

Growing Table Grapes

under the High Desert Conditions of Intermountain Western USA



By:

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Dr. Esmaeil "Essie" Fallahi is a Professor of Pomology and Viticulture and Research Director of Pomology and Viticulture Program at the University of Idaho, and the founder of the Intermountain Western region grape industry. Dr. Fallahi has spent nearly 3 decades on research on various deciduous fruits including grapes, and citrus fruit physiology. He had conducted over 25 years of research on table grape and about 15 years of on wine grapes under climatic conditions of Southwest Idaho, USA.

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DISCLAIMER

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Chapter 1

Introduction and Climate

Introduction. The annual world grape production exceeds 67 million tons. The genus *Vitis* has over 70 species of which, *Vitis vinifera* accounts for more than 90% of the world grape production. Grape germplasm collections, including wild species, cultivars, and selections have been established in many countries as a result of active breeding programs using *V. vinifera* and/or interspecific hybrids. Controlled crossing between native table grape cultivars are underway to create new genotypes and to improve qualitative and quantitative traits of existing germplasm. Part of the reason for the increase in the grape production worldwide is due to the medical reports implying certain health benefits associated with grape consumption, and the fact that table grapes are an important part of staple and snack foods all over the world.

In the United States, California is the leading producer of grapes, and thus research involving numerous cultivars and methods of production and berry sensory characteristics are well documented in that state (Andris et al., 2001), while these factors are less studied in other states. The increasing costs of gas and labor, fluctuating prices of tree fruits, and the public concerns about the global warming have created challenges for traditional tree fruit growers in the recent years. These challenges have resulted in efforts to develop table grape cultivars or to modify cultural practices to produce table grapes adaptable to regions beyond California, to reduce the cost of transportation and to create a niche market.

Table grape, even at a small scale would fit perfectly in the operation of any wine grape, small fruit, and tree fruit grower in the Intermountain West region, including Washington, Idaho, Utah, Colorado, and Oregon. Table grapes in this region are harvested when most of the fresh table grapes in California are either finished or they are only available in storages. However, pre-acclimation plunging temperatures during fall, extreme sub-freezing temperatures during December and January, and spring frost are major limiting factors for production of table grapes in the region.

Wine grapes have been grown in Southwest Idaho since the early 1960's. However, table grapes were not planted during that time on a commercial scale due to the common belief that cold desert conditions of inland PNW, including Southwest Idaho and Intermountain Western make it impossible to produce table grapes. Fallahi et al. (2001) reported performance and adaptability of several table grape selections and cultivars in Southern Idaho. Long warm days during spring and summer and cool nights during late August, September and October, combined with well-drained sandy-loam soil provide excellent conditions for production of high quality grapes with outstanding flavors in Southwest Idaho. In spite of these favorable conditions, grapes in the region are subjected to the risk of severe winter injury in some years. However, since phylloxera (*Phylloxera daktulospharia* vitifolia) has not been found in Idaho, most grape vines are established on their own roots. Thus, when severe winter injury damages the upper portions of the vines, they may re-grow and a new canopy can be established.

The Pomology and Viticulture Program at the University of Idaho initiated and has been extensively studying the adaptability and feasibility of growing table grapes in southwest Idaho, which has representative climate conditions to those of other locations in the Intermountain West region, during the past twenty four years. In this book, we will discuss various aspects of cultural practices for table grape production in the Intermountain Western region of the USA based on our results in southwestern Idaho and the existing information from other areas. The materials presented here can be applied in other places in the world with similar climatic conditions.

Climatic Conditions of the Region. The area of Idaho south of the Salmon River, Utah, Nevada, as well as the area of Arizona north of the Colorado River, and the parts of Colorado that are just west of the Rockies are collectively named the Intermountain west region. The intermountain states are so named because they lie between (or at least amidst) the Rocky Mountains, the Sierra Nevada and the Cascades. Large areas of these states are less mountainous than the typical mountains found in these states. The climate of the Intermountain Region is affected by location and elevation. The winters depend on location. In the southern parts, the winters are short, and have little precipitation, with not as much snow. In the northern portions, the winters are cold and can have significant snow, with hot and dry summers. This portion lacks precipitation as well, but the weather is moderate.

Southwest Idaho includes several counties including Canyon, Ada, Gem, Payette, Owyhee, and Washington counties. Soils in the region are sandy loams with a pH of about 6.6 to 8.3. Agricultural crops produced in the region are extremely diverse due to the relatively mild weather conditions and long growing season. The number of frost-free days that normally occur in this region are adequate for many of the major deciduous fruits, including apples, peaches, nectarines, pears, plums, cherries, wine grape, and recently table grapes, although spring frost is always a danger. It is important to note that occasionally winter temperatures may plunge down and seriously damage grapes. In the following table, key weather variables are presented for each month between 1992 through 2005. In general, climate conditions of Yakima and Tri cities in Washington are similar to that of Parma, Idaho.

Weather Factor	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average Max. Temperature (F)	36.5	44.8	56.2	65.6	74.2	82.0	92.1	90.6	80.2	67.0	49.7	38.9	64.8
Average Min. Temperature (F)	19.2	24.2	29.5	35.8	43.4	49.6	54.5	52.2	43.2	34.4	26.7	21.6	36.2
Average Total Precipitation (in)	1.32	0.92	0.96	0.88	1.05	0.82	0.22	0.36	0.52	0.77	1.14	1.21	10.16
Average Total Snow Fall (in.)	6.4	2.2	0.6	0.1	0.0	0.0	0.0	0.0	0.0	0.0	1.4	4.0	14.7
Average Snow Depth (in.)	2	1	0	0	0	0	0	0	0	0	0	1	0
Percent of possible observations for period of record. Max. Temp.: 98.5% Min. Temp.: 98.5% Precipitation: 98.7% Snowfall: 97.9% Snow Depth: 95.3%. Note: The latitude of Parma is 43.785N and the longitude is -116.942W and the elevation is 2,231 feet.													

Chapter 2

Site Selection and Soil Preparation (Photos 1-2)

Site Selection. A vineyard can be planted on flat or slopped ground. Generally, in a vineyard with a southern facing slope, grapes would often mature earlier than a one on flat ground or on a site with northern facing slope. However, since late season table grape production is one the primary objectives for growers in Idaho and the PNW, a northern slope can be used for vineyards, as well as a western or facing southern slope. Growers or home gardeners should try to select the warmest site with the least chance of cold injury during extreme winter and spring weather conditions.

Early fall and spring frost can be as detrimental to the vine as the winter injury in Idaho and the PNW. If freezing temperatures occur in mid-late October when vines are not fully acclimated, vascular tissues are damaged and this occurrence may kill the vines. Sap movement in the vines starts during early spring (usually mid to late March) under Southwest Idaho conditions. Grapes vines start their active shoot growth in early May under Southwest Idaho conditions. As the vines come out of dormancy, they become more susceptible to frost injury. Thus, vines can receive different levels of frost injury during the start of the sap movement through the early stages of shoot development. Therefore, it is important to avoid planting grapes in the bottom of draws and hills where there is a greater chance of cold air accumulation. A gentle slope with high drainage capability is a good site for planting.

A spring frost can cause a split in the bark, particularly on the southwest side of the trunk. This split becomes a potential site of entry for gall bacteria *(Agrobacterium vitis)* which can cause enlargement of the upper part of the trunk while the bottom part stays extremely thin, which cause permanent damage to the vine. Any mechanical injury such as a wound caused by a hoe or tractor when weeding can become a site of entry for crown gall bacteria. Thus, efforts should be made to reduce or eliminate both spring frost and physical injury. Gall-infested vines have knobby on roots, trunk and arms of grape vines. Galls first appear in early summer as a white, fleshy callus growth, and turn brown by late summer and become dry and corky in the fall. Vines with severe gall damage have poor growth and are more susceptible to adverse environmental conditions such as frost.

Site Preparation. The vineyard soil should be ripped down to 24 inches or more at different directions (north-south and then east-west) and disked before planting. Grape vines can be grown in a wide variety of soils type but they do best on deep sandy loam soils with a pH of 6.5-7.5, which are typical of those in southern Idaho.

Soil needs to be tested for its physical and chemical properties as well as for nematode and other parasites in a reliable laboratory. Most soils in southwest Idaho would benefit from a pre-plant application of phosphorous. However, one should be aware that over application of P could induce zinc deficiency in the future.

Vineyard soils may need to be fumigated if the laboratory recommends so. This is particularly true when the site was previously planted with a crop that had nematode infestations. One should make sure that no residual fumigant remains in the soil at the time of planting. There are rather simple tests that certain laboratories including the Nematology Laboratory at the University of Idaho Parma Research and Extension Center and Western Laboratory in Parma, Idaho can perform to determine if the soil is safe to plant after a fumigant is applied to the soil.

Chapter 3

Grape Vine Propagation (Photos 3-20)

Grape vines can be propagated in different ways: 1) Rooting the dormant cuttings, 2) Direct start of the plant in the green house, 3) Direct planting in the vineyard. These propagation methods are described in detail as follows:

1) Rooting the Dormant Cuttings: Dormant cuttings 0.25 to 0.75 inches in diameter and 14 inches in length can be obtained from Foundation Plant Materials Services (FPMS) at the University of California-Davis or other sources. Orders from FPMS should be made by mid-November of the year prior to propagation. The cuttings from Idaho vineyards should be taken from late February to about March 20, while vines are still dormant. Cuttings can be as long as about 16 inches or shorter than 14 inches as long as each cutting has about 4 to 10 nodes. Internodes in some cultivars are shorter and thus have higher numbers of buds per unit length. We suggest taking uniform-sized cuttings and not mixing cuttings of different cultivars in a bundle. Cut the basal portion of each cutting flat and the top of the cutting at a slanted angle. Put the dormant cuttings in bundles of 2 to 100 and wrap in two places, one wrap near the top and the other one near the middle of the bundle. This will provide cuttings with more room on their basal portion for root development, thereby reducing the possibility that roots of different cuttings will intermingle. Tag each bundle with the name of cultivar and date of burial in the rooting pit.

Dip the cuttings in IBA (Rootone) to stimulate rooting. This hormone can be purchased either as a white powder or in solution form, although the solution form is easier to use. Make a solution of one portion Rootone and nine portions water and dip the basal end of each bundle in the solution for only 5 seconds. Remember that soaking for a long period could damage the tissues. Dig a 2-ft deep hole in the ground, and bury the dormant cuttings in damp soil with the basal ends upward and only about 1 inch of the cutting exposed. It is essential to add water to make sure all air pockets in the rooting pits are filled with damp soil. Then, cover the rooting ends of cuttings (the 1 inch of the basal ends that is exposed) with about 1.75 inches of fine sand. If practiced correctly, 1 inch of the basal ends of cuttings will be covered with sand and additional

0.75 inches of sand will cover the top of the entire rooting pit. Spray some water to dampen the sand and soil and then cover with heavy black plastic. Make sure to tack the edges of the black plastic in the soil around the hole. Keep sand damp (but not soaking wet) for about 6 to 9 weeks (March 5 to May 12), depending the temperature. With this technique, the rooting end of each cutting is kept warm and moist, while the rest of the cutting is kept cooler. After this period, roots or callus is formed only on the rooting area, while the rest of cutting is not as advanced.

At this time, the cuttings will have varying degrees of initial rooting-tissues, ranging from extensive tender, white roots to only callus tissues. The more advanced the rooting system provides a greater chance is for a successful planting. However, in most cultivars, a reasonable amount of callus formation is sufficient to produced a good root system after planting. The method of handling theses callused/rooted plants is extremely critical at this step. Take the bundles out of the pitting ground very gently and carefully. Although it is almost impossible to avoid breakage of tender roots and occasionally newly grown buds/shoots, one should try to keep the breakage at a minimum. Keep the rooted or callused bundles in damp peat moss or in covered container and carry to the actual planting site or nursery. Care should be taken to avoid exposure to light, high temperature or wind. Accordingly, this process will be more successful on a cloudy, calm, and cool days. Plants handled in this manner can only be kept for a few days in damp peat moss in a cool and dark place, and therefore should be planted as soon as possible.

2) Direct Starting of Plants in Containers in the Greenhouse or Outdoors: Cuttings should be obtained and dipped in a hormone solution in the same manner as described earlier in the “rooting the dormant cuttings” section. Cuttings can be shorter than that described in the dormant cuttings section and even 3-node cuttings can be used in this technique. Cuttings are then planted directly in containers filled with media. It is best to bury at least two buds in the planting media. The media in containers can be different proportions of sand, peat moss and vermiculite. We have experienced good results with a media containing equal proportions of sand, vermiculite, and peat moss.

Wide varieties of containers are available in commercial nurseries. A popular container is one made of folding-paper that has an opening about 1.5 x 1.5 inches wide and 10 inches deep. These containers can be initially packed one third of the way with media and the rest can be packed after the cutting is placed in it. Special trays can be purchased that holds several of these containers. It takes a few weeks for these cuttings to root and grow and the growing process is faster in the green house than outdoors. However, growers can induce callus or roots first (as described previously in the “rooting the dormant cuttings” section) and then plant the rooted/callused cuttings in containers in the greenhouse, or outdoors when danger of frost is over. These plants can grow faster than non-rooted cuttings and the vines can then be planted in the actual vineyard.

If container-grown vines are kept outdoors, they do not need to be acclimated before planting. However, it is important to acclimate the greenhouse-grown vines before they are planted in the vineyard. Immediate transfer of these plants from the greenhouse to the field can cause severe foliage burning (plant transplant shock). Acclimation can be accomplished by gradually exposing the greenhouse-grown vines to ambient temperatures and outdoor conditions for just a few hours a day for about a week and then leaving them outside of the greenhouse for a couple of days.

3) Direct Planting in the Vineyard: This is the simplest method of planting and requires less care in handling but the rate and success of rooting is less than the other methods described earlier. In this method, dormant cuttings are planted directly in the vineyard with or without dipping in rooting hormone. Usually 2 cuttings are placed in each planting hole for a better chance of success. Some cultivars are rooted more successfully with this technique and it is still the traditional method of planting grapes in many countries.

Chapter 4

Planting a Vineyard (Photos 21-34)

Principals of Planting. Planting holes should be about 18 inches deep. Make sure to leave some loose soil in the bottom of new plants in the planting hole. Plant the newly callused or rooted plants about 4-6 inches away from the vine support (bamboo shoot or post) and leave only one or maximum two buds out of the ground. It is advisable to orient the bud toward the vine support so that the future trunk can easily be trained to the vine support. Under Southwest Idaho conditions, the rooted or callused cuttings can be planted from late April through May 10, depending on temperature.

The vines, which are grown in containers in the greenhouse or outdoors, should be planted as any regular potting plant. Container-grown vines are often planted in the vineyard between May 10 and 30th, depending on temperature under Southwestern Idaho conditions. Fill the planting hole gently to reduce breakage of tender buds or foliage. Gently tamp and pack the soil after planting to eliminate air pockets and excessive sinking after irrigation. Vines need to be watered soon after planting to provide moisture to the tender callus, root, and bud tissues as well as for situating plants in a more stable and permanent position. It may be desirable to form a basin that can hold about 2-3 gallons of water, if plants are to be watered by hand after planting. It is extremely important to water newly planted vines shortly after they are planted, particularly when the weather is hot. Dormant plants that have established roots and have been grown in the nursery for a year or more should be completely buried when the short shoots (usually 4-5 inches long) are still dormant (early March to mid-March). In some cases, a 2-3 inches brim can be placed above the buried plant. These plants may have better chance of survival as they have stored food in the roots and ready to take off and grow when the weather warms up. The callused or newly rooted plants take about 3 to 4 weeks to grow, depending on the temperature. Under warm conditions, new growth can be seen in about 2 weeks. At this stage, make sure that rodents, ground squirrel, rabbits, cut worms or other animals do not damage the tender buds and newly grown shoots.

Plants in the vineyards can be planted at 6 ft x 10 ft, 7 ft x 10 ft, 8 ft x 10 ft, 7 x 11 ft, 6 ft x 12 ft, or 7 x 12 ft spacing. Using a 9 ft spacing between rows will be too tight for table grapes when canopies are fully-grown, and that might cause difficulties operating tractors and spray equipment alleyways. Also, dense planting (i.e. 6 x 9 ft), particularly with a single bi- lateral cordon training system may result in excessive powdery mildew infestation that is difficulty to control. The problem will intensify when the cordon arms are trained at 40 inches than 57 inches from the ground.

Use of Grow Tubes after Planting. Grow tubes are used to accelerate the growth of the vines after planting. These tubes act like a "micro-greenhouse". Grow tubes are made of paper, milk cartons, plastic, or similar materials and their lengths typically vary from 6 to 24 inches. When grow tubes are used, vines grow rapidly to reach the light at the end of the tube. The warm and protected environment inside of the tube will increase the growth. The rapid growth of vines in the grow tube often makes the stem stay green, fragile, and "leggy". Thus, under some conditions, these vines may not acclimate before the temperatures drop below freezing and thus, vines may suffer freeze injury. Therefore, it is recommended that, under conditions of southwest Idaho, grow tubes either not be used at all or if they are used, they should be removed after the growth reaches the top of the tube or by the middle of July at the latest.

If grow tubes are removed suddenly, the green stems and dull green leaves inside the tubes will be shocked and may exhibit symptoms of transplant shock. To avoid this, one side of the grow tube can be cut or grow tubes can be moved up a few inches to allow the stem and foliages to become better acclimated before completely removing or cutting the tubes. In addition to accelerating growth, grow tubes serve as a barrier when herbicides are applied between plants on a row. In many grape-producing regions in the Intermountain West, ground squirrel and rabbits can seriously damage the newly plated vines or re-growth of the older vines at the beginning of the season. Because new vines have only a few buds, any damage from animals can adversely affect and delay or prevent growth. Under this conditions, use of grow tunes will protect the vines until they are established. A few weeks later, these grow tubes can be removed as there will be sufficient growth, and ground squirrel gradually go to hibernation.

Chapter 5

Support and Training Systems (Photos 35-51)

Introductory Remarks on Training.

The most important management objective in a vineyard is the establishment of a strong and well-structured vine framework and root system. A well-trained vine is easier to manage and will produce higher quality fruit. Although many of the principles of vine training in wine, raisin, and table grapes are similar, trellising and cultural practices in table grapes are different. There are differences in trellis system requirements even between different cultivars of table grapes. In the following section, a few important training and support systems are described. In this section, information gathered from our experiences in Idaho are combined with some recommendations, particularly hand-drawings from the University of California Cooperative Extension System (Christensen, 1998; Peacock, 1998a; Peacock et al., 1998, with written permission granted by Professors Christensen and Peacock).

First Year Training.

The vines should remain uncut and grow as bushes during the first growing season. This will allow for maximum leaf area and root system development, which is extremely important for vine survival during the first year. If grow tubes have to be used for growth acceleration, rodent control, and herbicide spray protection, it is best to attach them immediately after planting, but remove them as soon as growth reaches to the end of the grow tube. Removing grow tubes will typically be in the middle of the hot season and extra care should be taken to prevent heat shock injury and this issue will be discussed later.

Training the vines up to the support stake and cordon wire during the first year is not advisable under Idaho and Intermountain west conditions, although it is occasionally practiced in drip-irrigated vineyards in California. If vines are trained up to the support stake in the first year, bud break and shoot development along the new cordon branches can be erratic due to the limited root system development. Also, there is a great chance that upper foliages are damaged due to the first frost and thus, labor spent on training will be wasted.

Application of excess nitrogen fertilizer and late season irrigation during the first year should be avoided as these practices may result in juvenile (green and succulent) shoots, which are susceptible to freeze injury.

Irrigation applications to the new vines must be slowed down by the end of August and must be stopped at the beginning of September and resumed only when signs of severe water stress in the leaves are observed (new or old leaf dehydration, starting from the edges). By reducing water at the end of August, the green vines are forced to acclimate and become more resistant to frost damage that usually comes during late October or early November under Southern Idaho and Intermountain west conditions. If all procedures are practiced correctly, at least 4 to 5 inches of bottom of the stems from the current year's growth should be acclimated (have a woody texture with light to dark brown color). It is a recommended practice to use about one 5-gallon bucket of clean hardwood saw dust to cover about 5 to 6 inches (at least 2 buds) of the lower parts of the current year's stem just a day before a severe frost is forecasted. This practice will protect at least two buds if the winter temperatures plunge down to several degrees below freezing. However, even this practice may not protect vines if the temperatures are extremely low. Saw dust should be gently removed after the danger of spring frost is over to prevent rodents from nesting during the next growing season. When removing sawdust, extreme care should be taken to avoid breaking newly-emerged or developed shoots.

Second Year Training: Establishing the Trunk.

Common Points on the Second Year Training. At the end of the first dormant season (Mid- March to Mid- April), all shoots except one or two strong and well-placed shoots should be cut. The tip of many or all shoots will have freeze damage during late fall, winter, or early spring. The severity of damage varies from variety to variety and from year to year. The one or two remaining shoots should be cut back to where tissues are alive. For a better uniformity, these remaining shoots can be cut back to as few as two buds if needed (Illustration 1).

Single or double shoots should be selected and directed up the stake as the permanent trunks in the second year. Selection of shoots for the main trunk and excess shoot removal should start when shoots are at least 8 to 12 inches. Removal of excessive shoots that come out of the trunk or below soil level is extremely important. There is a risk of accidentally removing or breaking the wanted shoots at early stages of growth, as shoots are extremely tender and brittle at that time. Most growers prefer to wait until the shoots are 18 to 24 inches long. This allows one to select and tie the main shoot (s) for training and then remove all others in one operation. Tender shoots can be removed by hand, and more woody shoots (shoots longer than 18 inches) should be cut with a sharp pruning shear. During the trunk selection and training process, first three or four 12- to 18-inch upright shoots are retained and loosely tied to the stake. These are the shoots that can easily be tied to the stake without breaking. After tying these shoots, remove two to three and allow only two of the healthiest and best shoots to grow as the permanent trunks and tie them to the stake. If there is only one shoot available, train that one and select a second one when it grows from the lower portion of the canopy. The reason for selecting three or four shoots for tying in the initial step is to make sure there are spare shoots if some of them break accidently in the tying process.

As the main trunks grow, they should be tied up the stake every two weeks to prevent breaking and assure a straight trunk. We have not noticed any difference on which side of the stake the trunks are trained too, although we have trained mostly on the west side or south sides of stakes. The top 1/3 of cordon-trained vines should always be brought over the wire attachment side of the stake. The cordons will then be in position to be attached directly to the wire and not bent around the stake over to the wire. The excess shoots and clusters must be completely removed or drastically reduced in the second year in order to strengthen the vine structure.

Any lateral shoot arising from the bottom 2-1/2 feet of the main trunks must be removed during tying process. No leaf should be removed when the main trunks are still green, as they are the primary source of food for the vine. However, both leaves and shoots arising from the main trunk should be completely removed after the canopy structure has been formed and when the trunks are woody. At this stage, leaves on the main trunks are extremely broad and course and gradually turn greenish purple. At this stage, vines are trained using one of the following training systems:

1) Upright Bilateral Cordon (or simply referred to as "bilateral cordon"): Pressure-treated wooden posts or steel posts, 8 to 10 ft length, are pounded or augured into the soil at a 18 to 24 ft spacing with 6 to 8 ft above the ground. The spacing between these posts varies, depending on the desired strength of the canopy, post diameter, and wind speed. One 7.5 ft U-shaped, galvanized metal post or a bamboo pole is inserted 1.5 ft into the ground next to each vine. Bamboo poles come in different heights and diameters. We prefer the 8 ft bamboo poles with a 1 inch diameter. They are more expensive than the narrower bamboo poles but provide a stronger support system. Twelve- or 12 ½ - gauge galvanized wires are installed at 16 inches above the ground for attaching the drip irrigation line and at 42 to 60 inches above the ground (depending on the desired canopy height) as cordon wires. Based our extensive research in Idaho, we recommend that cordon wires be installed at 55 to 57 inches from the ground level. This allows easier shoot and cluster thinning and harvesting. A 12 to 36 inch cross arm is installed horizontally on each metal post at about 12 to 18 inches above the cordon wire. We prefer and recommend a 36-inch cross arm rather than shorter ones. A 36-inche cross arms will allow more open space between risers which are tucked between wires and thus, facilitates for better air movement and light penetration. Sometimes two cross arms are installed at about 12 and 24 inches above the cordon wire. In this case, if the cordon arm is trained at 55 to 57 inches above the ground, the pressure-treated wooden posts must be at least 10-ft long with 8 ft above the ground. Two parallel wires are also installed, one on each side of the cross-arm, to keep the shoots in an upright position.

