

COLLEGE OF AGRICULTURE
AGRICULTURAL EXPERIMENT STATION
BERKELEY, CALIFORNIA

VINE PRUNING IN CALIFORNIA

PART I.

By FREDERIC T. BIOLETTI



The native vine of California (*Vitis Californica*).

BULLETIN No. 241

(Berkeley, Cal.)

BENJAMIN IDE WHEELER, President of the University.

EXPERIMENT STATION STAFF.

Heads of Divisions.

THOMAS FORSYTH HUNT, Director.

EUGENE W. HILGARD, Agricultural Chemistry (Emeritus).

EDWARD J. WICKSON, Horticulture.

HERBERT J. WEBBER, Director Citrus Experiment Station; Plant Breeding.

HUBERT E. VAN NORMAN, Vice-Director and Dean of the University Farm School;
Dairy Management.

WILLIAM A. SETCHELL, Botany.

MYER E. JAFFA, Nutrition.

ROBERT H. LOUGHRIDGE, Soil Chemistry and Physics (Emeritus).

CHARLES W. WOODWORTH, Entomology.

RALPH E. SMITH, Plant Pathology.

J. ELIOT COIT, Citriculture.

JOHN W. GILMORE, Agronomy.

CHARLES F. SHAW, Soil Technology.

JOHN W. GREGG, Landscape Gardening and Floriculture.

BERNARD A. ETCHEVERRY, Irrigation.

FREDERIC T. BIOLETTI, Viticulture and Enology.

WARREN T. CLARKE, Agricultural Extension.

JOHN S. BURD, Agricultural Chemistry.

CHARLES B. LIPMAN, Soil Chemistry and Bacteriology.

CLARENCE M. HARING, Veterinary Science and Bacteriology.

ERNEST B. BABCOCK, Genetics.

GORDON H. TRUE, Animal Husbandry.

JAMES T. BARRETT, Plant Pathology.

FRITZ W. WOLL, Animal Nutrition.

BURR B. PRATT, Pomology.

WILLIAM G. HUMMEL, Agricultural Education.

FRANK L. PETERSON, Farm Mechanics.

DAVID N. MORGAN, Assistant to the Director.

MRS. D. L. BUNNELL, Librarian.

DIVISION OF VITICULTURE AND ENOLOGY.

FREDERIC T. BIOLETTI.

W. V. CRUESS.

F. C. H. FLOSSFEDER.

L. BONNET.

A. E. WAY.

W. F. OGLESBY.

VINE PRUNING IN CALIFORNIA.

INTRODUCTION.

Literature.—A large number of books have been published on the pruning of the vine but none of them are very well adapted to the needs of the Californian vine grower. Most publications in English refer to methods suited to the Eastern States and to Eastern varieties or to the conditions of hot-house cultivation. Foreign publications, besides being more or less inaccessible, are adapted to conditions different from those of the Pacific Slope or treat the subject so widely that the grower is at a loss to choose from such a mass of material.

In 1897 the College of Agriculture published Bulletin 119, "Vine Pruning," for which there was so much demand that the edition was quickly exhausted. This bulletin was revised and republished in the Report for 1897-98, appearing in 1900. This edition has also been long exhausted. In 1907 Bulletin 193 was issued containing articles on the "Pruning of Young Vines" and the "Pruning of the Sultanina." Of this, also, there remain no copies available for distribution.

Need of the Bulletin.—The demand for information on vine pruning still continues and its necessity is made evident by the unsightly, defective and unprofitable condition of many of our vineyards. This seems a suitable time for the publication of a new bulletin which will incorporate the experience of the older and more skillful grape growers and the result of the experiments and observations of the Experiment Station workers. The constant influx of new settlers who are planting and growing vines with little knowledge of the methods which have proved best in California and the opening up of new vine-growing districts make necessary some guide that will help to avoid the numerous mistakes made in the past.

Definition.—The term pruning, both by derivation and usage, is applied to various operations which consist in cutting off certain portions of the vine. There are other operations, however, the purpose of which is similar or identical, which must logically and for convenience be discussed at the same time. Some of these are the removal of buds and shoots by other means than cutting and the attachment of the vine or its parts to stakes, wires, or other supports. For this reason some writers call the subject the "pruning and training of the vine." The word "training," however, is misleading when applied to any of the vineyard operations used in California. It implies methods of shaping the vine which we do not use and does not properly describe the various operations of suckering, disbudding, water-sprouting and the attachment of fruit canes which we do use. The word pruning, moreover,

seems sufficient alone, as all the other operations follow and are necessitated by the methods of cutting or pruning-proper adopted.

