines begin spotting early in spring, the disease does not attract attention until midsummer when the half-grown berries begin to rot. Light brown, soft spots appear and grow until the entire berry is discolored in two or three days. The day after the berry is discolored, small black spots appear. Soon the decaying berries shrivel and within 10 days turn into black, hard, shriveled mummies that may remain attached to the bunch for several weeks. The mummified berries are not easily dislodged from the cluster or vine. The fruit is covered with small pimple-like structures called pycnidia that produce infective spores. Leaf spots also contain many conidia that help identify of the disease.

The fungus is dormant in the winter. During warm, moist spring weather, spores on dried fruit on the vine or the ground infect young leaves and shoots. Additional spores are produced in these lesions that are rain splashed and can infect other leaves and fruits later in the season.

Many grape varieties grown in Kansas are susceptible to black rot. Therefore, the strategy for controlling black rot involves both cultural and chemical practices. It is very important to remove as many mummified berries containing

fungal inoculum from the vineyard before new spring growth appears. Early fungicide applications beginning when new shoots and leaves develop are critical in suppressing black rot. For details on scheduling fungicide sprays, consult the *Commercial Spray Schedule for Small Fruits and Grapes*. This publication can be purchased from Dr. Sorkel Kadir. Contact Christy Dipman at 785-532-6173 or 785-532-1437.

Anthracnose. Anthracnose or birds-eye rot is often confused with black rot. Anthracnose occurs during rainy, humid weather in early summer and is promoted by poor pruning and air circulation.

Anthracnose can affect the leaves, shoots and fruit. Leaf spots are small ($^1/_{16}$ to $^1/_4$ inch) with brown to black margins or angular edges. The lesions may coalesce or remain isolated. The center of the lesion turns grayish white and dries. The necrotic tissue eventually drops from the leaf, leaving a 'shot-hole' appearance. Young leaves are most susceptible to infection. The lesions may prevent normal development, which results in malformation or complete drying of the leaf. Because the youngest leaves are most susceptible, the malformations are most obvious at the tips of the shoots, which may appear burned.

Grape clusters are susceptible to infection before flowering. Lesions on berries are surrounded by dark brown or black narrow margins. The center of the lesions are violet in early stages, but turn velvety and whitish gray. Lesions on the berries may extend into the pulp. This increases fruit cracking.

Dormant applications of Bordeaux mixture or liquid lime sulfur just before bud break in spring help control anthracnose. Foliar applications of fungicides are recommended at two-week intervals during the growing season, beginning when shoots are 5 to 10 cm long.

Downy mildew. Certain grape varieties are susceptible to downy mildew. The disease tends is most severe in spring and after harvest. It flourishes in cool, moist weather.

Symptoms of downy mildew begin on older leaves near the center of the vine. As leaves mature, the disease spreads to foliage at the shoot tips. On highly susceptible cultivars, even the newest leaves and shoots may be affected by autumn. The disease can completely defoliate susceptible cultivars, especially when the weather favors disease growth, or it may affect only a few older leaves on resistant cultivars.

The downy mildew organism overwinters in old, diseased leaves on the ground. Weathering and decomposition during the spring spreads the spores, and rain or wind carries spores to new shoots, tendrils, leaves or fruit, where infection starts. While the disease damages some leaves before late summer, the greatest damage is in August and September.

The first symptoms of downy mildew infection are light-yellow spots on the upper leaf surface. As the disease takes hold, white moldy growth appears on the leaf underside. If severely infected, the spots may merge and cover most of the leaf. The mildew invasion kills the leaf and eventually the leaves dry and crumple. When these leaves fall, the sun may scald the unshaded fruit clusters. Vines that lose leaves before ripening cannot mature the fruit normally.

Downy mildew may attack the fruit in June when the grapes are about the size of small peas, or more commonly during late summer when nights become cooler. Berries infected in June become soft and covered with white downy mildew. Fruit does not soften or have downy growth in late-season infections. Instead, it turns dull green, then brown, and withers and shatters easily.

Removing or enhancing leaf debris decomposition in winter helps suppress downy mildew. Prune vineyards to allow for maximum air circulation. Several fungicides are labeled for control of downy mildew. These products are usually needed later in the growing season around harvest.