Illustrations for various stages of the upright bilateral cordon training for the young and mature vines are borrowed with permission from Christensen (1998) of University of California, and shown in Illustrations C4 to C9. The upright bilateral cordon is often used for spur-pruned table grape cultivars. In this system, the one or two trunks per vine are trained as a bilateral cordon system at about 42 to 57 inches above the ground and at about 12-18 inches below the cross arms. Under Intermountain west conditions, we prefer to train two trunks for each vine to increase the percentage of vine survival in case cold, diseases, or other factors damage one of the trunks. To form two uniform cordon arms, allow the main trunks to grow about 18 inches beyond the cordon wire in less vigorous cultivars and 24 inches beyond the cordon wire for ‘Flame’, ‘Alborz’, ‘Emerald’, and more vigorous cultivars. Then cut the main trunks at about 5 inches below the cordon wire. This practice will allow the main trunk to reach optimum inter-node length and to produce two cordon arms just below the points of heading and below the cordon wire. Once the cordon arms are about 24-30 inches in length, gently twist the arm 1.5 to 2 times on the right side of the cordon wire clockwise and the arm on the left side counter clockwise and tie the arms with ties. Twisting more than two times may result in girdling the arm by the wire. The first tie of each arm should be strong to keep a large portion of the arm’s weight. Never tight the ties too tightly and always allow some room for the vine growth. That is why it is important to use flexible ties rather than rigid and inflexible ties that may girdle vines.

It is important to be extremely gentle when bending each arm as they are brittle and may break. If one arm breaks, find another best-positioned arm to replace it or allow the broken arm to grow and become the permanent cordon. The first round of each arm around the wire should have a gentle bend rather than a sharp right angle.

When the vines are young (during the second or third year of planting, depending on cultivar), each of the two cordon arms may be cut at 18-24 inches in length and then extended up to 42 inches later. The maximum length of each arm is dependent on the in-row vine spacing and the vine vigor. Obviously for a 6-ft in-row spacing, the length of each arm will be shorter than that of an 8-ft spacing, but we do not recommend expanding the arm length beyond 42 inches.

When the length of each cordon arm is shorter than 21 inches, vines should be spur pruned to leave about 4 spurs of 2 buds (not counting the basal buds) on each cordon arm. When vines are mature (older than 3 years old, depending on cultivar), each cordon arm should be spur-pruned to leave 6 to 8 spurs of 2 buds not counting the basal buds, during the dormant season (early March) of each year. The tip of cordon arms must be cut several times during the growing season to keep them at the desirable length in order to stimulate lateral shoot (riser) growth. Failure to do this will likely result in poor riser formation and bud development. The tip of lateral risers on each arm can be shortened if the growth is excessive. During May, June, and July of each year, in addition to the routine shoot thinning (as described later for Alborz table grape), downward-growing branches and shoots that are growing from obviously wrong locations should be removed. Excessive shoot removal, to the extent practiced for wine grapes, is not necessary for table grapes in Idaho. Upright shoots are positioned upward between the two wires on the cross arms during each growing season. We do not recommend cutting risers just above the cluster as this practice will lead to smaller berry size.

2) Slanted Bilateral Cordon. The training in this system is like the Upright Bilateral Cordon except that each cordon arm is installed on a hanging-bracket at about 52 to 57 inches from the ground on a gable system and each vine is slanted to the opposite side of the adjacent vine. Thus, a Y shape support system needs to be installed to support the vines. This system is often used for 'Flame Seedless' in California and its suitability in Idaho is being evaluated by the Pomology Program at the University of Idaho. However, our results show that this system can successfully be used for 'Alborz' table grapes.

3) Double Bi-Lateral Cordon System. This system is similar to the Upright Bilateral Cordon system except that vines have two bi-lateral cordons. A double bi-lateral cordon system with various table grape cultivars has been evaluated at the University of Idaho Parma Research and Extension Center for over 12 years. The first bi-lateral cordon arms should be installed about 38 inches above the ground and the second set at about 52 inches above the ground, parallel to the lower cordon arms. In this system, risers on both cordons should be growing upward. This system can be attractive for use in the back yards, on chain link fences, and on walls. However, our study showed that the lower arms in this system can become shaded, and less productive over time, and thus not suitable for commercial plantings. The double bilateral cordon can easily be converted to a single bilateral cordon by cutting the one sets of the arms. In that case, it is better to cut the lower set of arms. Higher arms are well exposed to light and it is easier to perform cultural practices such as pruning and cultural practices with these higher arms. By cutting the lower arms, the height of arms in the new Upright bi-lateral cordon will be about 52 inches from the ground level. In our experiments, a significant improvement in grape quality was observed within 2 years after the lower arms of double bi-lateral cordon were cut.

4) Geneva Double Curtain (GDC). This method was developed by Nelson Shaulis of Pennsylvania in 1960's, who developed it while working at the Geneva Agricultural Experiment Station in New York. The technique was developed to improve grape quality by reducing shade within a dense canopy. To establish this system, a divided trunk or two trunks from each vine are grown at about 5 ft. above the ground. From this height, two permanent cordons grow, each one trained out to run along a supporting wire, approximately 4 ft apart. Along the cordon are the spurs that produce the fruiting canes, which hang down towards the ground. Hence the canopy has been divided into two 'curtains', improving exposure to light, quality of fruit and yield. It is particularly useful for vines of high vigor. This system improves productivity. However, the 4-ft space between the two curtains may result in canopies becoming too dense, which can increase the chance for diseases such as powdery mildew, particularly in the areas with high rainfall and/or irrigation.

5) Head Training. This system is used for cane-pruned vines such as 'Vanessa', 'Thompson Seedless', 'Askari', 'Superior Seedless', and sometimes 'Calmeria'. The main shoot is topped when it has grown 18 inches beyond the desired head height. Head height will depend on trellis design. Various steps of Head Training are shown in Illustration H4 to H8 and these illustrations are borrowed from Illustrations for various stages of the upright bilateral cordon training for the young and mature vines are borrowed with permission from Christensen (1998).

a. Single Cross Arm systems. In this system, a 3- to 4-ft cross arm with 4 or 5 wires is used. The fruiting canes are tied to the center 2 or 3 wires. The outer wires serve as foliage support. About five lateral shoots will be chosen and trained on the top portion of the main trunk. The vines should be directed so that the top lateral shoot is about 8 inches below the cross arm. Tie the top of the main shoot (trunk) of the vine securely. Lateral shoots developing from the bottom 2/3 of the trunk are removed (H-5). Wrap the lateral shoot growth loosely onto the wire as it develops to keep it supported (H-6). The head of a mature vine can be maintained within a distance of 6 to 18 inches from the single cross arm. The fruiting canes can then be easily wrapped onto the wires, and the shoots for next year's canes will mostly develop in full sunlight. Sunlight exposure of shoots contributes to the fruitfulness of their developing buds. These well-exposed shoots can then be selected as "sun canes" during pruning for the following year's crop.

Low-headed vines have difficulty in maintaining vine shape and canes are potentially shaded. Low-headed vines must depend on longer arms extending from below. The arms are often difficult to re-establish once removed by pruners. One or two arms may ultimately dominate or all the arms may be eliminated by pruners. Fruiting canes arising from low heads will be more crowded and create a shaded environment and thus have a lower potential for fruitfulness and percent bud break.

b. Double cross arm systems. Use a top, longer cross arm with three wires for foliage support and a lower, shorter cross arm with two wires for the fruiting canes. This will allow all the fruit to develop under the canopy's shade. Unfortunately, this method forces one to head the vines below the lower cross arm and thus far below the top of the vine canopy. More of the shoot growth for fruiting canes is subsequently shaded, reducing bud fruitfulness. This can be a serious problem with the highly vigorous Thompson Seedless vines.

Vines should be headed at or just below the lower cross arm. This assures that the shoots will reach full sunlight within as short a distance as possible, improving their potential for bud fruitfulness. Make the cut so that the top shoot will be no farther than four inches below the cross arm. Leave 4 to 5 lateral shoots at the top and remove the remaining lower shoots (H-5). The head of mature vines should be maintained within a 2 to 14 inch distance from the lower cross arm.

6) Quadrilateral Cordon Training. In this method, vines are trained on a gable system and in many cases, the gable system is similar to that of Slanted Bilateral Cordon, as described earlier. However, the main trunk is cut at about 4.5 ft height and two short arms (each about 8-12 inches) are allowed to grow opposite the orientation of the vine row. A Bilateral Cordon should be established parallel to the vine row orientation on a hanging- bracket on each arm. Thus, each vine will have two bilateral (quadrilateral) structures. This system needs a gable or Y trellis system (divided canopy) to support the vine. Each of the hanging brackets, and hencethus bilateral arms, will be positioned at about 52 to 57 inch height above the ground level. Each metal arm on this gable system should be between 39 to 60 inches on each side. A cross arm will connect these two metal arms and several lines of wire can be installed on the cross arm and arms. Thus, fruits will be produced at 52-57 ft height from the ground. This system allows for a better air ventilation and reduces the powdery mildew infection. This system is often used for cultivars such as ‘Autumn Royal’ and ‘Red Globe’ in California. We are experimenting the suitability of this system for cultivars such as ‘Alborz’, ‘Jupiter’, ‘Kashishi’, ‘Red Globe’, and ‘Emerald’, and ‘Autumn Royal’ under Idaho climatic conditions. At this point, we do not know how these cultivars may perform with this system. In California, only more vigorous cultivars are trained into Quadrilateral Cordon system and ‘Flame’ is not usually trained into system.

Based on our preliminary 4-year study (1998-2011), this training design shows extremely positive and promising results by producing much higher yield of high quality clusters and berries as compared to a Bi-Lateral Cordon System for ‘Alborz’, Emerald, and ‘Kashishi’ cultivars. However, we are continuing this study for another 3 years to have a more solid recommendation for this style of training.

Third Year Training.

1. Spur-Pruned Cultivars. Over cropping during vine training should be avoided. It can lead to permanently weakened vines and uneven spur development.

This is controlled by proper pruning, shoot thinning, and cluster thinning. In all training systems described above, the training system that was started during the second year of growth will be continued and completed during the dormant season (usually early-to-mid March) or at the beginning of the third dormant season (usually early to mid March). In the spur-pruned system, one makes sure that canes with at least 3/8 inch in diameter are kept on each arm. Smaller canes may produce erratic bud break. Some varieties have a tendency to push end buds only if weak cordon branches are left too long. Cutting back cordons to where they are of adequate diameter will improve bud break and shoot growth uniformity. The remaining length of cordon can be extended the following year.

Some growers prefer to delay any cordon development of weaker vines for one additional year. They cut the branch canes all the way back to the stake and develop the cordon in one step the following year rather than in two steps over two years.

Always prune to a bud that is located on the bottom of the cane on the end of the cordon arm if the arm is to be extended the next year. The shoot from this bud grows from the underside of the cane in the direction of the cordon, which makes a straight and easy-to-tie cordon extension.

Some times bud break can be a particular problem in young vines where only the ends of the canes may push, leaving blank areas in the center. Highly vigorous vines are most susceptible. It is advised to bring cordons out in two steps if this problem is anticipated. This helps force buds within the shorter cordon sections each year.

Depending on the training system, remove the ends of full cordons so that there is an 6 to 12 inch space between the vines. This distance encourages the riser to grow at the proper positions on the cordons and prevents the intermingling of shoots and clusters of adjoining vines.

Lateral shoots will develop on cordon arms. Usually spurs are not left on the shoots on the newly established cordons. These shoots are often uneven in development and spacing along the branch canes. By cutting all the laterals off (called “Slick pruning”), the main (axillary) buds at each node will push more evenly. "Slick pruning" also reduces the number of shoots to thin out next spring. An exception to this response would be extremely vigorous vines. One-bud spurs should be left where the branch canes are over 5/8 inch in diameter. This helps avoid blank areas along the branch canes where buds can get "buried" in the growth of large diameter wood.

Thin the clusters to 1 per shoot. However, weak shoots should carry no crop; two clusters are sometimes left on exceptionally vigorous shoots where higher cropping capacity is warranted.

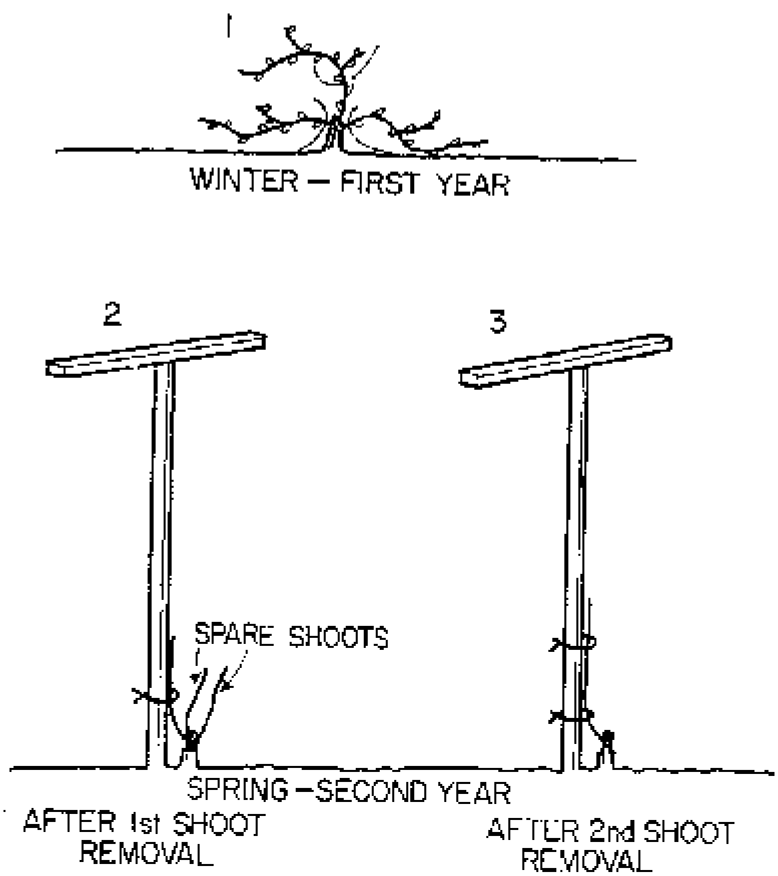
2. Head-Trained or Cane-Pruned Cultivars (Thompson Seedless). Prune back to 2 or 3 canes (10-12 nodes) on vigorous vines. Select two or three well-placed renewal spurs of two nodes each (H-7). Leave only one short cane plus three spurs on low to moderately vigorous vines and no canes and three to four spurs on weak vines. Leaving more fruiting wood will require more cluster thinning. Third-leaf vines are much more fruitful than mature vines. Canes and spurs of the third-leaf vines are from lateral shoots with high light exposure which originated from the main shoot during training. These lateral shoot canes are highly fruitful from the first through fifteenth node, typically averaging 1.2 to 1.3 clusters per node. Thus, a vine with two 12-node canes and three 2-node spurs (30 nodes total) normally produces 35 to 40 clusters. This is a more than adequate cluster count for a vigorous third-leaf vine. A total of three canes may be justified where extreme vigor has produced trunks of 1-1/4 inch diameter or more and canes of 5/8 to 3/4 inch diameter. Four canes can produce as many as 60 to 80 clusters - far exceeding the capacity of most vines to produce fruit of normal size and maturity. All shoots arising from the lower 2/3 of the trunk are removed in the spring. Wait until the shoots are 8 to 10 inches in length so that their bases will break out. This eliminates future growing points.

Fourth Year Training.

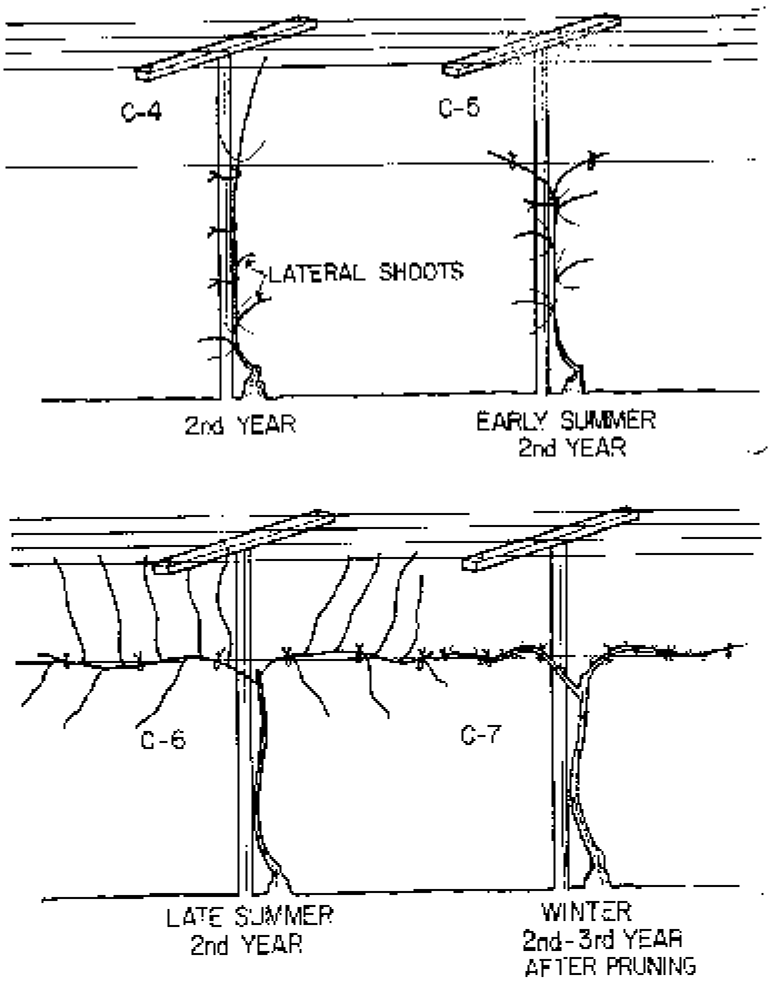
1. Bilateral cordon training, spur pruning. Continue and complete the training that was started in the second and third seasons. Make the final selection for spur positions on all fully extended cordons (C-9). Space spurs at 4 to 6 inches for a total of 7 to 8 spurs on each cordon arm. Prune spurs to 1 or 2 nodes, depending on the variety (not counting the basal bud). Spurs left on the side or underside of the cordon to fill in blank areas should be pruned with the buds oriented for vertical growth. Provide for a 6 to 12 inch spacing between the cordon ends of adjoining vines. Remove all canes located in the "crotch" where the trunk divides, leaving a 6 to 8 inch spur-free area. Extend all cordons as necessary with canes of at least 3/8 inch diameter. The training processes of the third year will be continued and completed during the fourth year.

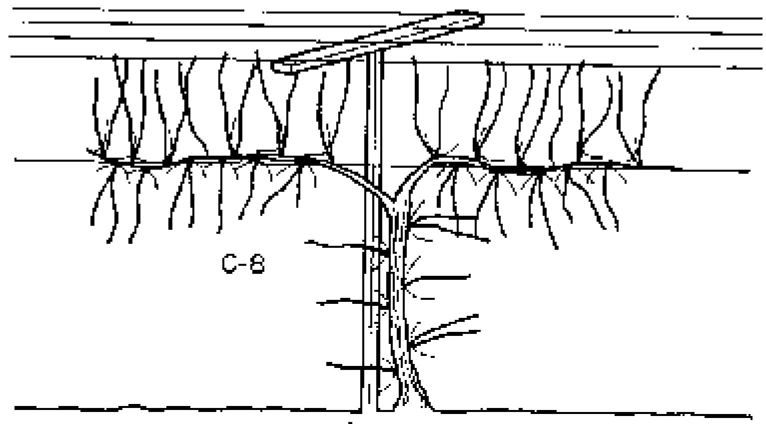
2. Head training, cane pruning. Prune back to 4 to 5 well-placed 12-15 node canes on vigorous to exceptionally vigorous vines (H-8). Leave only 2 to 3 canes on low to moderately vigorous vines and none to one cane on weak vines. Leave four to five renewal spurs if they are well positioned to provide canes for the following year.

DEVELOPING THE TRUNK

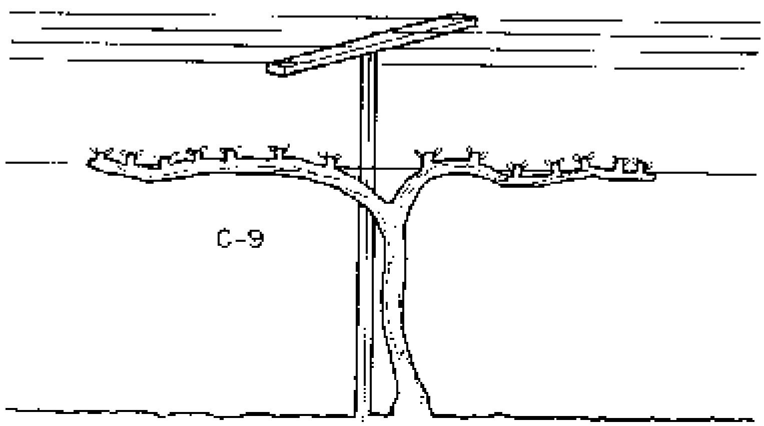


CORDON TRAINING—SPUR PRUNING

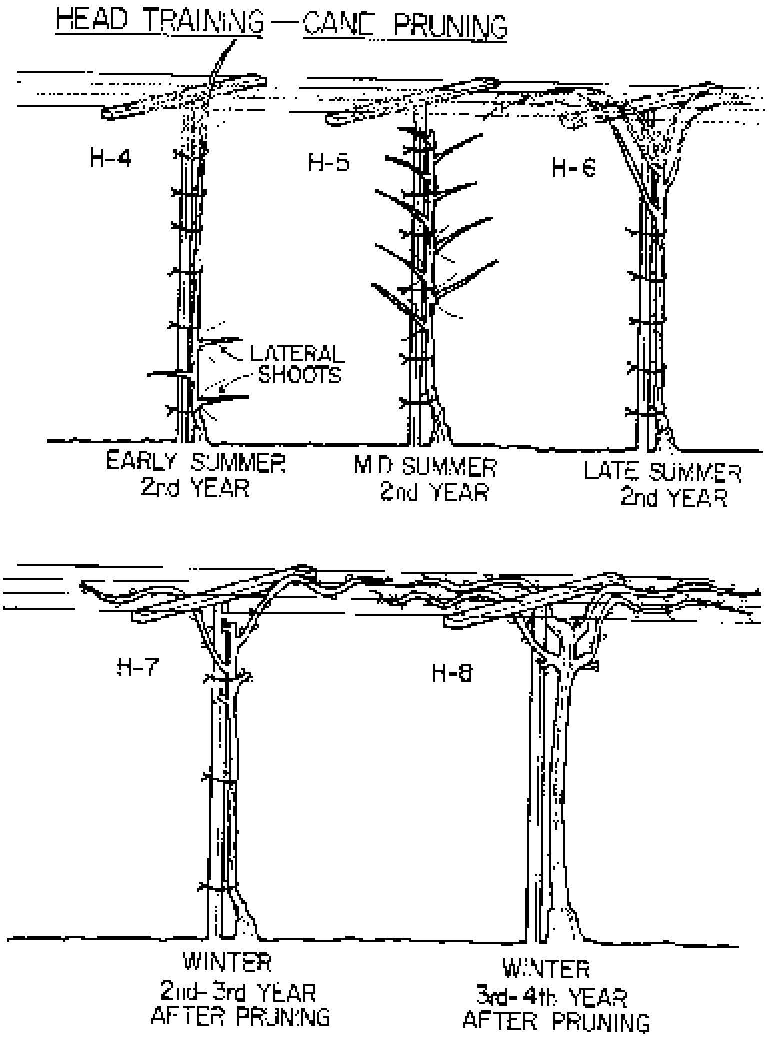




SPRING
3rd YEAR
DESHOOTING



WINTER
3rd -4th YEAR
AFTER PRUNING


HEAD TRAINING—CANE PRUNING
H-4
H-5
H-6
LATERAL SHOOTS
EARLY SUMMER
2nd YEAR
MID SUMMER
2nd YEAR
LATE SUMMER
2nd YEAR
H-7
H-8
WINTER
2nd-3rd YEAR
AFTER PRUNING
WINTER
3rd-4th YEAR
AFTER PRUNING

General Maintenance in Training during the Second through Fourth Year Training.

Shoot Thinning. Shoot thinning ("crown suckering") should be practiced in the spring. This practice removes excess crop, provides for permanent spacing of spur positions, and removes unwanted growing points in future years. The shoots should be thinned when 8 to 10 inches long so that their bases will break out easily. This removes the base buds which would provide future unwanted growing points. Remove all shoots arising from the main trunk to just above the bend of the branch canes. This leaves an open, deshooted area about 8 inches wide where the cordons separate.

When the spur-pruned vines are young and where permanent spur positions are desired, retain single upright growing shoots - normally spaced at 4 to 6 inch intervals. Remove all extra shoots from the underside of the branch canes. In the young vines of several spur-pruned varieties, each fully extended cordon arm should have 7 or 8 shoots remaining. However, it may be necessary to leave a shoot at each node on vigorous vines with exceptionally long internodes such as ‘Flame Seedless’. Later, when final crop adjustment is done and cluster removal and shortening procedures are completed, young vines (3-5 years old), can easily support 20 clusters per vine. In a one-year study, we have observed that each mature ‘Alborz’ vine (older than 5 years old) can support up to 36 clusters with no adverse effects on berry size, if shoots are thinned and crop density is adjusted correctly.

