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Texas Vineyard Guide

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FOREWORD

The cultivation of grapes for commercial wine production (viticulture) is a new and rapidly expanding industry in Texas. Because the industry is new, few Texans have the skills needed to take advantage of job opportunities in the state's vineyards. These job opportunities are numerous because viticulture is an unusually labor-intensive agricultural endeavor.

The State Employment and Training Council of Texas recognized the need for viticulture training materials and the benefits such materials would provide for the Texas labor force and the viticulture industry. The SETC and its staff worked for more than a year to gain approval to spend funds available through the federal Comprehensive Employment and Training Act for this unique, far-sighted project.

Traditionally, viticulture publications have been written primarily for vineyard owners and managers. This guide, plus an innovative, illustrated manual and sound-slide presentation, provides easy-to-understand, task-by-task instructions for vineyard managers to use in teaching their laborers.

The SETC is pleased with the great potential of this project to help economically disadvantaged, unemployed and under employed Texans find jobs, usually with salaries substantially above the minimum wage, in this exciting new industry.

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Austin, Texas
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Texas Vineyard Guide

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Chapter 1. INTRODUCTION

Growing wine grapes in Texas is both old and new. Many early German, Czechoslovakian and Italian settlers in Texas cultivated grapes for home winemaking, and there were at least 16 wineries in Texas before prohibition (figure 1-1). Texas reached international fame through the legendary T.V. Munson of Denison, Texas, who developed more than 300 varieties for the new world and also saved the European wine industry from the phylloxera root louse with the introduction of Texas rootstocks. With the passing of prohibition in 1921, the old wine grape industry of Texas died a premature death.

The new Texas wine grape industry has experienced revolutionary growth since 1970, and significant expansion is expected within the 1980s (figure 1-2). Vineyard acreage has increased from fewer than 90 acres in 1970 to approximately 3,000 acres in 1982. This acreage could increase to 9,000 acres by 1990. The number of wineries has increased from one to 13 during the same period. This expansion in vineyards could require a significant number of new workers because grape growing is very labor intensive.

This publication has been prepared in cooperation with the State Employment and Training Council of Texas to assist vineyard laborers, managers and owners to learn the basics of vineyard establishment, young vine training, mature vine training, vineyard management and grape harvesting. Literature on grape growing has traditionally been academic or directed only toward the vineyard owner and manager.

The vineyard owner and manager will develop an overall training sequence for their workers. An example of how this publication can be used is given below:

Step 1. Vineyard owner and managers study grape literature.

Step 2. At the close of the day, inform workers of what vineyard operations will be conducted the next day.

Step 3. Immediately before vineyard workers go to the field, show them illustrations and slides on the tasks to be done that day.

Step 4. Manager and foreman conduct a method demonstration in the vineyard with questions and answers on a one-to-one basis.

Step 5. Foreman remains in the vineyard checking individuals for an understanding of skills.

Step 6. Advanced, skilled workers should work as a team on a one-to-one basis with persons needing help during field work.

If the above sequence is carried out consistently, over time, covering all possible vineyard operations and problems, the employees involved will receive highly intensive training which is impossible to achieve in most organizations, but highly desirable in vineyard operations, because of the complexity of the tasks and the costliness of mistakes.

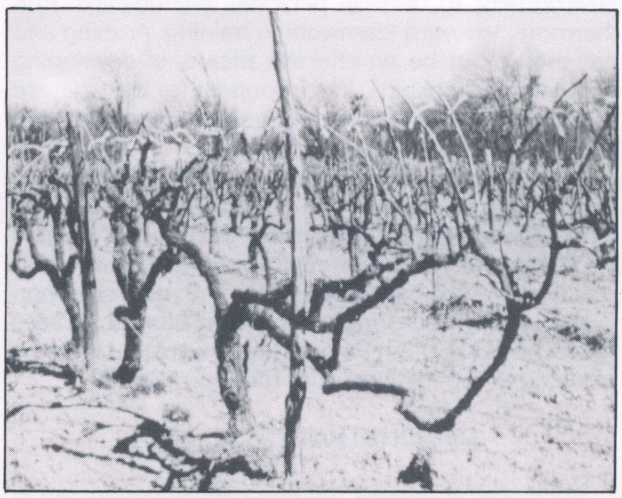

Figure 1-1 Val Verde Winery established in 1883 at Del Rio, Texas.

*Respectively, Extension horticulturist, Extension assistants in horticulture, associate professor of horticulture and Extension horticulturists, The Texas A&M University System.

Figure 1-2 New University of Texas vineyard at Bakersfield, Texas.

All too often, vineyard problems are blamed on laborers, but in actuality, owners and managers did not take the time or effort to properly train the foremen and laborers. This publication will assist owners and managers in this training.

WORKER MOTIVATION

Vineyard workers should feel good about their job and be productive. In addition to good training, this can be implemented by establishing positive worker relationships and worker involvement in decision-making.

Personal relationships among workers can be a positive factor in productivity. These relationships can arise from the work setting, from lunch or water breaks or from car pools. If workers develop positive relationships with each other, their productivity can increase. Vineyard workers can eat together to provide an environment to develop personal relationships. Furthermore, vineyard teamwork in training, pruning and harvesting can be an effective means of developing personal relationships. It is important for the vineyard manager to see positive personal relationships develop.

Worker involvement in decisionmaking helps productivity for a long time. The Japanese have recently demonstrated the importance of this concept. Workers should be included and feel they are truly involved in making vineyard policy decisions. The most common examples are the setting of work hours and schedules by workers. Ask them "When do you want to start in the mornings?" or "Did we work too long today?"

DEMONSTRATION PLOTS

Additional employee training can be conducted in special small demonstration plots. Conduct method demonstrations to show laborers how to train, prune, cultivate and propagate vines.

County Extension agents and horticulture specialists frequently need small result demonstration plots within a vineyard to learn and teach new viticultural alternatives such as varieties, fertilization, irrigation, propagation, training, pruning, trellising and fruit thinning.

This publication only illustrates a way to grow grapes in Texas. Numerous alternatives are and will continue to be available to the vineyard owner and manager. Use of demonstration plots is extremely important in evaluating other alternatives and teaching laborers how to implement them.

To productively grow grapes in Texas, the laborer must combine both science and art in the care of vines. The science is learned from material such as this publication. The art is learned from a friend in the vineyard.

Chapter 2. VINEYARD ESTABLISHMENT

The potential grape grower needs to pay very close attention to vineyard site selection. Since 1970, large vineyards and wineries have located in four general areas of Texas (figure 2-1). Some of the factors to consider in selecting a specific vineyard site are freedom from serious diseases such as Pierce's disease, cotton root rot and black rot; water quality and quantity; soil drainage and fertility; growing season, relative humidity, precipitation, freeze and hail probability; local wine laws and taxes; marketing alternatives; highways; electricity; and labor availability. The county Extension agent can provide you with valuable information on the fruit production history of the county. The Soil Conservation Service can provide you

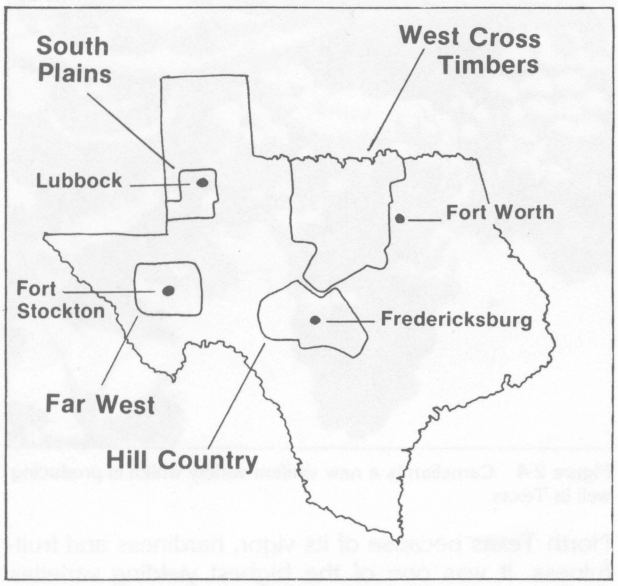

Figure 2-1 The four major grape growing areas of Texas in 1982.

with information on the various soil types of a county. Local commercial fruit growers can also provide excellent information on the potential for grape production.

VARIETIES

Selecting the correct grape varieties for your area is one of the most important steps in successful grape production. Grape varieties listed in this publication were evaluated throughout Texas on general adaptability, consistent production, wine quality and resistance to pests (figure 2-2). Because of the diversified climate in Texas, many grape varieties recommended in North Texas are a complete failure in South or East Texas. The bunch varieties are self-fruitful and require no pollination.

American grape varieties are hybrid bunch grapes which have developed in America. They have good disease resistance and fair fruit quality. American grape varieties are grown in most of Texas.

Lenoir (Black Spanish) is a small, black grape which forms large, tight clusters (figure 2-3). The vine is vigorous and produces moderate crops. Lenoir is

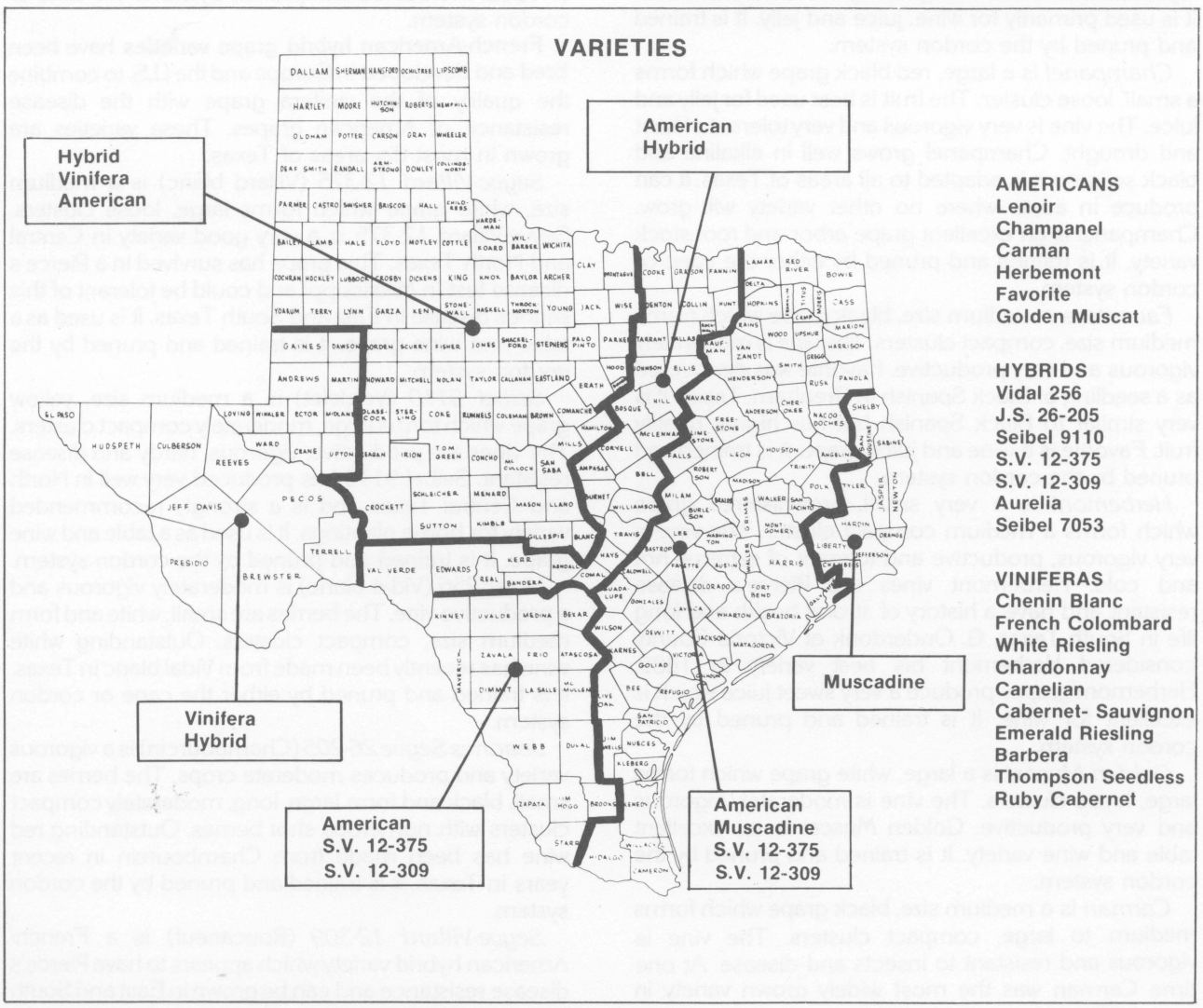

Figure 2-2 Grape varieties recommended for the various areas of the state.

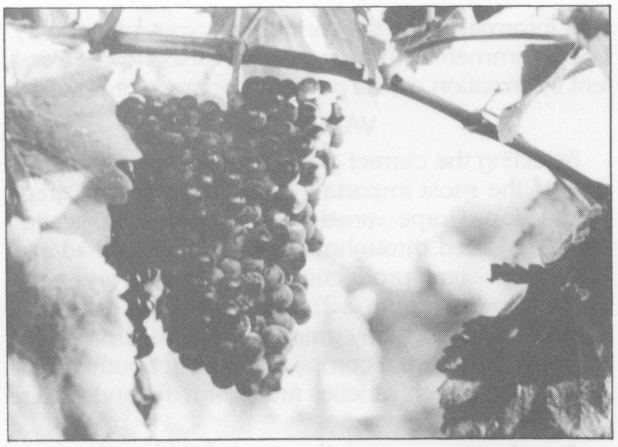

Figure 2-3 Black Spanish grapes as they have been grown for 99 years at Val Verde Winery at Del Rio, Texas.

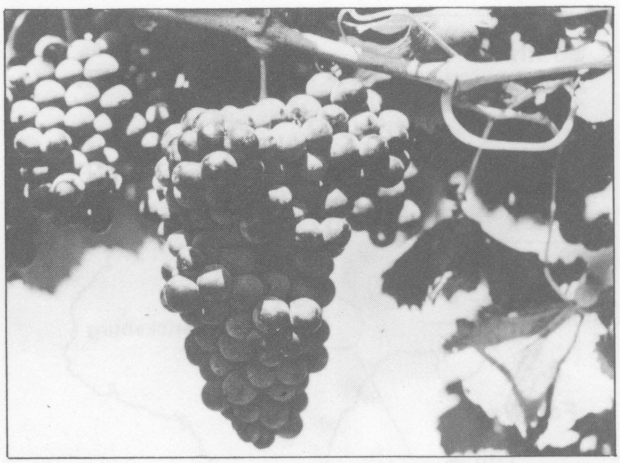

Figure 2-4 Carnelian is a new vinifera variety which is producing well in Texas.

highly susceptible to leaf and fruit diseases and must be sprayed regularly. It is resistant to Pierce's disease and can be grown in all of Texas. Lenoir has been reported as an outstanding variety in Texas since 1889. It is used primarily for wine, juice and jelly. It is trained and pruned by the cordon system.

Champanel is a large, red-black grape which forms a small, loose cluster. The fruit is best used for jelly and juice. The vine is very vigorous and very tolerant of heat and drought. Champanel grows well in alkaline and black soils, so it is adapted to all areas of Texas. It can produce in areas where no other variety will grow. Champanel is an excellent grape arbor and root-stock variety. It is trained and pruned by either the cane or cordon system.

Favorite is a medium size, black grape which forms medium size, compact clusters. The vine is moderately vigorous and very productive. Favorite was discovered as a seedling of Black Spanish in Brenham, Texas. It is very similar to Black Spanish but has higher quality fruit. Favorite is a wine and juice grape. It is trained and pruned by the cordon system.

Herbemont is a very small, brownish-red grape which forms a medium compact cluster. The vine is very vigorous, productive and tolerant of extreme hot and cold. Herbemont vines are Pierce's disease resistant and have a history of strong health and long life in South Texas. G. Onderdonk of Victoria County considered Herbemont his best variety in 1889. Herbemont grapes produce a very sweet juice which is excellent for wine. It is trained and pruned by the cordon system.

Golden Muscat is a large, white grape which forms large, loose clusters. The vine is moderately vigorous and very productive. Golden Muscat is an excellent table and wine variety. It is trained and pruned by the cordon system.

Carman is a medium size, black grape which forms medium to large, compact clusters. The vine is vigorous and resistant to insects and disease. At one time Carman was the most widely grown variety in North Texas because of its vigor, hardiness and fruitfulness. It was one of the highest yielding varieties grown at the Montague Experiment Station from 1940 to 1962. It is trained and pruned by either the cane or cordon system.

French-American hybrid grape varieties have been bred and developed in Europe and the U.S. to combine the quality of the vinifera grape with the disease resistance of American grapes. These varieties are grown in most dry areas of Texas.

Seyve-Villard 12-375 (Villard blanc) is a medium size, white grape which forms large, loose clusters. Seyve-Villard 12-375 is a very good variety in Central and North Texas. This grape has survived in a Pierce's disease test in Mississippi and could be tolerant of this serious disease in East and South Texas. It is used as a table and wine grape. It is trained and pruned by the cordon system.

Seibel 9110 (Verdelet) is a medium size, yellow grape which forms large, moderately compact clusters. The vines are productive, vigorous, hardy and disease resistant. Seibel 9110 has produced very well in North and Central Texas and is a strongly recommended variety for home plantings. It is used as a table and wine grape. It is trained and pruned by the cordon system.

Vidal 256 (Vidal blanc) is moderately vigorous and a productive vine. The berries are small, white and form medium size, compact clusters. Outstanding white wine has recently been made from Vidal blanc in Texas. It is trained and pruned by either the cane or cordon system.

Joannes Seyve 26-205 (Chambourcin) is a vigorous variety and produces moderate crops. The berries are small, black and form large, long, moderately compact clusters with numerous shot berries. Outstanding red wine has been made from Chambourcin in recent years in Texas. It is trained and pruned by the cordon system.

Seyve-Villard 12-309 (Roucaneuf) is a French-American hybrid variety which appears to have Pierce's disease resistance and can be grown in East and South

Texas. The fruit is white to pink and is good for eating or making white wine. Roucaneuf has performed well at Castroville, Texas.

Seibel 7053 (Chancellor) is a medium size, black berry which forms medium, compact clusters. It is a relatively high-yielding grape which has good wine potential. It is trained and pruned by the cordon system.

Aurelia is a large, white grape which forms short, loose clusters. The vines are moderately vigorous, relatively disease resistant and very productive. It has produced well in Central and North Texas. It is primarily a table grape but has made good table wine. It is trained and pruned by either the cane or cordon system.

The vinifera grape is the traditional wine grape of Europe and Middle Asia where it has grown since 1,000 years before Christ. It is the predominate grape in California. Vinifera varieties are well adapted to a dry climate and alkaline soils common to West Texas. They are susceptible to cold injury, Pierce's disease and black rot.

Chenin blanc is a medium size, white grape which forms large, compact, conical clusters. Chenin blanc is the most popular vinifera, white wine grape being planted in Texas today. The vines are vigorous. It is trained and pruned by the cordon system.

French Colombard is a medium size, white grape which forms medium size clusters. The vine is very vigorous with dense foliage. It is used as a white wine grape. It is trained and pruned by the cordon system.

Ruby Cabernet is a medium size, black, round grape which forms medium size, long clusters. The vine is moderately vigorous. It is commonly infested with a virus and needs to be purchased disease-free. It is trained and pruned by the cordon system.

Emerald Riesling is a medium size, yellowish grape which forms large, long clusters. The vines are vigorous. It is used as a white wine grape. It is trained and pruned by the cordon system.

Thompson Seedless is a white grape which forms large, long clusters. The vine is moderately vigorous. It is the most widely planted table grape in California. In all but Far West Texas it is subject to freeze injury, Pierce's disease and black rot. Thompson seedless must be cane pruned because the first two or three buds usually do not bear fruit.

Barbera is a medium size, black grape which forms medium size, short clusters. The vines are moderately vigorous and form relatively small canes. It is used as a red wine grape. It is trained and pruned by the cordon system.

Carnelian is a medium, blue-black grape with small seeds and thick skins. Clusters are large, making it an excellent producer (figure 2-4). It is a vigorous upright grower, but it is not well suited to sandy soil types. It does poorly under saline or alkaline soil conditions. Vines can be trained to a bilateral cordon.

Cabernet Sauvignon is a small, round, black, thick-skinned grape. Clusters are medium to small. It has a vigorous vine growth which is upright but often trailing in late season. It may either be cordon or cane pruned.

Sauvignon blanc is a medium to large, round, greenish grape that forms medium size, well-filled, compact clusters. The flavor is distinct and aromatic. The vines have a spreading growth habit and are very vigorous. The vines must be cane pruned to produce heavy crops.

White Riesling is a small clustered, white grape which has made very good wine on the South Plains. The vine is moderately vigorous and cane pruned.

Chardonnay is a small clustered, early white grape and is being tried by many growers on the South Plains and Far West Texas. Outstanding wine has been made from Texas-grown Chardonnay. This is a vigorous vine which is cane pruned.

CLEARING THE VINEYARD SITE

Begin site preparation in September before planting in February. A full year or 18 months are optimum. Remove trees, brush and large rocks and kill perennial weeds which would otherwise start growing again in the spring. Remove brush from the site so that it does not interfere with trellis construction, planting or vineyard management.

Laborers can clear small vineyard sites using chain saws to cut trees and larger shrubs. Only physically strong laborers should be expected to operate a chain saw.

Where heavy stands of mesquite or other trees exist, use bulldozers to clear the surface and root plow to adequately cut all the roots. Then root rake the soil to remove most of the roots. Use a tractor to shred shrubs with trunks less than 2 inches in diameter.

After bulldozing and shredding operations are completed, workers must pick up smaller pieces of roots by hand. Under heavy brush conditions, one

Figure 2-5 Chisel is used to break plow pan and improve internal soil drainage.

person will require 1 full day to pick up roots and brush from 1 acre.

Use chisel plowing to break up plow pans and cut roots. This can be done with a tractor to a depth of 18 inches. At least two trips down the row are needed; four trips would be ideal. The soil should be relatively dry for the plow pan or clay layers to be broken (figure 2-5).

Deep plowing is needed in the winter months or dry summer months to kill perennial weeds such as johnsongrass and bermudagrass.

Disking follows deep plowing to begin breaking up soil clods and smoothing out the vineyard row. The soil cannot be wet or totally dry for the disk to work properly.

In tighter, poorly drained soils, use a bedding disk to build a low terrace down the row for improved surface water drainage away from the vines.

VINEYARD LAYOUT

When planting a vineyard remember that it will be set as you plant it for many years. Plan the design well on paper before the planting date.

Direction of the Rows

Row direction depends on a number of factors that should be evaluated for each vineyard site. Factors to consider include prevailing spring wind direction, maximum light interception, slope of the land and pesticide spray runs. Plan the vineyard layout so it will be asthetically pleasing and environmentally sound.

Southwest to northeast is a good direction for vineyard rows in Texas because it offers protection from wind drift, leaning of the vines and sunburn. Rows running lengthwise in a southwesterly direction are less likely to lean or fall over from high winds which come from the southwest during the growing season.

Vine foliage protects the fruit from sunburn when rows are planted in a southwesterly direction. The sun strikes the top of the foliage during the hotter part of the day.

A major disadvantage of southwest to northwest rows is that spray equipment runs in only one direction. Driving into the prevailing wind while spraying is good, but when the end of the row is reached and the equipment is driven with the prevailing wind, the tractor operator becomes covered with pesticide.

Southwest to northeast rows may cause wind erosion when the prevailing wind is from the southwest. Trellised vines may cause a tunneling effect which could cause training problems as they are all blown down the row.

For hillsides, plant on contoured terraces to prevent surface erosion and to maintain uniform water pressure throughout the drip irrigation system.

In West and Northwest Texas flood irrigation may be used. The slope of the land determines the direction to plant rows. Flood irrigation and straight rows are adapted to relatively flat lands that can be graded to slopes of 0.15 percent or less.

If a square or rectangular site is cleared on level ground, sides of the rectangle should run southwest and northeast, and the ends should be square and at right angles to the sides. On small acreages, it may not be possible to arrange a southwest to northeast rectangle because of property borders. In this case, plant rows running parallel to the border. Such an arrangement avoids leaving land unused and helps insure that vineyard rows are the same length.

It is important to have vineyard rows about the same length for easier management operations. Having rows the same length avoids undue damage to endposts and anchor wires when equipment turns at the end of rows. Number vineyard rows so that work assignments, irrigation schedules, etc., can be understood and sites located easily.

PLANTING THE VINES

Plant vines in January or February. Early planting results in good root growth before buds begin to grow in March or April.

Purchase Healthy Vines

The vine stem should be at least 3/8 inch in diameter. Vines smaller than 1/4 inch are weak and can have problems surviving. They should have healthy, white to tan colored roots at three or more nodes. If plants are received with black roots, return them to the nursery or discard. They should be certified as disease-free. Instruct the nursery on how to pack and ship the vines. Roots should be in contact with a moist, not wet, packing material during shipment. The total package must be sealed in polyethylene film.

Heal-In to Prevent the Unplanted Vines from Drying Out

Once you receive the vines, do not allow the roots to dry out. *Immediately* after the vines are received at the vineyard site from the nursery, place in a shaded location and heal-in the vines by covering roots and tops with soil. Do not heel-in vines with straw because they frequently become too dry.

A second method is to store the new vines in a refrigerator. If so, pack the roots in moist, but not wet, sawdust or spagnum moss. Wrap the tops in polyethylene. Refrigerators are very dry and serious vine loss can occur if drying out is not prevented.