Powdery mildew. The disease is generally less economically important than other grape diseases in Kansas. However, certain grape cultivars are susceptible to severe damage from powdery mildew.

Powdery mildew is a disease of the foliage and cluster stems. The infection produces a white, powdery superficial growth on the upper side of leaves or on the other green parts of the vine. Severely affected leaves turn brown and fall. Powdery mildew appears primarily on the upper surface, while downy mildew appears on the underside. Infected berries appear russetted or scurfy (rough, blotchy surface) and fail to mature properly, but do not rot.

Early season fungicide applications control mildew on susceptible cultivars. Some of the fungicides used to control black rot are also effective on powdery mildew. For details on chemical control consult the *Commercial Spray Schedule for Small Fruits and Grapes*. (To purchase, contact Christy Dipman at 785-532-6173 or 785-532-1437.)

Annual Grape Management Schedule

January

- Plan calendar for coming year
- Determine supplies on hand
- Begin pruning of large vineyard, start with the hardiest American hybrids
- Order supplies
- Develop budget for the coming production and marketing season
- Build your public relations with your buyers
- Check and repair equipment
- Attend fruit meetings and discuss your successes and problems with other fruit growers

February

- Evaluate winter bud and cane damage
- Begin/continue pruning of large vineyard, start with the hardiest American hybrids
- Prepare to receive and handle new plants
- Make needed trellis repairs
- Check and prepare the irrigation system for the growing season

March

- Complete pruning
- Fertilize and chop and disc ground cover for new planting
- Plant new vines in late March
- Eliminate perennial and biennial weeds before bud break
- Apply pre-emergent herbicides to established plantings
- If vines were infested with Anthracnose last growing season, spray vines before bud break
- Apply half the recommended amount of nitrogen and other nutrients if necessary (refer to soil test and cultivar profiles)
- Scout for insects that damage buds and young shoots

April

- Plant new vines if not already done
- Begin disease and insect control programs
- Start monitoring soil moisture levels and irrigate as needed
- If grape berry moth was a problem last season, place pheromone traps in the vineyard to monitor for their presence
- Continue scouting for insects and the damage caused by insects

May

- Fertilize/sidedress new plantings
- Use cultivation to control weeds in new plantings
- Mow grass between rows
- Mid-May start shoot and cluster thinning
- Continue scouting for insects and the damage and check pheromone traps
- Irrigate as needed

June

- Early June, start training new grape planting
- Continue weed control in new plantings
- Remove suckers from base of vine
- Bloom vine stage, fertilize with second half of recommended nitrogen application
- Bloom vine stage, spray to control grape phylloxera if the leaf form caused severe damage the previous season
- Late June, finish shoot and cluster thinning
- Late June, shoot position vigorous vines and vines trained to a Geneva Double Curtain System
- Continue scouting for insects and disease and apply control measures as needed
- Mow grass between rows
- Irrigate as needed
- Second application of herbicide may be necessary

July

- Continue training the new planting
- Continue pest control program; check the harvest intervals of the pesticides
- Mow grass between rows
- Irrigate as needed
- Finish shoot positioning
- Collect leaf petioles for analysis of vine nutrient level
- Apply fungicide for bunch rot before installing bird net
- If bird net is being used, it needs to be applied when grape color change starts
- Prepare for crop harvest

August

- Continue training the new planting
- Check weed control in new plantings
- Irrigate as needed
- Check fruit maturity - test for sugar content, flavor and pH and start harvesting early cultivars
- Mow grass between rows
- Check vines for signs and symptoms of anthracnose
- Estimate vigor of the vines to evaluate nitrogen status

September

- Begin plans for new plantings next spring; plow ground if it is in grass; treat for white grubs; sow ground cover
- Establish sod middles for new plantings
- Continue maturity checking and harvesting
- Continue disease management strategy if disease pressure has been high
- Irrigate as needed
- Clean equipment

October

- Order plants if you plan new plantings next year
- Repair equipment
- Continue to irrigate plants as needed until leaf drop

November-December

- Review disease, insect and weed management strategies
- Take a standard soil test and adjust pH if necessary
- Determine financial loss or gain from your grape operation
- Outline goals and strategies for coming year
- Take inventory of chemical supplies and order needed chemicals.