Early Basal Leaf Removal. Basal leaves and laterals are usually removed around the time of berry set. Leaves are pulled at this time on a number of table grape varieties including ‘Flame Seedless’, ‘Alborz’, ‘Ruby Seedless’, ‘Fantasy Seedless’, ‘Crimson Seedless’, ‘Christmas Rose’, ‘Exotic’, and ‘Ribier’. The process of leaf removal is called “leafing” and is most beneficial with high vigor vineyards on standard "T" trellises that tend to haystack the canopy. The amount of leafing ranges from a few basal leaves and side shoots (in moderately vigorous vineyards) to removal of all primary leaves and lateral shoots beginning at the base of the shoot and continuing to the node opposite the top cluster on each shoot (in vineyards with high canopy density).

Removing basal leaves increases light and reduces humidity within the fruit zone, and facilitates manual operations such as cluster thinning and harvest. However, the benefits of leafing moderate to low vigor vineyards is questionable, and leafing any vineyard can increase fruit damage from heat and bird activity.

Tying Materials. Plastic, twine or vinyl tape can be used to tie the main shoot as it is trained up the stake. Stronger flexible tapes are recommended to tie the cordon branches. Tape stretches and does not girdle. Twine or other tapes must be tied loose enough to prevent cane girdling and may have to be cut loose and retied for next season's growth. Wires should not be used for tying branches. Wires can girdle branches when they grow, particularly when they are not removed a few months after tying.

Chapter 3

Table Grape Cultivars for Idaho (Photos 52-96)

Variety Evaluation at the University of Idaho. The University of Idaho Pomology and Viticulture program has tested adaptability, berry maturity and fruit quality of wine grapes during 1990 to 2005 (Fallahi et al., 2004; Fallahi et al., 2005a; Fallahi et al., 2005b; Fallahi et al., 2005c) and table grapes in the intermountain west region of the United States during the period from 1990 to 2012 (Fallahi, 2012). A summary of results for several table grape varieties are reported in Table 5. ‘Pasargad’, ‘Reliance’, 'Ruby', ‘Alborz’, ‘Flame’, and 'Lakemont' had heaviest clusters over several seasons. 'Emerald', 'Exotic', ‘Autumn Royal’, and 'Fiesta' also produced heavier clusters than many other grapes. ‘Canadice’, ‘Concord Seedless’, ‘Glenora’, ‘Interlaken’, NY 65.479.1, ‘Reliance’, and ‘Romulus’ had greatest soluble solids concentrations (SSC). ‘Challenger’, ‘Emerald’, ‘Exotic’, ‘Autumn Royal’, ‘Kashishi’, ‘Anahita’ (Ralli), ‘Red Globe’, and ‘Italia’ produced the heaviest berries. Considering all quality attributes (combination of SSC, berry weight, berry tenderness, and/or cluster size) ‘Alborz’, ‘Flame seedless’, ‘Emerald seedless 01’, 'Italia', ‘Princess’, ‘Autumn Royal’, ‘Kashishi’, ‘Ralli’ (also known as ‘Anahita’), ‘Jupiter’, and 'Saturn' had high overall fruit quality, and therefore, can be considered for planting under Southwest Idaho conditions and other similar climatic regions in the Pacific Northwest. However, advantages and disadvantages of each variety should be considered before planting on a large scale.

'Pasargad', and 'Reliance' have pleasant flavors, but berries are fragile and cannot tolerate long distance transportation. ‘Reliance’ is a very cold tolerant variety and berries mature in late ‘August’ to early September under Southern Idaho conditions. ‘Pasargad’ berries will stay attached to the cluster until late fall every year. In addition to fresh consumption, ‘Pasargad’ is excellent for juice and raisins. Many selections from New York were tested but not recommended for Idaho as most of them have thick or slip skin. Among all New York selections, NY 47616 (also known as ‘Sweet Shelly’ in

Idaho) is the earliest-maturing table grape for Idaho and has small black berries that resemble blue berries. Berries of NY 47616 shatter easily and are very flavorful and can be consumed fresh or mixed in ice cream. Berries of NY47616 can also dried as raisins for cooking in muffins or mixed with breakfast cereals. This grape variety could have a great potential for small-scale production for sale in farmers markets. Although this grape is not a typical commercial table grape, it is highly favored by hundreds of people who have tried it during educational field days and workshops.

Table 1. Origin and parentage of some table grape varieties evaluated in Idaho.

Variety	Origin	Parentage
Alborz	ID	Sport of Flame
Canadice	NY	Bath x Himrod
Challenger	MO	Unknown, NY material?
Concord	MA	Vitis labrusca
Concord Seedless	?	Sport of Concord?
Delight	CA	Scolorkerteck kiralynoje x Sultanina
Einset	NY	Fredonia x Canner
Fantasy	CA	B36-27 x C78-68
Fiesta	CA	Complex, includes Calmeria, Red Malaga, Sultanina
Flame	CA	Complex, includes Calmeria, Red Malaga, Sultanina
Fresno	CA	Complex, includes Calmeria, Red Malaga, Sultanina
Himrod	NY	Ontario x Sultanina
Interlaken	NY	Ontario x Sultanina
Mars	AR	Island Belle x Ark. 1339
NY36095	NY	Ontario x Sultanina
NY36289	NY	(Hubbard x self) x Interlaken
NY36661	NY	Bell x Interlaken
NY47616	NY	Bath x (Fredonia x Black Monukka)
NY65.479.1	NY	(Muscat Hamburg x Hubbard) x (Ont.x Bl. Munukka)
NY65.483.2	NY	(NY 10782 x Muscat Hamburg) x Suffolk Red
Pasargad	ID	Sport of Himrod
Red Globe	CA	Plant Patent 4787
Reliance	AR	Ontario x Suffolk Red
Ruby	NY	Keuka x Ontario
V52139	ON	Seibel 8357 x Bronx
Vanessa	ON	Seneca x (Bath x Interlaken)

Table 2. Average cluster weight of table grape varieties treated with 3 GA sprays but without cluster cutting, cluster removal, or girdling at the University of Idaho in August and September 1997-2000 in Parma.

Varieties	Aug. 1997	Aug. 2000	Avg. of August 1997 & 2000	Sept. 1997	Sept. 1998	Sept. 1999	Sept. 2000	Avg. of Sept. 1997 – 2000	Avg. of all harvests 1997 - 2000
Alborz	316.3	478.5	437.2	452.4	439.9	400.5	402.6	423.8	430.5
Canadice	173.5	262.2	208.5	193.3	114.7	95.0	221.7	169.0	193.6
Challenger	159.1	318.9	289.9	158.0	211.4	185.5	256.8	200.6	222.7
Concord	111.3	118.1	112.9	147.4	101.8	106.1	136.8	121.2	119.1
Concord(seedless)	92.90	351.6	270.2	-	237.7	169.9	294.1	233.9	243.8
Delight	267.1	362.6	341.0	210.5	262.4	191.0	381.7	249.7	268.4
Einset	127.5	147.7	135.5	132.2	65.9	90.7	178.5	113.4	120.5
Emerald	-	326.5	326.5	-	-	-	526.7	526.7	426.6
Exotic	-	557.1	557.1	-	-	-	429.9	429.9	493.5
Fantasy	-	-	-	299.9	-	-	-	299.9	299.9
Fiesta	532.5	-	532.5	480.9	-	-	-	480.9	506.7
Flame	372.7	431.0	411.5	374.9	417.9	233.7	362.2	338.0	365.1
Fresno	135.5	210.6	205.5	318.1	174.5	147.0	185.9	182.5	186.5
Glenora	-	200.4	200.4	-	-	-	219.5	219.5	191.2
Himrod	215.1	303.3	282.3	131.9	242.6	111.6	283.7	193.4	216.3
Interlaken	182.2	223.8	199.9	187.4	158.5	126.2	262.5	144.4	159.1
Italia	-	242.2	242.2	-	-	-	-	-	242.2
Lakemont	-	476.1	476.1	-	-	204.4	437.1	320.7	372.5
Mars	-	71.6	71.6	136.8	-	81.6	57.8	102.0	85.8
NY36095	173.4	248.2	218.4	230.2	271.4	159.6	166.6	222.7	220.5
NY36289	169.3	-	169.3	168.7	55.9	52.7	106.8	144.2	151.9
NY36661	-	167.4	167.4	163.6	127.6	84.9	157.7	124.2	140.5
NY47616	108.2	93.4	100.9	88.2	72.7	73.5	77.5	82.1	88.5
NY65.479.1	241.8	121.0	136.1	193.5	96.7	78.2	125.8	127.3	129.6
NY65.483.2	120.8	324.5	265.1	148.2	115.9	144.0	300.2	164.1	191.6
Pasargad	129.2	333.3	268.9	182.8	220.4	202.8	298.8	226.2	247.5
Reliance	216.8	319.9	281.0	216.7	249.2	148.4	361.0	221.1	242.3
Romulus	-	256.4	256.4	-	-	72.4	-	72.4	205.3
Ruby	-	154.5	154.5	333.6	240.0	119.2	222.4	267.0	245.0
Saturn	-	187.8	187.8	-	-	194.3	278.0	236.2	201.4
V52139	-	226.7	226.7	255.4	275.3	137.7	231.0	213.8	221.5
Vanessa	168.3	187.9	177.1	184.6	164.0	89.8	160.2	162.6	169.1
LSD	120.4	129.0	122.2	131.7	74.0	97.6	194.2	99.8	99.8

Table 3. Soluble solid concentrations (ºBrix) of table grape varieties treated with 3 GA sprays but without cluster cutting, cluster removal, or girdling at the University of Idaho in August and September 1997-2000 in Parma.

Varieties	Aug. 1997	Aug. 2000	Avg. of August 1997 & 2000	Sept. 1997	Sept. 1998	Sept. 1999	Sept. 2000	Avg. of Sept. 1997 - 2000	Avg. of all harvests 1997 - 2000
Alborz	14.47	19.67	18.20	16.92	20.08	18.12	23.47	18.83	18.69
Canadice	18.27	26.23	22.98	18.35	25.80	23.75	27.60	21.05	22.26
Challenger	15.35	18.60	17.65	19.33	16.44	17.72	22.88	18.92	18.59
Concord	12.35	16.63	15.10	17.28	19.47	19.47	19.70	18.76	17.60
Concord(seedless)	20.60	23.00	22.25	-	22.50	25.40	24.70	24.20	23.58
Delight	15.27	19.17	17.92	18.20	19.92	20.37	22.52	20.91	20.23
Einset	17.92	22.80	20.22	21.09	22.70	24.48	23.70	22.49	21.82
Emerald	-	20.27	20.27	-	-	-	22.80	22.80	20.80
Exotic	-	17.00	17.00	-	-	-	20.10	20.10	17.57
Fantasy	-	-	-	15.60	-	-	-	15.60	15.60
Fiesta	14.93	-	14.93	20.44	-	-	-	21.07	18.00
Flame	13.13	20.06	18.57	18.42	19.75	17.90	23.90	19.80	19.36
Fresno	12.12	20.90	17.43	16.30	22.50	23.00	21.00	21.58	19.88
Glenora	-	24.40	24.40	-	-	-	24.87	24.87	24.63
Himrod	17.90	22.96	20.84	20.36	21.92	24.90	23.85	22.51	21.97
Interlaken	18.38	23.88	20.69	20.00	23.40	24.65	24.00	22.56	22.03
Italia	-	19.80	19.80	-	-	-	-	-	19.80
Lakemont	-	13.60	13.60	-	-	19.40	17.20	18.30	16.73
Mars	14.40	19.40	18.07	17.00	-	19.60	20.50	18.70	18.41
NY36095	13.92	25.20	18.95	18.20	20.95	26.45	25.50	22.63	21.28
NY36289	15.84	-	15.84	18.83	22.15	25.20	21.40	20.17	18.74
NY36661	12.80	20.43	19.69	17.47	19.43	19.87	22.05	19.83	19.87
NY47616	17.22	21.47	19.00	21.30	20.40	23.43	21.25	21.51	20.58
NY65.479.1	14.70	23.83	22.37	20.10	23.10	25.20	23.65	22.77	22.56
NY65.483.2	16.50	20.27	19.18	20.57	20.70	17.77	24.05	20.36	19.95
Pasargad	13.93	21.55	18.68	19.03	21.83	19.00	23.90	20.20	19.65
Reliance	18.07	23.42	21.35	21.16	24.03	26.10	25.76	23.42	22.69
Romulus	-	22.40	22.40	-	-	28.20	-	28.20	23.70
Ruby	-	21.87	21.87	15.04	21.25	25.60	22.47	19.46	19.92
Saturn	-	19.27	19.27	-	-	18.80	19.30	19.05	19.73
V52139	-	13.45	13.45	16.87	15.90	18.65	19.47	17.73	16.73
Vanessa	17.53	21.93	19.80	17.13	20.70	21.80	21.80	18.83	18.99
LSD	4.34	2.27	3.02	2.72	2.08	3.06	2.12	2.58	2.34

Table 4. Average berry weight, berry skin type, color, and consumer fruit performance of various table grape varieties with 3 GA sprays but without cluster cutting, cluster removal, or girdling at the University of Idaho, Parma.

	Average of berry size (g)				Berry description		
Varities	Aug. 2000	Sept. 1999	Sept. 2000	Overall Avg.	Berry skin type	Berry color	Consumer preference (1-100)
Alborz	2.76	2.29	3.07	2.59	Tender	Dark Red	98
Canadice	1.87	1.03	1.84	1.66	Slip	Medium Red	40
Challenger	3.98	3.55	4.69	4.08	Tender	Dark Red	87
Concord	2.68	2.37	2.48	2.51	Slip	Black	35
Concord (seedless)	2.78	2.27	2.40	2.48	Semi-slip	Black	50
Delight	2.33	1.56	2.18	2.01	Tender	Yellow	80
Einset	2.31	1.95	2.46	2.23	Tender	Red	35
Emerald	-	-	4.66	4.66	Tender	Yellow	95
Exotic	4.88	-	4.84	4.86	Tender	Black	75
Fantasy	-	-	-	-	Tender	Black	70
Fiesta	-	-	-	-	Tender	Yellow	65
Flame	2.84	2.23	2.91	2.63	Tender	Dark Red	94
Fresno	2.09	1.95	2.61	2.16	Tender	Yellow	83
Glenora	2.41	1.20	2.39	2.20	Tender	Black	74
Himrod	2.79	2.09	2.72	2.55	Tender	Greenish Yellow	75
Interlaken	1.99	1.64	1.93	1.86	Slip	Yellow	40
Italia	4.10	-	-	4.10	Tender	Light Yellow	96
Lakemont	2.23	2.09	2.64	2.32	Tender	Greenish Yellow	70
Mars	2.42	1.87	2.93	2.41	Semi-slip	Black	50
NY36095	2.30	2.11	2.65	2.30	Semi-tender	Yellow	76
NY36289	-	2.30	2.85	2.59	Slip	Yellow	20
NY36661	2.22	1.49	2.26	1.95	Semi-Slip	Yellow	20
NY47616	1.75	1.29	1.62	1.55	Semi-slip	Black	68
NY65.479.1	2.18	1.92	2.29	2.11	Slip	Black	30
NY65.483.2	2.03	1.76	2.07	1.94	Slip	Black	74
Pasargad	2.54	2.39	3.04	2.61	Tender	Medium Red	86
Reliance	2.76	2.24	2.69	2.54	Semi-slip	Light Red	84
Romulus	2.45	1.54	-	1.99	Tender	Yellow	76
Ruby	1.33	2.03	2.80	2.35	Tender	Black	81
Saturn	2.92	2.53	3.38	2.94	Tender	Dark-red	96
V52139	1.58	1.70	2.09	1.76	Slip	Black	20
Vanessa	2.41	2.03	3.01	2.35	Tender	Light Red	85
LSD	0.59	0.53	0.73	0.53			

[z]10 = undesirable, progressing to 100 = outstanding; this rating is an overall fruit quality preference, including berry size, color, and peel tenderness, and seediness, assessed by over 200 people. Values shown in bold are ranking among the top ten cultivars/selections.

Description of Desirable Table Grape Varieties for Idaho and Intermountain West

'Alborz' and 'Flame Seedless'. Vine performance and berry characteristics of 'Alborz' are somewhat similar to those of 'Flame Seedless'. It is believed that 'Alborz' is slightly more cold tolerant than 'Flame Seedless' but we do not have sufficient information to verify this. In our evaluation, we have noticed that 'Alborz' berries are crunchier than those of 'Flame'. Otherwise, we have not seen significant differences in berry quality and maturity between these grapes.

'Alborz' is the most widely planted table grape variety in Idaho and Intermountain West region of the United States. In our long-term evaluation, we have demonstrated that if all cultural practices are practiced properly, including shoot thinning, cluster removal and cluster shortening, cluster and berry quality of 'Alborz' will be perfectly acceptable for both regional and export markets. However, it must be emphasized that this grape should be planted in the warmest locations of the Intermountain West region of the United States or other regions with similar climatic conditions worlwide. Berries of this cultivar are naturally small to medium size. Under conditions of Southwest Idaho, 'Alborz' and 'Flame Seedless' are harvested between early and late September. In California, most of the 'Flame Seedless' table grapes are harvested by early August. During the time that Idaho growers can harvest fresh crop of 'Alborz' or 'Flame', California markets it's stored 'Flame Seedless'. Thus, when Idaho growers improve their storage facilities, they could store their grapes later than California and perhaps market them in January.

'Alborz' should be spur pruned. The most common training for this variety is single bilateral cordon. In our study, training 'Alborz' cordons at 55 to 57 inches from the ground provided better light penetration and air movement and reduced the severity of powdery mildew infections compared to training them at 42 inches. This practice also improved cultural practices such as shoot thinning and cluster or crop management and harvest. Thus, we recommend a cordon height of 57 inches rather than 42 inches from the ground for 'Alborz' and several other varieties. The cross arm (preferably 3 ft long) for “catch wires” can be installed 16 to 18 inches above the cordon wire. Suitability of other methods of canopy management is being experimented at the University of Idaho Pomology Program now. Among these experimental methods are Slanted Bilateral Cordon and Quadrilateral Cordon Training. As mentioned earlier, a quadrilateral cordon system seems to show higher yield and has other advantages to a simple bi-lateral cordon training system in our preliminary 4-year study. But we need additional years of evaluation to recommend this system.

‘Emerald Seedless’. Berries are green, medium to large size, and seedless. There are fewer clusters per vine in this cultivar than most other cultivars but clusters are extremely large and attractive. In ‘Emerald’, up to about 10 to 12 clusters per vine is sufficient for a complete crop . This cultivars blooms about 5 days later than ‘Alborz’ table grape. Some clusters could reach 4 to 5 pounds. If clusters are protected from direct sunlight, berries can stay yellowish-green for a long time, which is a preferred berry color for commercial market. However, berries will change to yellow if shoots and leaves are pushed away or removed to allow light to penetrate inside of canopy. The berries that are excessively exposed to sun may not be attractive for market. However, certain farmers markets prefer yellow berries than green. The berry has thin skin, and thus extra care should be taken during harvest, storage, and shipment. This variety is extremely susceptible to powdery mildew and is somewhat susceptible to sunburn. Shoot thinning, creation of an aerated canopy, and timely and repeated fungicide applications will reduce the severity of powdery mildew. Growing ‘Emerald’ grapes would be a major challenge for organic growers, as most organic fungicides may not be as effective as traditional fungicides. Sulfur is an excellent way of controlling powdery mildew. However, sulfur spray should be stopped after temperatures exceed 88 to 90 F. Cluster removal may be beneficial if crop load is excessive but cluster shortening is not recommended, as clusters will be too compact. A maximum of 10 to 15 clusters per vine is sufficient for this variety. This cultivar does not need GA spray, and GA may have an adverse effect on berry appearance. This grape can be harvested between Sept 15 and October 15 under Southwest Idaho conditions.

'Emerald' vine should be spur pruned. Spacing plants very closely (i.e. 6ft x 9ft), will lead to a denser canopy, that will aggravate the mildew problem in many varieties, particularly in 'Emerald'.

'Ralli' or 'Anahita'. Berries of this variety are seedless, medium to large size and have bright red color that will turn darker if kept on the vine. Clusters for this variety are medium size and extremely attractive. Cluster shortening, GA spray, and girdling are not recommended, although minor crop adjustments (e.g., cluster removal) may be needed in some years. Our experiments show that girdling may have negative effects on berry quality and vine survival. This variety can be harvested between August 20 and September 20. The optimum training and pruning methods under for this region are currently being evaluated. It appears that vines can perform satisfactorily when they are spur-pruned and trained to a single bilateral cordon. However, this variety has the tendency to produce canes that dominate the cordon arms. Overall, the vine is not very vigorous. During the April freeze of 2007, we found that this cultivar is sensitive to spring frost.

'Kashishi': This grape variety originated in the northern part of Iran and southern regions of the former Soviet Union. The name in Persian (Farsi) translates into 'grape of the priests', perhaps due to its high quality. Although preferences vary widely, 'Kashishi' is generally considered the best seeded-grape among all varieties we have tested during the last several years. Although many American consumers prefer seedless grapes, some high quality seeded grapes such as 'Kashishi' would likely be more popular for export markets. Berries are naturally very large, tender, and oblong shape with beautiful maroon color. The vine is moderately vigorous. Usually, this variety does not need GA spray, vine girdling, cluster thinning or cluster shortening. Berries mature between September 10 and October 10 under Southwest Idaho conditions and shattering generally does not occur under normal conditions.

'Kashishi' should be spur-pruned. The most common training for this variety is single bilateral cordon. Suitability of other methods of canopy management is currently being evaluated at the University of Idaho.

Our results show that riser shoots on the main cordons show severe symptoms of frost injury, and up to 75% of the length of shoots may die from winter cold injury.

However, the main trunk and cordons rarely show injury from frost injury under the winters of Southwest Idaho. Interestingly, these vines survived the winter of 2014 when temperatures plunged down to -10 to -12 ^{o}F.

'Autumn Royal': Berries are large, seedless, crunchy, firm, flavorful, and have deep purple to black color. Clusters of this variety are large and compact. Requirements for GA spray on this variety are not yet well established for the Intermountain West region, but it seems that an early GA spray (at bloom) may reduce the fruit set and thus improve the quality by reducing cluster compactness. This grape can be harvested between September 15 and late October under Southwest Idaho conditions. Propagation of this cultivar is not as easy as 'Alborz'. Cuttings may not need any rooting hormones for rooting.

This 'Autumn Royal' is often trained into a quadrilateral cordon training system in California. Our experiments show that managing canopies of this variety with a single cordon system is difficult and many berries are often sunburned with this system of training. Overall, 'Autumn Royal' may have potential for planting under conditions of Southwestern Idaho but not reliably.

'Fantasy': Berries are naturally large, seedless, firm, crunchy, flavorful, and have deep black color. Clusters in this variety are loose and do not need cluster shortening, cluster removal, or GA sprays. 'Fantasy' can be harvested between September 1 and September 20the under Southwest Idaho conditions.

This variety is often trained to a single bilateral cordon. Productivity of this cultivar is low and irregular under Southwest Idaho conditions.

Overall, 'Fantasy' may have potential for planting in this region, but its productivity characteristics should be kept in mind before planting on a large scale.

'Jupiter': Berries are deep purple, medium size, semi-tender, seedless (or have small trace) and distinctively flavorful. Clusters are small to medium size, and thus do not need cluster shortening or GA sprays. However, removal of clusters with close spacing may improve berry size.

This cultivar can be harvested between September 1 and September 20th, although berries can remain on the vine after Sept 20 and get sweeter. Late harvested 'Jupiter' berries make excellent raisins.

'Jupiter' can be used fresh or as raisins. Vines of 'Jupiter' are extremely productive and cold tolerant. During April of 2007 and winter of 2013-2014, several varieties of wine and table grapes were damaged by frost while 'Jupiter' showed no signs of damage and produced a full crop in 2014. Temperatures plunged down to -12 ^{o}F during winter of 2013-2014. This variety is often trained into a single bilateral cordon. 'Jupiter' is recommended for a small-scale commercial planting under Southwest Idaho conditions. Due to the soft texture and medium size of berries, large-scale production may not be advisable unless the marketing commitments are established. Recently, we are finding an increased demand from consumers within or outside of the United States for 'Jupiter' Grapes.

'Princess': Berries are seedless, medium to large size, tender, and have light green color that can turn yellow if left on the vine. Berries are distinctively flavorful and have a pleasant taste. 'Princess' may not need GA sprays. This cultivar can be harvested between September 5 and September 30, although berries can stay on the vine until later.

Shortly after its release, 'Princess' was planted widely in California. However, 'Princess' fruit set can be problematic both in California and Idaho, and thus, its plating has slowed down. Preliminary experiments in California and Idaho show that poor fruit set in this variety could be the result of nutrient deficiencies, and the set may be improved by additional supplies of K at critical times before set. However, these observations are not conclusive and merits further study. In Idaho, we train 'Princess' grapes into a single bilateral cordon and spur prune them. However, in California, they train 'Princess' to single bilateral cordon, slanted bilateral cordon, or quadrilateral cordon and spur prune them in all training systems.

