VINE PRUNING IN CALIFORNIA

PART I.

By FREDERIC T. BIOLETTI

Objects.—The main objects of pruning, in the wider sense, are first, to give the vine a suitable form and to conserve this form; and second, to so regulate the bearing that the maximum quality and quantity of crop may be obtained for a long series of years at the minimum expense.

Scope.—The crop possibilities of a vineyard, both as regards quantity and quality, depend on many factors, of which the chief are the character of soil and climate, the amount of available water and the nature of the variety of vine. What part of these possibilities is realized depends on the operations of the vineyardist—on how he handles the soil and the vine. One of the most important of these operations is pruning. By improper pruning we may neutralize the most favorable conditions and destroy the effect of the most careful cultivation. The skillful pruner, on the other hand, gives his vines the opportunity to utilize to the full all the natural and cultural advantages. Many vineyards produce less than half their proper average crop owing to mistakes in pruning, and there are very few vineyards in the State where both the amount and quality of the crop could not be increased considerably by improved methods of pruning.

There are two great difficulties in the way of reforming the pruning methods in most vineyards. One is the difficulty of obtaining pruners possessed of the necessary skill and knowledge. The other is the lack of the proper knowledge on the part of the owner of the vineyard. Of these difficulties the latter is by far the most serious in its effects and its removal would in most cases obviate the greatest part of the trouble due to the former.

Some Results of Defective Pruning.—In order to emphasize the necessity for proper pruning it may be well to consider some of the results of defective pruning as shown below:

1. Deficient average annual amount of crop, due to—
   (a) Delay of bearing of young vines.
   (b) Irregularity of development of vines.
   (c) Failure to utilize properly full vigor of best vines.
   (d) Lack of sufficient fruit buds.

2. Inferior quality, due to—
   (a) Over-bearing of weak vines.
   (b) Irregular distribution of the grapes and consequent irregular ripening.
   (c) Injurious contact of grapes with soil, canes, and each other.

3. High cost of vineyard operations such as—
   (a) Cultivation, plowing, hoeing.
   (b) Pruning, suckering.
   (c) Control of diseases, oidium, vine-hopper.
   (d) Gathering, trimming, sorting, culling.
THE PRACTICE OF PRUNING

Pruning Systems.—There is a very large number of systems of pruning applied to the vine. These systems differ principally in the form given to the body of the vine, and in the management of the annual growth. Some of the differences depend on variations in the nature of the vines, on the cultural and growing conditions of the district, and on the objects of the grower. Others are unessential and are merely a matter of taste. The best system is that which is most adapted to all the conditions of the particular vineyard. Any system which does not take into account the nature of the vine is defective.

Ideals of Pruning.—Before commencing work, the pruner should form a mental picture of an ideal vine of the form desired. Vines are subject to so many accidents of weather, cultivation, and disease that, even with the greatest care and skill, it may be impossible to obtain a single ideal vine in the vineyard. The ideal vine, however, must exist in the pruner’s mind or all his vines will be unnecessarily defective. With this ideal constantly in mind, he is able to take such measures as will as much as possible direct the energies of the vine in the right direction and counteract all contrary influences and thus to make each vine approach as nearly as possible the perfect model.

This mental ideal is particularly necessary in the treatment of young vines. Only when it is strongly impressed on the imagination, is it possible to use such means and measures as will most rapidly and economically bring the vine to profitable maturity.

In the following account of the principal systems of pruning adapted to Californian conditions, a description is first given of an ideal mature vine in full bearing. This is followed by a discussion of methods of handling a young vine to make it approach as nearly as possible this ideal, and finally by an account of the regular pruning necessary to make the vine produce maximum crops to a respectable old age.

Californian Systems.—The systems of pruning in use in California may be divided into two classes according to the arrangement of the arms on the trunk of the vine. In the commonest systems, there is a definite head to the trunk, from which all the arms arise symmetrically at nearly the same level. The
Pruning Units:

1. Spurs
   a. Renewal Spur
   
   2-Bud Spur
   (1-3 Bud range)

   b. Replacement Spur
   (used to develop a new position)

   1-Bud only

2. Fruiting Cane (w/spur)

   2 year old wood

   8-10 Buds on each fruiting cane.

THANKS TO: SAMANTHA K.
Pruning Cuts:

1. Spur

   old renewal spur (2 yrs old)

   new renewal spur

2. Cane

   new fruiting cane

   2 year old spur

   3 yr old spur

   permanent vine structure

THANKS TO: SAMANTHA LE.
BUD FRUITFULNESS

1) By shoot vigor

Lack of CHO allocation to apical meristem

2) By bud position on shoot

Sub-optimal conditions for CHO

3) By cultivar and bud position on shoot

Large-cluster variety

Small-cluster variety
CAPACITY AND BALANCE CONCEPTS FOR PRUNING GRAPEVINES

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Viticulture and Winery Technology
Napa Valley College

Capacity: The condition or strength of the grapevine at the conclusion of one season that determines its ability to produce both crop and vine growth during the coming season.

\[ \text{CAPACITY} = \text{CROP LOAD} + \text{VEGETATIVE GROWTH} \]

Balance: The ratio between crop load and vegetative growth which results in the production of the highest quality fruit at the highest sustainable yield. Vines in balance ripen at the normal time for that variety in a given location and have proper Brix, acidity and pH values.