Trimming the Unplanted Vine

On the day vines are to be planted, remove them from the heel bed or refrigerator and trim. Use high quality, hand pruning shears for this task. Cut the top growth back to a single spur with only two buds (figure 2-6). Make the cut through the third bud. When roots arise from three nodes, remove the roots from the first node below the spur. Trim the roots at the lower two nodes to a length of only 2 or 3 inches.

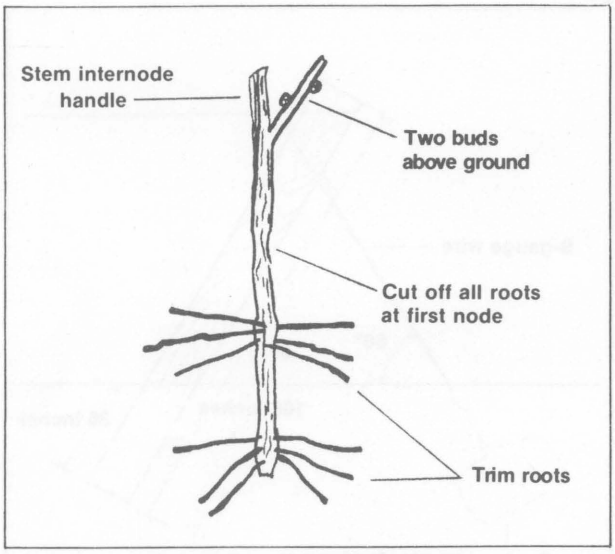

Figure 2-6 A vine trimmed and ready for planting.

Handling the Vine

In moving vines from the heel bed to the trimming room and then to the vineyard, take special care to prevent roots from drying out. Place vines in 5-gallon buckets half full of water. Move the vine directly from the bucket to the planting hole. Never spread or line out the plants on the soil surface before planting as exposure to the air for a very short time can kill or weaken the vine.

Digging the Hole

Use a hand post hole digger or shovel to dig the hole. Dig the hole approximately 6 inches in diameter and 8 inches deep or just large enough to receive the root system.

Planting the Vine

Plant the vine so that it is at the same depth as it grew in the nursery row. Pack the top soil firmly around the spread roots. If the vineyard has been prestaked, the spur above the stem should be very close to the stake so it can be tied to the stake. Irrigate the vine *immediately* after planting until the root zone is thoroughly soaked.

TRELLIS CONSTRUCTION

In ancient times grapevines grew primarily in trees or on the ground. Following hundreds of years of culture, growers began training them on trellises. Unpruned and unsupported vines require very little labor but come into production later, produce irregular crops and are short-lived.

In Texas, permanent supports or trellises are used for greater economic returns and consistent performance of vines. Vines are trained and trellised for either cane or cordon pruning.

TRELLIS OPTIONS

As a grower plans his vineyard he is faced with the decision of erecting the trellis the first year before planting or the second year after the vines have grown in place for 1 year.

Trellising the First Year

Advantages of first-year trellising are that the vines can be placed immediately adjacent to the stake, and the drip irrigation system can be placed in its permanent location on the trellis.

Trellising the Second Year

Advantages of trellising the second year are the economic savings on the trellis for 1 year. Planting without a stake is considerably easier and faster, thus making it more economical. Stakes are anchored stronger when placed the second year because the planting hole is not dug next to the stake, but rather the stakes are driven into their desired location. Do not delay trellis construction beyond the second year.

CONSTRUCTION PROCEDURE

The vineyard is lined out and planted the first year. It is staked the first or second year and then endposts are set and anchored. Following this, all holes for the intermediate posts are dug. Next, one wire is stretched from end post to end post. Intermediate posts are set, and stakes are driven into the ground and attached to the wire. In this way they can all be lined up straight down the row.

Construction of the grape trellis is very similar to the construction of a farm fence. Careful planning is required since the structure must be strong enough to carry heavy loads of vines and fruit as well as withstand winds when fully loaded.

Trellis construction is similar for all conventional grape training systems although they may vary in detail. In essence, trellises are all the same, consisting of end posts, stakes and wires that are strung between them. In Texas, intermediate posts may be installed where wind could blow the trellis down.

Two wires are most common, but some growers find that three wires are needed to support the vines.

End posts

The first step in the construction of a trellis is the setting of solid, immovable end posts. End posts should be 6 to 8 inches in diameter because they must serve as anchor points as well as wire supports. It is best to use durable posts of cedar or pine treated with creosote, pentachlorophenol or CCA. Do not use secondhand railroad ties or telephone poles because they rot prematurely. Wooden posts should be full length pressure treated. They are more expensive but have a longer life. The cost of labor and equipment to replace posts can be expensive.

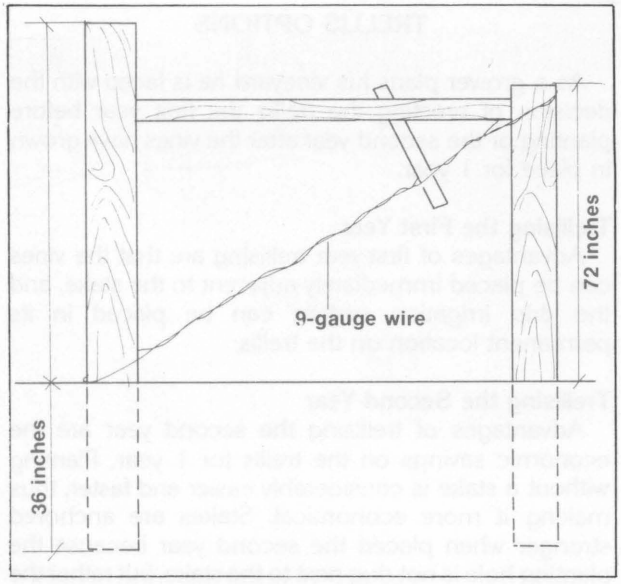

Figure 2-7 The "H" end post bracing.

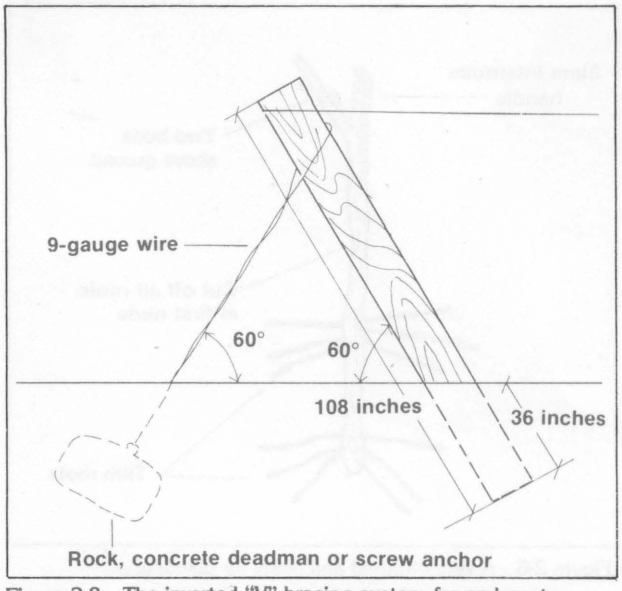

Figure 2-8 The inverted "V" bracing system for end posts.

Posts of concrete properly reinforced with steel rods are very durable and can be used.

The number of the row should be marked on each end post.

Bracing methods

The end posts must be securely braced as the trellis is no stronger than its end post. Three common methods of bracing include the "H" system, inverted "V" system and "vertical end posts."

The "H" or double post system is commonly used in fencing (figure 2-7). Two posts are set at least 6 feet apart with a horizontal cross member placed 12 inches from the top of the posts. A heavy piece of wood, 3 x 4 inches or larger, makes a good brace between the two posts. The posts are set 3 feet in the ground. A #9 wire is then doubled and wound between the base of the end post and the top of the inner post. The wire is tightened by twisting with an iron or wooden rod and latching it behind the nearest post or cross member to prevent the brace wire from unwinding. The brace wire also prevents the end post from becoming loose and lifting out of the ground. An advantage of this system is that it avoids the use of anchor wires beyond the end post.

The inverted "V" system is commonly used for high trellises and arbors (figure 2-8). It consists of a 9- to 10-foot long end post set at approximately a 60° angle rather than upright, with the base set about 3 feet into the ground. The top of the post is then tied with #9 galvanized wire to a large "deadman" placed 5 feet in the ground. Various objects such as rocks, concrete blocks, poured concrete or sizeable metal objects make excellent anchors or "deadmen." However, in rock-free soil an anchor screw can be turned into the soil at a 45° angle, pointing toward the top of the endpost.

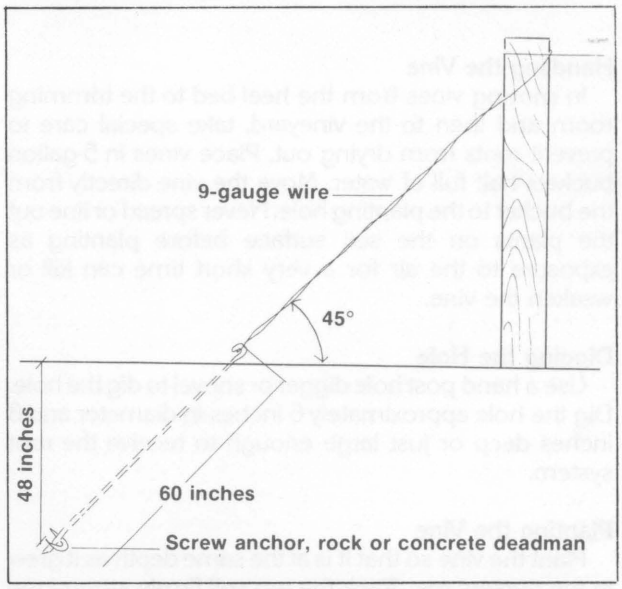

Figure 2-9 Vertical end post with anchor screw and wire.

The "V" system is strong and resists considerable pull when properly constructed. Failures are experienced if the angle of the pull on the "deadman" is overly vertical. If the "deadman" is placed further out so that the wire pulls at more than a 60° angle, it reduces the hazard of lift. A second weakness is corrosion of the wire at the ground line. However, this problem is reduced by utilizing a steel rod from the "deadman" to about a foot above the ground. The wire is then attached to a rod instead of directly to the "deadman." Another problem is that the size of the turn rows must be increased to 30 feet to properly turn equipment at the end of the row.

Vertical end posts are a slightly less expensive way to anchor trellises (figure 2-9). Rather than manually setting end posts at an angle, they can be set vertically and anchored by a rod or heavy wire on a 45° angle to a

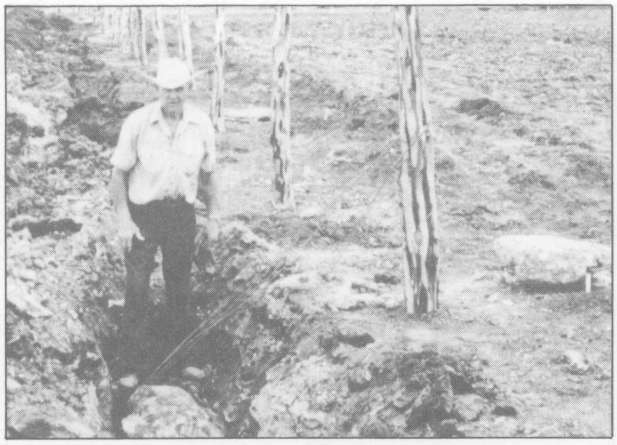

Figure 2-10 Deadman of 200-pound stone used to anchor end post.

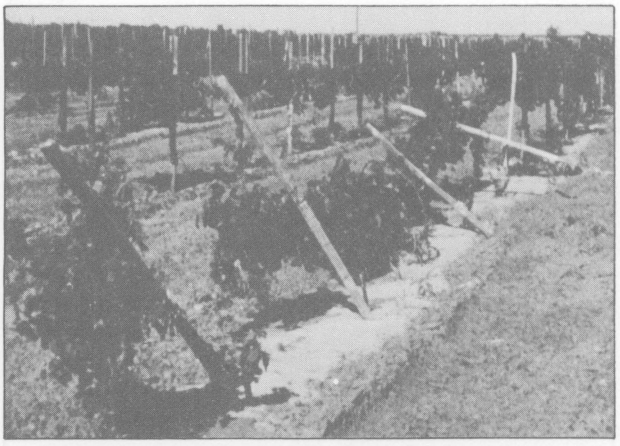

Figure 2-11 Intermediate posts are needed in Texas to prevent wind drift of stakes.

"deadman." They are at least 3 feet in the ground (figure 2-10).

As with the inverted "V" the primary disadvantage of the vertical end post system is the vulnerability of the supporting wire to damage by vineyard equipment. This hazard is minimized by placing a marker post where the wire enters the soil.

Intermediate Posts

Intermediate posts may be made from the same type of materials used for the end posts. However, they need not be as large since they do not carry the strain as end posts do. Rather, they help stabilize the trellis and keep it from blowing over (figure 2-11). Intermediate posts are usually 4 inches in diameter and are placed every 10 vines or 80 feet.

Stakes

Stakes are placed at every vine down the row. Various materials can be used for stakes, including 8-foot x 2-inch cedar stays, mahogany stakes, pentatreated stakes, wolmanized stakes or steel grape stakes. Wood stakes should be knot-free and full length pressure treated. Stakes are generally set 18 inches deep using a stake driver.

Wires

High tensil, 12- or 13-gauge galvanized wire is commonly used in Texas. While more expensive initially, it is more durable and may be the least costly over a long period.

Connecting wires. Wires may be secured to end posts in various ways. A common method is to wind the wire around the post at least twice and then twist the end several times around the wire. Some growers use special devices such as turn buckles to attach the wires to the end posts because they simplify tightening the wires. Other systems use a hole through the end post with a wire vice to prevent the wire from sagging.

Wires are fastened to intermediate posts and stakes with fence staples, grape wire clips or wire ties. Drive staples far enough to hold the wires close to the post but with enough play that the wire will slip through when tightening is needed. A light gauge wire may also be used to tie the wires. With steel posts, wire fasteners are used. Hang wires on the windward side or on the uphill side of posts.

Space wires vertically according to the training method to be followed and the height of the finished trellis. The 42-inch wire is usually connected first.

Cordon Trellis

Using the bilateral cordon system, place the cordon wire at 42 inches and the upper wire at 66 inches above the ground. A "catch wire" of 13-gauge is fastened at 52 inches to train the vertical arms in an upward manner. An alternative to a single wire at 66 inches is to place a crossarm with two wires at that height. This provides for better utilization of sunlight and mechanical harvesting. A drip irrigation wire is sometimes used at 18 inches.

Cane Trellis

The cane training system will have wires at 42 and 66 inches above the ground.

Trellis Maintenance

Trellis wires should be slack in the fall. If taut, contraction of the wires during cold periods puts a severe strain on the trellis. Generally, the wires have stretched sufficiently so that loosening is not necessary. Tighten the trellis wires each spring. The best time to do this is after pruning but before growth when the canes are tied to the wires.

Chapter 3. VINE TRAINING

The purpose of training is to shape the vine into a form that optimizes productivity and facilitates management practices.

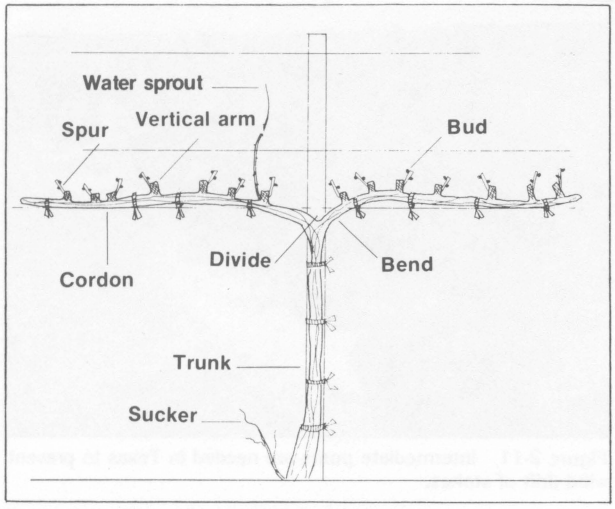

Figure 3-1 Parts of a cordon-trained vine.

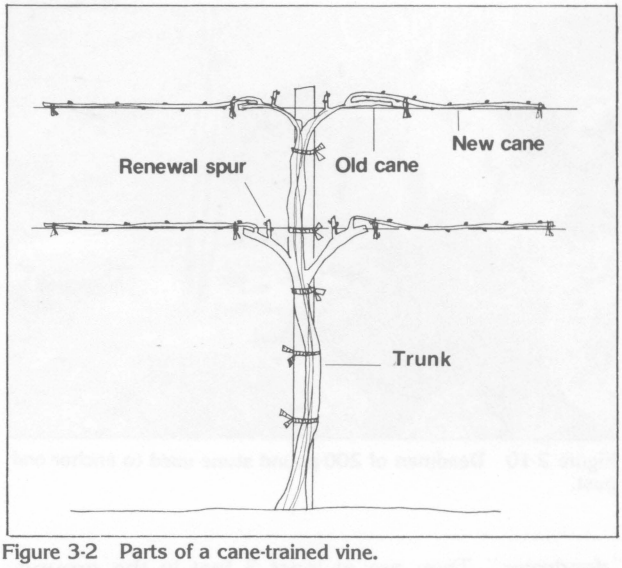

Figure 3-2 Parts of a cane-trained vine.

Around the world there are various types and versions of training. The two common training systems used in Texas are the cane method and the cordon method.

The primary purpose in both of these methods is to establish an upright, single trunk with either side canes or side cordons. A trellis is needed to support the vine. Vines are trained on the trellis during the first 3 years. During this period, most of the yield that could have been harvested is sacrificed to achieve effective vine training and maintain maximum vine health. No grapes should be produced the first or second year, a light crop the third year and only one-half crop the fourth year.

To understand how to train a vine, names of the various parts of the grape vine must be understood — cordon-trained vine (figure 3-1) and cane-trained vine (figure 3-2).

Terms used in vine training include the following:

- Trunk - the main vertical stem, body of the vine.
- Cordon - a horizontal extension of the trunk.
- Vertical arm - an extension of the cordon containing the spurs.
- Shoot - the present season's growth, containing the leaves and fruit clusters.
- Cane - a dormant 1-year-old shoot without leaves.
- Spur - a cane which is cut back to two or three buds.
- Sucker - an undesirable shoot which comes from the trunk.
- Water sprout - a vigorous, non-fruitful shoot from upper part of the vine.

GENERAL INSTRUCTIONS

It is necessary to repeat tying, pruning and disbudding several times in the second and third summers. Always leave all foliage on the leading shoot and cordons to provide photosynthetic needs.

Always try to first select the shoot or cane you want to train, tie it and then remove unnecessary shoots. This way, if the selected shoot breaks, you can replace it.

When cutting back shoots or canes make the cut through a bud one node beyond the desired bud.

Ties on shoots should always be semi-loose to permit stem enlargement. A polyethylene tape, commonly used with a tapener, is a good choice for tying (figure 3-3). Other common plant ties may also be used. Tying materials should be elastic or biodegradable.

Do not tie the first 18 inches from the tip of a growing shoot. This growth is very tender and easily damaged.

An experienced member of the training crew or crew chief should be responsible to see that the vines are

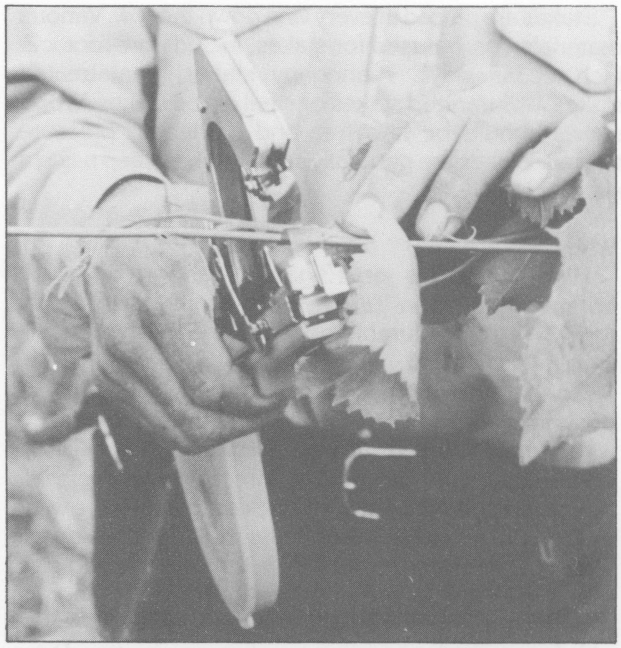

Figure 3-3 A tapener used for tieing vines with polyethylene tape.

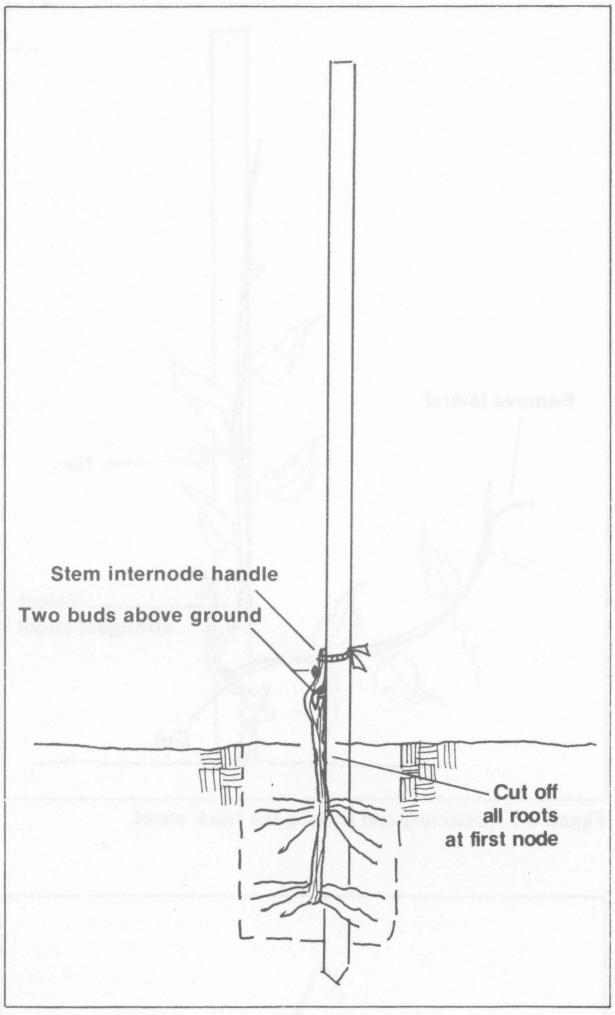

Figure 3-4 Pruning the vine at planting.

properly trained on a constant basis. If a laborer is pruning or tying the vines improperly, he should immediately be taught the proper way. The crew chief can pay bonuses to laborers who do the best work in the shortest time. Other workers are then encouraged to work faster and do the job right. Each person should work down an assigned row.

Training Begins at Planting

Remove all shoots except the most vigorous one and cut it back to two strong buds. Make the cut through the third bud. If the vineyard is staked, tie the stem internode handle to the stake (figure 3-4)..

First year. The primary objective in the first year is the development of a healthy and strong root system. Therefore, do not interfere with growth during this season by pruning or training the vine (figure 3-5). This may seem unusual, but it is necessary.

Beginning the second year the vine receives either cordon system training or cane system training. Each of them is discussed separately.

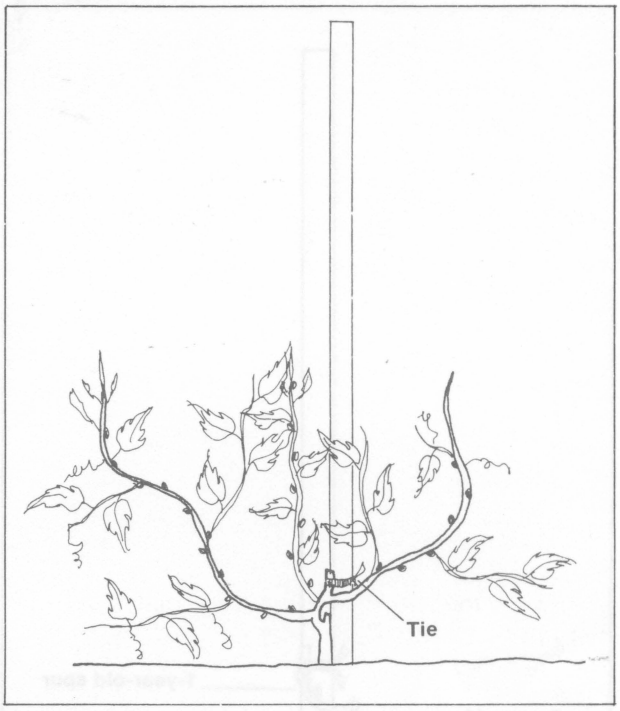

Figure 3-5 Vine grows at random the first year.

CORDON TRAINING

Second year. In the winter after the first season, prune off all top growth except the cane closest to the stake. Cut this cane to a length of two buds. Make the cut through the third bud (figure 3-6). If the vineyard is staked the second year, tie the plant to the stake after pruning. Tie the stem internode handle above the second bud to the stake.

Soon after growth begins in spring, select a strong shoot which is close to the stake to build the trunk. The selected shoot should be 12 to 18 inches long. Tie the selected shoot to the stake, then remove the other shoots (figure 3-7).

Tie the trunk shoot to one side of the stake four to six times during the season to develop a straight trunk. Remove lateral shoots but not the leaves on the lower 30 inches of trunk. As rapid growth begins, this training may be needed as often as once a week (figure 3-8).