'Princess' has an outstanding fruit quality and is in high demand. Thus, researchers in California and Idaho focus on improving the fruit set issue in this cultivar.

‘Italia’: This grape is widely planted in Italy. ‘Italia’ is the best green, seeded grape among all varieties we have tested during the last several years. Since many American consumers prefer seedless grapes, some high quality seeded grapes such as ‘Italia’ would be likely more popular for export markets. Berries are naturally large, tender, and oblong shaped with beautiful green color that can turn yellow if left on the vine and exposed to sun light. The vine is not vigorous. Our research shows that ‘Italia’ does not need GA spray, vine girdling, cluster thinning or cluster shortening. Girdling wounds in ‘Italia’ would heal very slowly and may cause problems with vine survival. However, girdling enhances berry maturity. Berries mature between September 10 and October 1st (depending on the temperatures during the growing season) but cluster can be retained on the vines until October 15 under Southwest Idaho conditions. Berries do not shatter under normal conditions.

‘Italia’ should be spur-pruned. The most common training for this variety is single bilateral cordon.

In Idaho, ‘Italia’ can be kept in a regular storage at 32 ^{o}F for several weeks, perhaps until Thanksgiving or Christmas.

‘Saturn’: Berries are medium size, red to dark red, and are seedless or have small traces of seed, particularly when summer temperatures are excessively high. Berries are flavorful and clusters are small. These characteristics make this cultivar an excellent choice for children school lunch, as they may not be pack or eat an entire large-clustered grape.

Excessive shading will result in poor color. Grapes are harvested between September 1 and September 25. ‘Saturn’ should be trained into a single bilateral cordon system.

Table 5. Summary of various characteristics of some of the newer table grape varieties in Idaho

Variety	*Seed Status*	*Berry size*	*Cluster Size*	*Berry Color*	*Approx. Harvest in Idaho*	*Skin*	*GA Needs*	*Comments*	*Over-all Preference*
Autumn Royal	Seedless	Large	Large	Black	Sept 10-Oct 15	Tender	Yes?	Mild sunburn	Excellent
Princess	Seedless	Medium	Med-large	Green	Sept 5-Sept 30	Tender	No	Poor Set	Excellent
Ralli	Seedless/ Trace	Medium-large	Medium	Red-maroon	August 25-Sept 30	Tender	No	Cold sensitive	Excellent
Jupiter	Seedless/ Trace	Medium	Medium	Black	Sept 1- Sept 25	Tender	No	Cold Resistant	Excellent
Kashishi	Seeded	Large	Medium	Maroon	Sept 12-Oct 15	Tender	No	Pleasant	Excellent
Emerald	Seedless	Medium	Very large	Green	Sept 10-Oct 15	Tender	No	Very susceptible to sunburn & Powdery mildew	medium
Alborz	Seedless	Medium	Large	Red	Sept 1-Oct.10	Tender	Yes	Needs crop management	Excellent
Neptune	Seedless	Medium-large	Medium	Green	Sept 5-Oct 5	Slip	Yes	Nice berries, Muscat flavor	Medium
Red Globe	Seeded	Large	Large	Red	Sept 20-Oct 20	Tender	No	Late season	Good
Flame Seedless	Seedless	Medium	Large	Red	Sept 1-Oct.10	Tender	Yes	Needs crop management	Excellent

Chapter 6

The Role of Gibberillic Acid and Girdling in Table Grapes

1. Gibberillic Acid

Gibberellins are naturally occurring compounds that influence plant growth. Many different forms of gibberellins have been identified in plants. Gibberellins are considered as growth-promoting hormones and are involved in phototropism, breaking dormancy, and cell enlargement. Gibberellic acid number 3 (GA3) is a form of gibberellin that is commercially used for berry enlargement in certain table grapes. GA3 (simply referred to as GA) also elongates clusters. It is commercially available in both powder or liquid formulations, and it is commercially available under trade names of Pro-Gibb® 4% or Gib-Sol®. For home owners, the 4% liquid formulation (containing 1.0 gram/fluid ounce of formulated product) is the easiest to use. Pro-Gibb is also available at higher concentrations higher than 4%.

In some seedless varieties such as 'Alborz', 'Flame', and 'Thompson Seedless', both a bloom spray (to reduce berry set) and one or two sizing sprays (to increase berry size) are generally applied. Application of GA either at bloom or at sizing in these varieties increases the berry size to some extend but not as much as when it is applied at both bloom and sizing times. Concentrations of GA sprays applied at bloom are generally lower than sizing sprays. Not all varieties respond to bloom sprays for thinning. These varieties may require a gibberellin spray only for increasing the size of the berry. In general, the rate of gibberellin used may increase as the season progress. Berry size in seeded grapes such as 'Italia', 'Kashishi', and 'Red Globe' are generally larger than seedless grapes because seeds produce natural gibberellins which increase the size of the berries. It is not necessary to spray GA on 'Italia', 'Kashishi', and 'Red Globe' in Idaho.

Gibberellic acid should only be applied at the levels recommended on the label as exceeding those rates may seriously damage the plant. Our experience in Idaho shows that excess application of GA reduces fruit color and delays berry maturity (Fallahi et al., 1995). Also, some varieties are sensitive to GA3 application. Thus, GA3 should only be applied to the varieties that are listed on the label.

Since the labels on the 4% liquid formulations often refer to actual grams of gibberellic acid applied in the finished spray per acre, conversion for only a few grapevines is difficult. Thus, we provide the following table in which the values have been converted to parts per million (ppm) in a one gallon water solution. One gallon of solution is enough to treat two mature grapevines

Table 6. Gibberellic acid preparation for use on various table grape varieties

Desired concentration of final Gibberellin spray	Number of drops of 4% Pro-Gibb liquid added to one Gallon of water
1 ppm	2 drops
2 ppm	5 drops
5 ppm	12 drops
10 ppm	23 drops
20 ppm	47 drops
40 ppm	94 drops
60 ppm	141 drops

2. Girdling

The cambium layer is located between two types of cell structures known botanically as the xylem to the inside of the cambium and the phloem tissue to the outside of the cambium layer. Water and minerals absorbed by the roots are transported by the xylem tissues to the upper portions of the plant. Sugars and amino acids which act as the building blocks for starch, protein, and fat, are transported through phloem tissues. In grapes, these materials are produced in the leaves and are generally transported downward in the phloem tissue and laterally via vascular ray cells. Girdling causes a temporary disruption of this downward movement of foods without interfering with the upward movement of water and minerals, and this could result in the production of larger berries.

Girdling is the removal of a strip of bark on either the trunk or canes. On the trunk this removed live tissue varies in thickness from a minimum of .55 mm to 1.5 mm (about 1/4” to 1/16”) or slightly more, being the thickest on young vines and the thinnest on old vines. The thickness averages about 1.0 mm on moderately vigorous vines of moderate trunk diameters. The live cambium layer lies under several layers of dead loose bark, a layer that accumulates annually and which is more or less persistent.

Trunk girdling knives are manufactured in three widths, 1/8, 3/16, and 1/4 inch, and cane-girdling knives are produced in one width, 3/16 inch. The 1/8 inch is generally only used for reopening girdles. Currently the 1/4 inch trunk girdler is the most common one used on ‘Thompson Seedless’ for berry enlargement, and the 3/16 inch for maturity enhancement on such varieties as ‘Cardinal’ and ‘Ribier’.

Girdling can be done with a sharp pocket knife, as long as it is done completely. An inexperienced person can easily cut either too deep into the woody structure or too shallow into the bark of the vine. Cutting too deep may injure the vine, while cutting too shallow will not result into a true girdling. Two or three hours after girdling, the girdling area can be checked. If the cut was too shallow, strands of vascular tissues and a light brownish color can be observed in the wound area. At this time, these remaining strands should be completely cut and removed.

Our experiments show that ‘Alborz’, ‘Flame’, and ‘Crimson’ girdling wounds are healed in about 4 to 6 weeks. However, girdling wounds in ‘Italia’ do not heal easily and thus are not recommended. Girdling vines in Idaho should be avoided as much as possible. This is because girdled vines can be seriously damaged or die if extremely low temperatures occur during the following winter.

Chapter 7

Crop load, Shoot Management, GA and Girdling with Emphasis on 'Alborz' Grape (Photos 97-117)

Maintaining a proper leaf-to-fruit ratio is essential for producing high quality fruit in any fruit crop, including table grapes. Crop management in table grapes starts with training and dormant pruning of the vines. Since 'Alborz' table grape is the main cultivar in Idaho, we will emphasize the various aspects of crop load management of this cultivar in this section.

Berry Description: 'Alborz' berry quality and vine performance are very similar to 'Flame Seedless'. Berries in this cultivar are medium-sized, red, seedless, firm, crisp and flavorful, and ripen during September in Idaho. Due to cooler weather in September, berries in 'Alborz' will stay firm until mid- to late-October if they are protected from wasp and birds. However, berries maintain their commercial quality until about September 15th under conditions of southwest Idaho.

Training and Shoot Thinning: Vines should be trained using a bilateral cordon and pruned to 12-16 two-bud spurs (6-8 bud spurs on each arm) during the dormant season (early to late-March in southern Idaho). When shoots reach eight to 15 inches, they should be thinned to two shoots per spur. Each of these shoots must have a strong cluster. These two shoots often arise from the two selected buds on the spur. However, under Southwest Idaho conditions, some times one of these two shoots may need to be selected from the shoots that arise from the basal bud. This situation occurs when there is severe winter or spring frost injury or due to early detailed pruning, leading to frost damage of the two selected buds. If the buds are frozen before pruning, the pruner should seek for alternative live buds. However, spring frost injury in the region is a commonly-occurring event. During the period of 2000 and 2014, we had a few years that temperatures plunged below freezing points as late as April 11. By that time, detailed pruning in most vineyards are completed and thus, sub-freezing temperatures may kill or weaken the two selected buds that were described above. If that is the situation in a vineyard, the grower may need to consider to do the detailed pruning as late as possible but before buds grow. All unproductive shoots which develop from latent buds and basal buds along the cordon and on the trunk should be removed.

Early Basal Leaf Removal: In some cultivars including ‘Alborz’ and ‘Flame Seedless’, basal leaves and laterals should be removed around the time of berry set. In Idaho, we remove all leaves that are grown between the basal and first cluster on each shoot at the same time that we remove the entire excess clusters and remove the tip of the remaining cluster as described in the next section. This Practice is most beneficial in cultivars with high vigor in vineyards with standard "T" trellises that tend to haystack the canopy.

Flower Cluster Thinning: Flower clusters should be thinned to one cluster per shoot when shoots reach 15-20 inches (when clusters are easily visible). Only the strongest and best shaped cluster is retained. If more than one cluster per shoot is retained, the berries will be smaller in size with poor color. In years that crop is extremely low and where shoots are strong, two cluster may be retained on each shoot. However, if low crop load is not an issue, this practice should be avoided. Side shoots and leaves above the clusters should not be removed; however, tendrils should be removed from the clusters at this time.

Cluster Shortening (Tipping): The clusters should be reduced in length at the time of fruit set, when clusters have separated and are easily distinguished. Usually, the cluster rachis is cut with clippers to remove the lower 1/2 to o 1/3 of the cluster. Only six to ten of the cluster branches should be retained to develop berries. This practice will result in a full and rounded cluster of excellent quality. The first branch of each cluster is usually a long one and is called “widow shoulder” or “un-wanted should shoulder”. Widow shoulder should be removed at the time of cluster shortening.

Gibberellic Acid Sprays: Gibberellic acid (GA) sprays may be applied to reduce fruit set and to increase berry size. In California, the first of these sprays is applied at a rate of 5 to 10 ppm when 50% of the clusters on the vine show that bloom has begun on about 60%-75% of the flowers. This application will reduce fruit set and increase berry size. Application of gibberellic acid at higher than 10 ppm at bloom time may produce small shot berries. Two additional "sizing sprays" of gibberellic acid may be applied in California. The first sizing spray is applied following bloom when the berry size is about 1/4" (5-7 mm) in diameter and the second "sizing spray" is applied a week later. Peacock (2005) has provided useful reading materials on the effects of GA on 'Flame Seedless'.

In Idaho, we have studied bloom application of GA only to a limited extend. We have observed excess thinning if GA at much higher rate than 10 ppm (50 ppm or 60 ppm) are applied at bloom time. However, we have applied 3 sprays of GA at "sizing", each at 40, 50, or 60 ppm and applied at 200 gallons per acre over several years. Application of 50 ppm showed satisfactory results and seems to be an optimum concentration although 40 ppm also worked well over several years. To obtain a 40 ppm GA solution from ProGib or FalGaro containing 4% GA, 1514 ml of one of these chemicals should be mixed with 400 gallons of water (757 ml of the chemical in 200 gal). To obtain a 50 ppm GA solution from ProGib or FalGaro containing 4% GA, 1892 ml of one of these chemicals should be mixed with 400 gallons of water (946 ml of the chemical in 200 gal). To obtain 50 ppm GA solution, In Idaho, we apply the first "sizing spray" soon after fruit set (when flowers are gone and berries about 4-5 mm) and apply the second and third "sizing sprays" five and 10 days after the first "sizing spray", respectively. Growers may wish to experiment with different frequencies and rates of GA at various spray volumes in a very small scale under their own conditions. A multi-GA spray may produce better berry uniformity. Application of GA after verasion will not lead to a significant increase in berry size.

Both late and high concentrations of GA may delay the berry color in 'Flame Seedless' and 'Alborz'. In two seasons, we applied 3 GA sprays at sizing at 40 ppm, 60 ppm, and 60 ppm to 'Alborz' at a weekly interval. The 60 ppm seems to delay the color development. We also applied GA at higher frequencies and concentrations than the labeled rate in 'Thompson Seedless' in Arizona over two seasons. In both locations and cultivars, although berry size increased, berry color decreased, particularly in the areas that the canopy was shaded. However, it is not easy to eliminate berry color problems by just increasing light exposure if the poor color is caused by excess GA application.

Girdling: Size girdling is performed at about the same time that the first sizing spray of gibberellic acid is applied. In girdling, a small width of cambium layer around the vine is cut. This practice can be done by either by removal of a complete ring or partial ring around the main trunk or individual arm. Our study shows that size girdling in 'Alborz' and 'Flame' increases berry size (Table 5) but it results in a slightly more "woody texture" in the berries as compared to non-girdled vines. Also, if a sever winter occurs after the girdling season, vines may suffer frost injury because this practice will limit movement of sugars and amino acids which act as the building blocks for starch, protein, and fat to the roots.

The girdling wound in 'Alborz' heals up in about 4 to 5 weeks under Southwest Idaho conditions. Girdling will stress the vines and fewer clusters should stay on the vine when girdling is practiced. In our study, berries in girdled vines reached an acceptable color and maturity when clusters were left on the vine long enough (Table 5). To prevent poor berry color development in some areas of the country, girdling is performed done when the berries change from a deep green to a translucent green (just before the red color begins to show). This is called "Maturity Girdling" and by this practice the fruit will turn color more quickly and the maturity will be increased as compared to "Size Girdling". However, for two reasons, we do not recommend "Maturity Girdling" for Idaho; 1) berry color development is not usually an issue in Idaho; 2) there may not be sufficient time for the girdling wound to heal on time and thus vines may de injured by frost. Overall, we strongly emphasize leaving a correct number shoots and clusters on each vine, cluster removal, and cluster shortening for improving berry size rather than girdling in Idaho. However, growers may wish to practice "Size Girdling" on a limited basis for suitability of this practice for their own conditions.

Timing for Bloom, Shoot Thinning, Crop Adjustment, and GA Sprays for 'Alborz' in Idaho: Phenological development of vines should be used as a gauge of timing of cultural practices rather than a calendar date. Timing based on phonological development stages will take into account temperature and other changes that may occur from season to season. However, we provide the approximate dates for bloom, crop adjustment, and GA sprays under conditions of Parma, Idaho during the last few years in Table 7. During this period, vines were in full bloom between June 8 to 17 and clusters were reduced and shortened between June 12 and July 1st. These dates corresponded with the 'fruit set stage', and were the perfect timing for cluster shortening (reducing the length of the clusters). However, based on experience, cluster numbers could have been reduced a few days earlier than the dates we actually reduced them. Reducing cluster numbers during the "Estimated cluster adj." dates which are referred to as "Estimated cluster adj." in Table 7 would have made the operation smoother because shoots were shorter.

It is important to underscore that cluster shortening, first GA spray, and size girdling (if needed) all are practiced at the same time period and the timing coincides with the fruit set stage (Table 7).

Table 7. Average dates of dormant spray applications, full bloom, cluster thinning and cluster shortening, and gibberellin acid (GA) applications in 'Alborz' grapes at the University of Idaho Parma Research and Extension Center in 2000-2007.

Year	*Dormant spay*	*Full bloom*	*Actual Cluster ad.*[z]	*Estimated cluster adj.*[z]	*Girdling*	*First GA*	*Second GA*	*Third GA*
2000	April 3	June 10	June 21	June 6	June 21	June 20	June 27	July 3
2001	April 3	June 10	June 22	June 7	June 22	June 21	June 30	July 7
2002	April 7	June 14	June 25	June 10	June 25	June 24	July 2	July 9
2003	April 9	June 14	June 25	June 10	June 25	June 24	July 1	July 9
2004	April 10	June 9	June 23	June 9	June 23	June 23	June 30	July 8
2005	April 5	June 17	July 1	June 17	July 1	July 1	July 8	July 14
2006	April 13	June 9	June 16	June 5	June 16	June 18	June 28	July 5
2007	April 6	June 8	June 12	June 1	June 16	June 15	June 22	June 28

[z] The Actual cluster adj.(adjustment) = the actual date that we removed the excess clusters and shortened 1/3 to ½ of the remaining ones. Estimated cluster adj. = the estimated date that we could have removed the excess clusters for a smoother operation and better results, because shoots were shorter.

Yield Capacity: Under ideal conditions, an Alborz or 'Flame' vine should have a total of about 32 clusters after cluster thinning and shortening are complete (16 spurs per vine 8 spurs /arm x 2 buds/spur x only one shoot per bud x only one cluster retained per shoot = 32 clusters). Using this principal and a bilateral cordon system, 'Flame' table grape produces an average of 700 to 800 boxes and maximum of 1000 to 1200 boxes (each box is 18 lbs) per acre annually in California. When production reaches 1000 boxes or higher per acre, berry size may reduce and biennial bearing may take place. Our 3-year research in Idaho showed that under a 6 x 9 ft vine spacing, 'Alborz' table grape produced 15.21 kg/vine (33.46 lb/vine or 12.27 tons/hectare or 1498 boxes/acre) when an average of 25 clusters were retained per vine and clusters were thinned (Table 8). The berry size quality in our experiment was generally acceptable. In a different experiment with 'Alborz' table grape in 2007, we found that increasing the number of clusters per vine to 28 or 36 increased yield and berry size (Table 9). However, berries from vines with 28 clusters had better over-all quality than those with 36 clusters per vine.

Extrapolating from the above experiments, we believe that high quality 'Alborz' and 'Flame' can be produced in Southwest Idaho at a comparable level of productivity as that in California if there is no severe frost and if shoot thinning, cluster management, and other cultural practices such as powdery mildew sprays are performed in a timely and correct manner. Even if the vine spacing was at 8 x 11 ft and each vine had 33.46 lb/acre, we would have had 920 boxes of grapes/acre. If we had shortened the 'Alborz' clusters more severely to gain even larger berry size, one might assume that our production would have still be within 700 to 800 boxes/acre, which is similar to the production range for 'Flame Seedless' in California. However, growers should assume that frost is unavoidable and must calculate a lower production than California when estimating or predicting the potential yield under Southwest Idaho Conditions.

Table 8. Effects of crop load management on fruit quality and yield in 'Alborz' grape in 2007.

Target Cluster No.	Actual cluster No.	Cluster length (cm)	Cluster weight (g)	Yield (kg/vine)	Yield (T/acre)	Berry weight (g)	Berry size (mm)	Berry color (1-5)	Berry soluble solids (ºBrix)
Control	71 a	29.3 a	684.0 b	29.4 a	23.74 a	3.44 b	16.15 b	3.00 b	18.83 b
20	19 b	19.7 b	870.1 ab	14.6 c	11.75 c	3.74 a	16.94 a	3.63 a	20.12 a
28	28 c	19.9 b	1003.0 a	20.0 b	16.15 b	3.83 a	17.07 a	4.02 a	20.27 a
36	34 d	20.6 b	820.3 ab	25.8 a	20.59 a	3.97 a	17.16 a	3.71 a	20.12 a

Values within each column are significantly different if followed by a different letter at 5% level, using LSD.

Table 9. Effects of number of clusters on yield and berry quality in 'Alborz' table grape in 2007.

	Cluster attributes		Berry quality attributes			Average annual yield	
Treatments	Weight (g)	Length (cm)	Weight (g)	Color (1-5)	Sugar (Brix)	(kg/vine)	(t/acre)
No cluster removcal no cluster cut	488.6 c	28.7 a	2.85 c	2.63 b	18.1 b	23.34a	18.83 a
No cluster removal,but cluster cut	518.6 c	22.0 b	3.36 b	3.06 ab	18.6 ab	19.02b	15.34 b
Cluster removal,but cluster not cut	633.2 ab	29.8 a	3.31 b	3.22 ab	19.1 ab	15.70b	12.66 b
Cluster removal and cut	569.9 bc	23.1 b	3.41ab	3.41 a	19.5 a	15.21b	12.27 b
Cluster removal ,cut and girdle	708.4 a	22.6 b	3.77 a	3.25 ab	17.8 b	18.33b	14.78 b

Values within each column are significantly different if followed by a different letter at 5% level, using LSD.

Color Enhancement

The weather conditions in Idaho are excellent for development of berry color without application of color-enhancing chemicals such as Ethrel® . Ethrel® is the trade name – distributed by Rhone-Poulenc Ag. Company. Shorter days and cool nights during the ripening period in Idaho are ideal conditions for pigment and color development of table grapes. Using appropriate training systems and canopy management practices that leave the optimal number of shoots can provide sufficient light penetration for excellent color development in 'Alborz' and other grape cultivars. Berries produced inside of a dense canopy do not receive sufficient light and stay green. As mentioned before, "maturity girdling" can increase berry color in California but is not necessary in Idaho. Recently, application of abssesic acid (ABA) has shown to increase berry color in California.

Home gardeners may not wish to apply gibberellin or ethephon sprays or to girdle the vines. However, we recommend that home owners remove and shorten some clusters even if no girdling or chemicals are applied. That way, while they will be enjoying a natural way of grape production while reducing the chance of winter freezing injury in the vines by over-cropping them.

Chapter 10

Irrigation

Although different irrigation systems can be used for vineyards in Idaho, the PNW, or other similar regions worldwide. our experience shows that drip irrigation is the best system for production of high quality table grapes. We have tested overhead irrigation for table grapes in Idaho over several years and do not recommend it for several reasons. First, overhead irrigation may use over 65% more water than a drip system. Also, overhead irrigation deposits undesirable stains on berries in all table grape cultivars. The stains are due to calcium deposits that are commonly produced by most water sources in the Southwest Idaho.

Drip system, if designed and installed properly and if water requirements are calculated correctly, can provide optimum amount of water to the root zone with less weed development. Drip lines are installed either as buried lines along side of the vine row or on the lowest wire (about 16 inches from the ground) with two one gal/hr or two gal/hr emitters per vine to deliver total of 2 gal/hr or 4 gal/hr water per vine, respectively. Many other drip irrigation designs consisting of pre-installed and pressure-compensated emitters with different spacing and water delivery capacities are available in the market. Any of these drip systems can be installed as long as it provides sufficient amounts of water to the root zone. Our experience with buried drip lines show that lines should not be buried deeper than 3 to 4 inches and or placed further than 12 to 16 inches from the vine row. A large portion of water will move downward in our sandy loam soils when drip lines are buries too deep. Also, deeply buries drip lines are more likely to get damaged by gophers and other rodents. Growers should consult with the irrigation dealers and specialists for advantages and disadvantages of each system.

It is important to make sure that root zone gets water when plant are young. If the spacing between emitters is too far apart, water may not penetrate the root zone of some plants throughout the vineyard. This problem can be reduced by increasing the duration and/or frequency of drip irrigation. However, water distribution from drip emitters varies in every type of soil and the wetting pattern may not exceed 1.5 to 2 ft from the drip line in a sandy loam soil. In emitters with a higher water delivery rate, the wetting pattern could be wider than those with a smaller water delivery rate. Thus, an emitter with 1 gal/hr capacity will have a wider and faster speed of wetting than the one with 0.52 gal/hr. When a drip system is used, the required water should be applied at least in two applications in each week. Smaller amounts and more frequent applications of water through a drip system is more efficient than a single application.