Vines out of balance will ripen poorly, make inferior wine, and long-term yields will be low. There are two out-of-balance situations, overcropping and undercropping.

Overcropping: Too many buds were left at pruning time.

Undercropping: Too few buds were left at pruning time.

Measuring vine balance: A comparison of crop yield and vegetative growth (one-year old wood) can be used to determine if a vine is balanced. The following values can be used as a guide:

<table>
<thead>
<tr>
<th>Vine Condition</th>
<th>Crop Weight/Pruning Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Balance</td>
<td>3 to 5# crop/1# wood</td>
</tr>
<tr>
<td>Overcropping</td>
<td>more than 5# crop/1# wood</td>
</tr>
<tr>
<td>Undercropping</td>
<td>less than 3# crop/1# wood</td>
</tr>
</tbody>
</table>

Note that an undercropping condition may also result from excessive fertilization or irrigation, or if some condition at bloom time interferes with normal fruit set, thus reducing crop.

Revised 1/05
SOME EXAMPLES OF VINE RESPONSE TO PRUNING

### Table 1: Vine Response to Pruning

<table>
<thead>
<tr>
<th>PRUNING</th>
<th>JUNE</th>
<th>OCTOBER</th>
</tr>
</thead>
<tbody>
<tr>
<td>SEVERE</td>
<td>1.8 # LEAVES</td>
<td>6.7 # LEAVES</td>
</tr>
<tr>
<td>LIGHT</td>
<td>7.4 # LEAVES</td>
<td>14.9 # LEAVES</td>
</tr>
</tbody>
</table>

**Conclusion:**
The total leaf area of the vine varies directly with the total number of shoots that develop. More shoots = more leaf area = more vine capacity.

<table>
<thead>
<tr>
<th>PRUNING</th>
<th>SHOOTS</th>
<th>AVE. LGTH.</th>
<th>TOTAL LGTH.</th>
<th>CROP WEIGHT</th>
</tr>
</thead>
<tbody>
<tr>
<td>SEVERE</td>
<td>23</td>
<td>5.8'</td>
<td>133'</td>
<td>3.1 # FRUIT</td>
</tr>
<tr>
<td>MODERATE</td>
<td>33</td>
<td>4.7'</td>
<td>155'</td>
<td>11.4 # FRUIT</td>
</tr>
<tr>
<td>LIGHT</td>
<td>48</td>
<td>3.7'</td>
<td>178'</td>
<td>25.4 # FRUIT</td>
</tr>
</tbody>
</table>

**Conclusions:**
Pruning reduces capacity (capacity = vine growth + crop). The vigor of individual shoots varies inversely with the number of shoots allowed to grow (few shoots ---> vigorous individual shoots).

<table>
<thead>
<tr>
<th>PRUNING</th>
<th>SHOOTS</th>
<th>AVE. LGTH.</th>
<th>TOTAL LGTH.</th>
<th>CROP WEIGHT</th>
</tr>
</thead>
<tbody>
<tr>
<td>SEVERE</td>
<td>22</td>
<td>6.8'</td>
<td>150'</td>
<td>NO CROP</td>
</tr>
<tr>
<td>MODERATE</td>
<td>35</td>
<td>5.8'</td>
<td>200'</td>
<td>NO CROP</td>
</tr>
<tr>
<td>NONE</td>
<td>64</td>
<td>4.2'</td>
<td>270'</td>
<td>NO CROP</td>
</tr>
</tbody>
</table>

**Conclusion:**
Pruning reduces capacity (capacity = vine growth + crop)

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**Figure 79:** The relation of vigor (length) of shoot growth to fruitfulness of the buds of Muscat of Alexandria and Alicante Bouschet. (WINKLER, GEN VIT, 1974)
SOME COMMON ERRORS IN VINE PRUNING AND THEIR REMEDIES

By FREDERIC T. BLOLETI

Pruning cannot be reduced to a few mechanical rules. There is no simple answer, that is not misleading, to such questions as: How should you prune a two year old vine? or, How many spurs should be left on a six-year-old Muscat?

It would be almost impossible to find two vines that should be pruned absolutely alike. Each vine is a special case. To watch an expert prune one vine will not aid a beginner to prune another unless the reasons for the cuts are explained and understood.

These reasons, however, are based on a few relatively simple principles. If these principles are known, a good method can be devised and most serious errors avoided. Some of these principles are:

1. Each year the vine bears a crop and develops the buds which produce the crop and growth of the following year.
2. The condition of a vine at the end of a year determines how much crop it can bear and how much growth it can make the next year.
3. The more crop a vine bears in one year the less growth it can make in the same year, and vice versa.

The last statement indicates that growth and bearing vary inversely, but this is true only roughly, and within somewhat narrow limits. If the crop is reduced to zero we get maximum growth, but if we reduce the growth to zero, the crop disappears also.

Neither of these extremes can be reached by winter pruning, but they can be approached closely. If we prune off most of the fruit buds the vine will yield little crop and will make a vigorous growth. This can be carried on indefinitely if the patience and the bank account of the grower hold out. If we leave most of the fruit buds, the vine will try to produce a very large crop and may even succeed for one year. During this year the growth will be small and if Principle 2 above is true, it will have little crop or growth the next year. Repetition of this attempt the second and the third year may result in the actual death of the vine or at least in excessive weakness from which it recovers with difficulty.
CHOICE OF A TRAINING AND PRUNING SYSTEM

The choice of a training and pruning system for wine grapes is based on the genetically-determined cluster size of each particular cultivar.