When the trunk shoot reaches the top of the stake, cut the shoot through the node nearest the cordon wire (figure 3-9). Tie the stem internode handle to the stake. Make sure the trunk is tied to the same side of the stake as the wire attachment. Lateral shoots will force along the trunk. Select two shoots which are branching off about 6 to 10 inches below the lower wire. Do not remove the remaining laterals until selected cordons are estabished. Do not remove the leaves from the trunk but remove all other lateral shoots. Never pull the top over to form only one half of a cordon. Also do not leave more than one cordon on each side.

When the two laterals are 18 to 24 inches long, tie them on the cordon wire on both sides of the trunk.

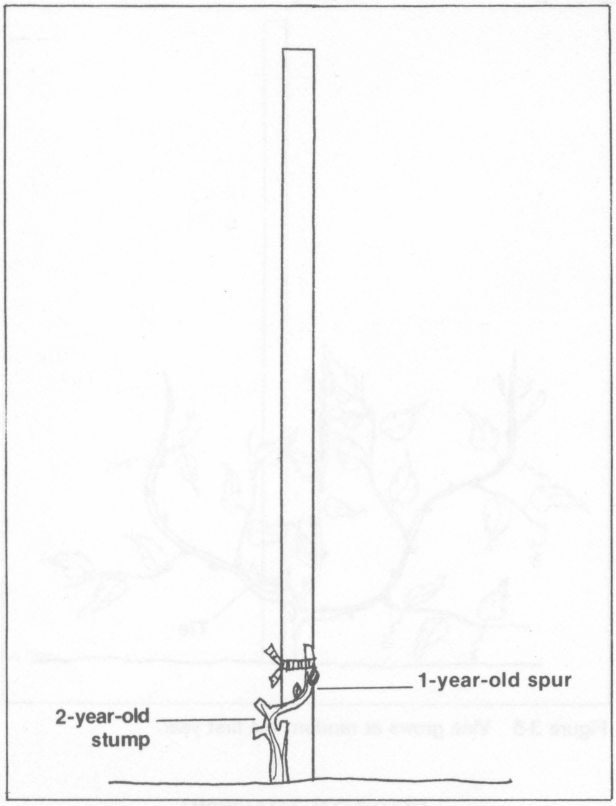

Figure 3-6 Pruning before growth begins the second year.

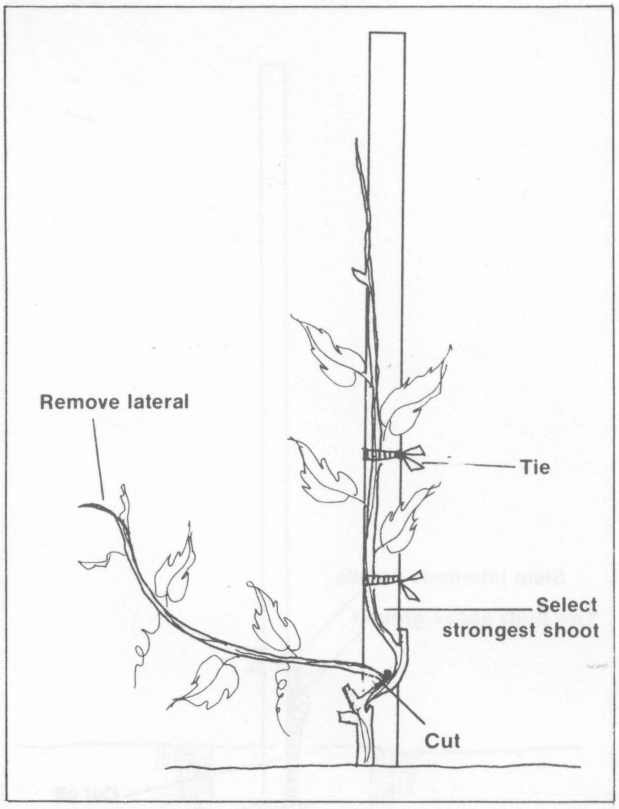

Figure 3-7 Selecting and training the trunk shoot.

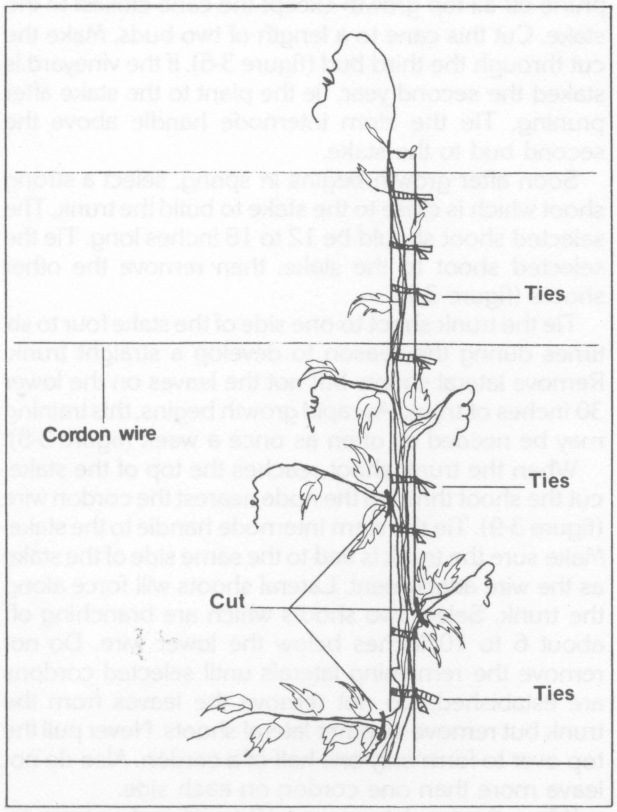

Figure 3-8 Remove lateral shoots on lower trunk and tie trunk shoot to keep it straight.

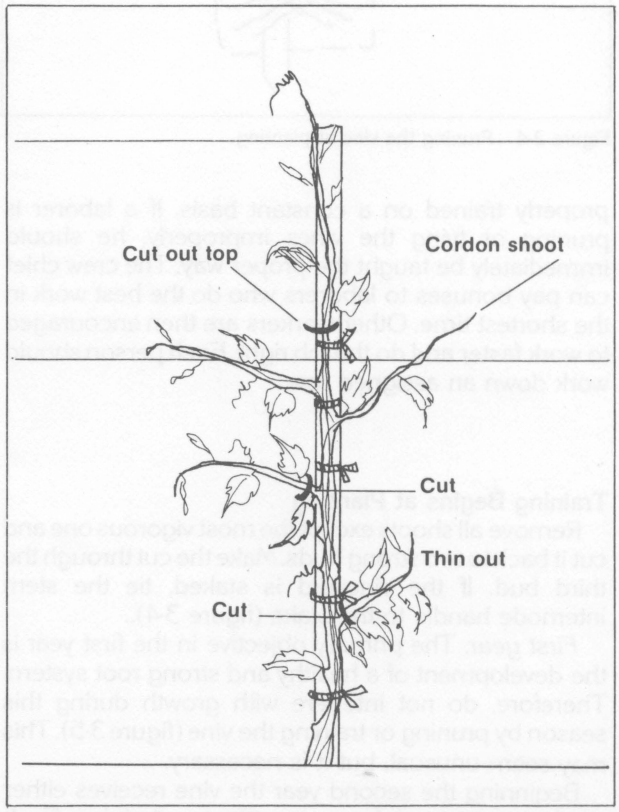

Figure 3-9 Cut out trunk shoot and select cordon shoots below wire.

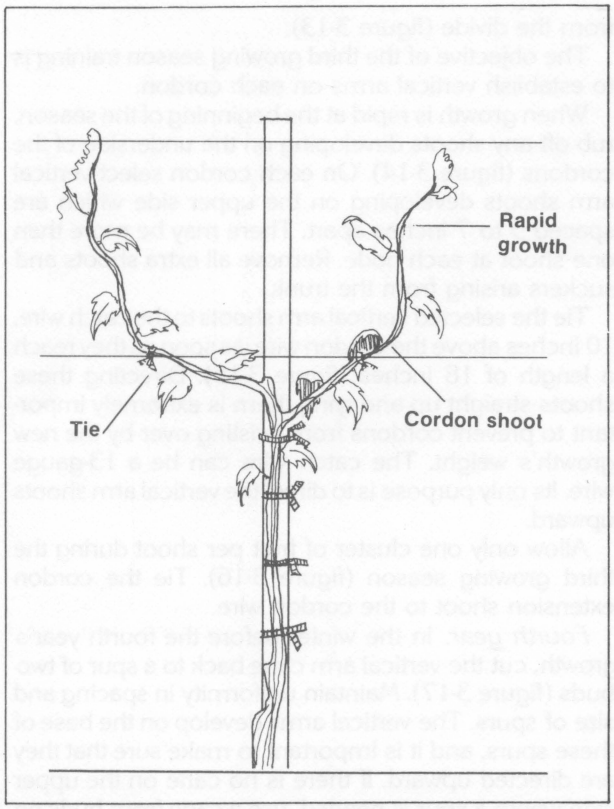

Figure 3-10 Tie the cordon shoots to the cordon wire only after they are 18 inches long.

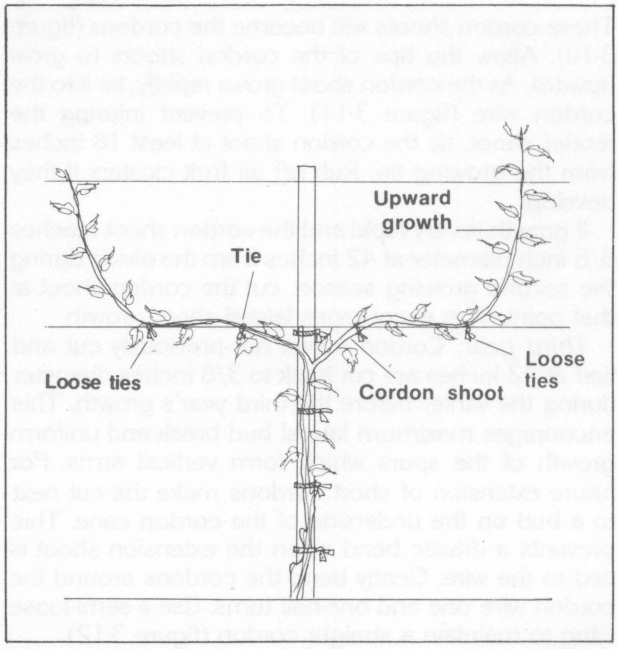

Figure 3-11 Tie the cordon shoot to the cordon wire to develop a straight cordon.

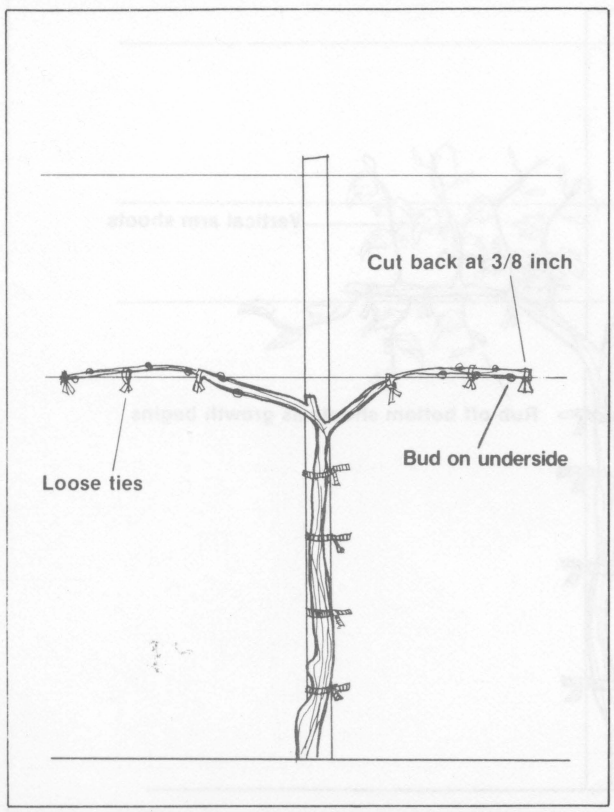

Figure 3-12 Cut back the cordon shoot to a diameter of 3/8 inch during dormant pruning before growth begins the third year.

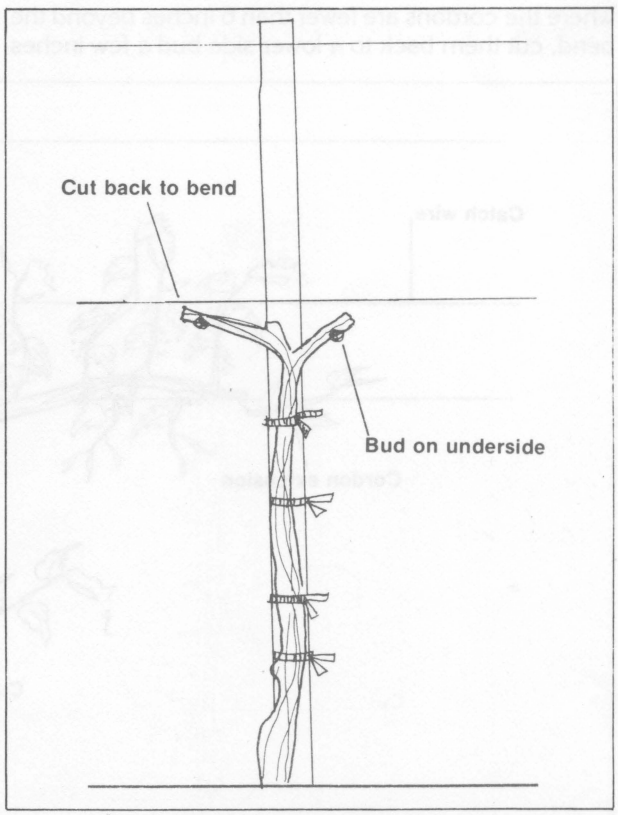

Figure 3-13 Prune weak vines with cordon shoots less than 3/8 inch in diameter back to one bud on the lower side of each bend.

These cordon shoots will become the cordons (figure 3-10). Allow the tips of the cordon shoots to grow upward. As the cordon shoot grows rapidly, tie it to the cordon wire (figure 3-11). To prevent injuring the tender shoot, tie the cordon shoot at least 18 inches from the growing tip. Rub off all fruit clusters if they develop.

If growth is very rapid and the cordon shoot reaches 3/8 inch diameter at 42 inches from the divide during the second growing season, cut the cordon shoot at that point. This encourages lateral shoot growth.

Third year. Cordon canes not previously cut and tied at 42 inches are cut back to 3/8 inches diameter during the winter before the third year's growth. This encourages maximum lateral bud break and uniform growth of the spurs which form vertical arms. For future extension of short cordons make the cut next to a bud on the underside of the cordon cane. This prevents a drastic bend when the extension shoot is tied to the wire. Gently bend the cordons around the cordon wire one and one-half turns. Use a semi-loose tying to maintain a straight cordon (figure 3-12).

At this point, the vine should have the general form of the vertical trunk with horizontal cordons. Length of the cordon varies with the vigor of the vine.

Growers should not attempt to build cordons from canes less than 3/8 inch in diameter. On weak vines where the cordons are fewer than 6 inches beyond the bend, cut them back to a lower side bud a few inches from the divide (figure 3-13).

The objective of the third growing season training is to establish vertical arms on each cordon.

When growth is rapid at the beginning of the season, rub off any shoots developing on the underside of the cordons (figure 3-14). On each cordon select vertical arm shoots developing on the upper side which are spaced 5 to 7 inches apart. There may be more than one shoot at each node. Remove all extra shoots and suckers arising from the trunk.

Tie the selected vertical arm shoots to the catch wire, 10 inches above the cordon wire, as soon as they reach a length of 18 inches (figure 3-15). Directing these shoots straight up and tying them is extremely important to prevent cordons from twisting over by the new growth's weight. The catch wire can be a 13-gauge wire. Its only purpose is to direct the vertical arm shoots upward.

Allow only one cluster of fruit per shoot during the third growing season (figure 3-16). Tie the cordon extension shoot to the cordon wire.

Fourth year. In the winter before the fourth year's growth, cut the vertical arm cane back to a spur of two buds (figure 3-17). Maintain uniformity in spacing and size of spurs. The vertical arms develop on the base of these spurs, and it is important to make sure that they are directed upward. If there is no cane on the upper side where a spur is needed, use a cane from buds on the side of the cordon. In this case, cut the spur to one

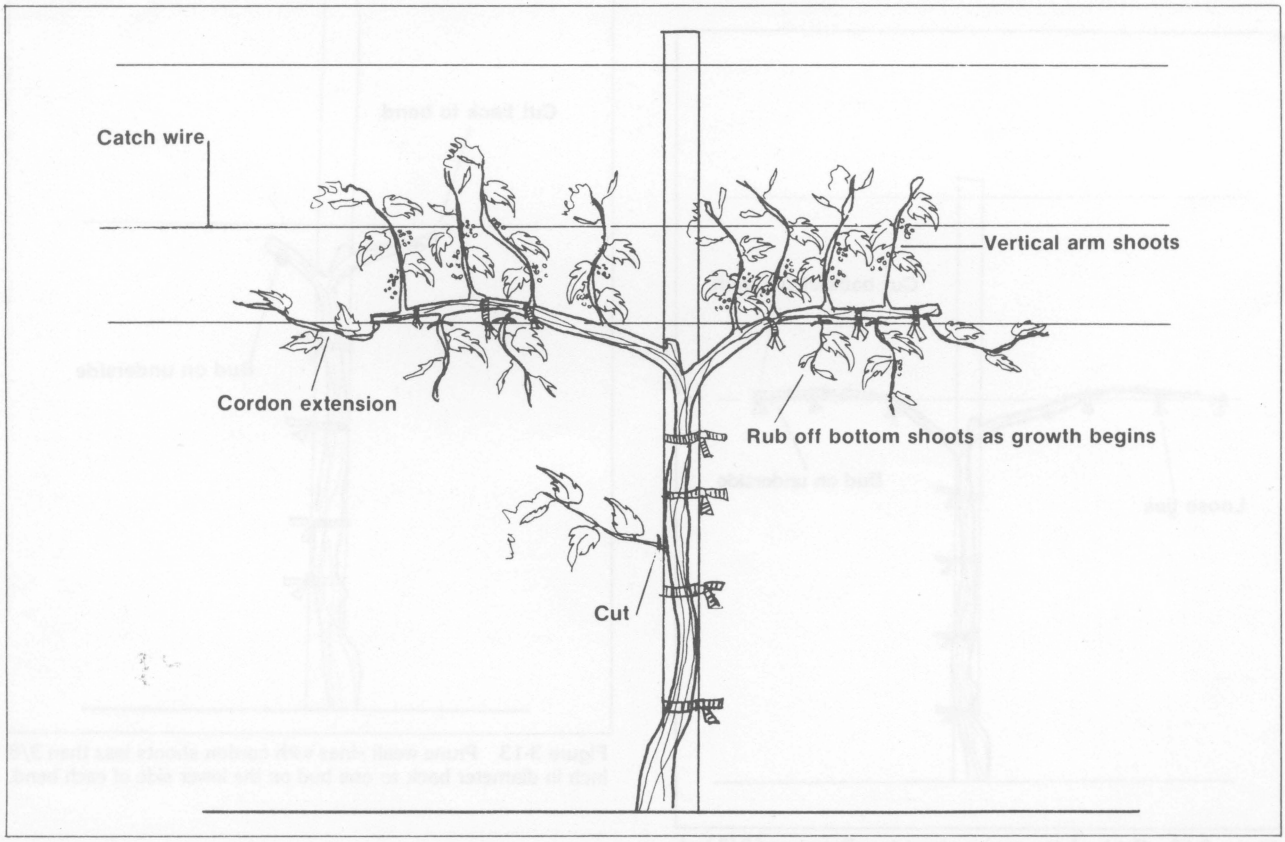

Figure 3-14 Select single vertical arm shoots and rub off shoots as they develop on under side of cordon.

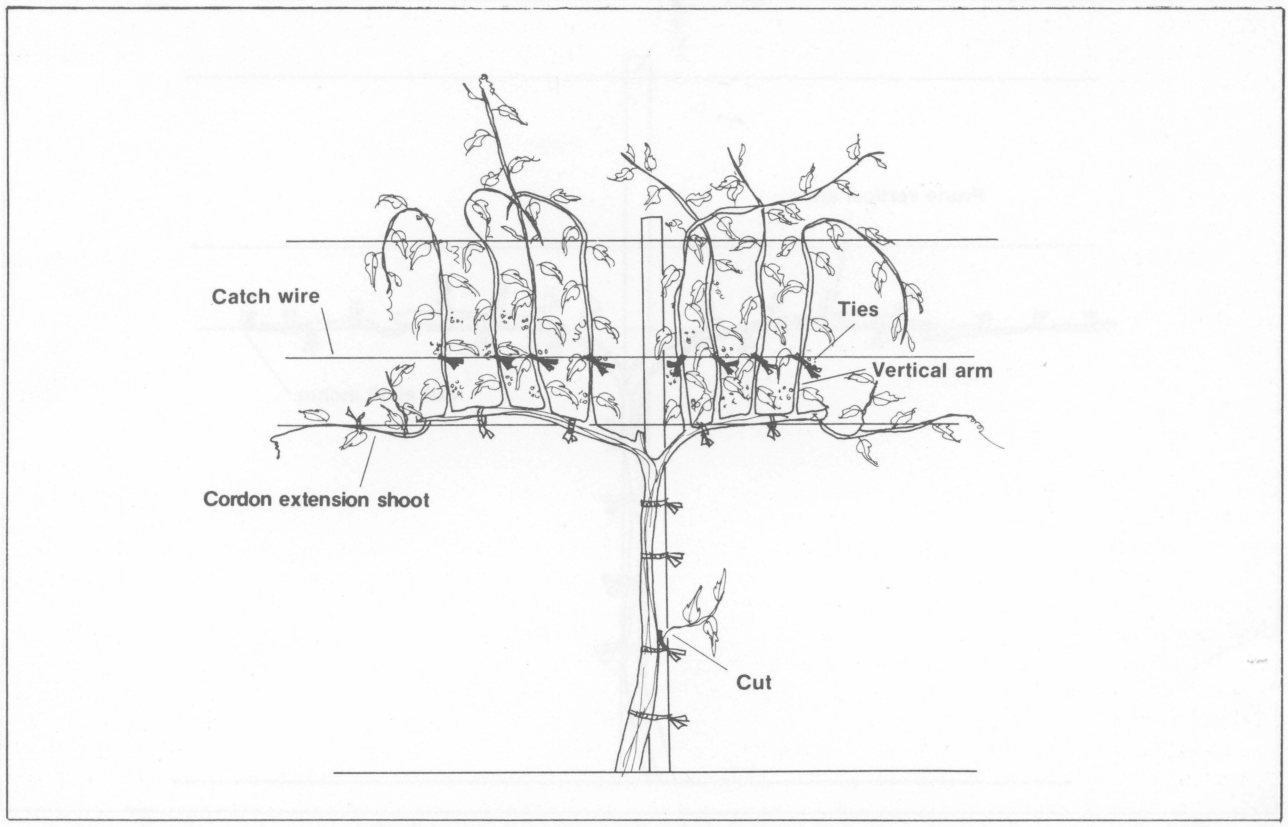

Figure 3-15 Tie vertical arm shoots to catch wire when at least 18 inches long.

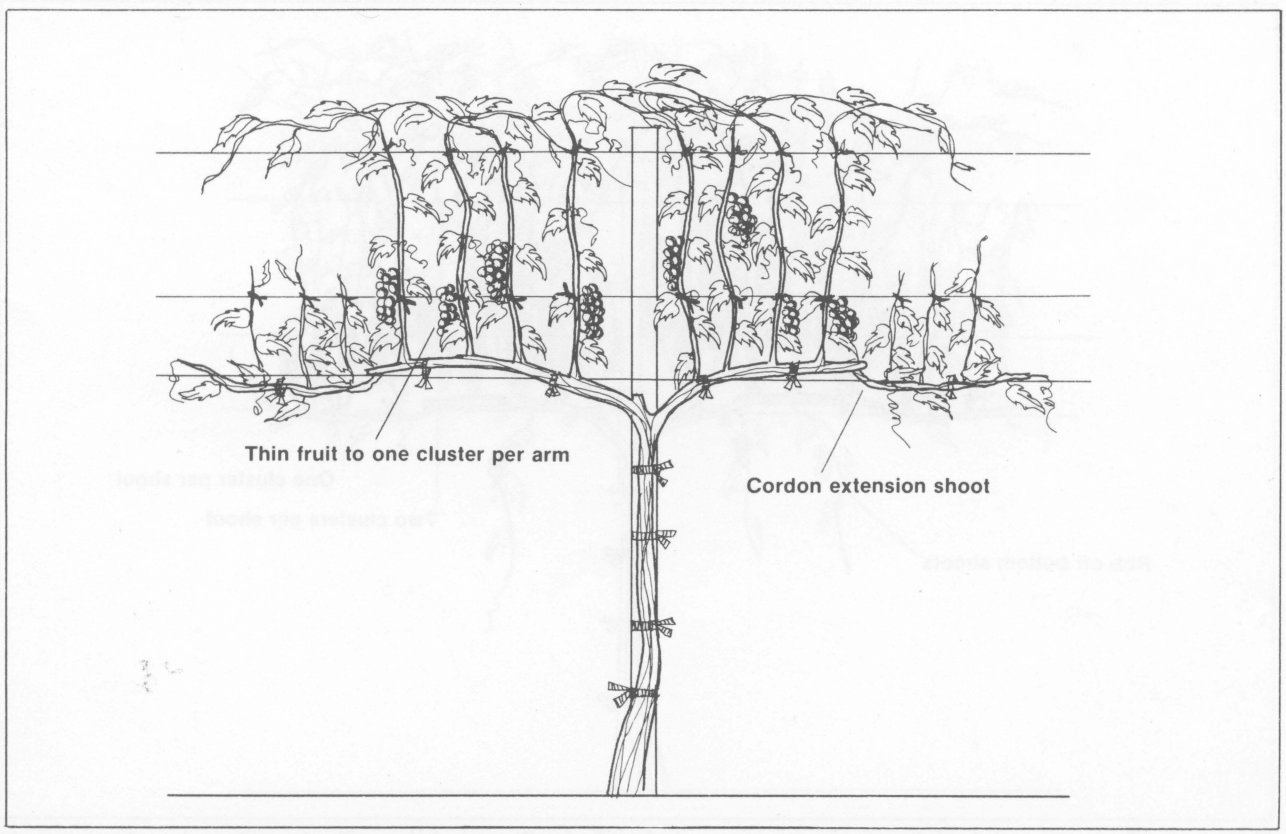

Figure 3-16 Remove all but one cluster from each vertical arm shoot during the third growing season.