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.

4. Shorter life of vines, due to—

- (a) Pruning and cultivation wounds.
- (b) Occasional over-bearing.
- (c) Growth of suckers.

A young vine under average conditions in California should bear a paying crop at three years; that is, in the autumn of the third leaf or third summer in the field. At four years it should be practically in full bearing. Under exceptionally favorable conditions, bearing may be nearly a year earlier than this. In the cooler regions and with certain varieties, a year longer may be necessary. These results can be obtained only when the pruning during the first years is properly done.

Irregularity of development of individual vines is incompatible with the highest returns for the whole vineyard. Vines dwarfed by defective pruning can not compete with their more vigorous neighbors and will fail to produce a full crop. Full returns from a vineyard can be obtained only when there is comparative uniformity of vigor in the individual vines. This uniformity can be obtained only by carefully adapting the pruning to each case. If vigorous and weak young vines are pruned alike, the former may bear nothing and increase their vigor, while the latter may bear worthless grapes and increase their weakness.

When the vines reach the age of full bearing, the failure to adapt the pruning to the individual case is equally disastrous. A method of pruning adapted to a weak vine would prevent a vigorous vine from bearing and waste its possibilities, while a method adapted to a vigorous vine would cause a weak vine to attempt to bear a large crop of worthless grapes and perhaps die in the attempt.

Certain methods of pruning may result in an abnormally large crop one year, though usually at the cost of quality. Such a crop is always followed by a small one. Alternate bearing of this kind diminishes the average crop of a term of years. The neglected possibilities of one year can be utilized by the vine only in part during the following year.

Unless the pruner can distinguish the fruit buds he may fail to leave a sufficient number. The loss from this cause is the greater the more vigorous the vines, and with certain varieties than with others.

Bad pruning is a frequent cause of inferior quality. When the crop is too large for the vigor of the vine or even of a part of the vine, the grapes will be small, will fail to develop sugar, flavor or color and may dry up or sunburn before they are ripe. These defects are due not so much to the total weight of crop, which may not be excessive, as to the excessive number of individual grapes and bunches.

Bad pruning results in uneven and improper distribution of the grapes on a vine. This is particularly harmful to shipping grapes,

resulting in uneven ripening and coloring. The grapes are subjected to different conditions of light and heat according to their distance from the ground and to the degree in which they are shaded by the leaves or other grapes.

On a vine of unsuitable form, the bunches may lie on the ground and be contaminated by the soil and subject to mildew and mold, or they may be entangled with each other or with the canes, making it impossible to harvest them without injury or loss.

Not only is the crop diminished and the quality injured by bad pruning, but the cost of production is increased.

Vines of proper and uniform shape can be plowed, cultivated and hoed with a minimum of labor. Such vines can be pruned and suckered at much less cost than irregular, misshapen vines. The control of the vine-hopper is impossible and that of oidium and other diseases more difficult unless the vines are of regular, standard shape.

The harvesting of the grapes, especially of shipping grapes, is much simpler and more satisfactory if the vines are well pruned. The cost of trimming and the loss in culls are much diminished and the shipping qualities of the grapes improved by proper pruning.

Finally, the useful length of life of the vineyard depends to a great extent on the pruning. Bad pruning not only results in large pruning wounds in vital parts but exposes the vine to serious mechanical injuries from the implements of cultivation. These wounds and injuries afford means of ingress to injurious parasites, borers of various kinds and particularly of infection by black knot and wood-rot fungi. Irregularity of bearing, also, not only makes the vine more susceptible to attacks of this kind, but occasional excessive crops may actually kill vines. Certain mistakes in pruning favor the growth of suckers, which appropriate the sap and cause drying up and final death of the crown and trunk.

Habit and Characteristics of the Vine.

Vitis vinifera.—With a few unimportant exceptions, all the vines grown for their fruit in California are varieties of *Vitis vinifera*, a plant originating apparently in the region south of the Caucasus but now growing wild throughout Western Asia and the Mediterranean countries and cultivated wherever the climate is suitable.

It is sometimes called the European vine because grown in Europe more largely than elsewhere, though many of our most valuable varieties originated in Asia and Northern Africa. The varieties are sometimes spoken of as Californian grapes because they are not grown east of the Rockies or to any great extent in North America outside of California. They include all the varieties of vines grown in California except resistant stocks and a few *Labrusca* or Eastern varieties such as Con-

cord and Pierce, grown to a limited extent. This difference of species between the varieties grown in the Eastern States and those grown in California accounts to some extent for the differences in methods of pruning, though the difference of climate is an equal if not more important factor.