Head-training with cane-pruning is suited to small-cluster varieties and either head-training or cordon-training with spur-pruning is suited to large-cluster varieties.

### SMALL-CLUSTER VARIETIES

<table>
<thead>
<tr>
<th>REDS</th>
<th>WHITEs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cabernet Sauvignon</td>
<td>Chardonnay</td>
</tr>
<tr>
<td>Cabernet Franc</td>
<td>Gewürztraminer</td>
</tr>
<tr>
<td>Malbec</td>
<td>Pinot blanc</td>
</tr>
<tr>
<td>Merlot</td>
<td>Pinot gris</td>
</tr>
<tr>
<td>Nebbiolo</td>
<td>Riesling</td>
</tr>
<tr>
<td>Petit Verdot</td>
<td>Sauvignon blanc</td>
</tr>
<tr>
<td>Pinot noir</td>
<td>Viognier</td>
</tr>
<tr>
<td>Syrah</td>
<td></td>
</tr>
</tbody>
</table>

### LARGE-CLUSTER VARIETIES

<table>
<thead>
<tr>
<th>REDS</th>
<th>WHITEs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alicante Bouschet</td>
<td>Chenin blanc</td>
</tr>
<tr>
<td>Carignane</td>
<td>Melon</td>
</tr>
<tr>
<td>Charbono</td>
<td>Muscat Canelli</td>
</tr>
<tr>
<td>Grenache</td>
<td>Semillon</td>
</tr>
<tr>
<td>Petite Sirah</td>
<td></td>
</tr>
<tr>
<td>Sangiovese</td>
<td></td>
</tr>
<tr>
<td>Zinfandel</td>
<td></td>
</tr>
</tbody>
</table>

SK 3/2011
PRUNING GRAPEVINES

A. J. WINKLER

CIRCULAR 477
The success of a vineyard may depend, to a large extent, on the pruning practices employed. This circular discusses the principles of pruning, the relationship between pruning and plant behavior, and the actual methods of pruning on both young and bearing vines.

Spacing and training of vines is not discussed here. That is felt to be another subject and is taken up in other publications.

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A. J. Winkler is Professor of Viticulture and Viticulturist in the Experiment Station, Davis.

JUNE, 1959

Typical mature, head-pruned vine, headed at about 24 inches.

Pruning consists in the removal of canes, shoots, leaves, and other vegetative parts of the vine. The removal of flower clusters, clusters, or parts of clusters is thinning. The removal of the ripe fruit is harvesting.

Pruning has three main functions: 1) to aid in establishing and maintaining the vine in a form which will save labor and facilitate the necessary vineyard operations such as cultivation, the control of diseases and insects, thinning, and harvesting; 2) to distribute the bearing wood over the vine, between vines, and between years in accordance with the capacity of the vines, in order to equalize production and secure large crops of high-quality fruit; and 3) to lessen or eliminate the cost of thinning in the control of crop. Pruning is the cheapest means of reducing the number of clusters.

Pruning distinguished from training

Training, both by derivation and usage, includes certain practices supplementary to pruning which are necessary in shaping the vine. It consists principally in attaching the vine as it grows to various forms of support. Whereas pruning determines the number and position of the buds that develop, training determines the form and direction of the trunk and arms and the position of the shoots that develop from the buds retained at pruning.

In training the young vine the grower is interested primarily in developing a single strong shoot with several well-placed laterals to form a permanent framework. In doing this he sacrifices some of the vine's crop potential in the early years in order to obtain a well-shaped vine as cheaply and as early as possible. With the bearing vine, on the contrary, the pruner must consider both wood and crop, since a proper balance between them is essential to the development of good fruit and the continued production of large crops. For this reason, training—the development of a young vine of desirable form—will be distinguished from pruning—the maintenance of the established form and the regulation of crop. Pruning will be discussed here. For a discussion of training see Leaflet 111, "Vine Spacing and Training."
Principles of pruning

When a vine has reached the stage of full bearing, pruning consists in the removal of all the growth except 1) bearing units—spurs and fruit canes for the production of fruit and new wood or fruit only; 2) renewal spurs, for renewal or the production of wood for the next year; and 3) replacement spurs, in the case of the older vines, for the replacing or shortening of arms. The old fruit canes and the arms or parts of arms to be replaced are removed.

Shoots are the current season's succulent growth of the vine. Canes are mature shoots. A fruit cane is the basal section of a cane, 8 to 15 buds long, retained to produce the crop on cane-pruned vines. It is always removed at the following pruning. A spur is the basal portion of a cane from 1 to 4 buds or nodes in length left after pruning of the cane. Water sprouts are any shoots that arise on parts of the vine which are older than one year. Suckers are water sprouts that arise below ground. The term is also frequently applied to water sprouts arising from the trunk.

The length of the bearing units is largely determined by the pruning habit of the variety to be pruned; that is, by the position on the canes where the fruitful buds are borne and by the normal size of the clusters. On varieties having fruitful buds to the base of the canes, short bearing units are retained. This is called spur pruning. On varieties on which the buds toward the base of the cane are sterile (unfruitful) or on which the clusters are very small, long bearing units must be used in order to secure a full crop. When this is done, it is called cane pruning. Occasionally bearing units of intermediate length—half-long pruning—are used. Owing to the difficulty of maintaining the shape of vines so pruned, this method is not recommended.