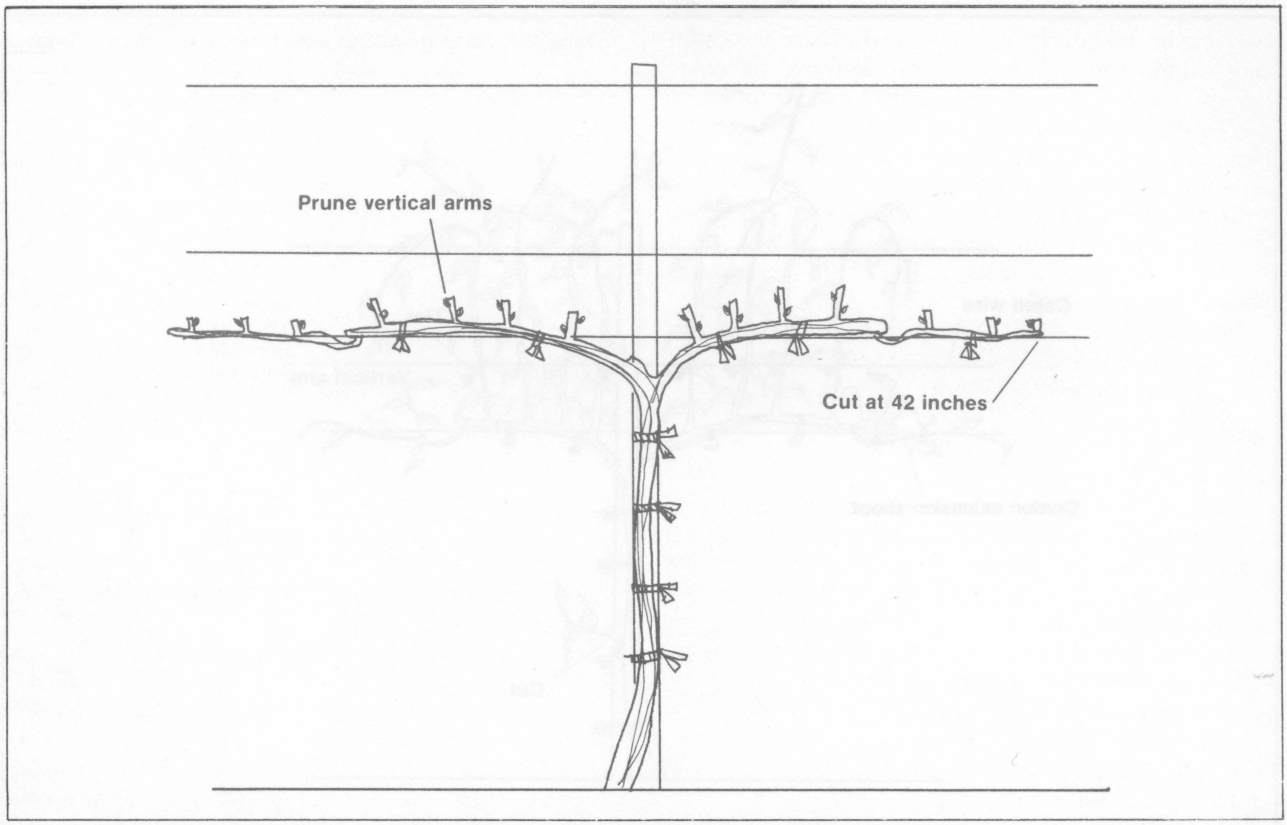

Figure 3-17 Prune the vertical arm cane back to two buds before the fourth year's growth begins.

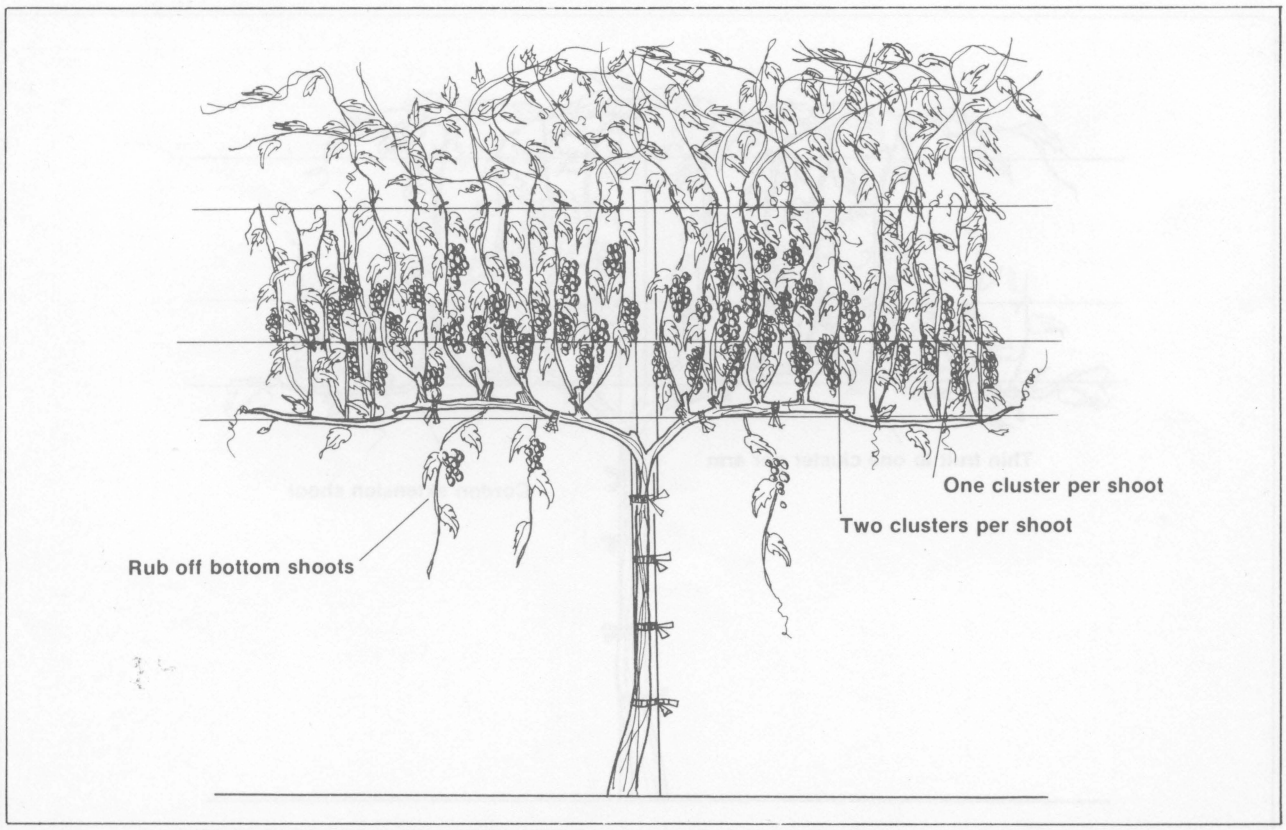

Figure 3-18 Cluster thin so that only two clusters remain on each shoot the fourth growing season. Shoots on the cordon extension should have only one cluster each.

bud and tie the developing shoot vertically to the catch wire during the growing season. Remove all other canes including growth beyond the 42-inch point or halfway to the next vine. Do not retain any canes on the bends or divide of the cordons. If necessary, untie and retie the cordons to avoid sagging.

During the fourth growing season, thin the clusters, leaving only two clusters on each vertical arm shoot (figure 3-18). Vertical arms on the cordon extensions should only have one cluster per shoot.

Maintain and perfect the vine's horizontal cordon and vertical arms in the following years. The cordons may "wrap" the wire and become self supportive.

CANE TRAINING

Most vineyards in Texas are cordon trained and pruned, but this is not always the case. Cane pruning is recommended for varieties which do not produce fruit on the basal buds such as Thompson seedless and for small-clustered varieties. In some varieties, cane training may result in overcropping. Varieties which are commonly cane pruned are listed in table 3-1.

The objective of cane training is to form a single, vertical trunk with four canes rather than cordons. There will be two canes at two wires, one on each side of the trunk. This is called the four-cane Kniffin system (figure 3-19). A second cane training method places one or two canes only on the lower wire on each side of the trunk (figure 3-20).

Table 3-1. Training systems used for varieties grown in Texas.

Cane training	Cordon training
Thompson seedless	Chenin blanc
Cabernet-Sauvignon	Emerald Riesling
White Riesling	J.S. 26-205
Sauvignon blanc	Vidal 256
Chardonnay	Carnelian
Champanel	French Colombard
Aurelia	Ruby Cabernet
	Seibel 7053
	Seibel 9110
	Seyve-Villard 12-375
	Seyve-Villard 12-309
	Black Spanish
	Herbemont
	Favorite
	Beacon
	Carman
	Carolina Blackrose
	Zinfandel

First year. The first year, prune the vine back to two buds at planting (figure 3-21). The vine is allowed to grow at random on the ground throughout the growing season (figure 3-22).

Second year. The vine is pruned back to two buds in the dormant season before growth begins the second year (figure 3-23).

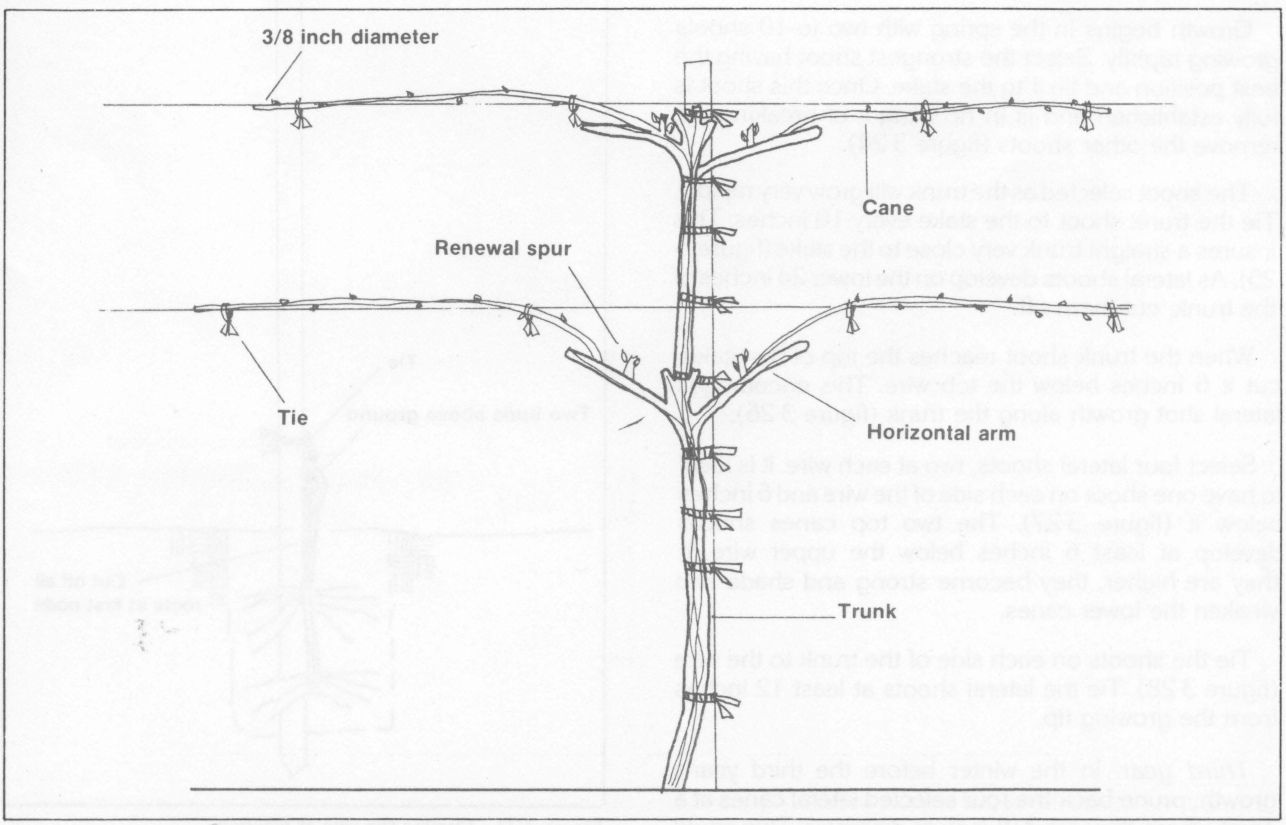

Figure 3-19 A mature four-cane, Kniffin-trained vine.

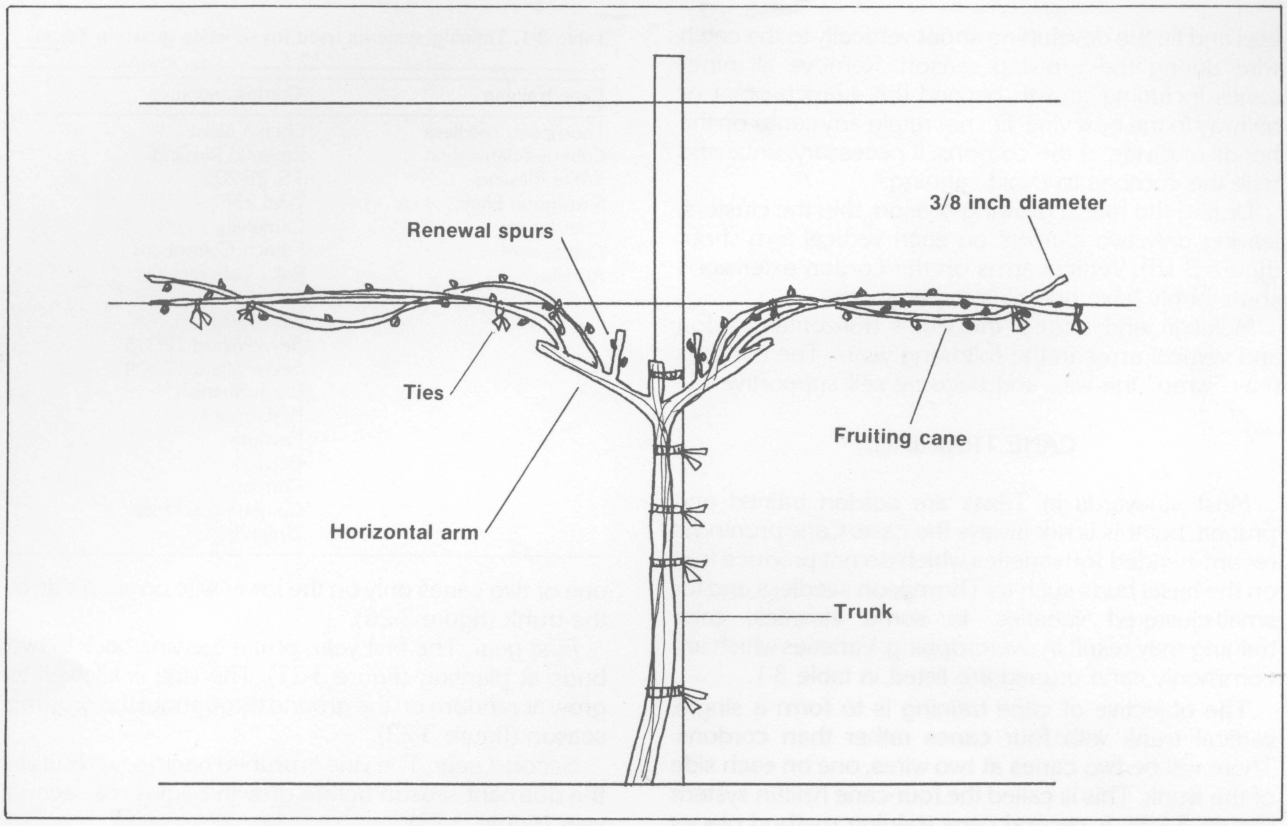

Figure 3-20 A mature cane-trained vine.

Growth begins in the spring with two to 10 shoots growing rapidly. Select the strongest shoot having the best position and tie it to the stake. Once this shoot is fully established and is in no danger of breaking off, remove the other shoots (figure 3-24).

The shoot selected as the trunk will grow very rapidly. Tie the trunk shoot to the stake every 10 inches. This insures a straight trunk very close to the stake (figure 3-25). As lateral shoots develop on the lower 24 inches of the trunk, cut them off.

When the trunk shoot reaches the top of the stake, cut it 6 inches below the top wire. This encourages lateral shot growth along the trunk (figure 3-26).

Select four lateral shoots, two at each wire. It is ideal to have one shoot on each side of the wire and 6 inches below it (figure 3-27). The two top canes should develop at least 6 inches below the upper wire. If they are higher, they become strong and shade and weaken the lower canes.

Tie the shoots on each side of the trunk to the wire (figure 3-28). Tie the lateral shoots at least 12 inches from the growing tip.

Third year. In the winter before the third year's growth, prune back the four selected lateral canes at a point where they are 3/8 inch in diameter. This could

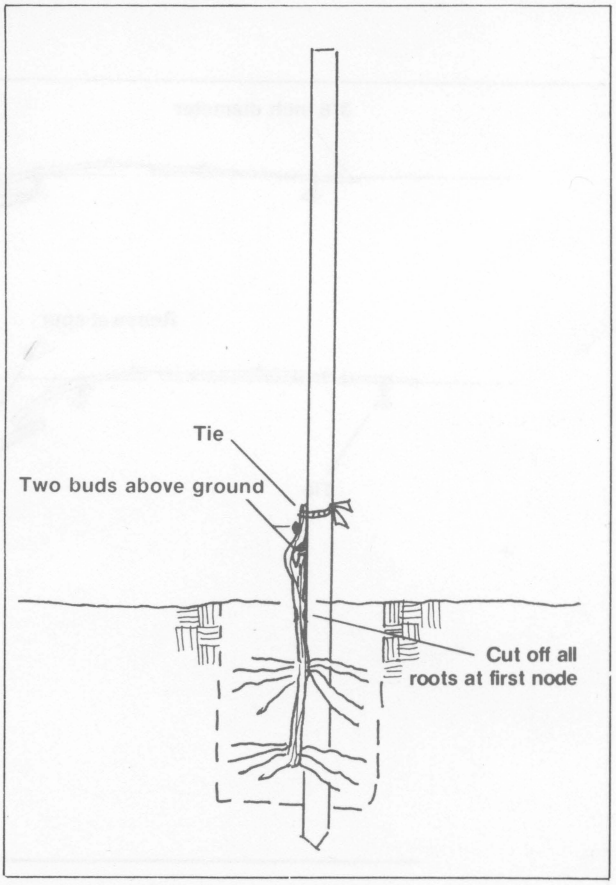

Figure 3-21 Pruning the vine at planting.

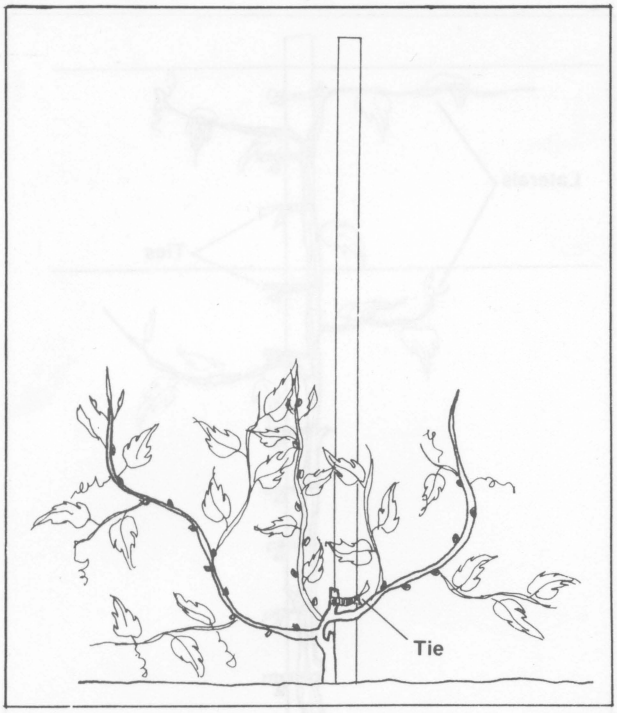

Figure 3-22 Vine grows at random the first year.

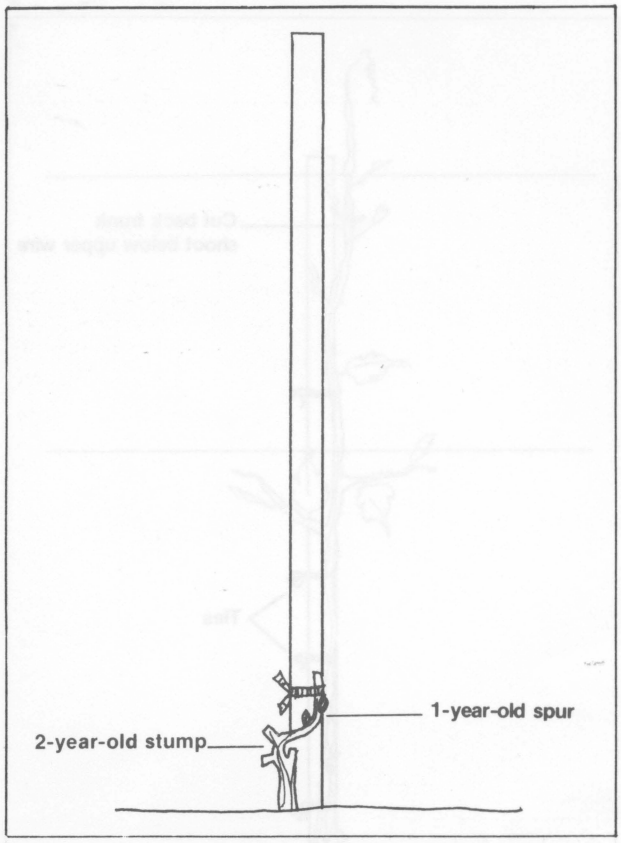

Figure 3-23 Pruning before growth the second year.

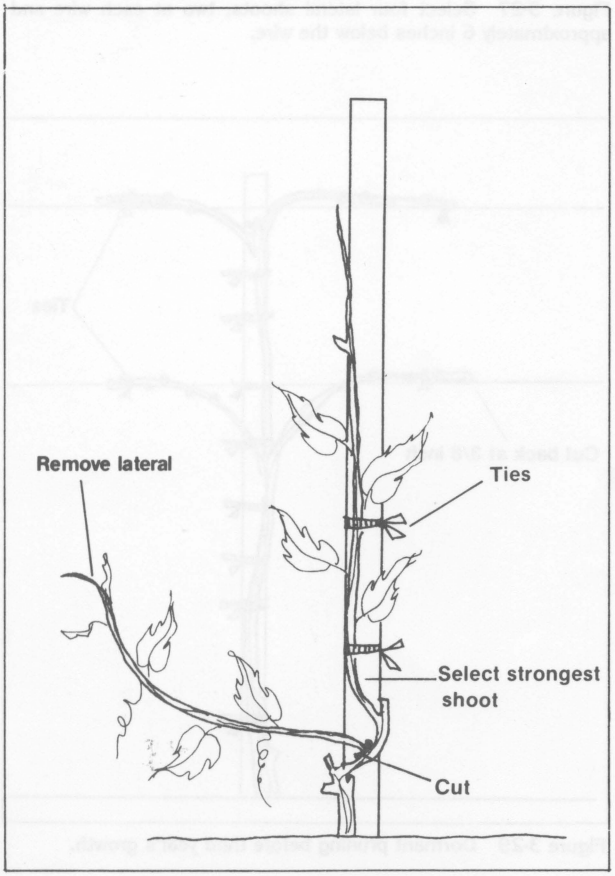

Figure 3-24 Selecting and training the trunk shoot.