If drip tubes without re-installed emitters are used, each emitter can be placed 7 inches away from the vine trunk. However, if drip lines with pre-installed emitters are used, vines are irrigated when needed as indicated by a WaterMark Soil Moisture Meter and sensor (Irrometer Co. Inc., Riverside, CA) and/or neutron probes.

In our studies with performance evaluation of table grape cultivars with an 8 x 9 ft vine spacing and a T trellis system in southwest Idaho, we applied approximately 21 inches of water through a drip system for mature table grape vines per year. When the vines were just planted and drip efficiency was very high, we applied about 10 to 12 gal/week in July during the first year, and this amount was increased with the age of the vine. When the vines were completely mature, we applied about 65 to 76 gal/week in an 8 x 9-ft space planting during warm months of summer. We must emphasize that these amounts are not necessarily the ideal amounts for grapes, as we had not targeted our experiments for determination of optimum amounts of water for grapes, and these amounts will be more precisely determined in the future. However, we believe that the 22 to 28 inches of water requirement in California is slightly higher than the amount that we need in Southern Idaho. In less efficient water delivery systems, the requirement may be as high as 36 inches per year. We should also underscore that water requirements will vary with many factors including grape type (wine vs. table grape), vine spacing, cultivar, soil type, age of vine, temperature, wind velocity, and stage of grape development. The best way to determine water requirements is using soil moisture meters, and or ET c (evapotranspiration for grapes). Probably the simplest way to examine if the applied water is sufficient is to dig a hole 12-18 inches deep (as deep as bulk of roots are penetrated), take a handful of moist soil and squeeze it with your hand. If you can make a ball with the moist soil, then the moisture is perhaps sufficient. If the “ball is too muddy, the moisture is too much and is the soil disperses and does not form a ball, the moisture is not enough. You have to develop a schedule that works well for your vineyard and soil type.

Any factor that affects evapotranspiration can also affect irrigation requirements. Thus, the vine vigor (leaf number and size and size of shoots) and trellis type can affect seasonal evapotranspiration. A table grape vineyard with a 42 inch cross arm and a seven foot stake will develop a full canopy by end of June that will shade 75% or more of the vineyard floor during midday, and the seasonal evapotranspiration is about 27 to 29 inches.

Water use begins with bud break. Water requirements are at maximum in July. During stage 2 of berry development (bloom to veraison), the water requirement is higher than at other growth stages. Berry cell division takes place during this period. Our studies show that water stress during this time can severely reduce berry size in table grapes. We have also found that ‘Flame’, ‘Alborz’, and ‘Challenger’ grapes are particularly sensitive to water stress during stage 2. Application of excess water during veraison will not reverse the severity of stress damage, and thus, will not drastically increase berry size if the stress was imposed on the vines during cell division and early stages of berry development. However, if berries are moderately and recently shriveled due to water stress, immediate application of a sufficient water may reverse the shriveling and berries may regain their turgidity. Peacock (1998b) has provided details on irrigation scheduling on grapes in California, which is a useful source for further study.

Chapter 11

Nutrition (Photos 118-123)

General Information

Grape vines require all macro nutrients such as nitrogen (N), phosphorous (P), potassium (K), calcium (ca), magnesium (Mg), and micronutrients such as iron (Fe), zinc (Zn), copper (Cu), manganese (Mn), and molybdimum (Mo). Fertile soils and soils that received extra nutrients during the previous seasons require less additional nutrients. Soils in Southwest Idaho, Eastern Oregon, and Central Washington generally have low organic matter and high pH (pH =6.5-8.5), which can limit P and micronutrient availability. Thus, N, P and micronutrients should often be applied for a sufficient grape production.

Soil analysis alone does not provide an accurate indication of the nutrient status of the vine, and thus tissue analysis of vines is also required. Soil analysis is a useful tool for studying problems related to certain chemical imbalances or excesses such as pH problems (alkalinity and acidity), salinity, cation exchange capacity, and excess boron. The vine nutrient status can be influenced by many different factors other than soil conditions, including rootstock, variety, interaction between variety and rootstock, and interaction between environmental conditions and genetic factors of each variety. Also, soil analysis is inefficient in determining the status and requirements of micronutrients for the vines. A foliar analysis using either leaf blade and/or petiole, sampled at bloom time, is needed to accurately monitor nutrients status of vines. Therefore, soil and plant tissue analysis are complimentary to each other. Growers should remember that the actual amounts of fertilizers discussed in this chapter are only for discussion purposes. We emphasize that both soil and tissue analysis are required to develop more accurate fertilizer recommendations for each vineyard.

To understand grape nutrition, it is essential to know the soil pH, texture, and availability of macro and micronutrients, and we will discuss these important factors in this chapter.

Soil pH

Soil pH is a measurement that is used to express the relative acidity or alkalinity of the soil. The solubility, and therefore the availability, of plant nutrients is influenced by soil pH. For this reason, each crop has an optimal pH range within which it grows best. Grapes are grown in a wide range of soil pH's. However, they thrive when soil pH is between 6 to 7 as most nutrients are readily available at this range. The range of pH is from 0 to 14, where 7 is neutral. A pH below 7 is acid and above this level is alkaline. The pH of the soil can be changed by applying amendments. Calcium carbonate ($CaCO_3$), or lime, will increase the pH of the soil, while applications of elemental sulfur will reduce pH. Where there is a deficiency of Mg, we can apply dolomite, which is a form of lime that contains calcium and magnesium carbonates.

Many soils in arid areas contain an excess amount of lime. These are referred to as calcareous soils and are naturally high in pH. Many fertilizer products produce acid in the soil. These include ammonium forms of nitrogen and those that contain sulfur. Liquid fertilizer blends containing sulfuric acid or other acids can also be used to reduce the pH of the soil. These are frequently applied in the irrigation water (fertigation).

Soil Texture

The mineral component of the soil is made up of particles of various sizes. The largest sized particle is sand and the smallest is clay. Silt is a particle intermediate in size to sand and clay. Loams are soils made up mixtures of these different sized particles. Most soil particles have negative charges on their surfaces and they attract and hold positively charged elements or cations. The only way a cation can be removed from the surface of a soil particle is if another soluble cation replaces it. This process is referred to as cation exchange. The quantity of cations that can be held by a soil is known as the cation exchange capacity (C.E.C.).

Soil Organic Matter

Organic matter is an important component of the soil that influences its structure, tilth, aeration, infiltration rate of water and water holding capacity. As organic matter decomposes in soil, it becomes an important source of nutrients for the crop and also increases the number of nutrient exchange sites in the soil. Adding significant amounts of organic matter to soils, therefore, will typically increase nutrient and water holding capacity and improve nutrient availability.

Salinity

A high salt content in the soil can cause serious injury to crops. Different crop species vary in their tolerance to salinity, with grapes being relatively sensitive to high salinity. Generally, low quality irrigation water is the source of the salts that are introduced to the soil. However, high concentrations of fertilizers can also contribute to the salinity.

The only way to reclaim saline soils is by washing the salts out of the root zone with a large amount of good quality irrigation water. Then, with adequate drainage, the salts can be leached away. This procedure is practiced in some table grape-growing area of the world.

The Macronutrients

Nitrogen:

In grapes, nitrogen is an essential component of proteins, chlorophyll, plant hormones, amino acids, and various alkaloids. Nitrogen in the soil is present primarily in three forms, ammonium, nitrate and organic nitrogen. When urea is applied to the soil, it is converted into ammonium fairly rapidly when soils are warm.

Nitrogen can be applied in various forms of organic matter. However, fresh organic matter that is very high in carbon relative to N can reduce the amount of available N in the soil. Nitrogen can also be applied in the ammonium and nitrate forms. Ammonium has a positive charge and is held on the surfaces of the soil particles. The process of converting ammonium-N to nitrate-N by bacteria in the soil is called nitrification and usually takes place in a very short time in warm, moist soils.

Nitrate is the form of N that is most readily available to the grape vines. However, since it is not retained by the soil particles, it is also readily leached out of the root zone with the movement of water. Since nitrate is a serious contaminant of ground water, it is important to apply only the amount nitrogen that will be needed by the vine. Drinking water with greater than 10 ppm nitrate is harmful for human consumption. Careful timing of N applications to meet the grape vine demand will help decrease nitrate pollution and increase fertilizer use efficiency.

Nitrogen can be supplemented by sources such as ammonium nitrate, calcium nitrate, ammonium sulfate, urea, or manure. Nitrogen-deficient vines are weak and have short growth period coupled with a pale yellowing of the entire leaf surface. Berries with N deficiency may exhibit symptoms of sunburn and poor quality. Applying N fertilizer may not significantly affect the appearance of the current year's berries, but it will affect the next year's crop. In Idaho, the best time for application of N fertilizer is just at the time of fruit set (after bloom is finished). The application can be split in two applications, about 2 weeks apart (at set and 2 weeks later). However, at this point, we do not recommend any postharvest application of N in Idaho and the rest of the Pacific Northwest, as this practice may enhance freezing injury the vines.

Proper amount and timing of fertilizer, particularly N application will save money, reduce the chance of groundwater water contamination, and improves yield and fruit quality. Application of excess N will result in too much vigor while reducing yield, color, and sugar accumulation. Excess N will also produce long shoots and increases cane diameter and distance between buds. Additionally, excess N will produce large leaves and excessive shading of lower leaves causing them to turn yellow and drop off. Water berry and powdery mildew and bunch rot will also increase in the vines with excess N and dense canopy.

Our study with table grapes showed that fertigation of 30 g N as UAN-32 per young vine, at a density of 806 vines per acre (6 x 9 ft spacing, 53 lbs N/acre) with a single bilateral cordon system, was excessive and lead to excess shading and powdery mildew infestation in 'Alborz' and particularly in 'Emerald' table grapes. However, application of N at the same rate to the vine of the same cultivars, trained at a higher canopy height and at a 8 x 9 ft spacing (605 vines/acre; about 40 lbs N/acre) was not excessive. Nitrogen was fertigated through drip system in all of our grape experiments.

This demonstrates that with a closer spacing, N is more concentrated and absorbed by the vines than in a wider spacing, and the problems associated with excessive shading would be exacerbated with the lower training of the canopy. Most of the nitrogen studies in California are focused on ‘Thompson Seedless’, and a range between 23 and 46 lbs of actual N per acre is recommended for that cultivar in each year. Application of N at an actual rate of 40 lbs/acre in the mature table grape vineyards at 519 vine per acre is commonly practiced in California, and based on those assumptions, Table 10 provides the rate of required N per vine in both young and mature vines in California.

The actual amount of N required will depend upon a number of factors which can affect the vine growth, including the soil texture, soil compaction, hard pan, nematodes, rootstock, phylloxera, soil organic matter, cultivar growing habit, etc. There is no specific study on the requirement of nutrients for table grapes in the Pacific Northwest at the present time. However, in a successful study for cultivar evaluation of wine and table grapes at 7 x 9 ft spacing (691 vines/acre) in Idaho, we applied actual N at rates of 0.6 g, 2.57 g, 6.71 g, and 11.65 g in mid- June (during active shoot growth) during the first, second, third, and fourth growing seasons, respectively. The N rate during the fourth year in that study was about 17.7 lbs/acre.

For young vines, it is better to apply N in two applications in smaller quantities rather than applying the entire amount in one application. The rates for N and other elements discussed in this section are only to provide a general idea about rather than an absolute recommendation. We strongly recommend that growers take tissue and soil samples for analyses every year and determine the requirements for N and other nutrients under their own specific conditions. Recommending a blank rate for all soil conditions and cultivars is not appropriate or efficient.

Table 10. Nitrogen Fertilization – Rate Per Vine Per Season

Nitrogen source	% N	Suggested weight of N source per vine	
		Mature vine	Young vine(1- 3yrs)
Calcium Nitrate	15.5	½ lb	¼ lb
Ammonium Sulfate	21	1/3 lb	1/6 lb
Ammonium Nitrate	33	¼ lb	1/8 lb
Urea	46	1/6 lb	1/12 lb
Dry Steer Manure (30 lbs./ton)	1.5	25 lbs	12 lbs

Phosphorus (P):

Phosphorus can be found as calcium phosphates in high pH soils or as iron and aluminum phosphates in acid soils. All of these forms are sparingly soluble and the availability of P is highly dependent on pH. The solubility of P is greatest at a pH of about 6.5..

Most fertilizer forms of phosphorus are quite soluble. However, when they are introduced into the soil environment, P is rapidly converted into the less soluble forms. Then, as plants remove phosphorus from the soil solution, a small amount of P goes back into solution to establish equilibrium between soil and solution P. Therefore, the soil has the capacity to store phosphorus and slowly release it over time.

Application of phosphorus is beneficial in most soils in Southern Idaho. It is better to apply about two to three tea spoons of super phosphate (0-45-0) to each planting hole and mix it well with soil at the time of planting. Phosphorus fertilizers that are applied on the top of the soil move slowly in the soil so it is better to make it available to the roots at the time of planting. Excessive P application can lead to Zn deficiency if soil Zn concentrations are deficient or marginal.

Potassium (K):

Potassium is a positively charged element, or cation, which can be retained on the surfaces of soil particles or in the layers between soil minerals. Some types of clays also have the capacity to hold large amounts of K within their structures. In addition, the organic matter in the soil can contain significant amounts of K. As a result, most soils have a tremendous capacity to store this element. However, if a soil has become depleted, these storage sites can become a very strong sink for any applied potassium. This will remove the nutrient from the soil solution and compete with the plant for the available K. In Southwest Idaho, most soils have sufficient K. However, after a few years of production, the soil K may be reduced. Therefore, it is important to monitor K in the vineyard soils and in leaf petiole and blade tissues and to fertilize with K when needed.

Our studies show that higher volume of water may increase plant K concentrations. Leaf K concentrations of vines grown under a sprinkler system is more than those grown under a drip system. Also, vines grown under deficit drip or deficit sprinkler irrigation systems may have less leaf K than those grown under full drip or full sprinkler systems.

Potassium is extremely important in many physiological and biochemical processes of grapes. This element is involved in regulation of “Guard Cells’’ in plants and these cells are the main gateway to gas CO_2 and O_2 gas exchanges. Thus, they are essential for photosynthesis. Potassium is also involved in sugar transport and a number of other processes. Usually there is a huge demand for K by the berries.

In a study on both table grapes and wine grapes, we applied actual amounts of 5.60 g P plus 6.72 g K during the third year and 9.72 g P plus 11.67 g K during the fourth year of planting in the middle of June under conditions of Southwest Idaho. All fertilizers in our experiment were applied in one single application each year. The growth and yield in all vines were satisfactory in that study.

Sulfur (S):

Sulfur must be present in the soil in the soluble sulfate form to be readily available to the grape vine. However, because it has a negative charge, sulfate can be leached out of the root zone with the downward movement of water. Therefore, it is important to carefully time the applications of sulfate forms of sulfur to meet the crop demand and to get the most efficient responses.

The Major Cations

Calcium is a divalent cation, which means it has two positive charges. In addition to being an important nutrient, it also exerts a strong influence on soil structure. The two charges of Ca can attach to two soil particles, causing them to stick together or flocculate. This creates openings between the clumps of particles which facilitates the movement of water and air.

Magnesium is also a divalent cation so it has the same effect on the soil structure as calcium. Magnesium is a vital crop nutrient so it is important to maintain adequate levels in the soil.

Sodium (Na) is a monovalent cation which means that it has only one positive charge. It has the opposite effect on the soil structure as the divalent cations, Ca and Mg. Sodium reduces the flocculation of the soil and causes the particles to flow together. This can form a layer that is nearly impervious to the movement of water and air. Crops growing in sodium saturated, or sodic soils frequently suffer from severe water stress.

The way to reclaim sodic soils is to replace the sodium on the soil particles with calcium. Then, with the downward movement of water, the sodium can be leached below the root zone. Calcium sulfate ($CaSO_4$), or gypsum, is one form of Ca that can be used for this purpose. If the soil contains free lime ($CaCO_3$), then acidic forming materials which reduce the pH can be applied to dissolve the lime and liberate Ca in the soil.

Elemental sulfur can also be applied to the soil as an amendment. However, it must be converted to sulfuric acid by bacteria before it will reduce the pH. This process can be very slow, taking many months or even years to complete. As a result, the application of elemental sulfur is not a very rapid method of reclaiming sodic soils.

The Micronutrients

Micronutrients are elements required by plants in relatively low quantities. However, this does not mean that they are less important than the macronutrients. Micronutrients are frequently applied to crops by foliar applications. This bypasses the interactions in the soil that can render them unavailable to the plants. Well timed applications of the proper rates of micronutrients in the appropriate form often result in very good responses.

Iron (Fe), manganese (Mn), zinc (Zn) and copper (Cu) are all metals which are less soluble in the soil at a higher pH. This is why we frequently see deficiencies of these nutrients in alkaline soils. Molybdenum (Mo), in contrast, is much more available in an alkaline soils. Boron (B) is present in the soil as borate, which is negatively charged. Since boron is not held by the soil particles, it can be leached out of the root zone with water movement. Micronutrients should be applied as foliar sprays. Under conditions of southwest Idaho and many areas of PNW, Fe and Zn could become deficient and should be applied annually. **MMMMMMMMMMMMMMMMM**

As Zn deficiency increases, leaves become smaller and less deeply lobed and will be more open and flattened out. Vines with Zn deficiency develop straggly clusters with a wide range of berry sizes. Small “shot berries” in Zn-deficient vines do not reach the normal size of the other berries in the bunch. In a very small-scale, during the early March, when the vines are dormant and the sap is not flowing, prune so that one-half inch of wood is left above the dormant bud. Mix one-quarter pound of zinc sulfate (36% metallic zinc content) into a quart of water and apply to the wound. Do not allow the solution to run down onto the dormant buds. Another alternative is to spray the leaf foliage in the spring one to two weeks prior to bloom or during the bloom period (can be combined with gibberellic acid bloom spray in prescribed varieties). Organic matter and soil clay particles tend to tie up zinc so that it is not readily available to the plant via soil.

Since the micronutrients are only needed by the crop in small quantities, it is easy for a plant to get too much of one of these elements. An excessive level, or toxicity, of an element can be just as harmful to the plant as a deficiency.

Analysis of Soil and Plant Tissue

The reason for soil testing is to determine the availability of nutrients to the plants. Analysis will also detect many of the other factors that influence nutrient availability. From the results we can determine the quantities of fertilizers and soil amendments required to optimize these factors and improve nutrient availability.

The difficulty with soil analysis is that it cannot measure some of the most important factors that affect how a plant absorbs nutrients from the soil. Temperature, moisture conditions, compaction and drainage are just a few of these factors. This is the reason we turn to plant tissue analysis. If we analyze the leaves of the plant, we can determine exactly how much of each nutrient the plant is absorbing from the soil and accumulating in the leaf. Plant tissue analysis can provide us with important information in addition to soil analysis that is very useful in managing our applications of crop nutrients. Table 11 is a general interpretive guide for grape tissue analysis at bloom and veraison time. This table is taken from Christensen (1998) online publication at:

http://www.google.com/search?client=firefox-a&rls=org.mozilla%3Aen-US%3Aofficial&channel=s&hl=en&q=Christenson+Pub.+NG10-00

Table 11. Interpretive Guide for Grape Tissue Analysis at Bloom and Veraison

Nutrient	Deficient (below)	Adequate (above)	Excessive[2] (above)	Toxic[3] (above)
N03-N, ppm	350	500	2,000	8,000
P (total), %	0.10 (0.08)[4]	0.15 (0.12)[4]		
K (total), %	1.0 (0.5)[4]	1.5 (0.8)[4]		
Mg (total), %	0.2	0.3		
Zn (total), ppm	15	26		
Mn (total), ppm	20	25	300	1,200
B (total), ppm	25	30	100	150 300 in blades
Na (total), %				0.5 0.3 in blades
Cl (total), %			0.5-1.0	1.5 0.5 in blades

[1]Critical N03-N levels are based on Thompson Seedless data only. Some laboratories report as % N03.
Multiply % N03 by 2258 for ppm N03-N (i.e., 1.0% N03 = 2258 ppm N03-N).
[2]Excessive levels may be cautionary rather than indicating known effects on vine performance.
[3]Critical toxicity values are not well defined due to variety, growing condition, and seasonal differences.
[4]Veraison (berry softening) petiole values are in parenthesis.

Chapter 12

Plant Protection/ Weed, Pest, and Bird Control (Photos 124-137):

Weed Control:

Weeds between vines should be controlled mechanically by hand during the first two years of planting, and after that they can be controlled by application of glyphosate (Roundup) during the growing season, particularly in early June to late July every year. Long-lasting soil residue herbicides are not desirable on soils with low organic matter as they may damage the vine for a long time.

The vineyard floor can be disked three to five times a year if clean cultivation is desired. A cover crop such as rye grass or crested wheat grass (*Agropyron cristatum* (L.) can be planted during the fall. Crested Wheat grasses are useful for soil stabilization. They compete well with other aggressive introduced grasses. Their drought tolerance, fibrous root systems, and good seedling vigor make these species ideal for reclamation in areas with 8 to 20 inches annual precipitation. This cover crop can not be irrigated with a drip system and will only receive water by rainfall if the vineyard is irrigated by drip irrigation, but it can still maintain an acceptable cover crop for the vineyard floor all year along.

Insect Control:

We recommend Flaherty et al. (1992) as an excellent source for studying about insect management of grapes. No pesticide is needed if no pest is seen in the vineyard. However, trips can be a problem, particularly in table grapes. Although Thiodane is registered for thrips in table grapes, we do not recommend as it severely damages berries in certain cultivars, particularly ‘Emerald’. In this section, we will emphasize on a few pests that are extremely important to Idaho.

1. *Cutworms*

Cutworms can be a serious problem for vineyards, particularly for young vines during early growing season. Cut worms live about 6 inches under the soil and climb up the trunk and feed on the young and opening-buds and new shoots and then they go back in the soil and hide during the days. If the cut worm problem is very serious in non-bearing young vines, make a basin that holds about 1.5 to 2 gallons of solution under each vine. Mix 1 pint of Lorsban in 100 gal and apply about 1.5 to 2 gal of mixed Lorsban solution in each basin trench the lower part of trunks in late April or when buds are just starting to move. Repeat this in early May or when the damage is observed (about 10-14 days apart from the first application), when shoots are about 1-2 inches and are actively growing. It is ideal to apply about 1 inch of water after application, if it is available. For control of cut worms in mature and bearing vines, Lorsban is also helpful. Again, follow the label for any chemical.

2. *Leaf Hopper.*

Background information: Grape leaf hoppers may infest grapes in two forms: 1) grape leaf hopper (*Erythroneura elegantula*) and/or Variegated leafhopper (*Erythroneura variabilis).* Leaf hopper has become a serious pest in Idaho in the last two years. It seems to be more prevalent in the vineyards that are adjacent to a wide open desert areas. Most of the information presented on the leaf hopper section are extracted from UC IPM Pest Management Guidelines: Grape UC ANR Publication 3448 Insects and Mites and the UC IPM by Bentley et al. (2006).

Description of the pest: The grape leafhopper is a problem in warmer areas. Leaf hopper is becoming a serious pest in both wine and table grapes in Idaho. Leafhoppers overwinter as adults and are found in spring on basal grape leaves and weeds. The adult grape leafhopper is about 0.12 inch long and light to pale yellow with distinct dark brown and reddish markings. Eggs of the first brood are laid in epidermal tissue on the underside of the leaves in April and May and appear as a bean-shaped, blisterlike protuberance that is slightly less than 0.04 inch long. Although similar in size to the grape leafhopper, the variegated leafhopper is darker in color and distinctly mottled brown, green, and white with a reddish tinge. The nymphs are almost transparent when first emerged, becoming orange-brown to yellow-brown, in contrast to the white nymphs of the grape leafhopper. Eggs are similar in appearance to the grape leafhopper but laid deeper within the leaf tissue. This latter characteristic reduces the effectiveness of the egg parasite against variegated leafhopper.

Damage: Nymphs and adults of both species remove the contents of leaf cells, leaving behind empty cells that appear as pale yellow spots or stippling. If populations are high, the entire leaf may be pale yellow or white. Loss of leaf efficiency and leaf drop can occur when leafhopper densities are extremely high. This can result in fruit sunburn and may delay fruit ripening, especially in young vines. If there is a significant reduction in the overall photosynthetic capacity of the vine, young or stressed vines may have less shoot growth the following season.

The accumulation of small droplets of excrement on berries and the associated growth of sooty mold results in berry spotting that is a concern in table grapes. Adult leafhoppers are also a nuisance to workers when populations are high at harvest time. Their excrement appears as minute, sticky clumps that darken with age.

Management: In most cases, predators and parasites may be able to maintain leafhopper populations below tolerance levels. However, grape leafhopper populations in some vineyards in Idaho may occasionally reach damaging levels and require treatment. If chemical control of leafhopper is necessary, wait until the second (summer) generation, whenever possible, before treating.