Estimated Costs and Returns from Grape Production (1999 estimate)

The costs for establishing and maintaining a vineyard will vary from grower to grower as prices paid for materials and labor vary. The size of the vineyard can also impact costs per acre, with larger vineyards benefitting greatly from economies of size. Also, grape yields and prices received for the crop will vary. The noted costs and returns in this section are estimates. They are provided as guidelines to the prospective grape grower.

The 1999 cost example listed is for approximately a one acre vineyard:

10 rows: 10 feet apart and 432 feet long; total area is 43,200 square feet

Line posts are spaced 24 feet apart with 18 posts per row. Grape vines are spaced 8 feet apart with 54 vines per row. There are 550 vines with replacements.

Custom rates are used for plowing, fertilizing, discing, harrowing, and mowing. Producers who own all of the equipment for the previous operations would not incur these direct costs but would have higher machinery depreciation and interest than is noted for this example. Interest on land, trellis investment and irrigation equipment investment is charged at 6 percent. Interest on machinery is charged at 10 percent. Labor costs are estimated at $10.80 per hour.

This budget shows direct expenses of establishing a vineyard for the first four years of operation. Other crop budgets would annualize the large expenses of vineyard establishment, calculating a fixed cost of operation that recaptures these establishment costs over the life of the vineyard. It is important for producers to estimate their own costs, therefore a column is included for this purpose. An operating budget for an established vineyard shows possible costs and returns.

Vineyard Establishment Cost per Acre – Year 1

	Unit	Price or Cost/Unit	Quantity	Value/Cost	Totals	My Costs
Variable Costs						
Preplant ground preparation						
Plowing	acre	15.00	2	30.00		
Fertilizing	acre	26.25	1	26.25		
Discing/harrowing	acre	12.00	2	24.00		
Survey stakes	bundle	16.50	11	181.50		
Lister	acre	12.00	2	24.00		
Labor	hour	6.50	5	32.50		
					318.25	
Trellis construction						
Trellis end posts	each	9.00	20	180.00		
Line posts	each	5.00	180	900.00		
#11 wire	lb.	.60	200	120.00		
Tractor/driver	acre	25.00	1	25.00		
Post hole digger	acre	25.00	1	25.00		
Labor	hour	6.50	16	104.00		
					1,354.00	
Planting						
Nursery stock	each	1.70	550	935.00		
Labor	hour	6.50	20	130.00		
					1,065.00	
Post planting care						
Irrigation equipment	acre	900.00	1	900.00		
Irrigation water	acre	42.00	1	42.00		
Irrigation labor	hour	6.50	5	32.50		
Herbicide	gal.	82.00	1	82.00		
Pesticide application	hour	10.00	3	30.00		
Sprayer	acre	2.65	2	5.30		
Cultivation	acre	12.00	4	48.00		
Vine training	hour	10.80	3	32.40		
Hoeing	hour	10.80	5	54.00		
Grass seed	lb.	2.50	5	12.50		
Tractor	acre	17.00	5	85.00		
					1,323.70	
Total Variable Costs per Acre					4,060.95	
Fixed Costs per Acre						
Interest:						
Land and buildings				60.00		
Trellis (full costs)				86.86		
Irrigation Equipment				54.00		
Machinery				60.00		
Insurance				3.75		
Real Estate Tax				12.23		
Total Fixed Cost per Acre					276.84	
Total Cost per Acre - Year 1					4,337.79	