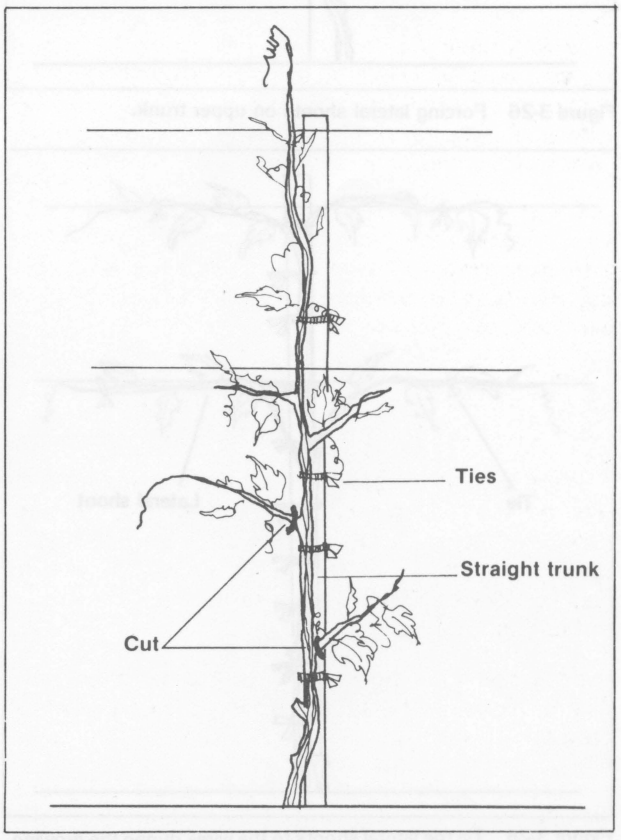

Figure 3-25 Tie the trunk shoot to stake to develop a straight trunk.

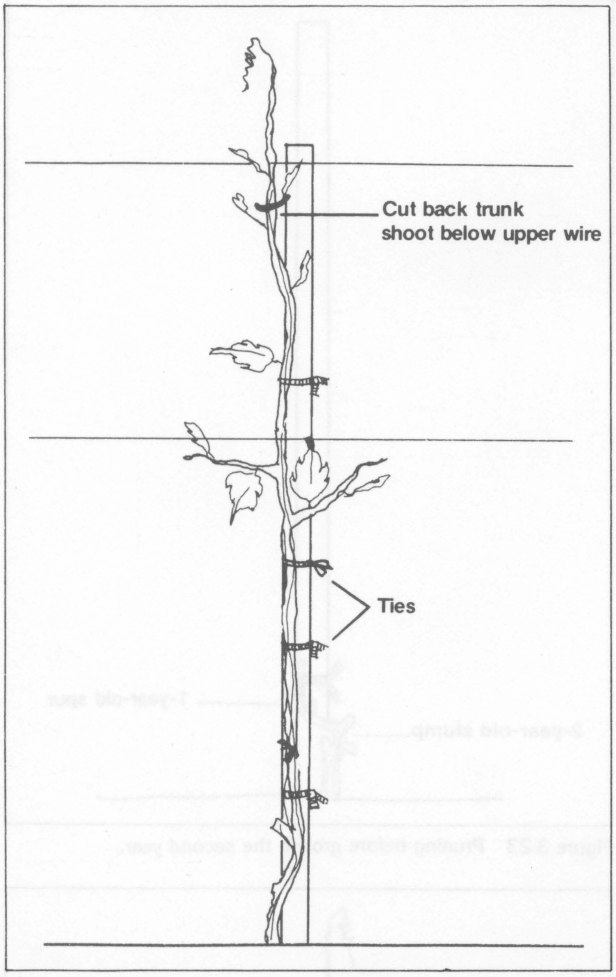

Figure 3-26 Forcing lateral shoots on upper trunk.

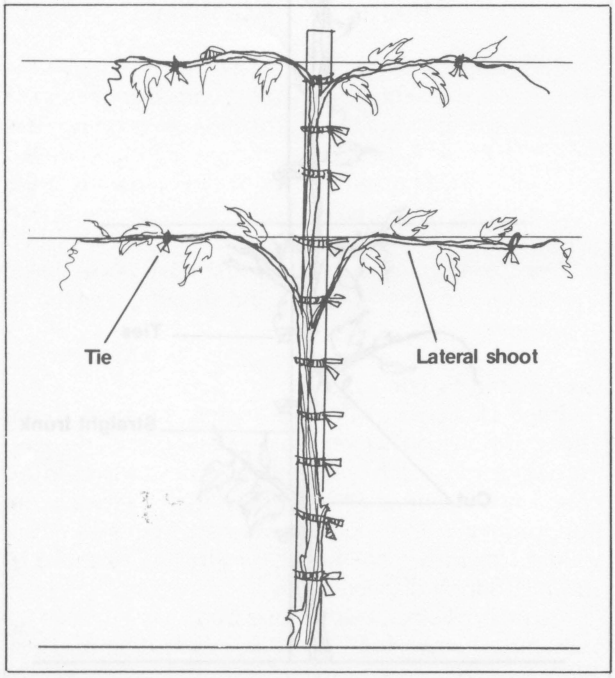

Figure 3-28 Tie the lateral shoots to the wires during the growing season.

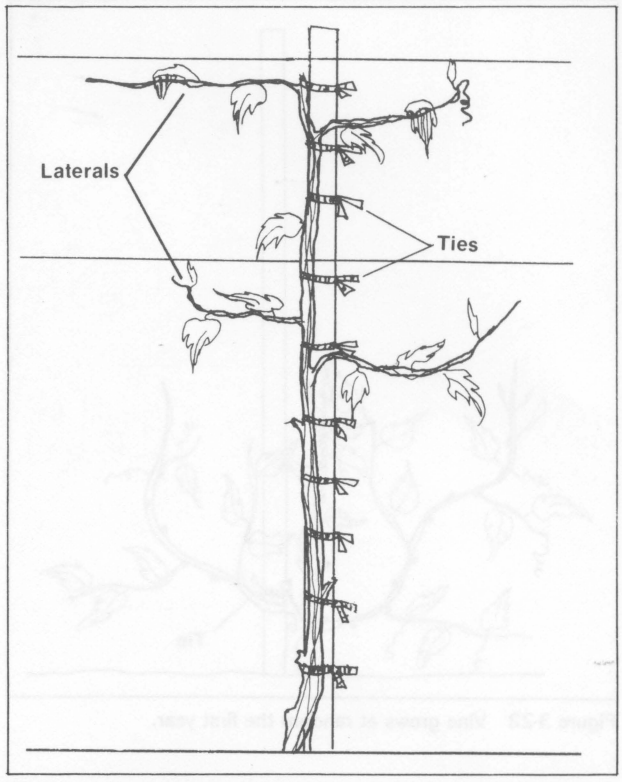

Figure 3-27 Select four lateral shoots, two at each wire and approximately 6 inches below the wire.

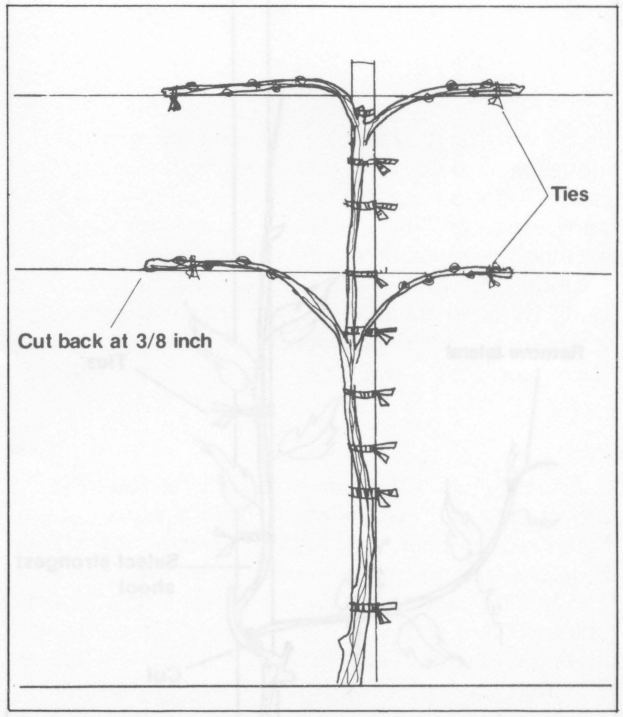

Figure 3-29 Dormant pruning before third year's growth.

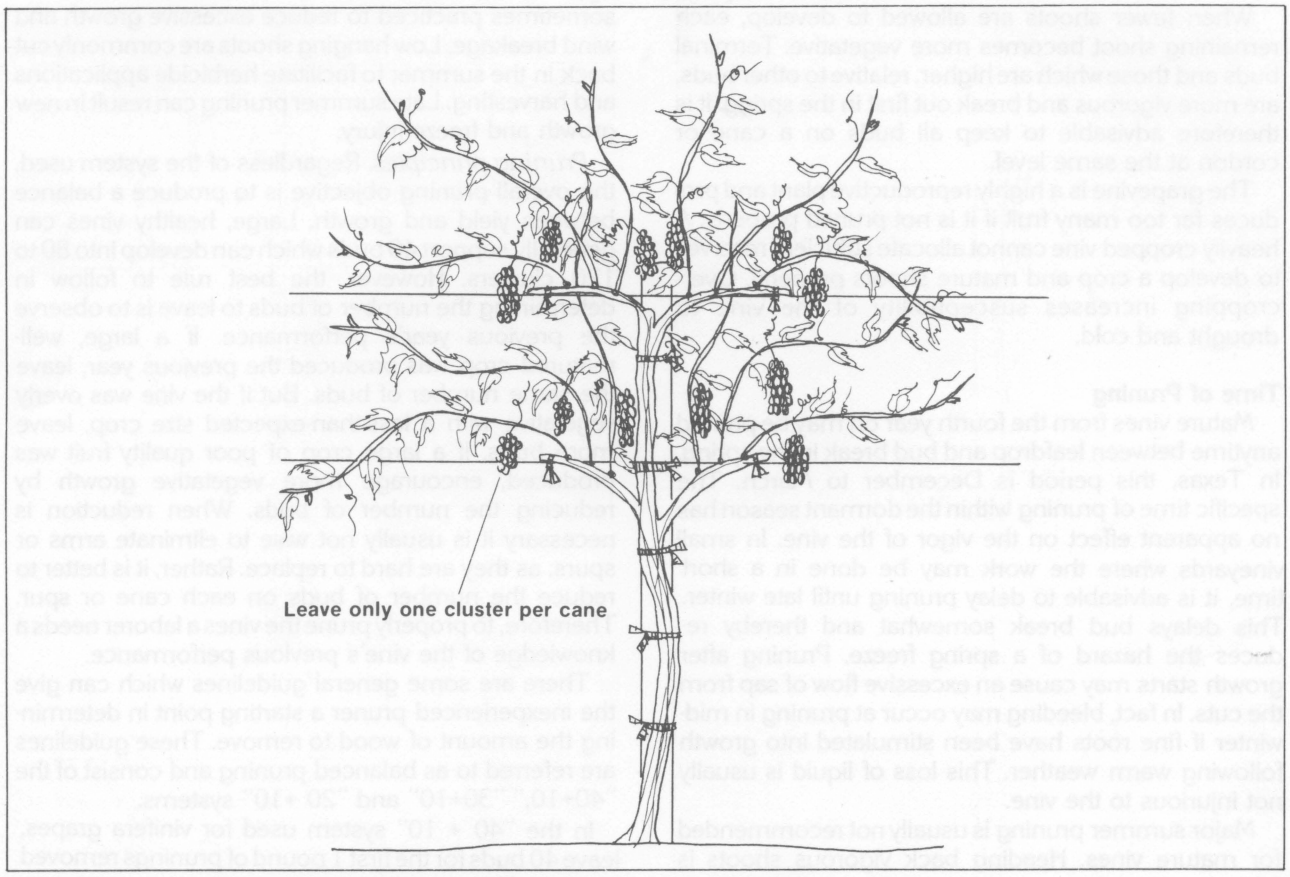

Figure 3-30 Cane-trained vine the third growing season.

be as short as 4 inches on one vine or as long as 24 inches on another vine. However, it is important for all four to be approximately the same length on a particular vine (figure 3-29). This short cane develops into the horizontal arm over the years.

During the growing season, allow growth from all buds. Remove any suckers or shoots arising from the lower trunk. Avoid overcropping in the third year by leaving only one cluster per shoot (figure 3-30).

Fourth year. In the winter before the fourth year's growth begins, develop four horizontal arms (refer to figure 4-5 on page 25). Each horizontal arm should have one fruiting cane and one two-bud renewal spur. The fruiting cane should be 42 inches long or cut at a point where it is 3/8 inch in diameter. Do not leave a fruiting cane that is smaller than 3/8 inch in diameter. The fruiting cane is growth which is only 1 year old. The renewal spur should be as close to the trunk as possible. Remove all other canes.

From the fifth year on, pruning is done to select one fruiting cane and one renewal spur from the horizontal arm each year before growth begins.

Chapter 4. PRUNING

Grapevine training is the development of young vines into a desirable form, and pruning maintains the established form. The purposes of pruning are threefold: (a) to regulate the amount of fruit produced during the growing season, (b) to direct fruiting to the proper place on the vine and (c) to maintain the vine in a form that facilitates management practices. To achieve these purposes, one must have some basic knowledge of the growth and fruiting habits of grapevines.

Growth and Fruiting Habits

Grape clusters form on the current season's shoot. These shoots, on which clusters are borne, develop from buds formed the previous summer and left on the canes after pruning. Shoots more than a year old are nonproductive and should be pruned. Canes which are small in diameter are not as productive as those of about 3/8 inch diameter.

A shoot developing from one bud may produce up to six fruit clusters, but usually only two to four develop. This depends upon variety, age and management practices.

When fewer shoots are allowed to develop, each remaining shoot becomes more vegetative. Terminal buds and those which are higher, relative to other buds, are more vigorous and break out first in the spring. It is therefore advisable to keep all buds on a cane or cordon at the same level.

The grapevine is a highly reproductive plant and produces far too many fruit if it is not pruned properly. A heavily cropped vine cannot allocate sufficient reserves to develop a crop and mature shoots properly. Overcropping increases susceptibility of the vine to drought and cold.

Time of Pruning

Mature vines from the fourth year on may be pruned anytime between leafdrop and bud break in the spring. In Texas, this period is December to March. The specific time of pruning within the dormant season has no apparent effect on the vigor of the vine. In small vineyards where the work may be done in a short time, it is advisable to delay pruning until late winter. This delays bud break somewhat and thereby reduces the hazard of a spring freeze. Pruning after growth starts may cause an excessive flow of sap from the cuts. In fact, bleeding may occur at pruning in midwinter if fine roots have been stimulated into growth following warm weather. This loss of liquid is usually not injurious to the vine.

Major summer pruning is usually not recommended for mature vines. Heading back vigorous shoots is sometimes practiced to reduce excessive growth and wind breakage. Low hanging shoots are commonly cut back in the summer to facilitate herbicide applications and harvesting. Late summer pruning can result in new growth and freeze injury.

Pruning principles. Regardless of the system used, the overall pruning objective is to produce a balance between yield and growth. Large, healthy vines can generally support 40 buds which can develop into 80 to 120 clusters. However, the best rule to follow in determining the number of buds to leave is to observe the previous year's performance. If a large, well-matured crop was produced the previous year, leave the same number of buds. But if the vine was overly vegetative with a less-than-expected size crop, leave more buds. If a large crop of poor quality fruit was produced, encourage more vegetative growth by reducing the number of buds. When reduction is necessary it is usually not wise to eliminate arms or spurs, as they are hard to replace. Rather, it is better to reduce the number of buds on each cane or spur. Therefore, to properly prune the vines a laborer needs a knowledge of the vine's previous performance.

There are some general guidelines which can give the inexperienced pruner a starting point in determining the amount of wood to remove. These guidelines are referred to as balanced pruning and consist of the "40+10," "30+10" and "20 +10" systems.

In the "40 + 10" system used for vinifera grapes, leave 40 buds for the first 1 pound of prunings removed

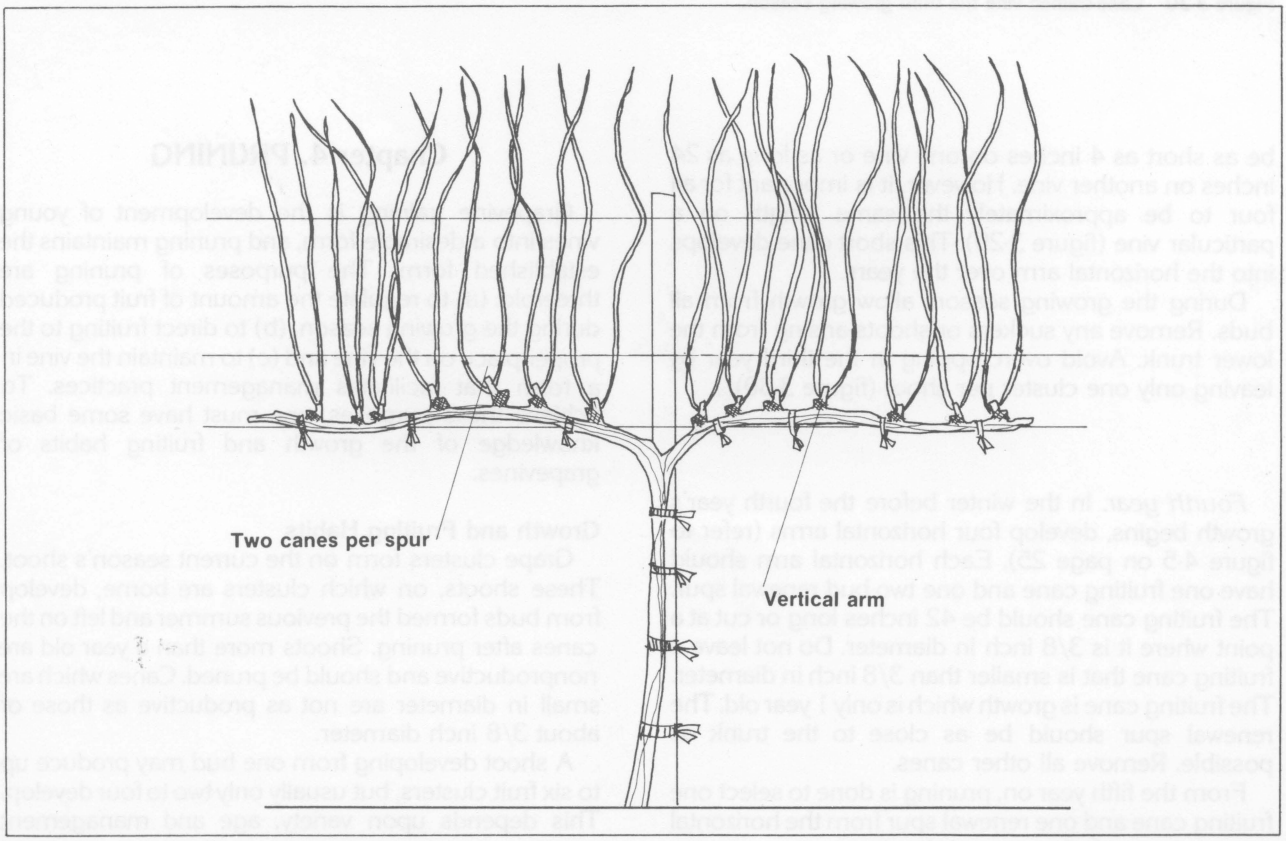

Figure 4-1 Mature vine before cordon pruning.

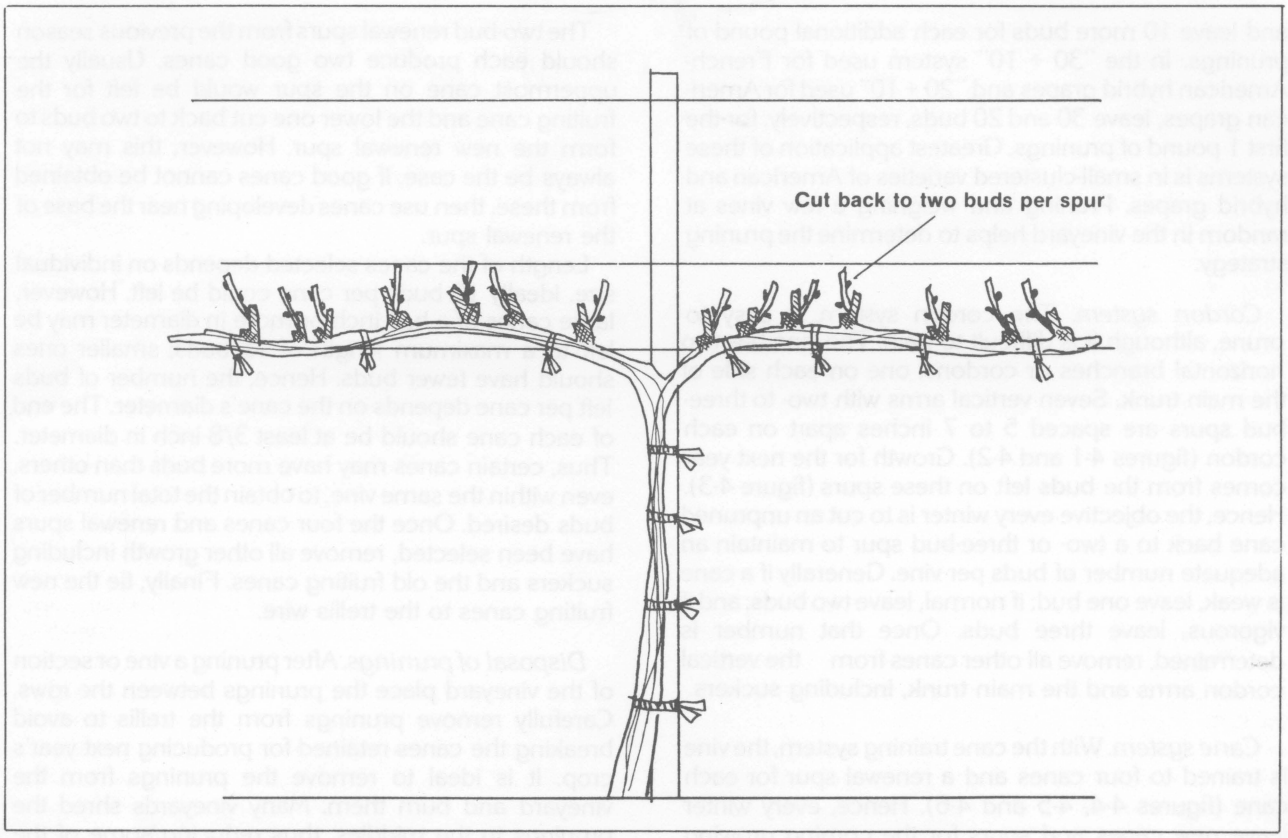

Figure 4-2 Mature vine after cordon pruning.

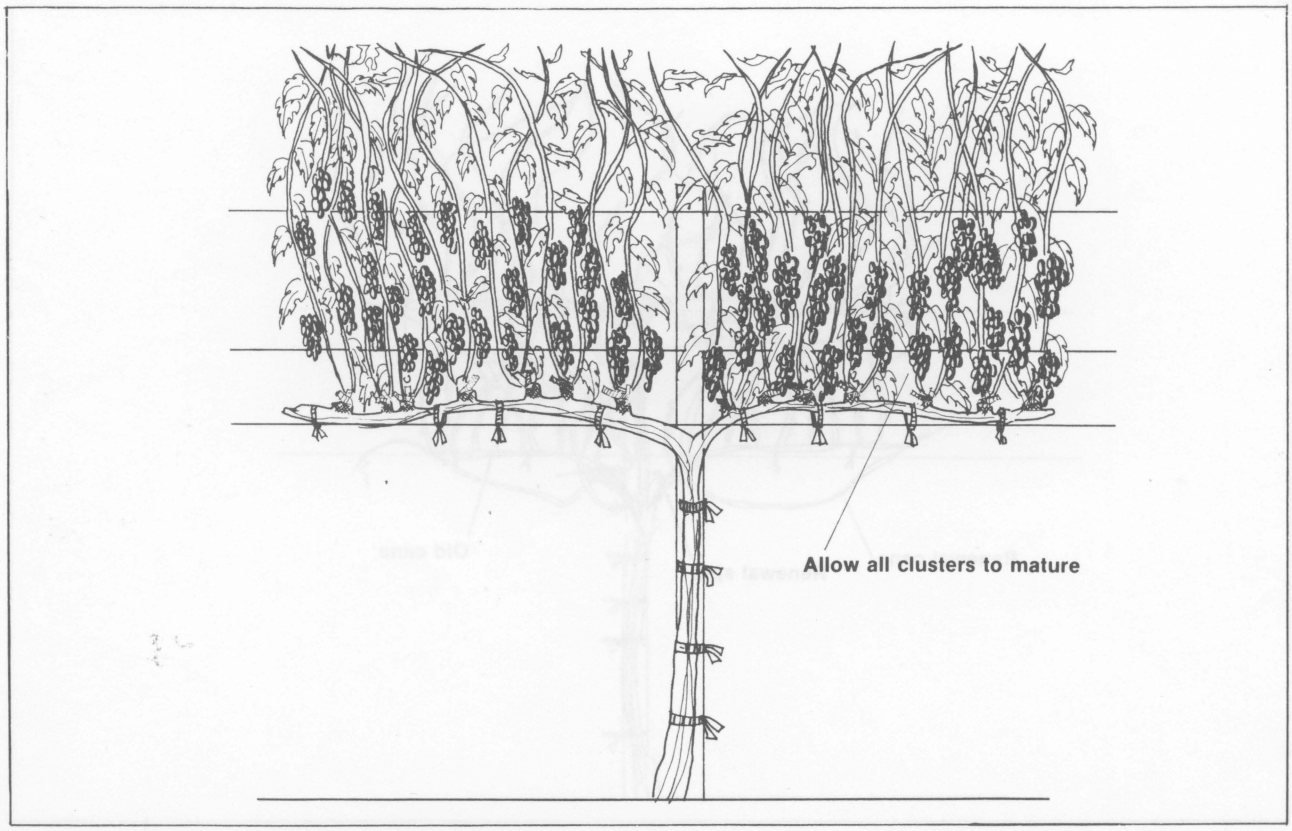

Figure 4-3 Growth and fruiting following cordon pruning.

and leave 10 more buds for each additional pound of prunings. In the "30 + 10" system used for French-American hybrid grapes and "20 + 10" used for American grapes, leave 30 and 20 buds, respectively, for the first 1 pound of prunings. Greatest application of these systems is in small-clustered varieties of American and hybrid grapes. Pruning and weighing a few vines at random in the vineyard helps to determine the pruning strategy.