Biological Control: Parasites are commonly found in vineyards during part of the season. These parasites may be more abundant in vineyards that are adjacent to prune and plum orchards, and riparian areas where other leafhoppers that overwinter in the egg stage reside. Anagrus spp. can parasitize these eggs and survive the winter. After a leafhopper egg is parasitized it becomes visibly red. Unfortunately, this parasite is not as effective on variegated leafhopper eggs as it is on those of the grape leafhopper. Sulfur sprays applied for fungal control are very toxic to Anagrus spp. General predators of grape leafhoppers include spiders, green lacewings (Chrysopa spp.), minute pirate bugs (Orius spp.), lady beetles (Hippodamia spp.), and predaceous mites.

Cultural Control: Removing basal leaves or lateral shoots during berry set and the 2-week period following (before adult leafhoppers emerge), as recommended for Botrytis bunch rot management, will normally reduce peak leafhopper populations during the season by 30-50%. This coupled with *Anagrus* activity may preclude the need for insecticide treatment even when leafhoppers exceed the thresholds below. Time leaf removal to coincide with first generation nymphal development up to and including the 5th instar but just before adults are present. Also, leaf removal will improve coverage and efficacy of pesticides. In warmer growing areas, be careful not to remove excessive numbers of leaves, which can lead to sunburned fruit, especially in cultivars such as 'Emerald' which is very sensitive to sunburn. Preventing overly vigorous vine growth will also help suppress leafhoppers. **I**f possible, remove weeds in vineyards and surrounding areas before vines start to grow in spring to reduce adult leafhopper populations that might disperse to new grape foliage.

Organically Acceptable Methods. Biological and cultural control methods, including basal leaf removal, assist in control. Narrow range oils, insecticidal soaps, or kaolin clay may give partial control when nymphs are small. Soaps may spot table grapes and should only be used before bloom on this crop.

Monitoring and Treatment Decisions. About 4 weeks after bud break, or whenever nymphs first appear, begin sampling for leafhoppers. Randomly select 20 vines in each block of the vineyard, each at least a few vines in from the end of the row.

How to monitor : *First generation nymphs*— On each vine, choose one leaf at the 3rd or 4th node up from the basal node.

Second and third generation nymphs— Choose young but fully expanded leaves in middle of canes.

Count nymphs on underside of each leaf. Note whether they are grape leafhopper nymphs, variegated leafhopper nymphs, or both.

Check the leaves for red, parasitized eggs or eggs with emergence holes.

Record the presence (+) or absence (-) for each leaf on a monitoring form.

Continue monitoring weekly until harvest. Starting at bloom, combine leafhopper monitoring with monitoring for spider mites.

Treatment thresholds. Treatment thresholds vary according to leafhopper generation; whether grapes are being grown for table, wine, or raisin use; canopy size; region; and degree of parasitization. A level of 10-30% parasitism on eggs of the first generation may result in economic control of the grape leafhopper during the second and third generations. However, if the leafhopper population is made up primarily of the variegated leafhopper, economic control by this parasite is less likely, although a combination of parasite and predator activity can be effective. Use the general guidelines below to help determine treatment needs. If treatment is necessary, removing basal leaves will allow better spray coverage and thus improve pesticide efficacy.

Treatment level is lower for table grapes than wine grapes because they need better fruit protection. For the first generation, treat if more than 15 leafhopper nymphs per leaf are found. In the second and third generations, early varieties (Flame Seedless) should not exceed 10 nymphs per leaf; midseason varieties (Thompson) 5 to 10 nymphs per leaf; and late varieties (Emperor) 5 to 8 nymphs per leaf. Large populations of adult leafhoppers in the fall are very annoying to workers who are hand harvesting grapes. A treatment just before harvest may be warranted if adult populations are high.

Common name (trade name)	Amount/Acre**	P.H.I.+ (days)

The following materials are listed in order of usefulness in an IPM program, taking into account efficacy and impact on natural enemies and honey bees. When choosing a pesticide, also consider information relating to environmental impact.

A. IMIDACLOPRID

(Provado Solupak) 75WP	0.75–1 oz	0

MODE OF ACTION: A neonicotinoid (Group 4A)[1] insecticide.
COMMENTS: Restricted entry interval: 12 hours. Foliar application: allow at least 14 days between applications. Do not exceed 0.5 lb a.i. of imidacloprid/acre/year. Repeat applications of *any* neonicotinoid insecticide (acetamiprid-Assail; imidacloprid-Admire, Provado) can lead to resistance to *all* neonicotinoids. Alternate neonicotinoids with an insecticide that has a different mode of action to help delay the development of resistance.

...OR...

(Admire Pro)	7–14 fl oz	30

COMMENTS: Apply a total of 7-14 fl oz/acre in one or two drip irrigation applications. Two applications 21–45 days apart are recommended on coarse soils or where the longest periods of protection are required. Make first application between budbreak and pea-berry stage. A total of 14 fl oz/acre is recommended where vigorous vine growth is expected or in warmer growing areas such as the Coachella, San Joaquin, or Sacramento valleys. Soil moisture is important for effective soil application; follow label instructions carefully. Repeat applications of *any* neonicotinoid insecticide (acetamiprid-Assail; imidacloprid-Admire, Provado) can lead to resistance to *all* neonicotinoids. Alternate neonicotinoids with an insecticide that has a different mode of action to help delay the development of resistance.

B. BUPROFEZIN

(Applaud) 70WP	9–12 oz	30

MODE OF ACTION: A thiadiazine (Group 16)[1] insecticide.
COMMENTS: Restricted entry interval: 12 hours. An insect growth regulator; kills predatory beetles. Good coverage is essential. Apply no more than 2 applications/season. Allow at least 14 days between applications. Use allowed under FIFRA section 2(ee) recommendation.

C. ACETAMIPRID
(Assail) 70WP 1.1 oz 7
MODE OF ACTION: A neonicotinoid (Group 4A)[1] insecticide.
COMMENTS: Restricted Entry interval: 12 hours. Repeat applications of *any* neonicotinoid insecticide (acetamiprid-Assail; imidacloprid-Admire, Provado) can lead to resistance to *all* neonicotinoids. Alternate neonicotinoids with an insecticide that has a different mode of action to help delay the development of resistance.

D. PYRETHRIN/ PIPERONYL BUTOXIDE
(Pyrenone Crop Spray) Label rate 0
MODE OF ACTION: A botanical (Group 3)[1] insecticide and a synergist.
COMMENTS: Restricted entry interval: 12 hours. Spray containers with 1 pt/150 gal water and as needed. Apply alone or in combination with a narrow range oil. Use in combination with a narrow range oil when treating the first generation leafhoppers, except on table grapes. Do not use oil on later generations.

E. ENDOSULFAN*
(Thionex) 50W 2–3 lb 7
MODE OF ACTION: An organochlorine (Group 2A)[1] insecticide.
COMMENTS: Restricted entry interval: 2 days. Dilute application only at 1 lb/100 gal water. Do not apply to Concord varieties as injury is likely to occur. Cannot be applied in any situation where run-off may occur; check with county agricultural commissioner. May not be effective in all areas because of resistance.

F. INSECTICIDAL SOAPS Label rates 0
And NARROW RANGE OIL#
MODE OF ACTION: Contact insecticides with smothering and barrier effects.
COMMENTS: Restricted entry interval: 12 hours. Partially effective on low leafhopper populations if applied when nymphs are small. Research indicates soap works better in combination with low rate of oil. Care must be taken as both products can spot the waxy bloom on the berry. Do not apply sulfur within 10 days of a sulfur spray.

G. METHOMYL*
(Lannate LV) 0.75–1.5 qt Raisin/Table: 1
(Lannate) 90SP 0.5–1 lb Wine: 14
MODE OF ACTION: A carbamate (Group 1A)[1] insecticide.
COMMENTS: Restricted entry interval: Check with county agricultural commissioner. Do not feed treated grapes to livestock. Disruptive to predators of mites and parasites of leafhoppers.

H. FENPROPATHRIN*
(Danitol) 5.33–10.66 fl oz 21
MODE OF ACTION: A pyrethroid (Group 3)[1] insecticide.
COMMENTS: Restricted entry interval: 24 hours. Not recommended for the San Joaquin Valley because of problems with mite outbreaks. See label for additional requirements regarding hand labor.

I. DIMETHOATE 25WP 6–8 lb 28
MODE OF ACTION: An organophosphate (Group 1B)[1] insecticide.
COMMENTS: Restricted entry interval: 2 days. To avoid visible deposits on grapes, do not apply after berries reach 0.25 inch diameter. May not be effective in all areas due to resistance. Disruptive to natural enemies.

J. KAOLIN CLAY#
(Surround) WP 12.5–37.5 14
MODE OF ACTION: Unknown. An inorganic insecticide.
COMMENTS: Restricted entry interval: 4 hours. An organically acceptable alternative for wine grapes.

** Apply with enough water to provide complete coverage.
+ Preharvest interval. Do not apply within this many days of harvest.
* Permit required from county agricultural commissioner for purchase or use.
# Acceptable for use on organically grown produce.
[1] Modes of action are important in preventing the development of resistance to pesticides. Rotate chemicals with a different mode-of-action Group number, and do not use products with the same mode-of-action Group number more than twice per season. For example, the organophosphates have a Group number of 1B; chemicals with a 1B Group number should be alternated with chemicals that have a Group number other than 1B. Mode of action is assigned by IRAC (Insecticide Resistance Action Committee). For additional information, see their Web site at http://www.irac-online.org/.

Bird Control

Birds can seriously damage berries, particularly in the early colored varieties. Using nets is the best way to reduce the bird damage. However, in a small-scale planting (in the back yard), individual clusters can be covered with papers sacks as long as air movement and light is not blocked. The flying of gas-filled owl kites or hawk or, the use of carbide cannons, and live traps and reflective ribbons are also effective to some extend. Early application of nets, particularly on the dense canopies can cause serious infestation of powdery mildew. In dense canopies, cover the top and sides of the canopy and loosely tie the nets in just a few places. This way, nets will not push tightly against the canopy and will reduce the chance of powdery mildew.

Chapter 13

Disease Control ((Photos 138-140)

The relative humidity in Southwest Idaho and some other areas in the PNW is lower than many other grape-growing regions. Therefore, there is less disease pressure in this area. However, grape powdery mildew is the major disease and must be controlled every year. When the pressure is low, three to four applications of sulfur early in the season (when the temperatures are cooler than 85 F), followed by several fungicide applications may control powdery mildew. But, powdery mildew has become a more serious disease during the recent years and thus, in the following section, we will discuss powdery mildew and its management in more detail. The following section on "Powdery Mildew" is mainly taken from the University of California Davis Extension Service by Gubler et al., (2006).

Powdery Mildew

Symptoms of Powdery Mildew: Symptoms of powdery mildew include red blotchy areas on dormant canes. On leaves, initial symptoms appear as chlorotic spots on the upper leaf surface. Signs of the pathogen appear a short time later as white, webby mycelium. As spores are produced, the infected areas take on a white, powdery or dusty appearance. On fruit and rachises the pathogen appears as white, powdery masses that may colonize the entire berry surface. The fungus survives the winter as dormant mycelium in buds or as cleistothecia (spore structures). Cleistothecia are the most important sources of overwintering inoculum. They mature in late summer and fall on infected green tissue and are washed onto the cordons and spurs with fall and winter rainfall. On warm winter and spring days when moisture is abundant, cleistothecia burst and release ascospores. Conidial spore production occurs 7 to 10 days after primary infection by ascospores and will continue throughout the season as long as moderate temperatures (70° to 85°F) exist.

Management of Powdery Mildew: Season-long control is dependent upon reducing early-season inoculum and subsequent infection. Thus treatment must begin promptly and be repeated at appropriate intervals. Timing of the first treatment depends on fungicide used and growth stage. Frequency of treatment thereafter depends on fungicide choice and weather conditions. Monitor and use the risk assessment index (RAI) model to determine necessary spray intervals. Treatment may be discontinued for wine and raisin grapes when fruit reaches 12 Brix but should be continued up to harvest for table grapes.

All powdery mildew fungicides, with the exception of oil, are best used as protectants. Discontinue the use of soft chemistry products (sulfurs, biologicals, systemic acquired resistance products, and contact materials) when disease pressure is high because by themselves they will not provide adequate control. If eradication is necessary, a light summer oil may be used anytime in the season if there is no sulfur residue present (i.e. at least 2 weeks after a sulfur treatment). Basal leaf removal can improve coverage and efficacy of powdery mildew fungicides on clusters.

Organically Acceptable Methods for Powdery Mildew Control: Sulfur, Serenade, Sonata, and Organic JMS Stylet Oil are acceptable on most organically certified grapes; check with your certifier for details.

Monitoring and Treatment Decisions: In spring, the overwintering cleistothecia produce ascospores, which are the primary source of infection. Ascospores are released when 0.1 inch of rain or irrigation is followed by 13 hours of leaf wetness when temperatures are between 50 and 80°F. Seven to 10 days after this initial infection, monitor vineyards for the presence of powdery mildew by collecting 10 to 15 basal leaves from 20 or so vines at random and examining the undersurface for powdery mildew spores. If spores are found, then monitor disease development by using the powdery mildew risk assessment index.

Powdery Mildew Risk Assessment Index (RAI): Once initial infection occurs, ideal temperatures for growth of the fungus are between 70 and 85°F. Temperatures above 95°F for 12 continuous hours or longer cause the fungus to stop growing. The risk assessment index relates air temperatures to disease development and tells you how often you need to spray to protect the vines. When using the risk assessment index, always monitor the vineyard for signs of the disease. If evidence of the disease is not recent, don't treat. You may monitor temperatures in your own vineyard and calculate the RAI using the rules below, or you may use weather equipment that has the UC Davis RAI built into its software.

Initiating the index. After you find powdery mildew, an epidemic will begin when there are 3 consecutive days with 6 or more continuous hours of temperatures between 70° and 85°F as measured in the vine canopy. Starting with the index at 0 on the first day, add 20 points for each day with 6 or more continuous hours of temperatures between 70° and 85°F. Until the index reaches 60, if a day has fewer than 6 continuous hours of temperatures between 70° and 85°F, reset the index to 0 and continue. If the index reaches 60, an epidemic is under way. Begin using the spray-timing phase of the index.

Spray timing. Each day, starting on the day after the index reached 60 points during the start phase, evaluate the temperatures and adjust the previous day's index according to the rules below. Keep a running tabulation throughout the season. In assigning points, note the following:

If the index is already at 100, you can't add points.

If the index is already at 0, you can't subtract points.

You can't add more than 20 points a day.

You can't subtract more than 10 points a day.

If fewer than 6 continuous hours of temperatures between 70° and 85°F occurred, subtract 10 points.

If 6 or more continuous hours of temperatures between 70° and 85°F occurred, add 20 points.

If temperatures reached 95°F for more than 15 minutes, subtract 10 points.

If there are 6 or more continuous hours with temperatures between 70° and 85°F AND the temperature rises to or above 95°F for at least 15 minutes, add 10 points. (This is the equivalent of combining points 2 and 3 above.)

Resistance Management:

Use the index to determine disease pressure and how often you need to spray to protect the vines. Spray intervals can be shortened or lengthened depending on disease pressure, as indicated in Table 11.

Table 11. Spray intervals based on disease pressure using the Risk Assessment Index.

			Suggested spray schedule			
	Pressure	Pathogen Status	Biologicals[1] and SARs[2]	Sulfur	Sterol-inhibitors[3]	Strobilurins[4]
0-30	Low	Present	7- to 14-day interval	14- to 21-day interval	21-day interval or label interval	21-day interval or label interval
30-50	Intermediate	Reproduces every 15 days	7-day interval	10- to 17-day interval	21-day interval	21-day interval
60 or above	High	Reproduces every 5 days	use not recommended	7-day interval	10- to 14-day interval	14-day interval

[1] *Bacillus pumilis* (Sonata) and *Bacillus subtilis* (Serenade)
[2] SAR = Systemic acquired resistance products (AuxiGro, Messenger)
[3] tebuconazole (Elite), triflumizole (Procure), myclobutanil (Rally), fenarimol (Rubigan), and triadimefon (Bayleton)
[4] azoxystrobin (Abound), trifloxystrobin (Flint), kresoxim-methyl (Sovran), and pyraclostrobin/boscalid (Pristine)

Alternating fungicides with different modes of action is essential to prevent pathogen populations from developing resistance to fungicides. This resistance management strategy should not include alternating or tank mixing with products to which resistance has already developed. Do not apply more than two sequential sprays of a fungicide before alternating with a fungicide that has a different mode of action.

Common name (trade name)	Amount/Acre**	P.H.I.+ (days)

The following materials are listed within groups in order of usefulness in an IPM program, taking into account efficacy. When choosing a pesticide, also consider information relating to environmental impact.

STEROL INHIBITORS

A. TEBUCONAZOLE

(Elite) 45DF	4 oz	14

MODE OF ACTION: A DMI (Group 3)[1] triazole fungicide.
COMMENTS: Restricted entry interval: 12 hours. Begin treatment when shoots are 8 to 10 inches long. Can be applied earlier but research shows that a wettable sulfur application (5 lb/100 gal water/acre) at budbreak should be used first. During cool springs when growth is slow, an additional wettable sulfur treatment is advisable 14 to 21 days later. Apply subsequent sulfur treatments at 14- to 21-day intervals until shoots reach 8 to 10 inches and treatments with sterol inhibitors or strobilurins begin. Because shoot growth rate is weather dependent, shoot length should not be used as a spray date indicator after the first treatment. Alternate use with fungicide of different chemistry.

B. TRIFLUMIZOLE

(Procure) 50WS	Label rates	7

MODE OF ACTION: A DMI (Group 3)[1] imidazole fungicide.
COMMENTS: Restricted entry interval: 12 hours. Begin treatment when shoots are 8 to 10 inches long. Can be applied earlier but research shows that a wettable sulfur application (5 lb/100 gal water/acre) at budbreak should be used first. During cool springs when growth is slow, an additional wettable sulfur treatment is advisable 14 to 21 days later. Apply subsequent sulfur treatments at 14- to 21-day intervals until shoots reach 8 to 10 inches and treatments with sterol inhibitors or strobilurins begin. Because shoot growth rate is weather dependent, shoot length should not be used as a spray date indicator after the first treatment. Alternate use with fungicide of different chemistry. Do not apply more than 32 oz of product/acre/season.

C. MYCLOBUTANIL

(Rally) 40WP	4 oz in 50 or more gal water/acre	14

MODE OF ACTION: A DMI (Group 3)[1] triazole fungicide.
COMMENTS: Restricted entry interval: 1 day. Begin treatment when shoots are 8 to 10 inches long. Can be applied earlier but research shows that a wettable sulfur application (5 lb/100 gal water/acre) at budbreak should be used first. During cool springs when growth is slow, an additional wettable sulfur treatment is advisable 14 to 21 days later. Apply subsequent sulfur treatments at 14- to 21-day intervals until shoots reach 8 to 10 inches and treatments with sterol inhibitors or strobilurins begin. Because shoot growth rate is weather dependent, shoot length should not be used as a spray date indicator after the first treatment. Alternate use with fungicide of different chemistry. Apply no more than 1.5 lb maximum/season. Do not apply by air.

D. FENARIMOL

(Rubigan) EC	3–6 oz	30

MODE OF ACTION: A DMI (Group 3)[1] pyrimidine fungicide.
COMMENTS: Restricted entry interval: 12 hours. Begin treatment when shoots are 18 inches long. Precede with a wettable sulfur application (5 lb/100 gal water/acre) that is applied at budbreak. During cool springs when growth is slow, an additional wettable sulfur treatment is advisable 14–21 days later. Apply subsequent sulfur treatments at 14- to 21-day intervals until shoots reach 18 inches and treatments with this fungicide begin. Because shoot growth rate is weather dependent, shoot length should not be used as a spray date indicator after the first treatment. Alternate use with fungicide of different chemistry. Do not apply more than 19 oz/acre/season.

STROBILURINS

A. AZOXYSTROBIN

(Abound)	11–15.4 fl oz	14

MODE OF ACTION: A QoI (Group 11)[1] fungicide.
COMMENTS: Restricted entry interval: 4 hours. Begin treatment when shoots are 8 to 10 inches long. Can be applied earlier but research shows that a wettable sulfur application (5 lb/100 gal water/acre) at budbreak should be used first. During cool springs when growth is slow, an additional wettable sulfur treatment is advisable 14 to 21 days later. Apply subsequent sulfur treatments at 14- to 21-day intervals until shoots reach 8 to 10 inches and treatments with sterol inhibitors or strobilurins begin. Because shoot growth rate is weather dependent, shoot length should not be used as a spray date indicator after the first treatment. Alternate use with fungicide of different chemistry.

B. TRIFLOXYSTROBIN

(Flint)	1.5–2 oz	14

MODE OF ACTION: A QoI (Group 11)[1] fungicide.
COMMENTS: Restricted entry interval: 12 hours. Do not apply to Concord grapes or crop injury may result. Begin treatment when shoots are 8 to 10 inches long. Can be applied earlier but research shows that a wettable sulfur application (5 lb/100 gal water/acre) at budbreak should be used first. During cool springs when growth is slow, an additional wettable sulfur treatment is advisable 14 to 21 days later. Apply subsequent sulfur treatments at 14- to 21-day intervals until shoots reach 8 to 10 inches and treatments with sterol inhibitors or strobilurins begin. Because shoot growth rate is weather dependent, shoot length should not be used as a spray date indicator after the first treatment. Alternate use with fungicide of different chemistry. Do not apply more than 8 oz/acre/season.

C. **KRESOXIM-METHYL**

(Sovran) 3.2–6.4 oz 14

MODE OF ACTION: A QoI (Group 11)[1] fungicide.

COMMENTS: Restricted entry interval: 12 hours. Begin treatment when shoots are 8 to 10 inches long. Can be applied earlier but research shows that a wettable sulfur application (5 lb/100 gal water/acre) at budbreak should be used first. During cool springs when growth is slow, an additional wettable sulfur treatment is advisable 14 to 21 days later. Apply subsequent sulfur treatments at 14- to 21-day intervals until shoots reach 8 to 10 inches and treatments with sterol inhibitors or strobilurins begin. Because shoot growth rate is weather dependent, shoot length should not be used as a spray date indicator after the first treatment. Alternate use with fungicide of different chemistry. Do not apply more than a total of 1.6 lb/acre/year.

D. **PYRACLOSTROBIN/BOSCALID**

(Pristine) 8–10.5 oz 14

MODE OF ACTION: A QoI (Group 11)[1] and carboxamide (Group 7)[1] fungicide.

COMMENTS: Restricted entry interval: 24 hours. Do not use on Concord, Worden, Fredonia, Niagara, or related grape varieties. Do not make more than 2 sequential applications before rotating to a fungicide with a different mode of action.

SULFUR COMPOUNDS

A. **SULFUR#** Label rates

(dust, wettable, flowable, or micronized)

MODE OF ACTION: A multi-site contact (Group M)[1] inorganic fungicide.

COMMENTS: In some counties there is a 3-day restricted entry period when using sulfur; consult your county agricultural commissioner. Begin treatment at budbreak to 2-inch shoot growth. Reapply at 7-day intervals if treating every other middle or at 10-day intervals if treating every middle. Reapply if sulfur is washed off by rain or irrigation. Sulfur can cause injury to foliage and fruit when applied just before or on days when the temperature exceeds 100°F. The amount/acre may be reduced during periods of high temperature to prevent burning. Do not apply within 3 weeks of an oil application.

BIOLOGICALS

A. **BACILLUS PUMILIS#**

(Sonata) 2–4 qt

MODE OF ACTION: A biological fungicide.

COMMENTS: Restricted entry interval: 4 hours. Begin making applications before disease onset or when disease pressure is low. Repeat at 7- to 10-day intervals until disease pressure is intermediate, then switch to a strobilurin, sterol inhibitor, oil, or sulfur. Apply in sufficient water to obtain thorough coverage.

B. **BACILLUS SUBTILIS#**

(Serenade Max) 1–3 lb 0

MODE OF ACTION: A biological fungicide.

COMMENTS: Restricted entry interval: 4 hours. Begin making applications before disease onset or when disease pressure is low. Repeat at 7- to 10-day intervals until disease pressure is intermediate, then switch to a strobilurin, sterol inhibitor, oil, or sulfur. Apply in sufficient water to obtain thorough coverage.

SYSTEMIC ACQUIRED RESISTANCE PRODUCTS

A. **HARPIN PROTEIN**

(Messenger) 4.5–9 oz 0

MODE OF ACTION: Unknown.

COMMENTS: Restricted entry interval: 4 hours. Begin applications when new shoot growth is present. Apply as a foliar spray on 7- to 14-day intervals before the onset of the disease when disease pressure is light. Discontinue use under moderate to heavy disease pressure.

B. **GABA/L-GLUTAMIC ACID**

(AuxiGro) 4 oz or 2-4 oz as a tank mix

MODE OF ACTION: Unknown.

COMMENTS: Restricted entry interval: 4 hours. Must be applied before the onset of powdery mildew infections. May be applied alone, in alternating applications with other powdery mildew products, or in tank mix combinations with other powdery mildew products. Discontinue use when disease pressure is moderate to heavy. Do not exceed 24 oz/acre/crop.