Vitis vinifera and its varieties, like all true vines, are sarmentose plants, that is, they possess long, slender, flexible trunks incapable of self-support and attaching themselves by means of tendrils to trees or other available support. If allowed to grow without restriction, they will grow to the top of high trees in a manner similar to the *Labrusca* vines of the Eastern States or the wild *Vitis Californica* of the Pacific States. (See cover cut and figure 1.)

In vineyards, the natural habit of the vine is modified to a remarkable extent, principally by pruning. Most cultivated *vinifera* vines are given the form of a low self-supporting shrub with a short, rigid, vertical trunk. This complete change of natural form is accomplished without noticeable injury to the vigor or productive capacity of the plant. In some cases, however, it may be carried too far and certain varieties require to be allowed to develop in a somewhat more natural direction.

Structure of a Cultivated Vine.—The cultivated vine has a permanent framework, consisting of root, trunk and arms, producing an annual growth of shoots, leaves and fruit above ground and of rootlets below.

The root and its branches extend in all directions through the soil wherever they find favorable conditions. Their extent is limited only by the competition of other roots or by mechanical obstructions. Their functions are to collect water and nutrient salts from the soil.

The trunk is usually vertical but may be in part horizontal. It varies in length from one to two feet in low vines and from three to six in high. Its functions are the conduction and storage of food materials and the support of leaves and fruit.

The arms are the smaller divisions of the framework attached to the trunk. They vary in length from a few inches to a maximum of about eighteen inches. They may rise radially from the top of the trunk (*vase form*) or along its whole length (*vertical cordon*). They may be in one vertical plane at the top of the trunk (*fan-shape*) or along the whole length of the trunk (*horizontal cordon*). Their functions are the production of young wood and the proper distribution of leaves and fruit.

The young wood produced each year by the arms is utilized to form the spurs and canes which bear the leaves and fruit. Its total length will vary in different cases from a few dozen feet to several hundred. In all cases from 90 per cent to 98 per cent of all the growth is removed at each pruning.

In order to discuss pruning intelligently, it is necessary to agree on the definition of the technical terms used. The terms and definitions employed here are in nearly all cases those used by the majority of



FIG. 1.—Trunks of *Vitis Californica*.

Californian grape growers. An attempt has been made to have them correspond as nearly as possible to the terms used in other countries and in the pruning of other plants. The main difficulty in this respect has been with the terms spur, sucker, water-sprout and lateral. In these

cases the usage of the majority of Californian grape growers has been followed.

TERMS REFERRING TO THE FORM AND STRUCTURE
OF A CULTIVATED VINE.

SUBTERRANEAN PARTS.

Root Tips. The extreme ends of the rootlets.

Rootlets. The finest roots, the growth of one season.

Root Branches. All the divisions and subdivisions of the main roots older than one season.

Main Roots. The main root branches arising from the underground stem or tap root.

Tap Root. A single plunging main root or prolongation of the underground stem.

Root Crown. The base of the underground stem or region from which originate the main roots.

Underground Stem. The part of the trunk below ground from the bottom of which start the main roots or tap root.

AERIAL PARTS. A. SKELETON OR FRAMEWORK AFTER PRUNING.

Trunk or Stem. The unbranched body of the vine.

Head or Crown. The top of the trunk, or region from which arise the arms or branches.

Branches. The main division (when long) of the trunk.

Arms. The main divisions (when short) of the trunk or branches.

Spurs. Short pieces of the bases of canes, 1 to 4 nodes with their eyes.

Fruit Spurs. Spurs left for the production of fruit.

Wood Spurs. (a) *Renewal Spurs.* Spurs left to supply fruit spurs, or fruit canes for the following year, 1 to 2 eyes.

(b) *Replacing Spurs.* Spurs left to supply growth for the replacing of defective arms, 1 eye.

Fruit Canes. Canes from two-year-old wood left for fruit, 1½ to 6 feet long.

AERIAL PARTS. B. ANNUAL GROWTH.

1. *Before the formation of leaves.*

Eyes. The compound buds on the canes.

Fruit Buds. Buds from which a shoot, bearing flowers, will be produced.

Wood Buds. Buds from which sterile shoots will be produced.