Thus, to the grower, pruning has two pronounced effects: it concentrates the activities of the vine into the parts left; and it diminishes the total capacity of the vine for growth and fruit production. Correct pruning consists in achieving the first to the extent required while minimizing the second effect as much as possible.

A heavy crop depresses vine capacity

Growers recognize that vines with a very heavy crop grow less vigorously than vines with a light crop, and also that vines which overbear in one year are likely to have a lighter crop the following year. For example, the crops of 1938, 1943, 1946, 1951 and 1955 were outstanding in volume. These years of excessive overcropping were in each case followed by lower yields. Owing to other conditions such as unusually favorable weather, etc., the years of lowest yield did not always immediately follow the heaviest crops. But they did follow.

Vine capacity related to total leaf area

Vine capacity is directly related to the number of shoots that develop and the resulting total leaf area. A vine with only a few shoots that elongate very rapidly will appear vigorous. Yet it will be excelled in production by another vine which makes less show of vigor, by reason of having numerous shoots of slower growth, but nevertheless produces a larger total leaf area.

Size of crop related to number of shoots

The fewer shoots permitted to develop, the smaller the crop, and the more vigorously each shoot will grow. This inverse relation between number of shoots and rate of growth finds special application in the development of young vines where a single strong shoot is desired to form the trunk. (See Par. 2 “Pruning distinguished from training.”) Similarly, the fewer the arms, the more vigorous each will be. This rule also applies to the fruit. To obtain large clusters, one must limit their number (several weeks before bloom); and if large berries are wanted, there must not be too many on a cluster.

Normal crop

A given vine in a given season can nourish and ripen properly only a certain quantity of fruit; that is, its capacity is limited by its previous history and its environment. Within the limit of a vine's capacity to bear fruit, the date of ripening is determined mainly by heat and cannot be hastened by further reductions in crop. The maximum amount the vine will bear without delaying maturity is therefore an index to its bearing capacity. This is its “normal crop.” As the crop is increased beyond this point, the first effect is delayed maturity. Further successive increases in crop result in lower sugar and low acid content, waterberries, drying of the tips of the clusters, reduced growth, immature wood, and poor fruit bud formation. The latter will limit the crop of the following year.

Growth and fruiting relationships

In addition to the above principles, the following relationships of growth and fruiting should be observed by the pruner:

The first growth in spring usually comes from the buds nearest the ends of canes or spurs, and those on the highest parts of the vine. This earlier start gives the shoots from such buds an advantage over later-starting shoots. Besides, a vertical position of a cane or growing shoot, through its effect on polar energy, tends to retard the development of buds on the middle and lower parts of canes, and the laterals on erect-growing shoots. In pruning, therefore, efforts are made to neu...
have grown an inch or two, one may re-
time when growth begins. Hence, by not
pruning until the upper buds on the canes
pruning may, however, slightly delay the
not frosted after growth starts. Very late
on the vigor of growth or production of
dormant period—between December 1
ipring. The time of pruning within the
tine is dormant, between leaf-fall in the
han position. Yet, to many pruners, posi-
tesulting in poorly matured wood. Time
uch canes start growth at about the same
mould select for fruit spurs and fruit
bundantly on one-year-old canes that
ement and a well-matured condition of the
wood. Canes with abnormally long inter-
ods should be avoided.

Capacity and total growth
As stated, capacity is directly propor-
tional to total growth. A cane of large
size, while having greater capacity than
a small one, is, however, likely by its con-
tinued vigorous growth to produce less
fruitful buds. This being the case, a large
cane should be pruned so that its growth
will be restrained and the spur or fruit
cane retained will carry more buds than
are supported by smaller canes.

Time of pruning

Generally pruning is done while the
vine is dormant, between leaf-fall in the
autumn and the starting of growth in the
spring. The time of pruning within the
dormant period—between December 1
and March 1—has little or no influence
on the vigor of growth or production of
fruit the following season, if the vines are
not frosted after growth starts. Very late
pruning may, however, slightly delay the
time when growth begins. Hence, by not
pruning until the upper buds on the canes
have grown an inch or two, one may re-
tard the starting of the lower buds (those
on the spurs) as much as a week or ten
days, and these may escape damage if
frost occurs within that period.

Only very late pruning considerably
affects the time of starting growth, except
for a few areas in southern California
and the Central Coastal counties. In these
areas late pruning has also resulted in
marked increases in yield. The reason for
this difference in response to time of
pruning is not fully understood at the
present time.

The various styles of pruning used in
commercial vineyards in California may
be grouped into three main classes or sys-
tems—namely, head, cane, and cordon.

Head Pruning

In the head system the mature vine has
a vertical stem or trunk, 1 to 3 feet high,
bearing at its summit a ring of arms or
short branches. Each winter pruning
spurs are left at the ends of these arms to
produce the shoots that will bear the next
crop and furnish canes for the next year's
spurs. Thus, this system consists of head
training and spur pruning. The point or
region where the trunk separates into the
arms is called the head.

The advantages of head pruning are
simplicity of form, ease of training, and
cheapness. The headed vine is the easiest
type to establish, largely because the
trunks are rigid enough to be self-sup-
porting. Cross-cultivation is possible, a
feature that may be advantageous when
the control of noxious weeds is a problem.