CONTACT MATERIALS

A. NARROW RANGE OIL#

(Organic JMS Stylet Oil, Saf-T-Side, etc.) 2%

MODE OF ACTION: A contact fungicide with smothering and barier effects.

COMMENTS: Restricted entry interval: 4 hours. Never mix oil and sulfur or apply one within 2 weeks of the other. Can be used as a protectant or eradicant. As a protectant, alternate it prebloom with the sterol inhibitors. At the 2% rate, this oil is an excellent eradicant and can be used as a stand-alone program at anytime during the season (except within 2 weeks of a sulfur treatment); good coverage is essential. Apply at 14- to 18-day interval. Do not use on table grapes after berry set.

B. QUINOXYFEN

(Quintec) 3–4 fl oz 14

MODE OF ACTION: A quinoline (Group 13)[1] fungicide.

COMMENTS: Restricted entry interval: 12 hours. Spray on a 14-day interval, otherwise use 5-6.6 fl oz to spray on a 21-day interval.

C. POTASSIUM BICARBONATE#

(Kaligreen) 2.5–5 lb 1

(MilStop) 2.5–5 lb 0

MODE OF ACTION: An inorganic salt.

COMMENTS: Restricted entry interval: 1 hour for MilStop; 4 hours for Kaligreen. Conditionally acceptable for use on organically grown produce; check with your certifier. Apply by ground only in sufficient water (25 gal/acre minimum) to ensure complete and thorough coverage of foliage and crop. Most effective when alternated with a sterol inhibitor and used as a protectant. Field reports suggest this material has eradicant activity; but this has not been demonstrated in University research. If used as an eradicant, contact of the disease organism is essential. Use of non-acidifying spreader/sticker or nonphytotoxic crop oil is recommended.

D. INSECTICIDAL SOAP#

(M-Pede) 1.5–2%

MODE OF ACTION: A contact fungicide with smothering and barier effects.

COMMENTS: Restricted entry interval: 12 hours. Alternate use with one of the sterol inhibitors. Apply in 100–150 gal water/acre. Complete coverage of upper and lower leaf surfaces, as well as grape clusters, is essential for control. Apply every 7–10 days. Do not combine with sulfur or apply within 3 days of a sulfur application. Do not apply to Calmeria or Italia varieties of grapes.

** Apply with enough water to provide complete coverage.

+ Preharvest interval. Do not apply within this many days of harvest.

Acceptable for use on organically grown produce.

1 Group numbers are assigned by the Fungicide Resistance Action Committee (FRAC) according to different modes of actions. Fungicides with a different Group number are suitable to alternate in a resistance management program. For more information, see http://www.frac.info/.

Chapter 14

Harvest, Handling, and Postharvest Storage (Photos 141-160)

With the exception of 'Sweet Shelly' and 'Ralli', all important cultivars mature between September 1st and late October under Southwest Idaho conditions. The information in this section are based on our experiences in Idaho and information reported by Crisosto et al. (2006). The table grape (Vitis vinifera L.) is a non-climacteric fruit and is subject to serious water loss following harvest, which can result in stem drying and browning, berry shatter, and wilting and shriveling of berries. Various pathogens such as gray mold, caused by the fungus (latin name) requires treatment storage and handling. 'Thompson Seedless' (Sultanina) and 'Flame Seedless' are the major cultivars in California that are marketed mostly during the summer months up to 8-10 weeks after harvest. Harvest of 'Flame Seedless' is mostly completed around first of 'August' in California, while harvest of 'Alborz' and 'Flame' starts in early September and continues through the entire month of September under Southwest Idaho conditions. 'Fantasy', 'Ruby Seedless', 'Crimson', and 'Red Globe' are also popular in California. These cultivars also mature later in Idaho as compare to California, but 'Crimson Seedless' window of maturity in California greatly overlaps with Idaho and thus this cultivar is not justified for planting for niche market in Idaho.

Desirable berry quality attributes include large berry size, color, soluble solids concentrations (SSC), low titratable acidity (TA), and high SSC/TA ratio and firmness. Other positive berry quality attributes are lack of defects such as decay, cracks, shriveling, sunburn, dried berries, and insect damage.

For California table grapes, well-developed standards exists for most quality attributes. Although there is no formal such standards developed for Idaho or other PNW states, the Idaho Table Grape Association is actively developing standards for Idaho table grapes. The standards for Idaho table grapes are expected to be very similar to those of California. However, grapes grown under high desert conditions of Southwest Idaho and Central Washington are believed to have extremely high flavor due to the warm and long days and cool nights of theses regions.

Cluster stems may be quite woody with advanced maturity (called cured) or succulent. Grapes with more cured stems shrink less and thus last longer in the storage as compared to those with succulent cluster stems.

Samples of berries from different areas of the vineyard should be taken to determine SSC and other maturity factors. Three to six berries should be taken from the middle area in order to have an average for the cluster, because the least mature berries are on the lower end and at the tip of the laterals, and the most mature near the base of the laterals at the top. Berries should be squeezed and a few drops of composite juice of berries should be put on the glass prism of a hand refratometer for reading the SSC values. Harvest date is determined by SSC of 14 to 17.5 degree Brix, depending on cultivar and production region in California. Degree Brix is a scale based on grams of sucrose in 100 grams of sugar and water solution. In early production areas, an SSC/TA ratio of 20 or higher is used to determine minimum maturity for cultivars that meet a low minimum SSC.

For red and black colored cultivars, there is also a minimum color requirement. For some colored berries, 85 to 95% of the berry should have color to be acceptable. In 'Flame', and 'Alborz', the berry color may range from pink to dark red and at least two third of the surface must have the kind and intensity of color specified for the berry to be considered colored. The term "fairly well colored" is used when the bunch meets the color requirements of the U.S. No. 1 grade in California grape industry. For the U.S. Fancy grade, the term "reasonably well colored" is used, and for the U.S. Extra Fancy grade the term "well colored" is used. In Southwest Idaho, all major table grapes develop excellent color without the use of any coloring chemicals as long as shoot thinning, cluster management, and nitrogen applications are practiced appropriately. Sunburn or excessive yellowish color in certain cultivars such as 'Emerald' could be a problem. Although golden yellow berries are usually sweeter, they are not popular in the commercial grape market. Developing a well-aerated canopy with medium vine growth and a good balance between shade and light (indirect light penetration) may help development of desirable color in cultivars such as Emerald. Removal of un-necessary and shading shoots and leaves, a few weeks before harvest, would improve berry color in colored cultivars. Although excessive yellow color is not desirable, removal of the unnecessary shoots and leaves will improve aeration and reduced late-season powdery mildew infestation.

It may be necessary to delay the harvest by 4 or 5 days if it rains severely at the anticipated harvest date. Delaying the harvest may ensure that berries are dried at harvest and have less chance for fungus development. Grapes are seldom harvested all at one time. The first harvest may start when only 10% of grapes are ready to take advantage of early market prices. In some cases, a cultivars such as 'Alborz', 'Emerald', 'Ralli' or 'Anahita' may be harvested as many as 4 or 5 times in Idaho.

In South Africa and Chile, grapes are packed in the shed. However, most California table grapes are being packed in the field. The most common field-packing system is the "avenue pack." The fruit is picked, trimmed, and placed into picking lugs. The picking lug is then transferred a short distance to the packer, who works at a small and portable stand in the avenue between vineyard blocks. Shed-packed fruit is harvested by pickers and placed in field lugs without trimming. Then placed in the shade of the vines to await transport to the shed. At the packing shed, the field lugs are distributed to packers who select, trim, and pack the fruit. Often two different grades are packed simultaneously by each packer to facilitate quality selection. In some operations, trimming, color sorting, and a first quality sorting may occur in the field. In all of the systems, grapes are nearly always packed on a scale to facilitate packing to a precise net weight, whether field or shed packed. In general mid and late season grapes are packed in plastic bags or wrapped in paper. For early season grapes, bulk pack is mainly used. In all cases, packed lugs are subject to quality inspection and check weighing. After packing and lidding, grapes are palletized, on disposable or recycled pallets. Some strapping in the field before loading is necessary in grapes packed in shoebox boxes. Often loaded pallets coming from the field pass through a "pallet squeeze," a device that straightens and tightens the stacks of containers. These pallet loads are unitized, usually by strapping or netting. Some palletizing glue is used in shed packing operations. This glue bonds the corrugated containers vertically on the pallet so that only horizontal strapping is required.

Pre-cooling conditions

Shortly after harvest, cooling must start and SO_2 applied, preferably within 12 hours of harvest. Many grape forced-air coolers in California are designed to achieve 7/8 cooling in 6 hours or less. After cooling is completed, the pallets are moved to a storage room to await transport.

Optimum Storage Conditions

Ideally, the storage room operates at 30oC to 32oF and 90 to 95 percent relative humidity (RH), with a moderate airflow 20-40 CFM per ton of stored grapes. The constant low temperature, high RH and moderate airflow are important to limit the rate of water loss from fruit stems. Fruit pulp temperatures in the stored fruit should be maintained at 31 to 32oF throughout its postharvest life. Freezing damage may occur in less mature grapes. The highest freezing point for berries is -3.0oC (26oF), but freezing point varies depending on

SSC. A 28oF freezing point for stems has been reported for wine grapes. New table grape cultivars are more sensitive to stem freezing damage.

Controlled Atmosphere (CA) Considerations

CA (2-5% O_2 + 1-5% CO_2) during storage/ shipment is not currently recommended for table grapes because its benefit is slight and SO_2 is used for decay control. CO_2 at 10-15% in air can be used to control grey mold for up to 2-4 weeks (depending of cultivar). CO_2 at 5-10% can be combined with CA to provide decay control equally effective to SO_2.

Physiological Disorders

Shatter: Shatter severity is often proportional to berry maturity. Berries of seedless cultivars are usually less well attached to the cap stem than seeded cultivars. Shatter varies considerably from season to season. In a cooperative research between the University of Idaho and University of Arkansas, we found that shattering also varies considerably among different selections. For example, selection A-2310 has outstanding flavor, crunch, and SSC, but berries shatter heavily before or at harvest. The same situation exists with 'Sweet Shelly' as described earlier. Grapes such as A-2310 and 'Sweet Shelly', therefore, may not have a high value as typical fresh table grape. However, these grapes can be harvested mechanically (by shaking) and berries sold in clamshell containers for consumption in the salad, mixing in the cereal, or cooking.

Gibberellin applied at fruit set weakens berry attachment. Shatter occurs mainly due to rough handling during field packing with additional shatter occurring all the way to the final retail sale. Shatter incidence can be reduced by controlling pack depth and fruit packing density (cubic inches per pound), using cluster bagging, gentle handling, and maintaining recommended temperature and relative humidity. Cane girdling reduces shattering incidence.

Waterberry: Waterberry is associated with fruit ripening and most often begins to develop shortly after veraison (berry softening). The earliest symptom is the development of small (1-2 mm) dark spots on the cap stems (pedicles) and/or other parts of the cluster framework. These spots become necrotic, slightly sunken, and expand to affect more areas. The affected berries become watery, soft, and flabby when ripe. In California, this disorder has been associated with a high nitrogen status vine, canopy shading, or cool weather during veraison and fruit ripening. Our extensive research in Idaho also confirms that excessive N application can increase waterberry incidence. Avoid over fertilization with nitrogen. Foliar nutrient sprays of N should be avoided in waterberry-prone vineyards. Trimming off affected berries during harvest and packing is a common practice, although labor intensive.

Postharvest Pathology

Pathogens on Berries: Gray Mold: (*Botrytis cinerea*). Gray mold is the most destructive of the postharvest diseases of table grapes, primarily because it develops at temperatures as low as 31oF and grows from berry to berry. Gray mold first turns berries brown, then loosens the skin of the berry, its white, thread-like hyphal filaments erupt through the berry surface, and finally masses of gray colored spores develop. Wounds on berry surface near harvest provide opportunities for infection. Although no wound is required for infection when wet conditions occur.

Removing desiccated infected grapes from previous season can reduce gray mold infection. Leaf-removal canopy management, pre-harvest fungicides, trimming visibly infected, split, cracked, or otherwise damaged grapes before packing is recommended. Prompt cooling and fumigation with sulfur dioxide (100ppm for one hour is essential to control gray mold during cold storage). Because of increased interest in the export market, there is a need to use SO_2 generating pads, especially for long-distance export marketing where grapes are in ocean transport for extended periods. These pads have sodium metabisulfite Incorporated into them that releases SO_2 during transit and marketing.

Other pathogens become important at warmer temperatures, and they appear commonly sometime during transport or marketing after grapes are removed from cold storage. Black rot, caused by *Aspergillus niger,* blue rot, caused by *Penicillium* spp., and rhizopus rot, caused by *Rhizopus stolonifer* or *R. oryzae.* They are at least partially controlled by sulfur dioxide fumigation, although little research has been done to show this (Snowdon, 1990).

We have stored various cultivars of table grapes in regular cold storage at 31-32 oF (without SO_2) and observed that 'Alborz' and 'Flame' do not last long under that condition. However, under this storage conditions, 'Red Globe' and 'Italia' could be kept until mid December with maximum of 30% fugal development. Berries in 'Kashishi' and 'Autumn Royal' showed over 60% fugal infestation under regular storage at 31 to 32 oF.

Sulfur Dioxide Use: Botrytis rot of grapes is not sufficiently avoided by fast cooling alone. It is standard practice in California to fumigate with sulfur dioxide (SO_2) immediately after packing followed by lower dose treatments weekly during storage. Formulas for calculating the initial and subsequent weekly SO_2 fumigation dosages using the traditional system are described by Nelson (1985) in Bulletins 1913 and by Luvisi et al. (1986) in Bulletin 1932, both published by the University of California. Recently it has been demonstrated that the amount of sulfur dioxide gas needed to kill *Botrytis* spores, or to inactivate exposed mycelium is dependent on the concentration, and the length of time the fungus is exposed to the fumigant. A cumulative concentration, calculated as the product of the concentration and the time, called "CT product", describes the sulfur dioxide exposure needed to kill the decay organism. A CT of at least 100 ppm-hour is the minimum required to kill spores and mycelium of *Botrytis* at 0oC. This finding was the basis for the development of the total utilization system. Total utilization often uses about half as much sulfur dioxide as the traditional method and improves uniformity and effectiveness of SO_2 fumigant. In this total utilization system, the first fumigation is done in conjunction with forced air cooling. The forced air flows through the boxes and ensures good penetration of sulfur dioxide even to the center boxes on a pallet. In most combinations of boxes and packs, this system produces over 80% penetration, measured as percent of the room air CT product. The storage fumigation process is applied every 7-10 days. Details on SO_2 are in Bulletin 1932, as cited before.

We have studied the effects of excess SO2 on berry quality of table grapes when condensation takes place with both California-grown and Idaho-grown table grapes. Excess SO_2 caused severe injury near stem cap and increased berry shattering (see Photos).

During ocean shipment for periods longer than 10 days or long retail handling in which SO2, fumigation cannot be applied, the use of SO_2-generating pads in combination with a box liner is advised. These SO_2-generating pads have sodium metabisulfite incorporated into them to allow a constant and slow release of SO_2 during shipment and marketing. In California, the slow-release SO_2 generating pad used combined to a perforated polyethylene box liner (1/4" hole, 3" or 4" center) reduces water loss and assures gray mold control without enhancing SO_2 phytotoxicity.

Quarantine Issues

Issues associated with exotic pest quarantines, either addressing imported or exported table grapes, can change rapidly. Rules regarding import requirements are issued by the USDA Animal Plant Health Inspection Service (USDA-APHIS). This agency provides information to assist exporters in targeting markets and defining what entry requirements a particular country might have for table grapes. USDA APHIS, in cooperation with the State plant boards, developed a data base, called Excerpt, to track the phytosanitary requirements for each country. USDA APHIS also provides phytosanitary inspections and certifications that declare the grapes are free of pests to facilitate compliance with foreign regulatory requirements.

Grapes imported into the United States from other parts of the world are routinely fumigated with methyl bromide, following treatment schedules issued by the USDA APHIS, to prevent the entry of insect pests. Cold treatments are also accepted by USDA APHIS for the control of fruit flies. Of primary concern are the vine moth, *Lobesia botrana,* the Mediterranean fruit fly, *Ceratitis capitata,* and miscellaneous external feeding insects. Grapes exported from the United States may harbor pests of concern elsewhere, but they rarely require treatment, although this situation can change rapidly. Black widow spiders are occasional hitchhikers within grape clusters or within grape boxes; SO_2 fumigation, alone or combined with carbon dioxide, has been used successfully to kill the spiders before export. Omnivorous leafroller, *Platnota stultana,* is found on grapes in California, and has the potential to be a pest of regulatory concern on table grapes exported to counties where this pest is not found. Two methods to control this pest, insecticidal controlled atmosphere treatment (Ahumada, et al 1996), and low temperature storage combined with SO_2 slow-release generators have been developed to control this pest.

Chapter 15

Photo Section

Photo 1. Site preparation and dip ripping planting.

Photo 2. Ground fumigation before planting. before

Photo 3. Healthy vines from a divided canopy, suitable for obtaining cuttings for propagation.

Photo 4. Healthy vines from a bilateral cordon system, suitable for obtaining Cuttings for propagation.

Photo 5. The right arm of a healthy vine cordon system.

Photo 6. Examining health of a vine before from a bilateral obtaining cuttings for propagation.

Photo 7. A bundle of 100 Emerald cuttings

Photo 8. A bundle of 100 ‘Alborz cuttings

Photo 9. The top of cuttings will be “angled” will be put “upside” when burying for rooting.

Photo 10. The flat part of cuttings “slanted”.

Photo 11. Making bundles of 100 cuttings for rooting In early March.

Photo 12. Making fresh cuts just below the node before rooting.

Photo 13. Preparing 9:1 solution of IBA hormone for rooting.

Photo 14. A 4 x 5 ft rooting pit, prepared in early March

Photo 15. For rooting of the dormant cuttings, they are put up side down and the entire length but the top 1.5 inches is covered with soil. Then water is poured to and eliminate air pockets.

Photo 16. After the step in photo 5, put about 2.5 inches of fine sand on the top of cuttings.

Photo 17. Burying cutting upside down and covering with sand and a black plastic.

Photo 18. Cuttings are rooted after 6 to 8 weeks in the area cover with sand.

Photo 19. Rooted cuttings after 6 to 10 weeks, ready for planting.

Photo 20. Rooted cuttings are placed in a bucket of water while they are planted.

Photo 21. Support posts (in posts) are installed and places for vines are marked before planting. This is a preferred method in Idaho.

Photo 22. However, in some vineyards, vines are planted before the support system installed.

Photo 23. An 18-inch-deep hole is dug next to each bamboo pole or vine support.

Photo 24. Rooted cuttings or dormant plants are planted gently with only one bud above the ground and covered with aluminum sheet protection (see photo 25).

Photo 25. An 18-inch-deep hole is dug next to each bamboo pole or vine support.

Photo 26. Rooted cuttings or dormant plants are planted gently with only one bud above the ground and covered with aluminum sheet protection (see photo 25).

Photo 27. Installing the grow tubes after planting.

Photo 28. Grow tubes are installed and newly established vines are growing.

Photo 29. Vines are growing beyond a milk carton, used as a grow tube.

Photo 30. Cutting or removing a grow tube gently and gradually away from the plants in early July.

Photo 31. Growing rooted vines or un-rooted cuttings in paper or regular pots.

Photo 32. Rooted vines in pots are ready for planting. Note that roots are growing out of the pots.

Photo 33. Each newly pot-grown vine is planted between two drip lines in the vineyard.

Photo 34. Delay mowing could reduce the chance of cut worm damage.

Photo 35. One bucket of clean sawdust is placed on each vine in late October (before the first frost).

Photo 36. Growth during the 2nd year. The drip line is installed on a wire about 16 inches above the ground.

Photo 37. A perfect bilateral cordon training after selecting two cordons and removing the tip of the arms at 2nd or sometimes 3rd season.

Photo 38. Risers are growing on the arms after removal excess shoots and cleaning the trunks.

Photo 39. A perfect bilateral cordon training of a mature vine at the end dormant season.

Photo 40. Re-occurring growth on the lower portions of the canopy in the following season. The excess growth needs to be cleaned again.

Photo 41. Double bilateral cordon dormant after Dormant pruning.

Photo 42. A double bilateral cordon system being converted to a (single) bilateral cordon (compare vine 1 &2).

Photo 43. Wrong pruning may result in formation of blank arm blank arm with a few growing points at the end.

Photo 44. Often, a rough dormant pruning is proceeded by a detailed final pruning in grapes.

Photo 45. Slanted one-sided Bilateral Cordon pruning in 'Flame' at StevCo Inc. in California.

Photo 46. Installation of an Arbor or Slanted One-sided cordon arms system at the University of Idaho. Cordon wires at about 57 Inches above the ground.

Photo 47. A more advanced stage of an experimental Arbor or Slanted Bilateral Cordon systems at the University of Idaho Pomology Vineyards in 2007.

Photo 48. A completed Arbor training system in California.

Photo 49. 'Emerald' is sensitive to sunburn and if the canopy is too open, the sunburn damage will be severe. The damage can also be aggravated by GA spray.

Photo 50. A cane-pruned young 'Thompson Seedless' Vineyard in California.

Photo 51. A caned-pruned mature 'Thompson Seedless' Seedless' Vineyard in California.

Photo 52. 'Alborz' clusters after crop adjustment and cluster shortening in early September.

Photo 53. 'Alborz' clusters after crop adjustment and cluster shortening in mid- September.

Photo 54. 'Alborz' clusters after crop adjustment and cluster shortening in late September.

Photo 55. 'Flame Seedless' clusters after crop adjustment and cluster shortening in late September.

Photo 56. Un-cut 'Emerald' with ideal color.

Photo 57. Un-cut 'Emerald' with sunburn


Photo 58. ‘Emerald’ table grape with cut cluster and less exposed to light.


Photo 59. ‘Emerald’ table grape with cut cluster and fully exposed to sun.

Photo 60. ‘Anahita’ or ‘Ralli’ table grape at early stage of maturity, August 20, 2006.

Photo 61. ‘Anahita’ or ‘Ralli’ table grape at full maturity and color, September 12, 2006.

Photo 62. 'Kashishi' table grape (seeded), without GA or any cluster adjustment in late September.

Photo 63. 'Kashishi' table grape (seeded), without GA or any cluster adjustment in mid-October.

Photo 64. 'Autumn Royal' in late September to early October.

Photo 65. 'Fantasy' in mid-September.


Photo 66. 'Katie K' in late September.


Photo67. 'Jupiter' in mid-September.

Photo 68. 'Italia' in late September.

Photo 69. 'Sweet Shelly' in early September.

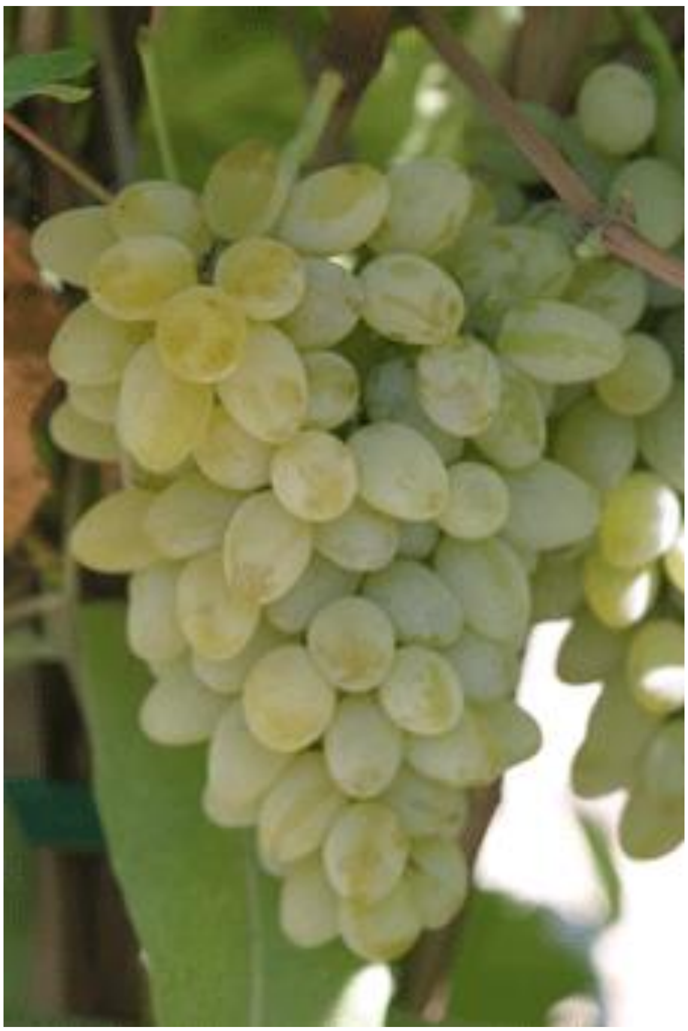


Photo 70. 'Neptune' in mid September.