Vineyard Establishment Cost per Acre – Year 2

	Unit	Price or Cost/Unit	Quantity	Value/Cost	Totals	My Costs
Variable Costs						
Nursery stock	each	1.50	10	15.00		_____
Pruning labor	hour	6.50	10	65.00		_____
Irrigation water	acre	42.00	1	42.00		_____
Irrigation labor	hour	6.50	5	32.50		_____
Fertilizer	acre	26.25	1	26.25		_____
Herbicide	gal.	82.00	1	82.00		_____
Fertilizer application	acre	7.07	1	7.07		_____
Fungicide	lb.	10.14	2.68	27.17		_____
Pesticide application	hour	10.00	6	60.00		_____
Sprayer	acre	2.65	4	10.60		_____
Plastic fastener	each	.02	2,200	44.00		_____
Twine	foot	.04	2,500	100.00		_____
Vine training	hour	6.50	4	26.00		_____
Hoeing	hour	6.50	5	32.50		_____
Mowing cover crop	acre	15.00	4	60.00		_____
Summer training	hour	6.50	10	65.00		_____
Total Variable Costs per Acre					695.09	_____
Fixed Costs per Acre						
Interest:						
Land and buildings				60.00		_____
Trellis (full costs)				86.86		_____
Irrigation Equipment				54.00		_____
Machinery				60.00		_____
Insurance				3.75		_____
Real Estate Tax				12.23		_____
Total Fixed Cost per Acre					276.84	_____
Total Cost per Acre - Year 2					971.93	_____

Vineyard Establishment Cost per Acre – Year 3

	Unit	Price or Cost/Unit	Quantity	Value/Cost	Totals	My Costs
Variable Costs						
Mowing cover crop	acre	15.00	1	15.00		_____
Irrigation water	acre	30.00	1	30.00		_____
Irrigation labor	hour	6.50	5	32.50		_____
Fertilizer	acre	26.25	1	26.25		_____
Herbicide	gal.	82.00	1	82.00		_____
Fertilizer application	acre	7.07	1	7.07		_____
Fungicide	lb.	10.14	7.36	74.63		_____
Insecticide	lb.	3.30	2.12	7.00		_____
Pesticide application	hour	10.00	7.5	75.00		_____
Sprayer	acre	2.65	6	15.90		_____
Plastic fastener	each	.02	540	10.80		_____
Pruning labor	vine	.38	540	205.20		_____
Vine training	hour	6.50	20	130.00		_____
Harvesting	acre	200.00	1	200.00		_____
Total Variable Costs per Acre					911.35	_____
Fixed Costs per Acre						
Interest:						
Land and buildings				60.00		_____
Trellis (full costs)				86.86		_____
Irrigation Equipment				54.00		_____
Machinery				60.00		_____
Insurance				3.75		_____
Real Estate Tax				12.23		_____
Total Fixed Cost per Acre					276.84	_____
Total Cost per Acre - Year 3					1,188.19	_____

Vineyard Establishment Cost per Acre – Year 4

	Unit	Price or Cost/Unit	Quantity	Value/Cost	Totals	My Costs
Variable Costs						
Mowing cover crop	acre	15.00	1	15.00		_____
Irrigation water	acre	42.00	1	42.00		_____
Irrigation labor	hour	6.50	6	39.00		_____
Fertilizer	acre	32.80	1	32.80		_____
Herbicide	gal.	82.00	1	82.00		_____
Fertilizer application	acre	7.07	1	7.07		_____
Fungicide	lb.	10.14	8.25	83.65		_____
Insecticide	lb.	3.30	6	19.80		_____
Pesticide application	hour	10.00	12	120.00		_____
Sprayer	acre	2.65	8	21.20		_____
Plastic fastener	each	.02	540	10.80		_____
Pruning labor	vine	.60	540	324.00		_____
Vine training	hour	6.50	60	390.00		_____
Harvesting	hour	6.50	40	260.00		_____
Harvest containers	box	.35	285	99.75		_____
Hauling	mile	variable	variable	variable		_____
Total Variable Costs per Acre					1,547.07	_____
Fixed Costs per acre						
Interest:						
Land and buildings				60.00		_____
Trellis(full costs)				86.86		_____
Irrigation Equipment				54.00		_____
Machinery				60.00		_____
Insurance				3.75		_____
Real Estate Tax				12.23		_____
Total Fixed Cost per Acre					276.84	_____
Total Cost per Acre - Year 4					1,823.91	_____