Base Bud. The lowest well formed eye at the base of a cane or spur.

Latent Buds. Buds which have remained dormant for one growing season or more.

Adventitious Buds. Buds arising from leafless parts of the wood.

Main Buds. The large central buds of the eyes.

Secondary Buds. The small lateral buds of the eyes.

2. During the formation of leaves.

Shoots. The succulent growth arising from a bud.

Fruit Shoots. Shoots bearing flowers.

Wood Shoots. Sterile shoots; shoots not bearing flowers.

Water-sprouts. Shoots arising from dormant or adventitious buds.

Suckers. Shoots originating below the surface of the ground.

Laterals. Secondary shoots arising from buds in the axils of the leaves of the main shoots.

3. After the fall of the leaves, before pruning.

Old Wood. Parts of the vine older than one year.

Canes. Young wood or growth of the current season, consisting of a series of *nodes*, each furnished with an *eye* and separated by the smooth portions called *internodes*.

Fruit Wood. Canes growing out of two-year-old wood.

Sterile Wood. Canes growing out of wood older than two years.

Roots.—The pruner has little to do with the roots except when planting or in cases where it is advisable to remove certain roots of young vines, either because they arise from the scion above the union or because they are too near the surface. Regular root pruning at intervals of several years is practised in some regions, but there seems to be no sufficient reason for the practice in California. Some of the pruner's operations on the above ground portions of the vine, however, may promote or restrict root growth.

Every year the vine makes a new growth of rootlets, and these rootlets are its sole means of obtaining water and soil nutrients. These it absorbs by means of the young cells and root hairs within an inch or two of the root tips. The rest of the root system serves to conduct the absorbed material to the aerial parts of the vine, to store reserve matters for spring growth and to hold the vine in place. The position, number and vigor of the roots depend more on the nature of the soil and cultural operations than on anything the pruner can do.

The amount of root growth and that of top growth are mutually dependent. Conditions or methods which stimulate one stimulate the other and we can not curtail one without diminishing the other. The position of the root system is due partly to the nature of the variety or species of vine and partly to the conditions of penetrability, moisture, aeration, and food supply of the soil. The roots will go where the conditions are most favorable and nothing we can do which does not change these conditions will affect the position of the roots except temporarily. The *rootlets* of a vine grown from a short cutting will finally occupy exactly the same position in the soil as those of a vine grown from a long cutting.

We can, to some extent, influence the position of the *main roots* by appropriate treatment of the vine when young. No main roots should arise nearer than four or five inches from the surface or they will be in danger of injury from the plow. The danger of shallow rooting is greatest in irrigated soils and can be avoided by infrequent and deep

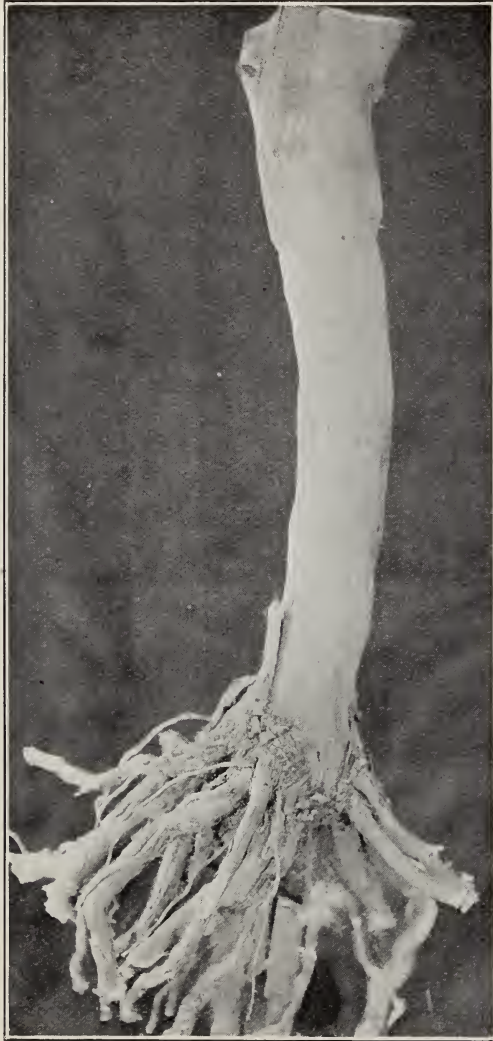


FIG. 2. Root crown of a four-year-old vine.

irrigations, by avoiding a continually wet surface in the growing season during the first two years and, when necessary, by removing the surface roots while they are small.