Cordon system. The cordon system is easy to prune, although it is difficult to train. The vine has two horizontal branches or cordons, one on each side of the main trunk. Seven vertical arms with two- to three-bud spurs are spaced 5 to 7 inches apart on each cordon (figures 4-1 and 4-2). Growth for the next year comes from the buds left on these spurs (figure 4-3). Hence, the objective every winter is to cut an unpruned cane back to a two- or three-bud spur to maintain an adequate number of buds per vine. Generally if a cane is weak, leave one bud; if normal, leave two buds; and if vigorous, leave three buds. Once that number is determined, remove all other canes from the vertical cordon arms and the main trunk, including suckers.

Cane system. With the cane training system, the vine is trained to four canes and a renewal spur for each cane (figures 4-4, 4-5 and 4-6). Hence, every winter leave new canes and spurs for the coming growing season.

The two-bud renewal spurs from the previous season should each produce two good canes. Usually the uppermost cane on the spur would be left for the fruiting cane and the lower one cut back to two buds to form the new renewal spur. However, this may not always be the case. If good canes cannot be obtained from these, then use canes developing near the base of the renewal spur.

Length of the canes selected depends on individual size. Ideally 10 buds per cane could be left. However, large canes of a half inch or more in diameter may be left to a maximum length of 15 buds; smaller ones should have fewer buds. Hence, the number of buds left per cane depends on the cane's diameter. The end of each cane should be at least 3/8 inch in diameter. Thus, certain canes may have more buds than others, even within the same vine, to obtain the total number of buds desired. Once the four canes and renewal spurs have been selected, remove all other growth including suckers and the old fruiting canes. Finally, tie the new fruiting canes to the trellis wire.

Disposal of prunings. After pruning a vine or section of the vineyard place the prunings between the rows. Carefully remove prunings from the trellis to avoid breaking the canes retained for producing next year's crop. It is ideal to remove the prunings from the vineyard and burn them. Many vineyards shred the prunings in the middles, thus reducing some of the labor cost for this operation.

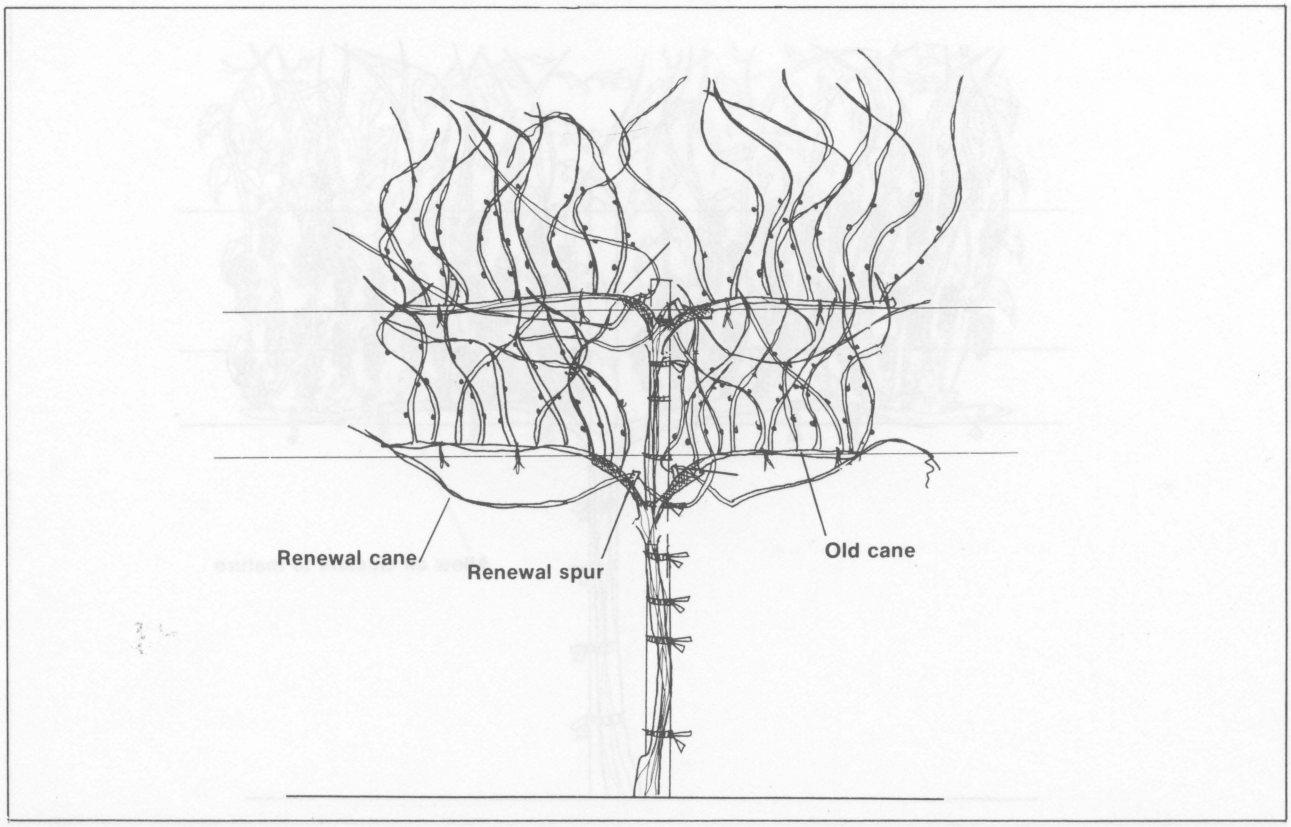

Figure 4-4 Mature vine before cane pruning.

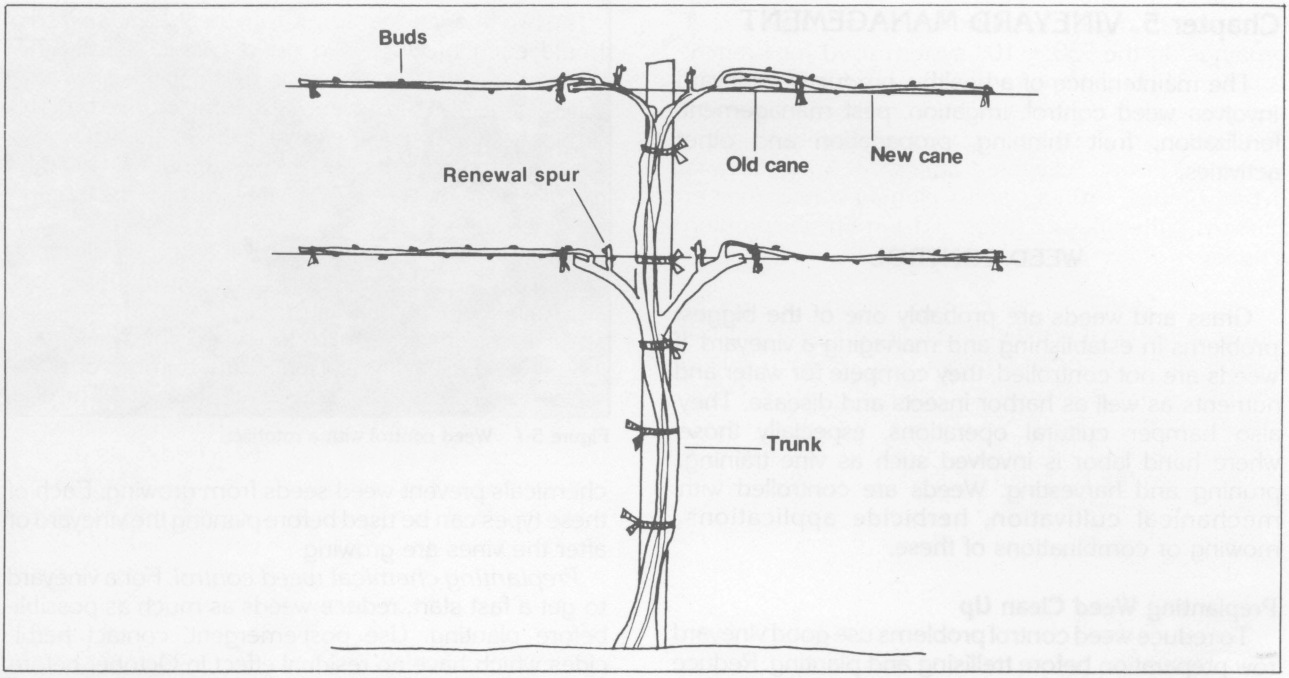

Figure 4-5 Mature vine after cane pruning.

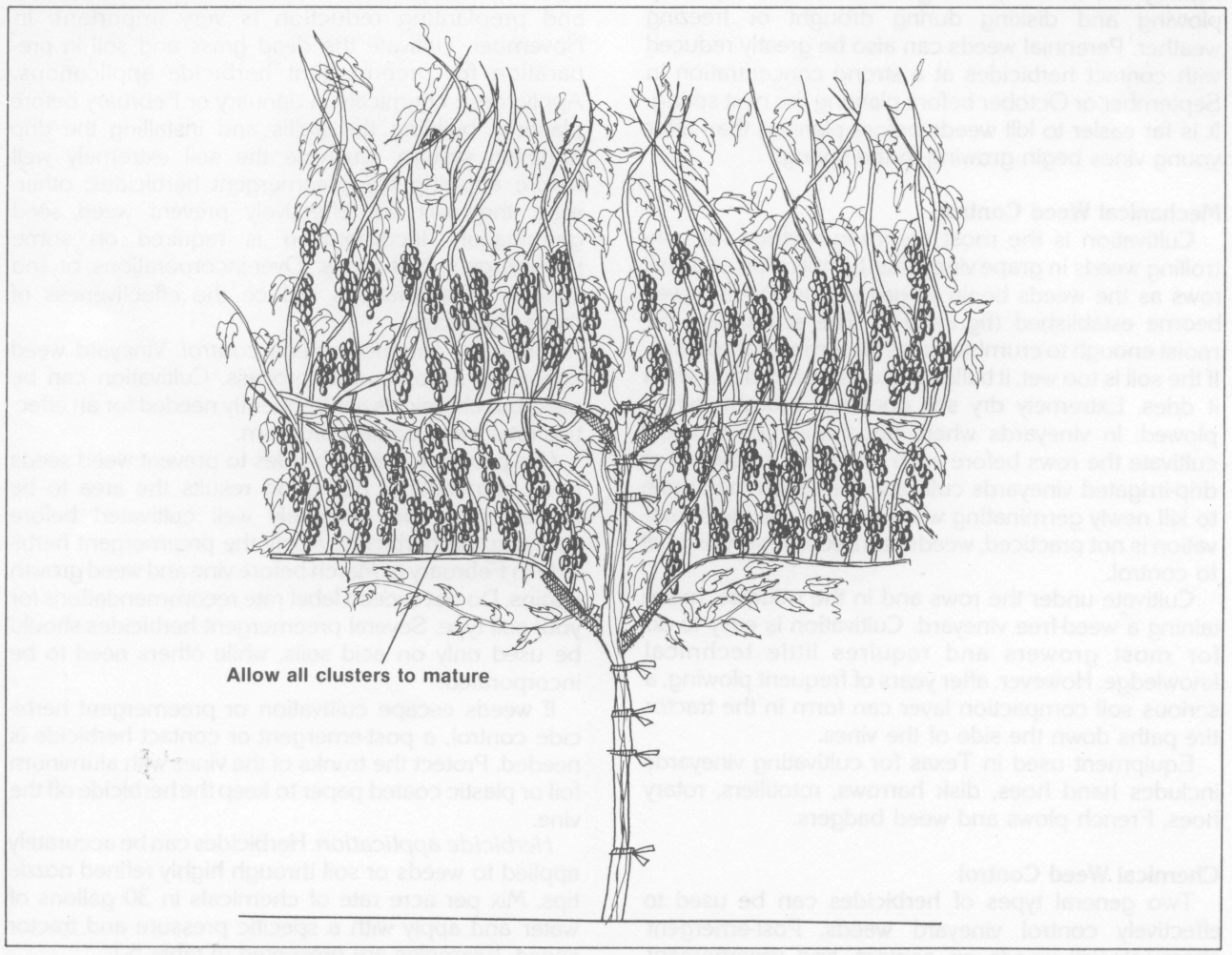

Figure 4-6 Growth and fruiting following cane pruning.

Chapter 5. VINEYARD MANAGEMENT

The maintenance of a healthy, productive vineyard involves weed control, irrigation, pest management, fertilization, fruit thinning, propagation and other activities.

WEED CONTROL

Grass and weeds are probably one of the biggest problems in establishing and managing a vineyard. If weeds are not controlled, they compete for water and nutrients as well as harbor insects and disease. They also hamper cultural operations, especially those where hand labor is involved such as vine training, pruning and harvesting. Weeds are controlled with mechanical cultivation, herbicide applications, mowing or combinations of these.

Preplanting Weed Clean Up

To reduce weed control problems use good vineyard row preparation before trellising and planting. Reduce all perennial weeds such as johnsongrass and bermudagrass before planting. This is done by deep plowing and disking during drought or freezing weather. Perennial weeds can also be greatly reduced with contact herbicides at a strong concentration in September or October before planting the next spring. It is far easier to kill weeds before planting than after young vines begin growing in the spring.

Mechanical Weed Control

Cultivation is the most common method for controlling weeds in grape vineyards. Simply plow and disk rows as the weeds begin to grow; thus weeds never beome established (figure 5-1). The soil should be moist enough to crumble as the plow moves through it. If the soil is too wet, it balls up into very hard clods when it dries. Extremely dry soil does not crumble when plowed. In vineyards where flood irrigation is used, cultivate the rows before each irrigation. In dryland or drip-irrigated vineyards cultivate after each major rain to kill newly germinating weed seeds. If frequent cultivation is not practiced, weeds can become very difficult to control.

Cultivate under the rows and in the middles, maintaining a weed-free vineyard. Cultivation is easy to do for most growers and requires little technical knowledge. However, after years of frequent plowing, a serious soil compaction layer can form in the tractor tire paths down the side of the vines.

Equipment used in Texas for cultivating vineyards includes hand hoes, disk harrows, rototillers, rotary hoes, French plows and weed badgers.

Chemical Weed Control

Two general types of herbicides can be used to effectively control vineyard weeds. Post-emergent chemicals kill weeds on contact, and preemergent chemicals prevent weed seeds from growing. Each of these types can be used before planting the vineyard or after the vines are growing.

Figure 5-1 Weed control with a rototiller.

Preplanting chemical weed control. For a vineyard to get a fast start, reduce weeds as much as possible before planting. Use post-emergent, contact herbicides which have no residual effect in October before planting to control johnsongrass or bermudagrass stands. These perennial weeds are difficult to control, and preplanting reduction is very important. In November, cultivate the dead grass and soil in preparation for preemergent herbicide applications. Apply these chemicals in January or February before planting, building the trellis and installing the drip irrigation system. Cultivate the soil extremely well before applying the preemergent herbicides; otherwise, they will not effectively prevent weed seed germination. Incorporation is required on some preemergent herbicides. Over-incorporations or too shallow incorporations reduce the effectiveness of these chemicals.

Vineyard chemical weed control. Vineyard weed control is a continuous process. Cultivation can be used but chemicals are frequently needed for an effective total weed control program.

Use preemergent herbicides to prevent weed seeds from germinating. For good results the area to be treated must be extremely well cultivated before applying the herbicide. Apply the preemergent herbicide in February or March before vine and weed growth begins. Do not exceed label rate recommendations for your soil type. Several preemergent herbicides should be used only on acid soils, while others need to be incorporated.

If weeds escape cultivation or preemergent herbicide control, a post-emergent or contact herbicide is needed. Protect the trunks of the vines with aluminum foil or plastic coated paper to keep the herbicide off the vine.

Herbicide application. Herbicides can be accurately applied to weeds or soil through highly refined nozzle tips. Mix per acre rate of chemicals in 30 gallons of water and apply with a specific pressure and tractor speed. Examples are presented in table 5-1.

Figure 5-2 Weed control using a contact herbicide.

Table 5-1. Herbicide spray nozzle calibration.

Teejet tips	Tip height	Tip spacing	PSI	GPM	MPH	Gallons per acre
8002	18 in.	20 in.	40	.20	2	30
8003	18 in.	20 in.	20	.21	2	31
8005	18 in.	20 in.	25	.40	4	29

PSI = pounds square inch.
MPH = miles per hour; 2 mph is 34 seconds per 100 feet or a slow walk.

For backpack sprayers use an 8003 tip, 20 pounds per square inch and a slow walk. These are ideally suited for small vineyards or spot treating (figure 5-2).

WEED CONTROL PROGRAM

An effective weed control system utilizing both mechanical and chemical weed control methods has been developed by the Texas Agricultural Experiment Station at Lubbock and is outlined below (figure 5-3).

Step 1. Sometime in late winter or early spring, till the vineyard to pull weed cover and soil from under the trellis. A French hoe is ideal for this purpose, but it is possible to get within 4 to 6 inches of the vines and stakes using a disk gang or a rear tool bar. If johnsongrass or bermudagrass is present, backpack spraying is needed to control these grasses around the vines. Once vines provide shade, the 8- to 12-inch strip under the vines is less of a problem.

Step 2. Weed cover, if present, is pulled out into the middle to be disked and incorporated into the soil. If heavy weeds are present, make several passes to get the soil surface smooth.

Step 3. Spray 1½ to 2 pints per acre of a preemergent herbicide down the row middles and incorporate it to a depth of 4 inches by disking.

Step 4. Then throw some of the treated soil back around the vines by reversing the direction on the disk tiller and driving fast. This usually leaves only a narrow strip or spot which is not covered with treated soil.

Step 5. In the late spring or early summer before heavy vine development, use contact herbicides to spot treat, using a hand sprayer or wick to kill escaping weeds or grass under the trellis. If weeds have been properly controlled to this point, weed problems later in the summer are easily controlled with disking, spot treatment or hand hoeing.

Figure 5-3 Weed control using a preemergent herbicide.

Herbicide Precautions

Herbicides are designed to kill plants and should not be sprayed directly on grape vines. Use herbicides only in sprayers identified for herbicides and not in insecticide and fungicide sprayers. Always read the herbicide label thoroughly before mixing and applying the chemicals. Always wash hands, clothes and body after herbicide use. Do not eat or smoke while mixing or using herbicides. Do not apply herbicides when winds are above 7 miles per hour. Take extreme caution when post-emergent herbicides are used around growing vines.

IRRIGATION

Irrigation is needed on all commercial vineyards in Texas. This is applied either by drip irrigation or flood irrigation. Avoid sprinkler irrigation because of salinity problems and fruit diseases.

Water management is more critical in arid parts of Texas. Irrigation principles are simple, but exact rules for their application are difficult. The amount and frequency of irrigation depends on location, precipitation during the growing season, temperature, evapotranspiration rate, soil's water-holding capacity, soil's water infiltration rate and variety vigor. Install the drip or flood irrigation system before vines are planted.

Establishment Irrigation

Irrigation is very important the first year of vineyard establishment for maximum root system development. During the second growing season irrigation is essential for trunk and cordon development. If growth is not rapid, proper vine training is difficult. In the third year, irrigation initiates vine vigor early in the season which continues through July to complete vine training, mature the first crop and develop strong wood for the next year's crop.

Mature Vine Irrigation

As vines come into production their water requirement increases. On mature, bearing vines water is essential in early spring as growth begins, in midseason for canopy development and 10 to 14 days before harvest when berry sugar is increasing rapidly. However, moderate stress during fruit maturation may enhance fruit quality.

Water Percolation

As rain or irrigation water enters the soil it is important for it to move through the soil. If internal drainage is inadequate, do not grow grapes. Check new sites for internal drainage by measuring water percolation. Fill a 32-inch x 8-inch test hole with 5 to 7 gallons of water. Dig the hole with a hand posthole digger. The time required for the hole to drain dry serves as a guide in evaluating water percolation. The soil needs to be moist when the test is run. The drainage index is presented in table 5-2.

Table 5-2. Classification of soil water percolation.

	Hours*
Excellent drainage	1
Very good drainage	8
Good drainage	24
Adequate drainage	48

*Time required for 7 gallons of water to drain from a 32-inch x 8-inch hole.

If the test hole has static water remaining after 48 hours, the soil is not suitable for commercial grapes.

Salinity

Every soil contains a certain amount of salt which may not be harmful until reaching a certain level. When salts accumulate beyond the critical level, available water to the vines is reduced.

Irrigation water has varying amounts of salt. Most of the salts remain in the soil after water is consumed. In most cases, rain leaches excessive salts below the root zone. But problems such as leafburns (figure 5-4) and yield reduction increase as the salt level in the water increases. If rain is insufficient for this purpose, apply additional irrigation water. In severe salinity casas, take special steps for soil and water management.

Remember that in irrigated vineyards one cannot keep a good soil indefinitely with poor quality water.

Irrigation Methods

Furrow irrigation is a common method used in grape production where there is an ample water supply with low salt problems and soil texture is medium to heavy (figure 5-5). In Texas, it is only adapted to relatively flat lands that can be graded to slopes of less than

Figure 5-4 Leaf salt burn from high salt levels in irrigation water.

Figure 5-5 Furrow irrigation with salt-free water.

0.15 percent. This is primarily in the El Paso, Lubbock and Val Verde County areas. Generally two low furrows are constructed using tractor-mounted bedders. The furrows are reconstructed after each disking and before each irrigation.

To obtain even water distribution it is necessary for the furrow to fill rapidly and add water at the rate at which it is absorbed by the soil. Soil texture and slope determine the length of run. It is shorter on light soils and longer on heavy soils.

While furrow irrigating, give attention to maintaining the furrows and the amount of water applied. In general, 1 to 1½ inches of water are needed per week from April through July supplied by irrigation, rainfall or both. Vines should not be stressed to wilting. Soils which are deep with high water-holding capacity usually require only three to five furrow irrigations per growing season.

Drip irrigation. Most grape vineyards in Texas are ideally suited to drip irrigation (figure 5-6).

Advantages of drip irrigation include the following points:

- Precise amounts of water can be delivered directly to each vine as needed.
- Water losses from evaporation, runoff and deep percolation are reduced.
- In young vineyards, water savings are particularly great.
- Weed growth is reduced between the rows.
- Localized wetting zone permits frequent cultural operations and reduces labor-scheduling problems.
- The system may be used for fertilizer application.

Figure 5-6 Drip irrigation with one emitter per vine.

- Low flow rate permits irrigation on soils where permeability is a problem.
- Salts in soil remain more diluted.

Disadvantages consist of the following points:

- A disadvantage is the high initial cost of installation.
- It is difficult to control weeds around the emitter when on the ground.
- Foreign particles in the water may cause severe clogging problems.
- Rodents, coyotes, etc., sometimes damage the lines.

The water distribution pattern under drip irrigation is much different from those under the more conventional methods. Water is added at discrete points on the soil surface rather than over the entire area.

Components and equipment. Components of a drip system can be grouped into three principal categories: (1) control head, (2) water distribution lines and (3) emitters. The actual layout and parts vary considerably from one vineyard to another, but they all have components of these three classes (figure 5-7).

Control head. This part of the system varies from one vineyard to another. A comprehensive system includes a pump, pressure gauge, water meter, filter and valves. Additional components such as a fertilizer tank and injector, manual or automatic time clock, pressure regulator, etc., are optional.

Filtration is a must for Texas vineyards. Irrigation waters contain varying amounts of sand, clay particles, salts and algae. River, canal and pond water usually require more filtration than well water. Suspended materials may accumulate in the small orifices and reduce or stop the flow from the emitters. Common types of filters are sand filters, screen filters and centrifugal filters. The type of filter required depends on water quality, ease of maintenance and emitter used.

Main lines. A system normally includes a main line which delivers water from the water source to the laterals to which the emitters are connected.