Net Investment Costs in Establishing a 1-acre Vineyard

First 4 Years **Category**	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Period**
Variable Costs					
Preharvest cost	4,200.95	695.09	711.35	1,193.52	6,800.91
Harvest cost	0	0	200.00	359.75	559.75
Total Variable Costs	4,200.95	695.09	911.35	1,547.07	7,354.46
Total Fixed Costs	276.84	276.84	276.84	276.84	1,107.36
Total Costs	4,477.79	971.93	1,188.19	1,823.91	8,461.82
Receipts					
Yield (tons)	0	0	2	5	7
Price ($/ton)	500.0	500.0	500.0	500.0	500.0
Total Receipts	0	0	1,000.0	2,500.0	3,500.0
Net Investment	(4,477.79)	(971.93)	(188.19)	676.09	(4,961.82)

Operating Budget for Established Vineyard

	Unit	Price or Cost/Unit	Quantity	Value/Cost	Totals	My Costs
Variable Costs						
Mowing cover crop	acre	15.00	1	15.00		_____
Irrigation water	hour	6.00	7	42.00		_____
Irrigation labor	hour	6.50	6	39.00		_____
Fertilizer	acre	32.80	1	32.80		_____
Herbicide	acre	82.00	1	82.00		_____
Fertilizer application	acre	7.07	1	7.07		_____
Fungicide	lb.	10.14	8.25	83.65		_____
Insecticide	lb.	3.30	6	19.80		_____
Pesticide application	hour	10.00	12	120.00		_____
Sprayer	acre	2.65	8	21.20		_____
Plastic fastener	each	.02	540	10.80		_____
Pruning labor	vine	.60	540	324.00		_____
Vine training	hour	6.50	60	390.00		_____
Harvesting	hour	6.50	40	260.00		_____
Harvest containers	box	.35	285	110.00		_____
Hauling	mile	variable	variable			_____
Total Variable Costs per Acre					1,557.32	_____
Fixed Costs per Acre						
Interest:						
Land and buildings				60.00		_____
Trellis (full costs)				86.86		_____
Irrigation Equipment				54.00		_____
Machinery				60.00		_____
Depreciation:						
Trellis (40 year life)				36.19		_____
Irrigation Equipment (20 year life)				45.00		_____
Machinery (10 year life)				60.00		_____
Insurance				3.75		_____
Real Estate Tax				12.23		_____
Total Fixed Cost per Acre					418.03	_____
Total Cost per Acre					1,975.35	_____
Returns:						
Yield				5 tons/acre		_____
Price received per ton				500.00		_____
Total Receipts				2,500.00		_____
Income over variable costs				**942.68**		_____
Income over total costs				**524.65**		_____

Checklist for Vineyard Establishment

1. Consults with Extension personnel and good grape growers and winemakers.
2. Read and educate prior to developing a vineyard.
3. Determine the market demand and profitability and visit wineries.
4. Site selection:
   a. Orientation.
   b. No shading.
   c. Good air movement.
   d. Area average minimum and maximum temperatures.
5. Survey the vineyard site:
   a. Draw the proposed planting.
   b. Row orientation.
   c. Spacing between and within rows.
   d. Tractor turning space at the end of a row.
   e. Harvest time.
   f. Irrigation system.
   g. Drainage system, if required.
6. Select appropriate cultivar.
7. Soil test.
8. Water source.
9. Site preparation:
   a. Work the soil when dry.
   b. Apply needed nutrients as recommended in soil test results.
   c. Control perennial weeds.
10. Order cultivars from reputable nursery six months before planting.
11. Install needed drainage, irrigation and deer fence.
12. Plant cover crop.
13. Plant the vines after spring frost has passed.
14. Use this book as reference and consult with K-State Research and Extension for advice.

Viticulture and Enology References

Visit *www.ncwine.org/supplies.htm* for a list of suppliers, services, and references on viticulture and enology. The list includes, animal control, vines, grafting, growth tubes, irrigation design and installation, packaging, pesticides, pruning shears, sprayers, tractors, tillers, vineyard supplies, commercial winemaking, home winemaking, nurseries, books and magazines.

Publications from Kansas State University are available on the World Wide Web at: *http://www.oznet.ksu.edu*

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