The disadvantages of head pruning lie
chiefly in the depressing effect of severe
pruning on the growth and productivity of
the vines and in the massing of the
fruit within a small area. Where the crop
is controlled entirely by pruning, as with
most head-pruned varieties, the pruning
must be severe in order to prevent over-
bearing.

Head pruning suits most varieties that
bear well on short spurs. It is used for
most wine grapes and for a few table
varieties.

A photo of a head-pruned vine appears on
page 2.
Cordon Pruning

Cordon-pruned vines have no definite head. The trunk, which is much elongated either vertically or horizontally, has arms at intervals of 8 to 12 inches over the greater part of its length. In California only the horizontal bilateral form is recommended. The trunk rises vertically to a point about 8 inches below the supporting wire of a trellis. At this point it divides into two equal branches, which rise to the wire in a gentle bend and extend in opposite directions along the wire to within 8 to 12 inches of the cordons of the adjacent vines on either side. The bends should be smooth and regular; the horizontal portions straight. No shoots should be permitted on the bends of the mature vines. The bearing units are spurs on short arms located at regular intervals on the horizontal part of the branches. They should, wherever possible, be on the upper side of the branches or at least extend in an upward direction if they originate elsewhere.

The fruit on horizontal cordon-pruned vines is well distributed, with all clusters hanging at about the same distance from the ground, a condition favorable to uniform development and maturation of the fruit. Some varieties that require long spurs with head training bear fair crops on spurs of normal length with the cordon system.

The greater length of the trunk of the vines makes the cordon the most laborious and most expensive system to establish. Not only is more work required, but the labor employed must be more skilled; and a trellis or some other permanent support is essential. Once established, the pruning of these vines is simple.

Head pruning of bearing vines

On a mature vine, the number and length of spurs left the previous year, together with the size of the canes and the number of clusters produced during the current season, may be used as a guide in determining the number and length of the spurs to leave on a vine. (The number of clusters produced may be determined by counting the stubs left where the clusters were cut off.) A vine that produced a good crop and has canes of normal size should be pruned to about the same number of spurs of similar length. A mature, horizontal, bilateral, cordon-pruned vine on a 4-wire sloping-top trellis. One wire supports the cordons; the upper wire on the sloping crossarm is not shown.
length (as measured by the number of buds) as the year before. If the canes are abnormally large for the variety, indicating that the vines were very vigorous the previous summer, more spurs, or longer spurs, or both, should be left in order to utilize this capacity in the production of fruit. If, on the other hand, the canes appear weak—that is, small for the variety—fewer buds should be left. To reduce the number of buds, one may reduce the number of spurs retained or may cut the spurs shorter. Spurs retained from large or vigorous canes should carry more buds than those retained from small or weak canes.

A good rule-of-thumb for the inexperienced grower to follow is to retain one bud (not counting base buds) on spurs that are the diameter of an ordinary lead pencil; two buds on spurs as large as one's little finger; three buds on those as large as the middle finger; and four buds on spurs as large as the thumb. Base buds, that are not to be counted, include all buds within one-fourth inch of the base of the cane. In general, the medium sized canes—those proper for 2- and 3-bud spurs—are the best.

The renewal spurs should be so placed that the form of the vine is maintained or improved. Whenever possible, canes from near the base of last year's spurs should be used for the new spurs. The arms elongate from year to year. When an arm becomes too long it should be shortened to a replacement spur made from a water-sprout or other suitably located cane.

Cane pruning of bearing vines

The renewal spurs cut to two buds the previous season should have produced two good canes apiece. On a properly shaped vine the uppermost cane on the spur would be used for the fruit cane, and the lower one cut back to two buds to form the new renewal spur. Wherever feasible this practice should be followed.

If, however, enough good canes cannot be obtained from those on renewal spurs, then canes arising near the base of the old fruit canes, or even well-matured water-sprouts, may be used for the new fruit canes or renewal spurs.

The number of fruit canes needed varies from one to six, according to the size and total growth of the vine. The length of these canes depends upon their individual size: large ones, a half-inch or more in diameter, may be left to a maximum length of fifteen buds; small ones should have proportionally fewer buds. If the crop is to be regulated by thinning, as with all table varieties when cane-pruned, a standard number and length of fruit canes may be adopted, and the crop on each regulated according to its capacity.

The renewal spurs should usually be as numerous as the fruit canes and should be given preference over fruit canes in choice of position so as to maintain or improve the form of the vine.

Cordon pruning of bearing vines

Since the annual pruning of the cordon vine consists in cutting to spurs, it resembles head pruning; in choosing the wood and estimating the number of buds to be left, the grower proceeds in exactly the same way. To maintain the capacity of the individual arms at the same level, the length of the spurs left must be regulated in accordance with the size of the canes from which they are made, as with head pruning. Sometimes one-bud replacement spurs at the base of the long fruit spurs or further down on the arm may be used advantageously.

Summer pruning

Suckering, crown suckering, pinching, topping, and the removal of leaves are the operations in summer pruning. Suckering—the removal of water-sprouts from the trunk and from below ground—should be done carefully and thoroughly in every young vineyard and at least once each year in every old one. As a rule, no water-sprouts should be permitted on the undivided portion of the trunk of mature vines either above or below ground.