Photo 71. NY 36095 in late September. September.

Photo 72. 'Delight' in mid September.

Photo 73. 'Red Globe' in mid October 20, 2007.

Photo 74. A- 2653

Photo 75. A-2494

Photo 76. A- 2640

Photo 77. ‘Princess’ table grape, early October.

Photo 78. ‘Himrod’.

Photo 79. ’Challenger’.

Photo 80. Fresno

Photo 81. Calmeria

Photo 82. ‘Vanessa’

Photo 83. ‘Canadice’

Photo 84. A-2494, a selection from coopertive work of University of Arkansas and University of Idaho.

Photo 85. 'Scarlet Royal'

Photo 86. 'Scarlet Royal'

Poto 87. 'Autumn King'

Photo 88. 'Ghandahar' (Seeded)

Photo 89. 'Tomcot'

Photo 90. 'Ghandahar'

Photo 91. Persian Gulf Beedaneh, ripe and yellow

Photo 92. Persian Gulf Beedaneh, mature but green.

Photo 93. Persian Gulf Beedaneh, yellowish-green.

Photo 94 ‘Sweet Scarlet’

Photo 95. Queen 4

Photo 96. Sugar Thirteen

Photo 97. Multitude of cluster-bearing branches growing on each spur, that shoots contains basal bud and two regular buds before thinning. good

Photo 98. Selecting two per spur, each with one cluster.

Photo 99. Multitude of branches with poor or no clusters, growing on each spur, that contains basal bud and two regular buds.

Phot0 100. Selecting two shoots without clusters.


Photo 101. An ‘Alborz’ cluster in nearly full bloom.


Photo 102. Cluster removal to reduce crop.


Photo 103. Early stage of cluster shortening. 1/3 to ½ of cluster tip is cut.


Photo 104. A cluster, cut at the correct time.

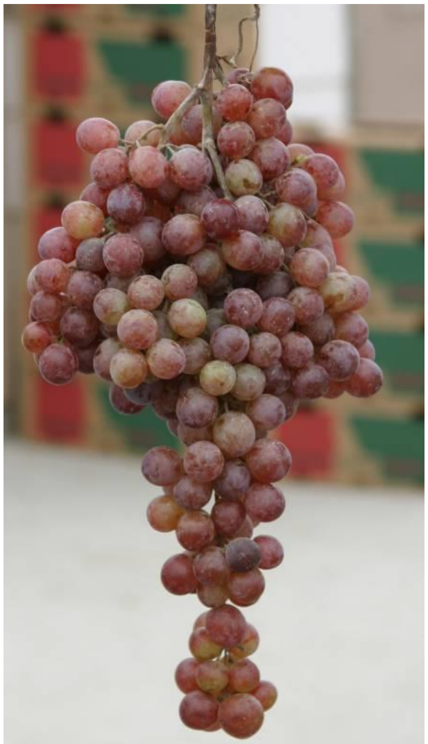


Photo 105. A non-cut cluster of ‘Alborz’.

Photo 106. A cluster of ‘Alborz’ from a vine that excess clusters were removed and remaining clusters were shortened.

Photo 107. A divided ‘Alborz’ table grape canopy where excess clusters are removed and remaining clusters are shortened. See the parallel lines of grape clusters which is evident in the row to the right.

Photo 108. Parallel-training of shoots. **Phot0 109. Dormant stage of parallel-trained canes .**

Photo 110. Parallel-trained shoots with one cluster of 'Alborz' grape each.

Photo 111. Parallel-trained shoots with one cluster of 'Anahita' grape each.

Photo 112. Excess GA application on 'Alborz' grape.

Photo 113. Size girdling of 'Alborz' to increase berry Photo.

114. Girdling completed in 'Alborz' table grape.

Photo 115. A girdled 'Alborz' grape vine that healed after 4-5 weeks.

Photo 116. A cluster from a non-girdled 'Crimson Seedless' grape.

Photo 117. A cluster from a girdled 'Crimson Seedless' grape.

Photo 118. Nitrogen deficiency (from Ontario Ministry of Agriculture, Food, and Rural Affairs site)

Photo 119. Potassium deficiency

Photo 120. Boron deficiency.

Photo 121. Magnesium deficiency.

Photo 122. Iron deficiency.

Photo 123. Healthy cluster on the far left and Zinc deficient cluster on the far right (from UC Davis site).

Photo 124. A preliminary damage of a bud by cutworm.

Photo 125. Cutworm damage on a grape bud.

Photo 126. Cutworm damage on a grape bud.

Photo 127. Cutworm feeding on a grape bud. Picture borrowed from Dr. Doug Walsh, Washington State Univ.

Photo 128. Lorsban applied in the planting basin of a newly-planted or established-vine.

Photo 129. Lorsban on the basin of a new vine.

Photo 130. Leaves damaged by 2-4,D spray.

Photo 131. Grape leaves misshapen by 2-4,D spray.

Photo 132. Clusters damaged by 2-4,D spray.

Photo 133. Clusters damaged by drift of 2-4,D spray from an adjacent wheat field.

Photo 134. Leaves damaged by Round Up weed spray.

Photo 135. Installing bird nets too tight will create a humid and dark environment, leading to powdery Infestation and poor color formation in the berries.

Photo 136. A perfectly trained 'Aborz' table grape vineyard with different gable canopy systems and a permanent bird net at the University of Idaho Pomology and Viticulture Program.

Photo 137. Perfectly netted canopy of a properly-netted 'Aborz' table grape vineyard with a bilateral cordon system after nets are removed.

Photo 138. Powdery mildew on the leaves late in the growing season.

Photo 139. Powdery mildew on an 'Emerald' cluster.

Photo 140. Removal of un-necessary shoots 2 to before harvest may improve color.

Photo 141. Checking the berry flesh color for weeks

Photo 142. Measuring berry diameter.

Photo 143. Checking for quality attributes.

Photo 144. Extracting juice for checking the

Photo 145. Reading soluble solids concentrations.

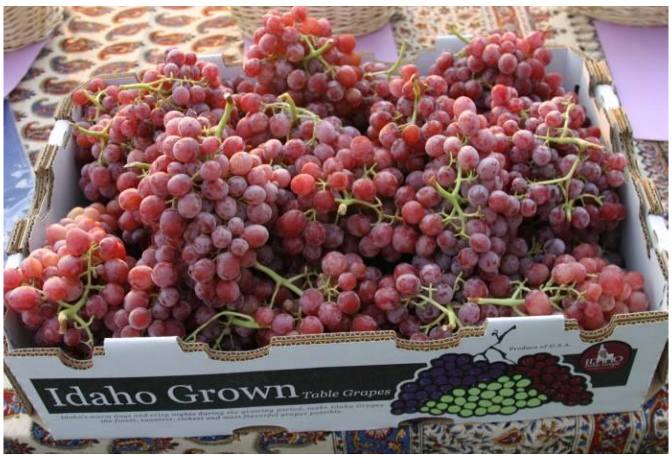


Photo 146. Boxes of 'Anahita' grown in Idaho.

Photo 147. Packing a box of 'Thompson Seedless' boxes packed in the field.

Photo 148. 'Thompson Seedless' wrapped in special papers and packed in a Styrofoam box..

Photo 149. Packing in clam shells containers.

Photo 150. Packing in clam shells containers.
Packing in clam shells containers.

Photo 151. SO_2 gas room for disinfection.

Photo 152. SO_2 gas room being filled with grape boxes.

Photo 153. SO_2 container.

Photo 154. A grape storage.

Photo 155. 'Thompson Seedless' kept in a regular storage without SO_2 at 32oF for several weeks.

Photo 156. 'Thompson Seedless' kept in a regular storage without SO_2 at 38 F for several weeks.

Photo 157. 'Thompson Seedless' treated SO_2 and kept at 38oF for several weeks.

Photo 158. 'Thompson Seedless' without sulfuric with (right) and treated with sulfuric acid (left) and both kept at 38oF for several weeks. The treated grapes are Damaged.

Photo 159. 'Persian Gulf Beedaneh' with sulfurs pads after 4 weeks at the 30 oF.

Photo 160. 'Alborz' with sulfurs pads after 3.5 weeks at the 30 oF.

Chapter 16

Conversion of Units

AREA EQUIVALENTS

One Acre = 43,560 square feet
= 160 square rods (rd)
= 0.405 hectares (ha)
= 4840 square yards
One are = 100 square meters
One hectare = 100 are = 2.471 acres

LIQUID EQUIVALENTS

One U.S. Gal. = 4 qt = 8 pt = 16 cups
= 3.785 liters = 128 fluid ounces
= 231 cu inch
= 8.3370 pounds of water
= 3785.4 cu cm
One qt = 0.9463 liters = 2 pt = 32 fl oz = 4 cups = 64 Tbs.
One tablespoon (Tbs) = 14.8 ml = 3 teaspoons = 0.5 fl oz.
Ounce (U.S. fluid) = 29.57 ml = 2 Tbs.
Ounce (British fluid) = 28.41 ml

TEMPERATURE EQUIVALENTS

(Degree F - 32) X 5/9 = degrees Centigrade
(Degree C X 9/5) + 32 = degrees Fahrenheit

LENGTH EQUIVALENTS

centimeter = 0.394 inch
meter = 3.28 feet = 39.4 inches
kilometer = 0.621 statute mile
inch = 2.54 centimeters
foot = 30.48 centimeters
yard = 0.914 meters
rod (16.5 feet) = 5.029 meters
statute mile (1,760 yards) = 1.61 kilometers

WEIGHT EQUIVALENTS

pound (avdp)(16 ounces) = 453.6 grams
ton, gross or long (2,240 lb) = 1.016 metric ton
ton, short or net (2,000 lb) = 0.907 metric ton
milligram = 10 to the minus 3 grams
microgram = 10 to the minus 6 grams
nanogram = 10 to the minus 9 grams
picogram = 10 to the minus 12 grams
1 mg/kg or 1 mg/L = 1 ppm
1 ug/kg or 1 ug/L = 1 ppb
1 mg/g = 1000 ppm
1 ug/g = 1 ppm
1 nanogram/g = 1 ppb
1 picogram/g = 1 ppt

Conversion of Units (Continued)

USEFUL CONVERSIONS

Multiply	by	To obtain
foot candle	10.764	lux
gal (US)	3785	cubic centimeters
gal (US)	3.785	liters
gal (US)	0.83	gal (Imperial)
gal	128	fluid ounces
gal/min	2.228 X 10 minus 3	cu ft/sec
gal/acre	9.354	L/ha
hectares	2.471	acres (US)
kilograms	2.205	pounds (advp)
kg/ha	0.892	lb/acre
liters	0.0353	cu ft
liters	1.05	quarts (US)
liters	0.2642	gal (US)
liters/ha	0.107	gal/acre
meters	3.281	feet
miles/hr	88	feet/min
miles/hr	1.61	km/hr
ounces (fluid)	29.573	milliliters
ounces	28.35	grams
pounds	453.59	grams
lb/gal	0.12	kg/L
lb/sq inch	0.070	1 kg/cm square cm (atm)
lb/1000 sq ft	0.489	kg/acre
lb/acre	1.12	kg/ha
square inch	6.452	cm square
yards	0.9144	meters
parts per million	2.719	lb ai/acre foot of water

Conversion of Units (Continued)

AMOUNT OF FORMULATED CHEMICAL (ACTIVE INGREDIENT BASIS)
TO BE PUT IN ONE GALLON TO APPLY ONE POUND PER ACRE
AT THE DESIGNATED GALLONAGE PER ACRE (1)
SOLID FORMULATIONS

Active ingredient content	Grams in each gal for 1 lb/A at designated gallonage/A	
	10 gal/A	15 gal/A
10.0%	453.39	302.39
18.5%	245.19	163.46
20.0%	226.80	151.20
25.0%	181.44	120.96
30.0%	151.20	100.80
33.3%	136.08	90.72
35.0%	129.60	86.40
40.0%	113.40	75.60
45.0%	100.80	67.20
50.0%	90.72	60.48
55.0%	82.47	54.98
60.0%	75.60	50.40
65.0%	69.78	46.52
70.0%	64.80	43.20
75.0%	60.48	40.32
79.3%	57.20	38.13
80.0%	56.70	37.80
85.0%	53.36	35.58
90.0%	50.40	33.60
95.0%	47.75	31.83
100.0%	45.36	30.24

(1) Calibrate sprayer for gallonage output of spray per unit time or unit area and convert to gallons per acre (1 Acre = 43,560 square feet). Amounts per gallon, for other gallonages than those shown, can be easily calculated using the 10 gallon per acre as a base, i.e., to mix a spray for 35 gallons per acre of a formulation having 3 pounds active per gallon, use 126.18 divided by 3.5 = 36 ml of formulation per gallon of spray; or to mix a spray for 7 gallons per acre from the same formulation, use 126.18 divided by 0.7 = 180 ml of formulation per gallon of spray.

Conversion of Units (Continued)

LIQUID FORMULATIONS

Pounds Active ingredient/gal formulation	Milliliters needed for 1 gram	Milliliters in Each Gal for 1 lb/A at designated gallonage/A	
		10 gal/A	15 gal/A
1.00	8.35	378.53	252.48
1.50	5.56	252.36	168.24
2.00	4.17	189.27	126.24
2.50	3.34	151.41	100.99
3.00	2.78	126.18	84.12
3.33	2.51	113.33	75.56
4.00	2.09	94.63	63.09
4.50	1.85	84.12	56.11
5.00	1.67	75.71	50.47
6.00	1.39	63.09	42.06

AREA EQUIVALENTS

One Acre	43,560 square feet 160 square rods (rd) 0.405 hectares (ha) 4840 square yards
One hectare	100 square meters
One hectare	2.471 acres

LIQUID EQUIVALENTS

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Conversion of Units (Continued)

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1 ug/g	1 ppm
1 nanogram/g	1 ppb
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Conversion of Units (Continued)

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Liters	0.2642	gal (US)
liters/ha	0.107	gal/acre
Meters	3.281	Feet
Miles/hr	88	feet/min
Miles/hr	1.61	km/hr
ounces (fluid)	29.573	Milliliters
Ounces	28.35	Grams
Pounds	453.59	Grams
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lb/sq inch	0.07	1 kg/cm square cm (atm)
lb/1000 sq ft	0.489	kg/acre
lb/acre	1.12	kg/ha
square inch	6.452	cm square
Yards	0.9144	Meters
parts per million	2.719	lb ai/acre foot of water

Chapter 17

Potential Sources and Partial List of Vendors for Table Grapes

Advising and Consulting on all issues related to table grapes production:

Dr. Essie Fallahi
Address: University of Idaho
29603 U of I Lane
Parma, Idaho 83660
E-mail: efallahi@uidaho.edu
Website: www.efallahi.com
Phone: Home: 208-454-8486
Office: 208-722-6701 extension 225
Cell Phone: 208-880-8088

Plant Materials, and Vineyard Supplies, Services and Design:

Tundra Ranch
Contact: Tom Elias
Phone: 208-896-5442
Cell Phone: 208-899-9148
E-mail: tomelias@frontiernet.net
Address: 7785 Sommercamp Road
Melba, Idaho 83641
Products/Services: grape cuttings and rooted grapes ready for planting, vineyard designs

KingZ Nurseries Inc.
Contact and Owners; Pat and Linda King
Location; 13306 Goodson Rd. Caldwell, Idaho 83607
Mailing; 13462 Goodson Rd. Caldwell, Idaho 83607
Phone # (208) 585-0065
web site www.kingsnurseries.com
e-mail patking@kingsnurseries.com
Products: 2 inch dia. plug rooted grape with green top ready to plant, tools for Vineyards Hand snips, short vineyard loppers, tapeing guns and tape, staples, blades Bamboo, wood posts inline and end drip tubing post pounder; installation posts and irrigation systems for vineyards; vineyard management.

Mann Nursery
Contact: Ron Mann
Phone: 208-642-6083
Products: Dormancy rooted table grapes; grape cuttings; potted grape plants; advising on table grape production

Wilbur Ellis Co.
Contact: Tom Tankerslee
Phone: 208-870-3127
E-mail: ttankers@wilburellis.com
Address: Wlibur Ellis Co.
P.O. Box 988
Caldwell, Idaho 83606

D & B Supply
Dan
Phone:
Products: Vineyard supplies, metal posts, wires for trellis system

Pipeco Inc.
Contact: Dick Bronson
Phone: 208-452-4561
Cell: 208-739-2169
Address: 203 Southeast 6th Street
Fruitland, Idaho 83619
Product and Service: Irrigation designs and equipments, drip and sprinkler systems for vineyards, and pruning supply.

References and Useful Reading Sources

Ahumada, M.H., E.J. Mitcham, and D.G. Moore. 1996. Postharvest quality of 'Thompson Seedless' grapes after insecticidal controlled atmosphere treatments. HortScience 31:833-836.

Andris, H., F. Jensen, and P. Elam. 2000. Growing Quality Table Grapes in the Home Garden. UC California Cooperative Extension. 66p.

Bentley, W.J., L. G. Varela, F. G. Zalom, R. J. Smith, A. H. Purcell, P. A. Phillips, D. R. Haviland, K. M. Daane, M. C. Battany, and J. Granett, Entomology. 2006. UC IPM Pest Management Guidelines: Grape C ANR Publication 3448; Insects and Mites. This publication can be viewed online at: http://www.ipm.ucdavis.edu/PMG/selectnewpest.grapes.html

Cappellini, R A., M.J. Ceponis, and G W. Lightner. 1986. Disorders in table grape shipments to the New York market, 1972-1984. Plant Disease 70:1075-1079.

Christensen, P. 1998. Training table grapes vineyards. University of California Cooperative Extension Tulare County. Publication TB 11-98. Can be viewed online at:
http://cetulare.ucdavis.edu/pubgrape/tb1198.htm

Christensen, P. 1998. Use of Tissue Analysis in viticulture. University of California Cooperative xtension Tulare County. Publication NG10-00. Can be viewed online at:
http://www.google.com/search?client=firefox-a&rls=org.mozilla%3Aen-US%3Aofficial&channel=s&hl=en&q=Christenson+Pub.+NG10-00

Amos, T.G., E.W. Boehm, G.A. Buchanan, I.J. Cameron, A.P. Chapman, R.M. Cirami, B.G. Coombe, D.M. Davidson, P.R. Dry, G. Due, R.W. Emmett, B.M. Freeman, R.P. Hamilton, A.R. Harris, P.F. Hayes, P.R. Hedberg, L.D. Jones, M.G. McCarthy, J.K. McGechan, P.R. Nicholas, M.D. Rebbechi, J.B. Robinson, R.E. Smart, E. Tassie, R.H. Taylor, R.T.J. Webber, and J.R. Whiting.1992. Viticulture. Volume 2: Practices. Coombe, B.C. and P.R. Dry (Editors). P. 211. Winetitles, Finbury Press, Adelaide, SA

Anticliff, A.J., R.M. Cirami, B.G. Coombe, P.R. Dry, G.R. Gregory, W.J. Hardie, D.I. Jackson, M.G. McCarthy, K.H. Northcote, R.E. Smart, M.B. Spurling. 1998. Viticulture. Volume 1: Resources. Coombe, B.C. and P.R. Dry (Editors). P. 376. Winetitles, Hyde Park Press, Adelaide, SA.

Crisosto, C.H., J.L. Smilanick, N.K. Dokoozlian, and D.A. Luvisi. 1994. Maintaining table grape post-harvest quality for long distant markets. International Symposium on

Table Grape Production, June 28 & 29,1994, American Society for Enology and Viticulture, p. 195-199.

Crisosto, C.H., E.J. Mitcham, and A.A. Kader. Grape Recommendations for Maintaining Postharvest Quality. This can be viewed online at: http://postharvest.ucdavis.edu/Produce/ProduceFacts/Fruit/grape.shtml

Fallahi, E., H. Heydari and M. Kilby. 1995. Maturity, quality, and production of 'Thompson
Seedless' grape as affected by frequency of Gibberellic Acid with and without naphthaleneaceti acid. Journal of Small Fruit and Viticulture, 3(1):49-61.

Fallahi, E., B. Fallahi, and I.J. Chun. 2001. Adaptation, maturity, and fruit quality of table grapes in the Intermountain West region of the U.S.A. Journal of Small Fruits Review. 1 (4): 29-42.

Fallahi, E., B. Shafii, B. Fallahi, J.C. Stark, and A.L. Engle. 2004. Yield, Quality Attributes, and Degree Day Requirements of Various Wine Grapes Under Climatic Conditions of Intermountain West Region. Journal of the American Pomological Society. 58(3): 156-162.

Fallahi, E., B. Shafii, J.C. Stark, and B. Fallahi. 2005a. Cane and leaf Growth and leaf mineral nutrients in various cultivars of wine grapes. J. American Pomological Society. 59(4): 182-191.

Fallahi, E., B. Shafii, J.C. Stark, B. Fallahi, and S.L. Hafez. 2005b. Influence of wine grape cultivars on growth and leaf blade and petiole mineral nutrients. HortTechnology15(4): 825-830.

Fallahi, E., B. Fallahi, B. Shafii, and J.C. Stark. 2005c. Performance of six wine grapes under southwest Idaho environmental conditions. Journal of Small Fruit. 4 (3):77-84.

Flaherty, D.L., L.P. Christensen, W.T. Lanini, J.J. Marois, P.A. Phillips, L.T. Wilson. 1992. Grape Mangement. Second Edition. Publication No. 3343. University of California Division of Agriculture and Natural Resources.
400 p.

Gubler, W. D., R. J. Smith, L. G. Varela, J. J. Stapleton, Parlier, G. M. Leavitt, and A. H. Purcell. 2006. *UC IPM Pest Management Guidelines: Grape;* UC ANR Publication 3448; Diseases. This publication can be viewed online at: http://www.ipm.ucdavis.edu/PMG/r302100311.html

Harvey, J. M. and W. T. Pentzer. 1960. Market diseases of grapes and other small fruits. USDA Agr. Handbook. 1899, 37 p.

Kanellis, A.K. and K. A. Roubelakis-Angelakis. 1993. Grape. p. 189-234, in: G.B. Seymour et al., (eds.). Biochemistry of fruit ripening. Chapman and Hall, London.

Lindsey, P.J., S.S. Briggs, K. Moulton, and A.A. Kader. 1989. Sulfites on grapes: issues and alternatives, p. 5-19, in: Chemical use in food processing and postharvest handling: issues and alternatives, Agricultural Issues Center, University of California, Davis.

Luvisi, et al., 1995. Packaging California Table Grapes University of California, DANR Publication 1934.

Luvisi, D. A., H. H. Shorey, J. L. Smilanick, J. F. Thompson, B. H. Gump, and J. Knutson. 1992. Sulfur dioxide fumigation of table grapes. Bull. 1932, Univ. Calif., DANR Publications, Oakland, CA. 21 p.

Nelson, K. E. 1978. Pre-cooling - It's significance to the market quality of table grapes. Int. J. -Refrig. 1:207-215.

Nelson, K.E. 1985. Harvesting and handling California table grapes for market. Bull. 1913, Univ. Calif., DANR Publications, Oakland, CA. 72 p.

Peacock, P. 1998a. Managing table grape canopy. Publication No. TB-2 96. This document can be viewed online at: http://cetulare.ucdavis.edu/pubgrape/tb296.htm

Peacock, P. 1998b. Water management for grape vines. Publication No. 1G1-95. This document can be viewed online at: http://cetulare.ucdavis.edu/pubgrape/ig195.htm

Peacock, P. 2005. Gibberellin and Flame Seedless Grapes. Publication No. TB 14-00. This document can be viewed on line at: http://cetulare.ucdavis.edu/pubgrape/tb1400.pdf

Peacock, W.L., F.L. Jensen, N.K. Dokoozia.1998. Systems and Canopy Management of Table Grapes in California. Publication No. TB9-94. This document can be viewed online at: http://cetulare.ucdavis.edu/pubgrape/tb994.htm

Ryall, A. L. and J. M. Harvey. 1959. The cold storage of Vinifera tables grapes. USDA Agr. Handbook. 159, 46 p.

Snowdon, A. L. 1990. A color atlas of post-harvest diseases & disorders of fruits and vegetables, Volume 1: General introduction & fruits. CRC Press, Inc. Boca Raton, Florida.

Winkler, A.J., J.A. Cook, W.M. Kliewer, L.A. Linder. 1974. General Viticulture. P. 710. University of California Press, Berkley, Los Angeles, London.

Yahia, E.M., K.E. Nelson, and A.A. Kader. 1983. Postharvest quality and storage life of grapes as influenced by adding carbon monoxide to air or controlled atmospheres. J. Amer. Soc. Hort. Sci. 108:1067-1071.

Yokoyama, Victoria, Y., Gina T. Miller, and Carlos H. Crisosto. 1999. Los temperature storage combined with sulfur dioxide slow release pads for quarantine control of omnivorous leafroller *Platynota stultana* (Lepidoptera: Tortricidae). J. Econ. Entomol. 92(1):235-238.