The best root system is that in which all the main roots arise from the root crown at the bottom of the underground stem. This does not

prevent the utilization of soil at higher levels, for rootlets will grow into all regions of the soil where the conditions are favorable whether below or above the main roots. No injury need be apprehended from the plowing up of small rootlets as they will re-form as fast as needed. The destruction of a main root, however, is harmful, as it not only destroys all the rootlets by means of which it was feeding the vine but the large wound may allow decay organisms to attack the vine.

The supposed superiority of a tap root is a mere superstition, except in so far as it involves a perfect continuity of healthy tissue from trunk to root branches. Two, three, or more main roots from the root crown are equally effective providing there are no unhealed wounds on the underground stem to be attacked by boring insects or decay fungi. (See Fig. 2.)

In wet soil there is usually a definite root crown at 6 to 8 inches below the surface. The planting of a long cutting will not alter this condition as the roots simply start where the moisture, temperature and aeration are most favorable and all below this point dies. In drier soil a short cutting will make a similar root crown, but on a longer cutting the main roots may arise at various levels. There is no objection to the latter form of branching, providing some roots start at the bottom of the cutting and completely heal the surface. A root crown at the surface of the ground is very objectionable as it is very subject to injury from plow and hoe, and consequently subject to infection by black knot and wood rot fungi. It also makes clean cultivation and the perfect and economical removal of suckers difficult. A clean, smooth, healthy underground stem of at least six inches is very desirable.

The Trunk. The trunk is the body, we might say the life, of the vine. Its main functions are to support the bearing wood at the right height from the ground, to carry water and nutrient salts from the roots to the leaves and elaborated food from the leaves to the roots. On its continued healthy state depends the vigor, crop and long life of the whole vine. It is a continuation of the underground stem and should be perfectly straight, smooth and without wound or branch or cane from the ground to the head. Its length or height depends on the variety, climate, and form of pruning, but should in all cases be sufficient to allow of close cultivation, easy hoeing, and proper suckering. This means a minimum of about ten inches. Except in certain forms of trellis and cordon pruning it should never exceed thirty inches. A greater height is expensive to develop and sustain, and gives no corresponding advantage.

The trunk is formed during the first three years of the life of the vine. Defects acquired during this period can never be wholly remedied.

The *Head* of the vine is the top of the trunk or region from which

the arms start. At first it is more or less indefinite, the spurs from which the arms finally develop being at various heights varying six, eight or more inches but none nearer than six inches from the surface of the ground. As the vine develops, the arms are gradually brought to practically the same level by the removal of ill placed arms before they become large and a definite head formed at the desired height.

Branches or long major divisions of the trunk are not used in any of the forms of pruning adopted in California. Their only use is in certain forms of high trellises or in covering an arbor. Where the trunk is simply elongated without branching or has only two horizontal



FIG. 3.—Carignane vine fifteen years old. Well formed trunk, head and arms; short spurs.

branches at the same level the form is called a *cordon*. In these forms there is no proper head or crown.

The Arms are the final divisions of the body of the vine which bear the spurs and fruit canes. They should be long enough to spread the crop sufficiently to give all the bunches the necessary sun, space and air to develop properly. They should not be long enough to interfere with cultivation nor to be in danger from the implements. The more vigorous the vine and the higher the trunk the longer the arms should be. The correct length will vary from six to eighteen inches.

The arms constantly tend to become too long, and it requires skill, knowledge and foresight on the part of the pruner to keep them within the required limits. Long arms tend to become weak and unfruitful and must periodically be replaced by new arms developed from as near the head of the vine as possible.

The *number* of the arms will depend on the style of pruning adopted, and on the size of the vine. With very short pruning, the number on a mature vine will vary from three or four on a small growing variety in poor soil to ten or fifteen with very vigorous vines. With longer pruning the number of arms is correspondingly decreased, while with long or cane pruning, two to four arms are all that should be given.



FIG. 4.—Muscat vine, over fifteen years old. Trunk too short, arms too long, but head of good form.