Lateral lines. Laterals are usually 1/2-inch or smaller polyethylene (PE) pipes. Laterals are stretched along

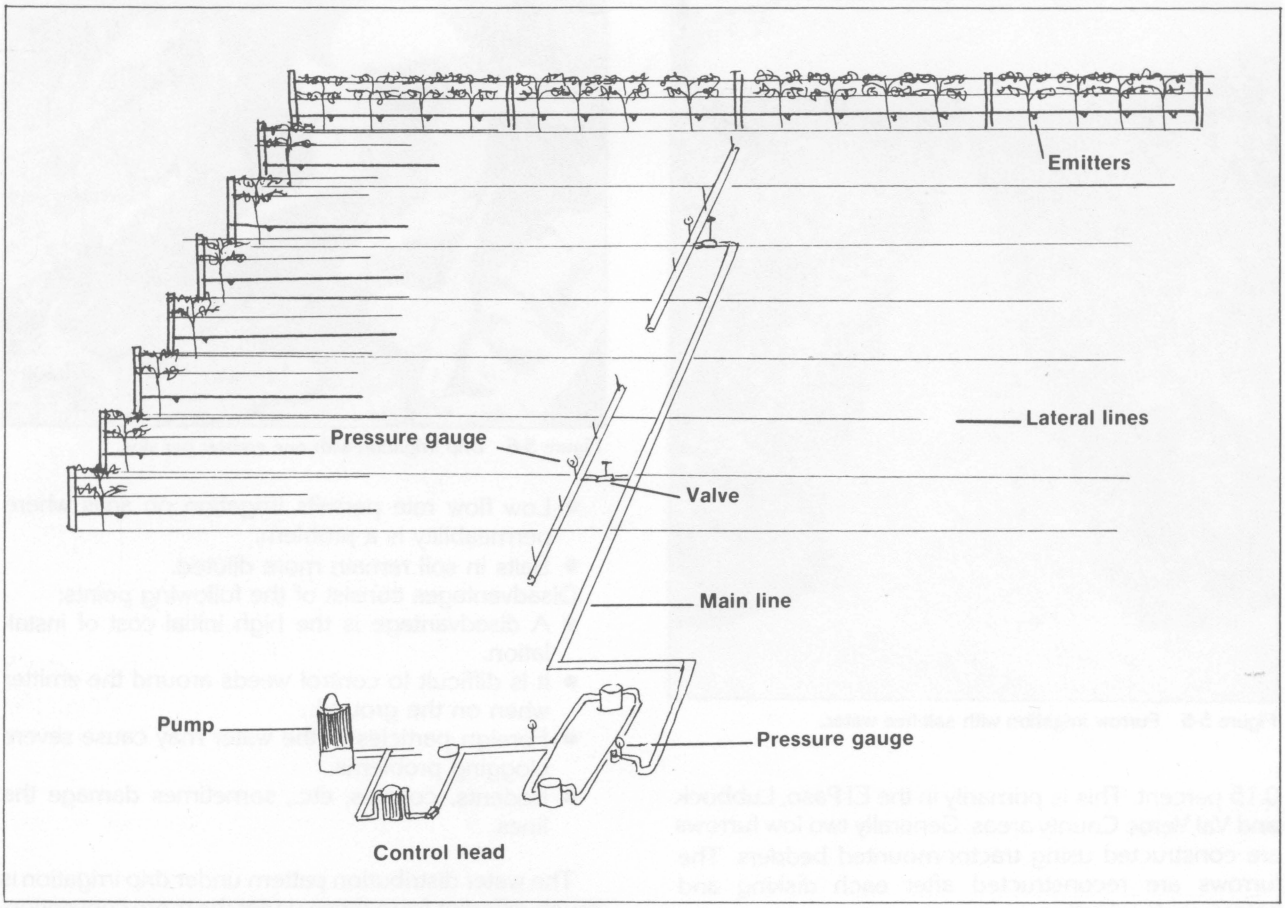

Figure 5-7 Components of a vineyard drip-irrigation system.

the vine-row. They can be hung on a low wire or laid on the surface. Hanging the lateral on a wire is very common as it enables cultivation and incorporation of herbicides. The lower trellis wire may also be used for this purpose. An outlet is needed at the end of the lateral to drain water for freeze protection and for flushing to clean out lines.

Emitters. Emitters are devices that apply water in the form of drops to the soil surface. The typical operating pressure of the emitters is 10 to 20 pounds per square inch. There is a great variety of available emitters.

Maintenance of a Drip Irrigation System

Check the system frequently to insure proper operation. Maintenance should include the following steps:

- Make sure the filter is clean and in good condition. Backflush or rinse filters after 12 hours of operation. When using surface water, clean filters more often than with well water.
- Inspect the entire system for leaks or clogging preferably every irrigation.
- Flush the laterals at least twice every season by opening the lateral end.
- Test the flow rate of the emitters. Attach a graduated container to the emitter to determine the amount of water applied in 1 hour.
- Check for plugging from the precipitation of calcium carbonate, iron oxide, bacterial slimes and algae growth. Usual treatments are acidification for calcium and iron precipitates and chlorination for bacterial slimes and algae. Chemicals used are presented in table 5-3.
- Check the operating pressure every irrigation. Never allow more than a 2-pound pressure loss from the pump to the last emitter.
- Avoid sagging laterals as this results in an uneven water supply and hinders mechanical operations.

Table 5-3. Chemicals used for flushing the drip system to remove precipitates or kill algae.

Problem	Chemical	Procedure
Precipitation of calcium carbonate or iron oxide	Sulfuric acid, phosphoric acid or hydrochloric acid	Inject acid to lower pH to 2 to 3 at the end of the lines. Once the system is acidified allow it to remain in the lines for ½ to 1 hour before flushing.
Algae	Copper sulfate or chlorine bleach	Run 1 to 2 ppm of copper sulfate or bleach through the system.

ESTIMATING WATER REQUIREMENTS

An advantage of drip irrigation is that a very small amount of water can be applied to young vines during establishment. However, in initial planning of the drip system consider the maximum amount of water that will be required by mature vines.

In determining irrigation well volume requirements, mature vines seldom need more than 56 gallons per vine per week. In arid regions of the state this volume can be as high as 84 gallons per vine per week.

During the first 3 years of a vineyard in Texas, water vines according to the following general schedule.

Table 5-4. Gallons of water applied per week per vine.

	April	May	June	July
Year 1	7	7	14	14
Year 2	7	14	14	28
Year 3	14	14	28	28

Beginning the fourth year, calculate the daily irrigation water requirement for each vine by using a class A pan formula. By using this formula, water requirements have been calculated for selected Texas locations and are presented in table 5-5.

Table 5-5. Typical peak water requirements for selected Texas locations in gallons of water applied per week per vine.

	April	May	June-harvest
Denison	40	43	57
Weatherford	46	48	71
Wichita Falls	52	54	72
Stephenville	46	48	71
Llano	37	40	57
Fredericksburg	37	40	57
Bastrop	31	35	48
Uvalde	35	40	55
Del Rio	40	43	50
Fort Stockton	55	63	74
Lubbock	41	45	54
Seminole	48	54	64
Alpine	55	63	74
Midland	48	54	64
El Paso	55	63	74

The amount of irrigation water actually needed is determined by considering only the area covered by the vine canopy.

Maximum daily evaporation for the year usually occurs during June, July or August and is the value presented in table 5-5.

Design the drip system so that the weekly water requirement can be delivered in a maximum of 3 days.

PEST MANAGEMENT

Grapes serve as hosts to numerous pests which create problems in keeping vines healthy and producing quality fruit. Fungi, bacteria, insects, nematodes, birds, deer and raccoons can all be serious pests of grapevines in Texas.

Figure 5-8 Typical leaf symptoms of Pierce's disease in South Texas.

Diseases

Texas grapes can become infected by a wide range of diseases. Bacterial, fungus and virus diseases are better prevented than controlled. Under conditions which are optimum for fungus disease growth, use fungicide sprays early to prevent disease. Once a disease develops on leaves or fruit it is very difficult to control.

Pierce's disease limits commercial production of most wine grape varieties to Central, North and West Texas. Variety trial demonstrations indicate that Pierce's disease is very destructive at Del Rio, Seguin and College Station. Pierce's disease is caused by a rickettsia bacterium and is present in numerous Texas grasses. It is transmitted from host grasses to grapevines by a leafhopper insect. It can also be transmitted by grafting.

Vines infected by Pierce's disease show a gradual decline and finally die. Leaves begin to dry up at the edges (figure 5-8). Red grape varieties have a purplish red margin next to the dead area of the leaf. As leaves dry up, the dead area is not uniformly distributed along the margins.

Growing resistant or tolerant varieties such as Black Spanish, Champanel and Roucaneuf is the only economically feasible control method for Pierce's disease in South and East Texas.

Cotton root rot affects grapevines in highly calcareous soils of high pH in Central, South and West Texas. It is not present on the South Plains of the Texas

Panhandle or on the acid soils of East Texas. The disease is caused by a highly destructive fungus, *Phymatotrichum omnivorum*, which attacks more than 2,000 different kinds of plants.

Vines infected by cotton root rot die rapidly. Seemingly healthy mature vines can be dead in only 1 week. Death commonly occurs in July just before harvest. Analysis of the trunk just below the soil line shows a reddish maroon colored rotten area extending up the stem from the rotted roots. Tan rhizomorphs of the fungus composed of many fungal strands may be found on the roots.

Tolerant rootstocks such as Mustang seedlings, La Pryor or Champanel may give some control. All other rootstocks or own rooted varieties appear to be susceptible. Soil sulfur treatments have been attempted in Mexico, but the treatment has not been completely effective. Do not plant grapes in alfalfa or cotton fields with a history of root rot.

Powdery mildew. American varieties have some resistance to powdery mildew, but all *vinifera* varieties are susceptible in varying degrees.

Powdery mildew is a fungus disease that infects grapevines in all areas of Texas.

This fungus grows on all above-ground parts of the vine. Powdery mildew causes curling and withering of young leaves and dark staining on the surface of mature leaves. It may appear as gray powdery growth on canes and when rubbed off, leaves web-like, dark brown discolorations. Other symptoms include dropping, discoloration or splitting of berries and browning and poor maturation of canes.

Begin sulfur or fungicide sprays before development of the disease in the spring approximately 2 weeks after bud break and continue every 2 weeks until berries are full size. Extensive use of sulfur may reduce beneficial insect populations and cause leaf burn above 90° F.

Figure 5-9 Serious black rot injury early in the season on Black Spanish grapes.

Bunch rot or gray mold is caused by a fungus called *Botrytis cinerea* and is common in most areas of the Texas grape industry. It is more prevalent during seasons of high rainfall.

The first signs are single berries turning brown, cracking and shriveling. As adjoining berries begin to rot a gray mold spreads over diseased berries.

Fungicide sprays at bloom time are the best prevention. This should be followed by two additional sprays 2 weeks apart.

Black rot is caused by a fungus called *Guignardia bidwellii* and can be a problem in all areas of Texas though it is seldom a problem in arid areas of West Texas and the Texas Panhandle.

Black rot first appears as small black spots on the leaves in late spring. It appears on fruit in early June as half-sized berries turn black and mummify. Under extremely moist conditions the entire cluster can turn black and mummify (figure 5-9).

Fungicide sprays every 100 hours at a relative humidity above 90 percent are required to prevent black rot. This is especially true for the Black Spanish variety in South and East Texas.

Downy mildew is a fungus disease caused by *Plasmopara viticola* in areas of East and South Texas where spring rains are prevalent. It is not common in arid areas of Texas.

White downy spots or masses appear on the lower surface of leaves. On the upper surface the spot is yellowish. Infected berries turn from dull green to brown and wrinkle. Control downy mildew with fungicide sprays during periods of high relative humidity. Benomyl is not effective in preventing downy mildew. Some American grape varieties show resistance, but additional chemical protection is usually needed. Most European varieties are very susceptible.

Nematodes are microscopic roundworms with piercing and sucking mouthparts. Several types of nematodes can infect grapevines. To date they have not been a major problem in Texas. The Dog Ridge, Champanel, Salt Creek, 1613, Harmony and Freedom rootstocks have shown tolerance to nematodes. However, the root knot nematode is present in many of the sandy soils of Far West Texas and presents a potential vineyards are estabished. Furadam® is the only chemical labeled for use against nematodes in Texas on established vines.

Crown gall or black knot is caused by a soil-inhabiting bacterium. Infection occurs through a soil-inhabiting bacterium. Infection occurs through wounds caused by hail, freeze or other factors. Rain-splashed soil carries the bacterium into the wounds. The pathogen can move in the vessels and spread to aerial parts of the vine. The bacterium stimulates the cells in plant tissues to grow rapidly, resulting in tumor-like, spongy overgrowths. These overgrowths are usually called "crown gall" when they develop around

the ground level or on roots. When they develop on aerial parts of the vine, they are referred to as "black knot." Gall development begins in the spring. Young galls are soft and cream to greenish in color. Galls may protrude through the bark, but often the entire stem is galled, and the bark is shredded and remains as thin strips over the swollen galls.

As galls age, they darken to a brown color, and the surface becomes cracked, rough and hard. When the gall dies, it becomes black and dry. Many galls die and disappear after several years.

The best prevention is sanitation. When making cuttings or pruning vines, avoid cutting into affected tissue with pruning shears, as the bacterium can spread easily from cutting to cutting or vine to vine. If the chance of cutting into infected tissue is great, sterilize pruning shears between cuts with 10 percent bleach.

Insects

Leafhoppers. Several forms of leafhoppers feed on Texas grapes from March to September. The leafhopper first feeds on leaves and stems as a nymph and later as adults. The insect sucks cell sap from the leaves. This feeding is not considered serious by some entomologists. The major problem with leafhoppers, however, is that they transmit Pierce's disease from grasses to grapevines in South and East Texas.

The western grape skeletonizer can defoliate grapevines in Far West Texas during the summer months. It is easily controlled with insecticides.

The grape leaffolder folds and eats grape leaves in every section of Texas (figure 5-10). It occurs in abundance on wild grapevines and is especially severe on Champanel vines if uncontrolled. Champanel vines have been 100 percent defoliated. There are usually three generations per year with the second generation causing the most severe damage. The larva grows from 1/16 to 1 inch long when fully grown. The first sign of grape leaffolder is folded leaves. If uncontrolled, leaves are eaten after taking on a grey color. Apply the insecticide as the insect begins to fold the leaves.

Cutworm larvae damage emerging buds and young growth in early spring throughout Texas. Cutworms eat new shoots from both primary and secondary buds on newly planted vines. Cutworms are frequently difficult to locate and identify because they normally feed at night. Use insecticide baits and larva insecticides to control cutworms.

The *grape phylloxera* is an aphid-like insect that attacks grape roots which can eventually kill the vine. It has not been a problem in Texas, but as vinifera vineyards become widespread, it could become a problem. It is controlled exclusively by resistant rootstocks such as Champanel, Dog Ridge, 1613, Salt Creek, Harmony and Freedom.

Grasshoppers can become extremely destructive to young vines during the vineyard establishment phase. They feed on other plants near the vineyard and migrate to the vines as other succulent plants mature.

Figure 5-10 Grape leaffolder on Champanel grape vine.

They are controlled by good weed control, grasshopper insecticide baits and insecticides.

Aphids are of significance to grape vineyards in early spring as they feed on young, rapidly developing shoots. They are usually very short-lived and can be controlled with several insecticides. When broad spectrum insecticides are used in abundance, friendly insects which normally feed on aphids are destroyed, and significant aphid populations can develop which can injure vines.

Green June beetles are a very common problem throughout Texas on grape clusters as they reach maturity. It is not uncommon to find 20 beetles feeding on a single cluster 1 day before harvest. They are easily controlled with insecticides.

Pesticide Usage

Do not spray grapes unless an economically significant pest problem exists. Prevent fungus diseases with fungicide sprays during periods of high relative humidity. Kill insects with insecticides when they are identified in the vineyard.

Equipment. Sprayers are generally of two types — hand gun or blowers. Hand gun sprayers need to deliver 200 to 500 pounds per square inch and at least 10 gallons per minute to adequately spray the vines. Blowers utilize a fan and high velocity air to carry the chemicals to the vines.

Pesticides need to be mixed in 150 to 300 gallons of water to adequately cover 1 acre of mature vines. For effective disease prevention and insect kill, cover each leaf and grape cluster.

Safety precautions. Vineyard managers or foremen should always mix the pesticides. They should be certified pesticide applicators with the Texas Department of Agriculture. Your county Extension agent can inform you on how to become a certified pesticide applicator. Laborers should not mix pesticides.

Figure 5-11 Butane cannon used to scare birds from vineyards.

Take extreme precaution when mixing pure pesticides with the water. When using liquids, rubber gloves are recommended. When using wettable powders, avoid inhaling the dust. Never smoke while mixing or spraying pesticides because the chemicals can be transferred from the fingers onto the cigarette paper and then into the lungs. Always wash hands and arms thoroughly with water after mixing each load of spray material. Always bathe thoroughly immediately after each spraying, making certain to shampoo hair thoroughly. The sprayer's clothing must be washed after each day's use. Do not wear the same spray-infected clothing several days in a row. When spraying, always travel so that the wind blows the spray material away from the applicator. These precautions apply for insecticides, fungicides, herbicides or any other agricultural chemicals.

Birds

Birds are common problems in most Texas vineyards. However, their damage is restricted to the fruit. Small, isolated vineyards and those with early ripening varieties appear most susceptible to damage. Monitor the vineyard for damage early in the season when the fruit just begins to ripen and change color. Early detection greatly increases the chance for success in controlling birds. There are many systems available to control or attempt to control birds. However, the keys to a good control program are diversity, persistance and imagination.

Shot guns are one method of controlling birds. However, it must be emphasized that all birds except feral pigeons, house sparrows. starlings and domestic birds are protected by law. In Texas, blackbirds, grackles, cowbirds and crows may be shot without a permit. A state and federal permit is required to kill all other birds. Also, the high costs of labor and ammunition make shooting expensive.

The most effective method for controlling birds is by using bird nets. They can reduce bird damage to nearly zero. However, nets are expensive and hard to install and remove. They also hinder harvesting.

Since it is either hard or expensive to kill or exclude birds from the vineyard, most control techniques use various scare devices or tactics. Such devices include butane cannons or carbide guns, hawk kits, distress tapes and firecrackers or bird bombs (figure 5-11). These seldom work well alone, but they work nicely in combination with one another. Since birds recognize change, butane cannons should be mounted on small trailers and moved continually to be effective. These guns are automatically controlled and have adjustable periods between explosions. Other devices such as hawk kits, distress tapes and bird bombs can be used in combination with these cannons to improve their effectiveness.

Deer

Deer can significantly damage vineyards in favorable habitat areas. Woodlands that provide deer cover generally have the biggest problem.

Deer can completely strip vines of foliage. This results in severe stunting of the vines. Buck deer can also damage trunks or cordons by scraping their antlers against them. This usually results in severe scarring and/or breakage.

Fencing is the most effective method of keeping deer out of the vineyard. At least an 8-foot high, mesh wire fence is required; higher fences may be required in some areas. It is important to fence around the entire vineyard, otherwise the deer will go around the ends of the fence to enter the vineyard. To be effective deer fences must be checked and maintained periodically.

Many repellants have been tried, but none are totally successful.

Rabbits, Raccoons and Squirrels

Rabbits, raccoons and squirrels can damage vines by gnawing on them as well as the fruit. The best way to deter these varmints and control the population is by trapping or shooting. In this way, large populations are prevented from becoming established in an area.

FERTILIZATION

Grapes have traditionally required little or no fertilizer in Texas. However, if vine vigor is low, fertilization could be needed.

As grapevines mature and begin to produce heavy yields, at least some fertilization is necessary to maintain good vigor, quality grapes and regular crops.

In Texas, during the first 2 years of vineyard establishment, nitrogen fertilizers are seldom needed except in deep sand where soil analysis shows a deficiency.

Fertilization replenishes the soil with nutrients used by the plant for fruit production.

Compared to other fruit crops, the grapevine has a modest demand for fertilizers. Only 10 percent of the total nutrients taken up by the vine are removed in the fruit. The amount removed with pruned canes varies from one vineyard to another. Some of the minerals in the leaves, and sometimes the pruned canes, are returned to the soil.

The relatively small demand for fertilizer is a result of the grapevine's deep and strong root system. With extensive branching and possible penetration into the subsoil, vine roots survey great volumes of soil.

Often grapes are grown in shallow, marginal soils of low or high pH and of poor inherent fertility. Presently in Texas, nitrogen deficiency problems rarely occur. The general rule that all Texas soils should be improved with nitrogen does not apply for grapes.

Nitrogen (N) is the major element to be concerned with in Texas. Phosphorus (P) use by the crop is very small or about 3 pounds per acre per year. Soils in Texas are usually rich in potassium (K) and do not require any amendment. Most of Texas' vineyards are grown on neutral to basic soil with a pH of 6.7 to 8.1, hence problems of zinc (Zn) or iron (Fe) deficiency may occur.

Laboratory Analysis

Observation of a vine's outward appearance is not always sufficient to determine fertilization needs as yields are affected before other symptoms show.

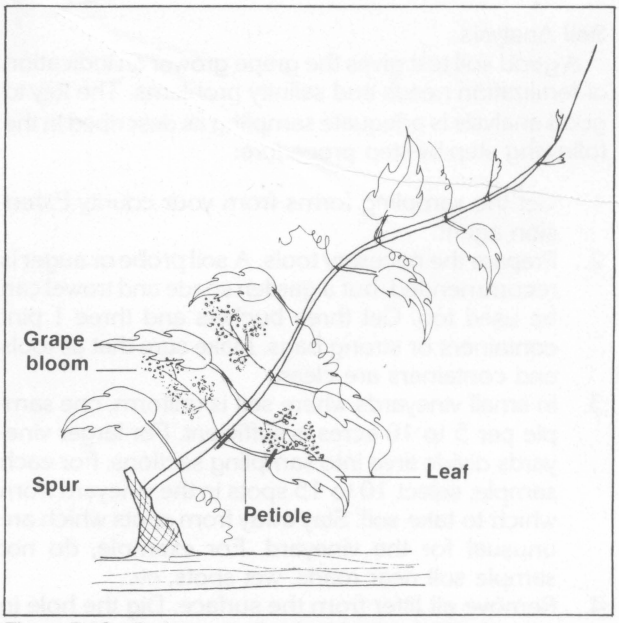

Figure 5-12 Petiole sampling for laboratory analysis.

Laboratory analysis of soil, leaf and water samples from the vineyard is recommended annually to confirm visual judgment.

The laboratory analysis for grapes is performed on the leaf petiole. A good sample size per variety is 25 to 75 petioles per vineyard or per section of 10 acres or less. Collect the petioles at or near the peak of the bloom from the leaves' opposite clusters (figure 5-12). Separately sample areas of different soil types or where other major conditions may cause a different response of the vines.

An analysis may be run for the three major elements (N, P, K) and specific micronutrients such as Zn, Fe, and B. Results are then interpreted with a set of critical values for each element (table 5-6).

Table 5-6. Nutrient composition of grape petioles.

Element	Petiole content (ppm)		
	Deficient	Normal	Excess
Nitrogen (NO^3-N)	350	600-1,200	2,000
Phosphorus (P)	1,500-2,000	3,000-6,000	--
Potassium (K)	10,000	10,000-12,000	30,000
Magnesium	3,000	5,000-8,000	10,000
Zinc	15	25-50	--
Boron*	25	40-60	300
Chloride	--	500-15,000	5,000

Blade content

These values can only serve as a general guideline since actual levels may vary with variety and location. High vigor varieties such as French Colombard may show only a moderate content of N. Therefore, visual observation of the vine should always be the primary criteria; use tissue analysis as verification.

Soil Analysis

A good soil test gives the grape grower an indication of fertilization needs and salinity problems. The key to good analysis is adequate sampling as described in the following step-by-step procedure:

1. Get the sampling forms from your county Extension agent.
2. Prepare the necesary tools. A soil probe or auger is recommended, but a garden spade and trowel can be used too. Get three buckets and three 1 pint containers or strong bags. Make sure that all tools and containers are clean.
3. In small vineyards where soil is uniform, one sample per 5 to 10 acres is sufficient. For larger vineyards divide area into sampling sections. For each sample, select 10 to 15 spots in the vineyard from which to take soil. Stay away from spots which are unusual for the vineyard. For example, do not sample soil near roads, wet spots, etc.
4. Remove all litter from the surface. Dig the hole in three steps: (a) 0 to 6 inches, (b) 6 to 12 inches and (c) 12 to 24 inches. Take a core or strip of soil about 1 inch thick for each of the three zones and put in the buckets. When using a spade, save soil from the middle of the slice. Mark the buckets accordingly (0 to 6, 6 to 12, 12 to 24). Repeat this procedure 10 to 15 times in the different spots. If the vineyard is drip irrigated, select the sampling spots 4 to 12 inches away from the emitter. For salinity tests, sample from the edge of the wetting zone. If the area is furrow irrigated, take the samples from the wetted area. Take equal numbers of soil cores from the furrow crests and the furrow bottoms.
5. Using your hands, mix the composite sample in the buckets well.
6. Fill the container or bag with ½ to 1 pint of mixed soil. When sampling for salinity analysis, use a 1 quart sample size taken from depths of 0 to 12, 12 to 24, 24 to 36 and 36 to 48 inches. Mark the containers clearly and keep a record of the samples.
7. Draw a rough sketch of the vineyard and mark the sampled spots. Without adequate records you cannot apply the soil test results to the specific areas.
8. Fill out the information sheets which provide the soil specialist with the history of your vineyard and contribute to a better recommendation. Mail the samples and information sheets to the soil lab. Soil analysis is recommended before establishment of a new vineyard and every year afterwards.

Nitrogen requirements. Fertilizer application rates can therefore range from 0 to 30 pounds of actual N per acre per year.

Sandy soils may require higher application rates. High vigor varieties require less nitrogen. Vineyards with sod in the middles generally require more nitrogen. Spot applications may be needed when only a few vines show deficiency symptoms.

Young vines in their first and second years seldom need fertilization.

Excess symptoms. Leaves are lush and dark green. Shoots have long and flattened internodes. The most significant negative effect of overfertilization with N is late season vigor which may result in severe freeze injury. It is not uncommon to have vines killed to the ground following November freezes. When excessive N is needed, flowers and berries shatter or fall off. Excessive N under droughty conditions and shallow soils could cause marginal leaf burn.

Form of fertilizer. With the choice of nitrogen source, there are four major points with which to be concerned: (a) cost per unit of N, (b) acidification potential, (c) application method and (d) equipment required. Common N fertilizers are compared in table 5-7.

Table 5-7. Common commercial sources of nitrogen.

Fertilizer	% N	Acidification potential	Application
Anhydrous ammonia (gas)	82	High	In irrigation water or soil injection. Requires high pressure equipment
Urea	46	Moderate	Broadcast followed by incorporation or irrigation
Ammonium nitrate	33	High	Broadcast followed by incorporation or irrigation
URAN 32 (solution)	32	High	Injected through irrigation system
Ammonium sulfate	21	Very high	Broadcast followed by incorporation
Aqua ammonia	20	High	Soil injection with regular equipment
Calcium nitrate	15	None. *Basic* effect	Broadcast or dissolved *and injected through* irrigation system
Mixed (complete)	Varies	Varies	Broadcast; sometimes incorporation or irrigation required

Pomace, the grape seeds and skins left over from wine production, has an N content of about 2 percent when dry and can serve as a fertilizer. It is spread down the middle of the rows and disked into the soil. It also temporarily reduces soil pH.