Crown suckering—the removal of water-sprouts from the branches and arms—should be employed with care. Usually one may open the head of the vine by judicious crown suckering in order to improve the quality of the fruit or to concentrate growth in parts where it is wanted. To remove unfruitful shoots in all cases, however, on the theory that they are useless, is a mistake. The foliage they produce nourishes the vine and makes it more capable of bearing fruit. Also, some shoots may be needed for use as replacement spurs. The constant and thorough removal of all water-sprouts from the large branches and arms admits the direct rays of the sun and causes "ball-headed" vines, which are subject to severe injury by sunburn.

Pinching, the removal of the growing tip of a shoot with thumb and finger, is often useful in arresting the elongation of very vigorous shoots. This operation lessens wind damage and aids in developing young vines. Pinching usually does not stimulate the formation of laterals.
Pruning cannot be reduced to a few mechanical rules. There is no simple answer, that is not misleading, to such questions as: How should you prune a two year old vine? or, How many spurs should be left on a six year old Muscat?

It would be almost impossible to find two vines that should be pruned absolutely alike. Each vine is a special case. To watch an expert prune one vine will not aid a beginner to prune another unless the reasons for the cuts are explained and understood.

These reasons, however, are based on a few relatively simple principles. If these principles are known, a good method can be devised and most serious errors avoided. Some of these principles are:

1. Each year the vine bears a crop and develops the buds which produce the crop and growth of the following year.
2. The condition of a vine at the end of a year determines how much crop it can bear and how much growth it can make the next year.
3. The more crop a vine bears in one year the less growth it can make in the same year, and vice versa.

The last statement indicates that growth and bearing vary inversely, but this is true only roughly, and within somewhat narrow limits. If the crop is reduced to zero we get maximum growth, but if we reduce the growth to zero, the crop disappears also.

Neither of these extremes can be reached by winter pruning, but they can be approached closely. If we prune off most of the fruit buds the vine will yield little crop and will make a vigorous growth. This can be carried on indefinitely if the patience and the bank account of the grower hold out. If we leave most of the fruit buds, the vine will try to produce a very large crop and may even succeed for one year. During this year the growth will be small and if Principle 2 above is true, it will have little crop or growth the next year. Repetition of this attempt the second and the third year may result in the actual death of the vine or at least in excessive weakness from which it recovers with difficulty.

One year of the kind of pruning shown in figure 1 might, with a vigorous vine, give 25 per cent or even 50 per cent more than a normal crop, but the grapes would be of inferior quality and the next year's crop so much below normal that there would be a net loss. If continued, the vines would be permanently weakened or killed.

The vine shown in figure 2 had been pruned the previous year to one cane of moderate length and two renewal spurs. It made an extremely healthy and vigorous growth.

![Fig. 1.—A Zinfandel 'pruned for crop.' A short life and a merry one.](image-url)
It probably produced a large crop of inferior grapes. With such weak growth the fruit could not have been good. The prospects for the coming crop are meager. All that can be done with such a vine is to cut it back to the old wood and grow a crop of canes for the crop of two years hence.

A consideration of the three principles mentioned indicates how we are to avoid both disastrous extremes.

We must leave enough fruit buds on a normal vine at the winter pruning to enable it to bear a good crop the following year and still have surplus strength to produce enough vigorous, mature buds for the next crop. Whether we have succeeded will be determined at the pruning of the following winter. If the vine has gained in size and vigor, we have not utilized its bearing capacity fully and the number of fruit buds left should be increased. If it appears weak it has been overtaxed and the number should be decreased.

In this way the vigor of the strong vines is utilized to obtain larger crops and the weak vines fortified so that they will give larger crops the following year.

This course of procedure applies not only to vines but to parts of vines, to arms and spurs. A thick, vigorous spur on a Muscat should have three or more buds; a weak spur, if it is necessary to leave it at all, only one. A vigorous fruit cane on a Sultanina should be left four or five feet long, with twelve to twenty buds, a weaker cane, only two to three feet, with half the number of buds.

This principle carefully carried out will maintain the vigor of the vines and the regularity of the crop.

Figure 4A is representative of a young Muscat vine or other short pruned variety, or the arm of an old vine. In either case it consists of a vigorous side with two large canes and a weak side with two small canes. In figure 4C one cane has been left on each side and both cut to about the same number of buds. The result will probably be that the weak side will produce several small bunches of poor grapes and make little or no growth, while the strong side will drop its blossoms, produce little or no fruit, and be still more vigorous next year. In figure 4N the length of the spur or the number of buds is in proportion to the vigor of the cane. The vigorous cane has been allowed four fruit buds and will probably produce several large bunches of good grapes and make a moderate growth for next year. The weak cane has been cut back to one bud and will produce little or no fruit. Its energies will therefore be expanded on producing stronger and more vigorous canes. The result at the next pruning will be that the two
sides of the vine or arm will be more nearly equal in vigor and size and equally capable of bearing an average crop.

Fig. 4.—Differential pruning.

Another principle which requires attention if the vines are to be permanently profitable is:

4. The amount and quality of all growth depends on the amount of sunshine it receives.

Failure to bear in mind this principle introduces serious difficulties in certain forms of cane and cordon pruning.