Time of application. The grapevine's greatest need for nitrogen is during early spring growth and through bloom. Therefore nitrogen should be available to roots as growth starts. A few days to 3 weeks are needed for most fertilizers to be converted to an available form.

The demand for nitrogen diminishes through mid and late summer. Totally avoid late season application.

Figure 5-13. Iron chlorosis on young grape leaves.

In very sandy soils where nitrate-N is susceptible to leaching, it is better to apply in two or three applications at 2- to 3-week intervals. Never fertilize after May because of potential freeze injury.

Iron

High pH in many Texas grape-growing soils causes minor element problems. Iron chlorosis is one of these.

This is very important the first 3 years of vineyard establishment. American and French-American hybrid varieties are prone to iron chlorosis more than vinifera varieties especially in Far West Texas.

New growth shows iron chlorosis first. When the deficiency is severe, old leaves are chlorotic. The network of veins remains green while leaves become pale green or yellow (figure 5-13). In severe cases leaves become nearly white followed by dark brown leaf margins. Under severe iron chlorosis conditions, vines produce poor fruit.

Correction of deficiency. Where iron chlorosis problems exist, soil treatment gives the best results. Iron ehelates are most effective. Fe-EDDHA as Sequestrene 138 or Feriplex 138 is most effective on alkaline soils.

Foliar sprays only benefit existing leaves. Repeat sprays of iron chelates are required at 10- to 20-day intervals.

Apply chelate iron to the soil at a rate of 1 tablespoon per vine in May at the first sign of interveinal chlorosis. It can also be injected through the drip system at a rate of 1 pound of chelate per acre.

First, mix the 1 pound of chelate in 50 gallons of water and then inject it through the system to 1 acre. Rootstocks of native Texas species are not susceptible to iron chlorosis.

Zinc

Mild deficiencies of zinc (Zn) have been encountered in Texas. Zn is usually present in the soil but may be in an unavailable form. Availability decreases with increasing pH, and deficiency problems may be expected in soils with pH greater than 7.0. Certain varieties and rootstocks are more susceptible to Zn deficiency than others.

Deficiency symptoms. Visual symptoms begin to show on newly formed leaves in early summer. Leaves turn chlorotic and have a characteristic widened petiolar sinus or leaf indentation where the petiole is attached. Leaves are smaller than usual, and growth may be stunted. Fruit develop in straggly clusters. Most of these symptoms can be confused with other nutrient deficiencies or viral diseases. Therefore verify diagnosis with petiole analysis.

Correction of deficiency. Foliar sprays of NZN or neutralized zinc sulfate can be used on vines. Apply NZN at a maximum rate of 1 pint per 100 gallons of water. It is essential to add at least ½ pound lime to every pound of $ZnSO_4$ to prevent foliage burn.

Water Analysis

Analysis of irrigation water for salinity, SAR or specific toxicity is advised for all vineyards before establishment and every year afterwards (figue 5-14). Usually laboratories which run soil analyses also carry out this test. Sampling instructions are available at the county Extension office.

Sample size is about 1 quart. Use of new plastic bottles is safer for shipment and freedom of contamination. If used plastic bottles are used, clean them thoroughly.

Collect samples from wells after the pump has been running for ½ to 1 hour. If the water source is a stream,

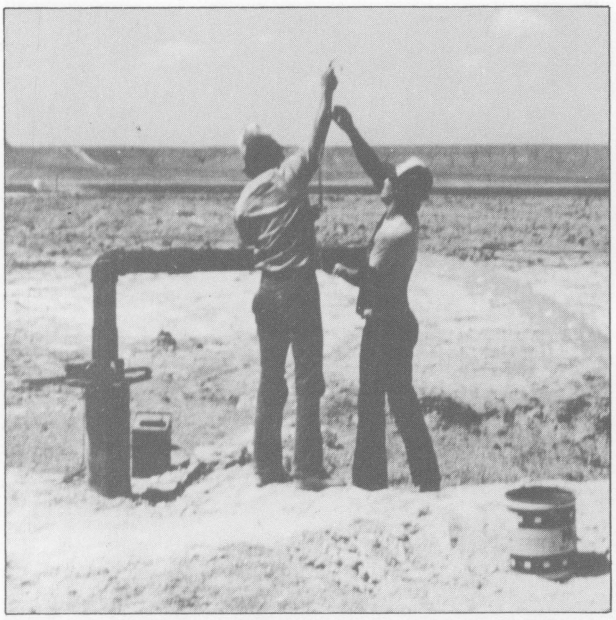

Figure 5-14 New wells should be tested for salt problems and production capacity.

collect sample of running water. Label and pack the bottles carefully, fill out information sheets and mail immediately.

Water Analysis Interpretation

Two common methods of expressing salt concentration in irrigation or soil water are: (1) in millimhos per centimeter, units of electrical conductivity (EC) and (2) parts per million (ppm). EC can be converted to ppm by multiplying EC by 640.

For grapes, no salinity problem usually occurs when the ppm is less than 640. Problems such as leafburn and yield reduction increase as the salt level in the water increases. When the ppm is 2,800 a 50 percent yield reduction is expected.

In severe cases of salinity, certain salts or ions such as boron or sodium may produce specific toxic effects. The sodium (Na) hazard deserves a special discussion.

Relatively high sodium levels cause clay dispersion and formation of massive rather than granular soil structure. This results in slow water infiltration problems. The sodium hazard is best described with the terms SAR, or adjusted SAR, which utilize the ratio of calcium and magnesium to sodium in the soil or in irrigation water. Severe water infiltration problems occur when adjusted SAR is greater than 9.0. Permeability problems are less severe when total salt concentration is high. If the irrigation water or soil SAR is above 10 when evaluating potential vineyard sites, consultation with a soil chemist is suggested.

CROP LOAD MANAGEMENT OR THINNING

Use cluster thinning to maintain vine health and improve grape quality. Thinning, along with pruning, reduces the grape crop to a level the vine should bear. Overloaded vines are weak and freeze susceptible. Also, grapes from overloaded vines ripen later, are more subject to decay and fail to develop good, uniform color.

Thinning Versus Pruning

Since thinning is performed after clusters form, thinning improves quality more than pruning does. Crop level and vine capacity can be judged better when thinning than when pruning. Hence, thinning along with proper pruning allows one to grow as many grapes as the vine will bear without decreasing quality. In the long run crop size may even increase because less severe pruning is required, allowing a greater leaf area to support the thinned crop. However, make sure that sufficient time and labor will be available to perform this task at the proper time.

Use either flower thinning or cluster thinning to thin vines.

Flower and cluster thinning is generally practiced beginning the second and third years. Remove all clusters the second year to maximize shoot and root growth. Only one cluster per bud or shoot is left during the third year. In later years, crop load is generally controlled by pruning. However, if vines are weak, it may be best to thin. Also vines that have a very heavy set require thinning to produce a high quality crop.

Flower thinning is performed between the time the shoots leaf out and fruit set occurs. The earlier this is done the greater the effect. By reducing the number of flower clusters without decreasing the number of leaves, there is more food available for the remaining berries. As a result, there is generally a better set of normal berries.

Flower thinning is usually used on varieties with loose clusters or which set many shot berries. Unless vines are very weak, never flower thin varieties that produce compact clusters, because it can cause clusters to become excessively compact. At the time of flower thinning there is very little foliage to hide the blooms, thus reducing the time required to complete the task. It can be completed in one-half to two-thirds the time required to cluster thin. However, this if offset by the difficulty of selecting the best potential clusters, and late developing clusters may be missed causing a heavier crop to set.

Cluster thinning removes entire fruit clusters after the crop has set. It is the easiest and most widely used method to reduce the crop on overloaded, high producing vines. It is used on varieties which set fruit well within the cluster but simply have too much fruit.

Essentially cluster thinning is a grading and sorting of fruit clusters at a very early stage. Undersized, misshapen or oversized clusters can be removed (figure 5-15). A method of thinning clusters late on overloaded vines is to wait until the fruit begins to color, leave the colored clusters and remove the green clusters. This reduces crop overload and gives a uniform maturity to all the clusters remaining on the vine. However, cluster thinning is a time-consuming

Figure 5-15 Cluster thinning to prevent overcropping.

Figure 5-16 Grape cuttings ready for callusing and propagation.

operation, and growers should not leave more buds than can be thinned economically.

CUTTING PROPAGATION

It is generally best to purchase vines from a nursery with a good, well-known reputation that handles healthy, vigorous and disease-free vines. The best vines are purchased from a nursery in a clean stock program.

It may become necessary, however, for a grower to produce some of his own vines if they cannot be obtained from a reliable nursery. Cuttings are used to produce such vines. Most of the vinifera cultivars root easily. American and French hybrid varieties root a little less easily, and the native American species are more difficult to establish.

Before collecting wood for cuttings, visually inspect the vines during the summer before harvest. At that time either mark the desirable vines or undesirable vines so that only wood from good vines will be taken. Select only wood from vines that are growing normally and have an average crop of well-colored fruit and uniform berry and cluster size. Avoid vines with light crops, poorly colored fruit, a shot berry condition, straggly clusters, malformed leaves, abnormally colored leaves and stunted vines.

Cuttings are collected during the dormant season when vines are pruned. Basal cuttings are considered the best. Generally they are the largest in diameter, have the most stored food and usually have shorter internodes at the base. Such cuttings form the heaviest rootings. Also, canes that have been on top of the vine, exposed to the sun, and have well-matured wood with relatively short internodes are preferred to those located on the lower parts of the vine that are somewhat shaded and have longer internodes. Cut canes into cuttings 14 to 16 inches long with four or five nodes (figure 5-16). The basal cut is made straight across through the bottom node or just below it. The upper cut is made 1 to 1½ inches above the top node at a 45° angle. Thus, it is easy to tell the top from the bottom when the cuttings are planted.

Cuttings may be planted immediately in the nursery row, or they may be stored for a short time. If not planted immediately, label and bind the cuttings with soft wire into bundles of 50 or 100. Then store the cuttings in a well-drained sand pit or trench. The pit is deep enough to permit the cuttings to be placed in an upside-down position and covered with a layer of sand 12 to 18 inches deep. The basal ends of the cuttings slowly callus in this manner. Callus forms first at the bases of the cuttings. Then the top buds begin to push. Roots do not appear at the base of the cuttings until the top buds are 1/2- to 1-inch long. The best time to plant cuttings is in April when there are roots at the bases of the cuttings and top buds are about 3/4- to 1-inch long.

Cuttings are normally planted in nursery rows 36 to 40 inches wide and 4 to 6 inches within the row following the callusing period. Plant the cuttings with only the top two buds exposed. Then water the rows to settle the soil.

Cuttings develop during the summer and fall. In the winter they are dug with shovels, a U blade or a chisel shank on the back of a tractor. Cut the tops of the rootings back to a single shoot with only two buds. Then, cut off the roots at the top node and cut back other roots to 2-inch lengths. Plant only rootings which are healthy with vigorous root and shoot growth. It is extremely important that root systems do not dry out from the time of digging until planting.

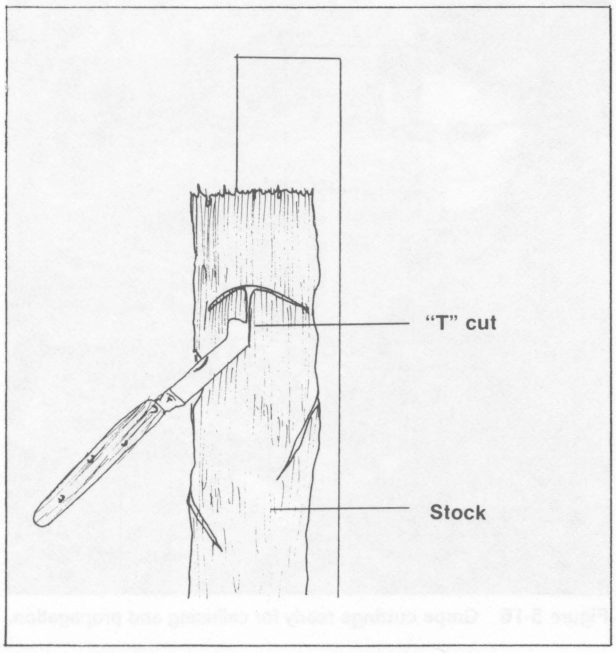

Figure 5-17 Preparing the stock for inserting the bud.

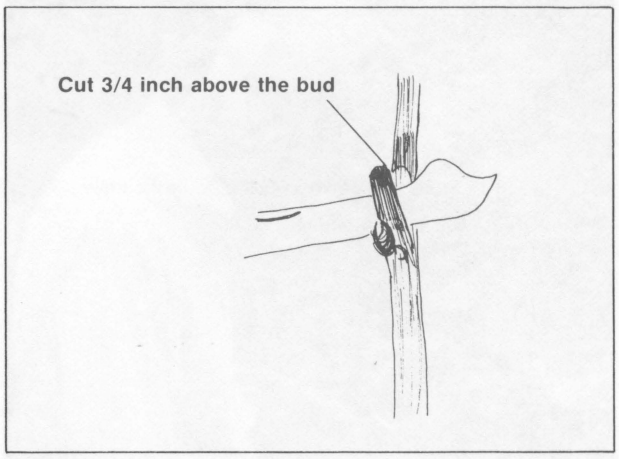

Figure 5-18 First cut in removing bud.

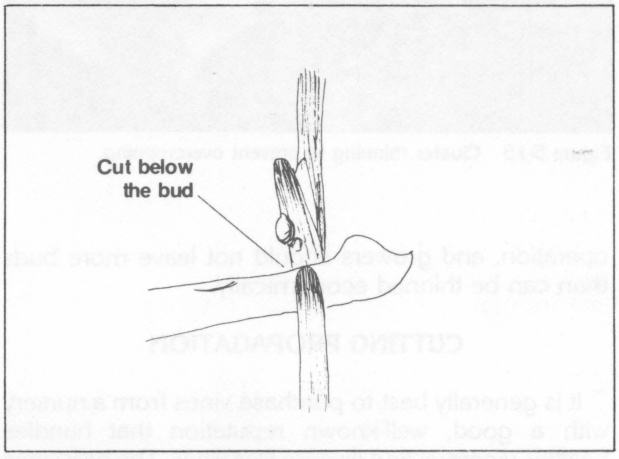

Figure 5-19 Second cut in removing the bud from the budstick.

CHANGING VARIETIES BY T-BUDDING

In the life of a vineyard it occasionally becomes necessary to change varieties because of poor performance, disease problems or a combination of both. T-budding is one of the most successful methods used to change varieties in Texas. Buds are generally placed just below the lower wire on a standard two- or three-wire trellis. This allows the original trunk to be retained so that herbicides and row plows can still be used.

Start T-budding in late April when the bark is slipping well and complete by June. This early cut-off date is necessary to get proper wood maturity to prevent freeze damage and winter kill.

Before budding, remove most of last year's brush. Leave several spurs on the old trunk so shoots can develop and cause the bark to slip. There may be 12 to 18 inches of shoot growth before the bark actually begins to slip.

Preparing the Stock

Cut the vine off about 12 to 14 inches below the lower wire. Remove all loose bark from the area where the bud is to be placed. Vine trunks are more oval than round so place the buds on those areas with the greatest curvature. Make a vertical cut 1½ inches long 2 inches below the top. Make the second cut at a right angle crossing the top of the first cut, thus forming the "T" (figure 5-17). Then use the point of the knife to peel open both corners. The trunk is now ready for the bud to be inserted.

Bud Sticks

Now remove a bud from a ½ inch diameter bud stick that was collected in January, February and March when the desired variety was dormant. The bud sticks were wrapped in moist, not wet, paper towels, sealed in a polyethylene bag and refrigerated at approximately 30° to 36° F. when they were collected.

First make a cut angling downward into the stick from ¾ to 1 inch above the bud to ¾ to 1 inch below the bud (figure 5-18). Make a second angled cut downward ½ to ¾ inch below the bud to intersect with the first cut, severing the bud from the stick (figure 5-19). These cuts are probably the hardest part of the entire procedure.

Inserting the Buds

Then insert the bud under the open corners of the bark and push the base of the bud shield well below the bottom of the vertical cut with the point of the knife blade (figure 5-20). Generally two buds are inserted at the top of the trunk opposite each other.

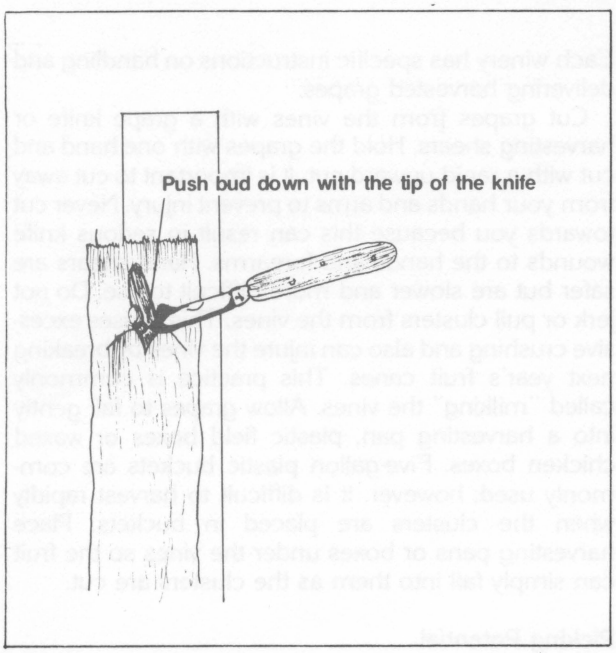

Figure 5-20 Inserting the bud.

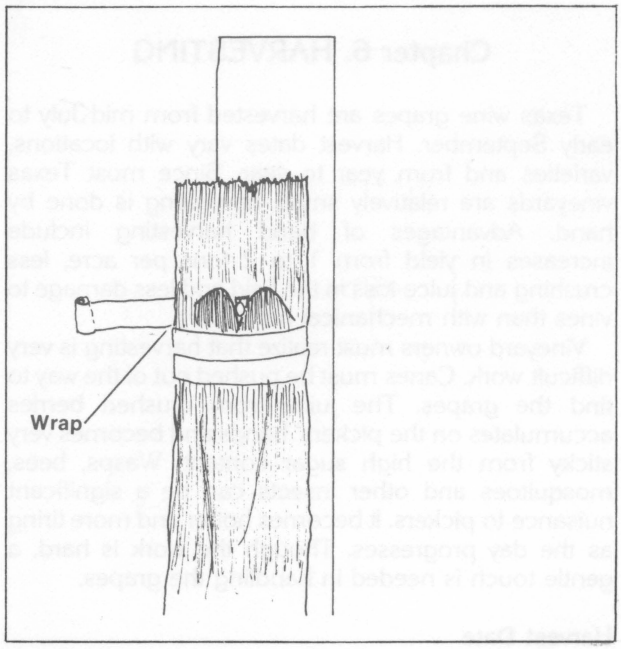

Figure 5-21 Wrapping the bud.

Wrapping the Bud

Cover the bud with tightly pulled, overlapping wraps of white, 4-mil plastic flagging tape (figure 5-21). Start the first one or two wraps of tape at the top to catch the two loose flaps of bark. Then move down below the bud and start wrapping upward. One or two wraps may be just below the bud. Place the next wrap over the bud, centering the bud in the tape. Then wrap upwards overlapping wraps to about 2 inches above the bud. Tuck the last wrap under the next to the last wrap and pull it tightly. Then use the budding knife to carefully make a very small slit in the tape over the bud being careful not to cut into the bud. The budder may also choose not to cover the bud eye with the tape. To prevent bleeding, make two slashes with a fine-toothed pruning saw on opposite sides of the trunk about 6 to 12 inches above the soil so that bleeding occurs at the cuts and not at the top of the trunk.

Figure 5-22 First shoot of a "T" bud with top of vine cut out.

Budding After Care

A few weeks after budding, the bud pushes out ½ to ¾ inch. Cut out the new growth above the bud or on the trunk. The bud will remain there for 4 to 6 weeks with no activity. Finally, the bud starts to push past the 1 inch length. After this happens, it grows very fast (figure 5-22). First one shoot develops, then a week later two or more shoots develop. As new shoots grow tie them to wires to prevent breaking off. These shoots form new cordons for fruiting the next year. Leave any fruit clusters which form the first year to slow down growth, help mature the wood and prevent freeze damage.

Inverted T-budding

This method gives as good a take as regular T-budding. The main advantage of inverted T-buds is that there is less tendency for the top shield of the bud to pull away from the trunk. Wrapping is also faster.

With either method a 90 percent take is expected. This may be even higher when more experience is obtained. It is an easy method to learn quickly.

Chapter 6. HARVESTING

Texas wine grapes are harvested from mid-July to early September. Harvest dates vary with locations, varieties and from year to year. Since most Texas vineyards are relatively small, harvesting is done by hand. Advantages of hand harvesting include increases in yield from 1 to 2 tons per acre, less crushing and juice loss in the field and less damage to vines than with mechanical harvesters.

Vineyard owners must realize that harvesting is very difficult work. Canes must be pushed out of the way to find the grapes. The juice from crushed berries accumulates on the pickers' hands and becomes very sticky from the high sugar content. Wasps, bees, mosquitoes and other insects can be a significant nuisance to pickers. It becomes hotter and more tiring as the day progresses. Though the work is hard, a gentle touch is needed in handling the grapes.

Harvest Date

The timing of harvest is determined by specific winery requirements. Conduct berry sampling on a daily basis beginning in mid-July. Collect 100 to 200 representative berries randomly for each variety throughout the vineyard. Determine the sugar, acid and pH for each variety. As harvest draws near, run the variety samples daily because sugars increase rapidly while acids decrease rapidly. In Texas, significant importance is placed on the juice acid because it is lost quickly under warm environmental conditions. It is easier for small wineries to add sugar rather than acid.

Typical chemical compositions of wine varieties in Texas are presented in table 6-1.

Harvesting Technique

Cut all low hanging canes from the vines 2 weeks before harvest. A crew of four people can harvest two rows at a time. Remove all grape clusters from the vines in one picking. Throw all green, immature or diseased fruit on the ground. Place harvested fruit on a trailer which is pulled down the rows. Grapes must be delivered to the winery the same day they are picked. Each winery has specific instructions on handling and delivering harvested grapes.

Cut grapes from the vines with a grape knife or harvesting shears. Hold the grapes with one hand and cut with a rapid upward cut. It is important to cut away from your hands and arms to prevent injury. Never cut towards you because this can result in serious knife wounds to the hands and forearms. Hand shears are safer but are slower and more difficult to use. Do not jerk or pull clusters from the vines. This causes excessive crushing and also can injure the vines by breaking next year's fruit canes. This practice is commonly called "milking" the vines. Allow grapes to fall gently into a harvesting pan, plastic field boxes or waxed chicken boxes. Five-gallon plastic buckets are commonly used; however, it is difficult to harvest rapidly when the clusters are placed in buckets. Place harvesting pans or boxes under the vines so the fruit can simply fall into them as the clusters are cut.

Picking Potential

One person can harvest 1 to 2 tons of fruit per 8-hour day. Pickers should be in the field at daylight and should stop after 8 or 9 hours or no later than 2 p.m. This insures high quality grapes and reduces the chance of laborer exhaustion and overheating.

One laborer can pick eight to ten 30-pound pans per hour. A person picking 2 tons per day will harvest 16 to 20 pans per hour. Pickers do not want to rest more than 10 minutes between trailer loads.

Crew Chief

A good crew chief is valuable and indispensable to the pickers. One crew chief is needed for every eight pickers. He is responsible for maintaining the health and moral of the pickers. This includes assigning the rows objectively, providing cool drinking water and restroom facilities, compensating workers for low-yielding rows, instructing pickers on the method of cluster removal and settling arguments. He is responsible for seeing that all fruit is removed from the vines and that no diseased or immature fruit is placed in the pans. Pans of fruit should be of high quality with a minimum of crushed fruit. He also is responsible for

Table 6-1. Composition of Texas wine grapes at harvest.

Variety	Location	Year	Date	Sugar	Acid	pH
Black Spanish	Castroville	1981	July 20	21	1.0	--
Champanel	Castroville	1981	July 25	18	1.0	--
Seibel 9110	Castroville	1981	July 17	17	1.80	--
S.V. 12-375	Castroville	1981	July 15	21	.85	--
Vidal 256	Lubbock	1981	September 10	20	.75	3.6
J.S. 26-205	Fredericksburg	1981	August 23	19	.75	3.3
Seibel 7053	Fredericksburg	1981	August 14	19	.65	3.4
Chenin blanc	Lubbock	1981	September 2	21	.79	3.5
French colombard	Lubbock	1981	September 6	20	1.02	3.4
Ruby cabernet	Fredericksburg	1981	August 14	19	.65	3.6
Cabernet sauvignon	Weatherford	1981	August 28	21	.80	3.8
White riesling	Lubbock	1981	September 7	20	.85	3.5
S.V. 12-309	Castroville	1981	July 19	17	1.0	--

issuing equipment and distributing empty containers ahead of the pickers. He issues receipts for the pans harvested for each crew to avoid disputes.

Equipment

Vineyard owners should supply harvesting knives and pans. Pickers pay a deposit for this equipment which is frequently taken from their wages. When the equipment is returned, deposits are returned.

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