In a common method of pruning the Sultanina and the Sultana, several fruit canes are taken from near the ground and tied vertically to the top of a high stake. In consequence of their position, the shoots from the top buds grow more vigorously and shade the shoots from below. The next year when it becomes necessary to supply new fruit canes, only weak and inferior canes are to be found below. If these are tied up the crop is small. If the canes at the top are taken there is nothing to tie them to. This condition becomes worse each year if the method is continued. Finally, it is usual to leave the last canes permanently to develop into three, four or five trunks and to leave spurs at their tops where the only good canes are to be found. This is a definite abandonment of the cane system and all that remains is a vine with multiple trunks which are difficult and expensive to handle, and which requires head pruning with spurs, a method not fruitful with these varieties.
The trellis system, in which the canes are tied horizontally to wires, avoids these troubles by exposing the head of the vine to the sun, thus insuring a perennial supply of vigorous fruit canes at a place where they can be used. A vine started with the upright system is with difficulty changed to the trellis system. This system is described in Circular 191 of this Station.

![Fig. 6.—An old Emperor vertical cordon.](image)

In the vertical cordon system, commonly adopted for the Emperor, similar difficulties ensue. The vine is given the form of a long upright trunk about four and a half feet high.

On this trunk, when the vine is young, are developed spurs or arms equally distributed every six to ten inches from the top to near the ground (see fig. 5). Within a year or two the lower spurs, shaded by the growth at the top of the trunk, weaken and produce small and inferior canes. Finally nothing grows except at the top and the cordon character of the vine is lost. The growth, concentrated at the top, becomes very vigorous, and loses the ability to bear on short spurs which is one of the advantages of the cordon (see fig. 6).

The horizontal cordon system, in which the trunk of the vine is carried horizontally at about thirty-six inches from the ground to the next vine, intensifies the cordon effects by making the trunks twice as long as in the vertical form and makes it permanent by insuring a continuous growth on all parts of the trunk, which is equally exposed to the sun along its whole length. This system is described in Circular 229 of this Station.

The errors discussed are:

1. Failure to modify the pruning according to the strength of the vine or of the cane. This results in irregular crops and irregular vines and a serious decrease in quality and average crop.
2. Serious injury to the vine or its destruction by attempting to obtain excessive crops without regard to the annual growth.
3. Adopting systems which in their nature cannot be permanent, i.e., vertical canes and vertical cordons.

These errors are discussed more fully and methods of avoiding them explained in other publications which can be obtained by application to the College of Agriculture, Berkeley, California.

The following supplementary references may be found useful:

2. *Pruning the Seedless Grapes*, Circular 191. (Methods of cane pruning.)
3. *Cordon Pruning*, Circular 229. (Horizontal unilateral vine cordons.)
4. *Vine Pruning Systems*, Circular 245. (Types of pruning recommended for California.)
Two golden rules of viticulture

In my travels around the world consulting to clients of different backgrounds and beliefs, I have learned the value of trying to distill some rather complex biology of the grapevine into simple, but hopefully, universal rules.

I want to explain the two rules I feel are most important for vineyard owners to follow. These are the “Two Golden Rules of Viticulture.”

If I thought they were original, I would call them ‘Smart’s Laws,’ but it seems that many of my good ideas are not original; most of them I learned from Professor Nelson Shaulis while a graduate student at Cornell University in New York.

I have had the opportunity to learn many other good ideas from friends and colleagues around the world, and I count commercial grape growers as a valuable source of viticultural wisdom.

These golden rules are particularly applicable to modern vineyards, which are often excessively vigorous, out of balance and shaded, as I have discussed in previous columns. Why are modern vineyards more likely to suffer these problems?

The modern viticulturist is able to avoid stresses to the vine due to shortages of water and nutrients, and is also able to avoid the effects of most weeds, pests, and diseases. But he or she is apparently rewarded for this good effort by the sight of a vineyard full of leaves.

It seems that we have been more successful in growing leaves and canes than fruit! Put another way, I say our canopy management practices have yet to improve to the same level as those of irrigation, fertilizer, pest, disease, and weed management.

Importance of vineyard balance

For vineyards to produce sufficient quantities of quality fruit, shoot growth needs to be balanced with fruit yield. If there is not enough shoot growth relative to the yield, we say the vineyard is ‘over cropped’ but perhaps more appropriately we should say ‘under leafed.’ Such vineyards are typically of low vigor, which in turn, is due to some stress such as pests, weeds, disease or perhaps a soil environment which hinders root growth.

The more common condition, however, is when the vines are ‘under cropped’ or ‘over leafed.’ I must say that this condition is so common that many folks regard it as normal. The appearance of vigorous shoots is symptomatic of this condition.

In spring, shoots grow quickly and the stems are thick, with large leaves and often many active lateral or side shoots. By midsummer, the shoots can be easily six feet or more in length, and because they can no longer support their own weight, they overlap and fall across the canopy. Of course, such canopies are heavily shaded unless some form of canopy management is used.

There is an important relationship between the above and below ground portion of the vine, which is not always appreciated. Vines growing in a deep fertile soil, or with a vigorous rootstock, or those well-supplied with water and nitrogen have a large root system. The root tips are the site of important hormone production which regulate fruit and shoot growth. The root system is also an important reservoir of stored foods for the vine. In other words, the bigger the root system, the bigger the vine’s potential for fruit and shoot growth.

There are several indicators of the size of the root system. Both the amount of shoot and fruit growth and the trunk diameter are two such indicators. Probably the easiest way to quantify this, however, is by weighing the pruning in winter. The one-year-old wood is simply collected from a vine at pruning and weighed. Studies have shown that this weight is proportional to the vine’s leaf area the previous year.

Golden Rule #1 relates to creating a desirable vine balance. If a vineyard has a large root system and a high potential for growth, then more buds must be left at pruning in order to balance the vine, otherwise, the individual shoots will be too vigorous as described above.

However, leaving too many buds at winter pruning will cause the growth of individual shoots to be restricted, and perhaps delayed ripening through ‘over-cropping’ or ‘under-leafing’ as well. Rule #1 relates the number of buds to be left at winter pruning to an estimate of the root system size, estimated by pruning weight.

GOLDEN RULE #1:

LEAVE ABOUT 12 TO 16 BUDS PER POUND PRUNING WEIGHT.

Experience will teach you how to modify this rule of thumb for your particular vineyard. If you are in a cool region, leave 12 rather than 16 buds per pound. For Pinot noir, which requires a larger leaf area to fruit weight ratio for good table wine quality, leave 12 rather than 16 buds. Similarly, leave 12 buds per pound for varieties with larger than normal bunches.

Importance of open canopies

Rule #2 tells how to produce open canopies, and can also be used as a guide for winter pruning and shoot thinning. If shoots in a canopy are too close together, there will be too much shading, and yield and quality will be less than the potential.

If, on the other hand, the shoots are too far apart, then sunlight will be wasted as it falls on the vineyard floor. For vertically shoot-positioned canopies where the vines are in balance, studies have shown that about five shoots per foot gives a canopy with sufficient gaps so there is not too much shoot and fruit shading, and little sunlight is wasted.

It is more difficult to develop a rule of thumb for the typical California or Australian sprawling canopies, because once the shoots grow more than about three to four feet in length, they cannot support themselves and fall down to create shaded canopies.
GOLDEN RULE #2:
PRUNE OR THIN THE CANOPY TO ABOUT FIVE BUDS OR SHOOTS PER FOOT OF CANOPY LENGTH.

With time, your local experience will allow you to modify this rule to suit your own vineyard and varieties. For example, non-shoot-positioned canopies can have more than five buds per foot without necessarily being shaded, and high vigor shoots should be spaced further apart, say three or four per foot.

Simultaneously applying rules #1 and #2: the tricky part

The observant reader will have already started to think: *Wait a minute.* How can there be two rules to apply? Both of which are to be used at winter pruning? What if they conflict? Or what if it is impossible to satisfy both rules?

That happens all the time. Consider a typical moderate to high vigor Cabernet Sauvignon vineyard in the Napa Valley, with vines spaced 8x12. In early winter, we measure a few vines and find the average pruning weight to be about six pounds. Applying Rule #1, we will want to leave 16 buds per pound (Cabernet being a vigorous variety), so that means 96 buds.

Applying Rule #2 suggests we want to leave five buds per foot of canopy, or about 40 buds. So Rule #1 says leave 96 buds, Rule #2 says leave 40 buds. They cannot both be right, or can they?

Let us think about the implications of following one rule, and disobeying the other. Leaving 96 buds as suggested by Rule #1 means that if there were 100% bud break, then there will be 96 shoots on the vine, or 12 per foot. This value is more than twice the value indicated by Rule #2, and we can expect the canopy to be dense and shaded.

What will happen if we follow Rule #2? Pruning to only 40 buds means that individual shoots will be too vigorous and out of balance, and the canopy will be shaded anyway because of long shoots, large leaves, and plenty of lateral growth.

Interestingly, different countries and regions have developed different approaches to this dilemma. In California, the tendency is to follow Rule #2 at both pruning and desuckering; while the resulting spur and shoot spacing are good, the shoots are typically over vigorous. These shoots become so long they cannot support themselves, overlap each other and create a dense, shaded canopy.

In Australia, the common attitude is to follow Rule #1. The vines are pruned to many buds ‘to control vigor, mate.’ The resulting bud and shoot density is high, and there may be, for example, 15 to 20 shoots per foot, so again the canopy is shaded.

^ Solution to the dilemma

The solution to the above problem is to divide the canopy; that is to make two feet of canopy for each foot of vine row length. One can use any one of several trellis systems, for example, Scott Henry, Smart-Dyson (to be described in the next *PWV* Nov/Dec’93 column), “U” or lyre trellis, Geneva Double Curtain (GDC), etc.

Whether vertically divided in the Scott Henry or Smart-Dyson, or horizontally divided with the ‘U’ or GDC, the result produces two feet of canopy for each foot of vine spacing.

This means that we can now apply Rule #1 and prune to the required 96 buds per vine which should give more balanced shoot growth. Dividing this figure by the doubled canopy length (now 16 ft.) gives six buds per foot, almost the desired value of five. One would install the new trellis and presume that as the shading is decreased, the pruning weight will be reduced and the crop will improve. It may be that the vine can be pruned to the desired value of five shoots per foot in future years.

Conclusion

The tricky part about the Golden Rules of Viticulture is to apply them simultaneously, like a pair of algebraic equations. Their application will quickly highlight problems of vines being out of balance, or shoots being so close together as to cause shading. Solutions to the problem are found by dividing canopies, but sometimes we also have to do vine removal. More of that in later columns.

Future columns will also deal with the question: Which trellis system should I use? and the related issues of the ease of construction and management of different systems. The next column will introduce a new training system know as the Smart-Dyson system. This trellis is a joint Australian-American collaboration, with some ideas from Portugal!