The *arrangement* of the arms depends principally on the planting plan and method of cultivation. When the vines are approximately equidistant in all directions and cross cultivation is practiced, the arms should be arranged as symetrically as possible in “vase-form.” When the vines are planted closer together in rows with wider “avenues” between them, especially when trellised, cross cultivation is impossible. In these cases it is of great importance that the arms should be “fan-shaped,” that is, arranged in a single plane. This makes it possible to plow and cultivate very close to the vine and even to cut out some of the ridge between the vines with horse hoes or cultivators. Care in shaping

the young vines properly in this respect will obviate a great deal of expensive hand hoeing when the vines are large. The formation of the arms takes place principally during the third and fourth years and mistakes made at this time can be remedied only imperfectly later and then at the cost of mutilating the vine. Trellised vineyards carelessly pruned in this respect often have a strip two feet wide along each row to be worked by hand. This strip can be reduced to six inches or less by carefully forming the vines when young.

At and near the ends of each arm are left pieces of young wood called *Spurs or Fruit Canes*, according to their length. The spurs vary in length according to their purpose. In ordinary short pruning most of the spurs are expected to produce fruit. Only fruit wood, that is, canes growing out of two-year-old wood, therefore, can be used for this purpose. The average length of a fruit spur is two nodes giving three eyes counting the *base bud* situated at the base of the cane or separated only by a very short node which is not counted. Fruit spurs will vary in length, however, from one node to four, according, principally, to the vigor and size of the cane. The larger the cane the more eyes are left on the spur it furnishes.

A *Renewal Spur* is not left primarily for fruit. Its purpose is to furnish shoots from which the fruit spurs and fruit canes are formed the following year. In ordinary short pruning, the fruit spurs function at the same time as renewal spurs. In long pruning, one or two renewal spurs must be left below each fruit cane to supply fruit canes for the following year. Such spurs usually consist of two full internodes, but in some cases may be reduced to a single node with two eyes including the base bud. As renewal spurs are not intended for fruit, only a sufficient number must be left to insure enough properly placed canes for the next pruning. This number will be the same as the number of fruit canes with one, two or three extra per vine to provide against the failure of some and, when necessary, for an increased number of fruit canes the following year. Sterile or fruit wood may be used for this purpose as either will produce fruit wood for the following year.

The function of a *Replacing Spur* is to provide for the shortening or replacing of an over elongated or otherwise defective arm. It consists of only one internode and its eye or even of simply the base bud, if this is well formed. As it is intended to replace an arm, it is chosen as near the base of this arm as is practicable without necessitating too large a wound when the arm is removed. Unless the arm is very defective its removal is deferred until the year following that in which the replacing spur is left. In this way no crop is sacrificed. The first year the crop is borne as usual on spurs or canes at the end of the arm. The next year the replacing spur has produced fruit wood from which

can be formed a fruit spur which in turn develops into a new arm. A replacing spur consists always of sterile wood, as it is made from a cane growing out of old wood near the base of the arm. Replacing of arms



FIG. 5.—Cross-section through vine "eye" showing central main bud and two or three lateral secondary buds.

should be done with sufficient frequency to avoid making the excessively large wounds which would be necessary if the arms were allowed to become very old and large. Spurs left to produce new arms on develop-

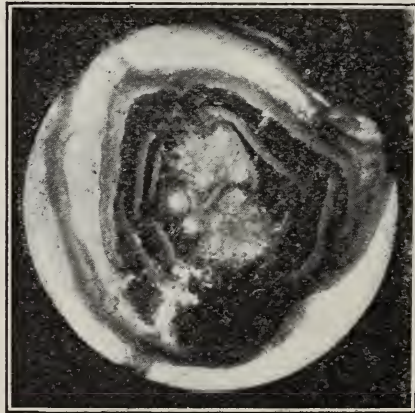


FIG. 6.—Cross-section through fruit bud showing two embryonic blossom bunches.

ing young vines are left longer and usually consist of fruit wood as they function as fruit spurs at the same time.

Some varieties of vines will not bear satisfactory crops on spurs owing to the sterility of the buds near the base of the cane or to the small

size of the bunches, which makes it difficult to obtain a sufficient number from spurs to constitute a full crop. In such cases it is necessary to adopt some form of long pruning, with *fruit canes*. A fruit cane is a

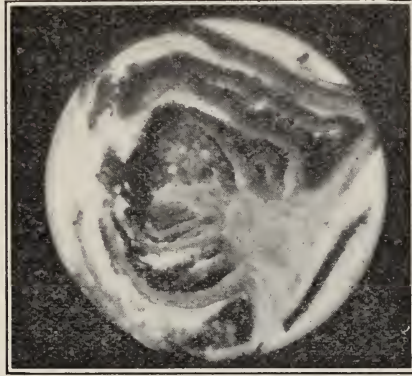


FIG. 7.—Longitudinal section of a fruit bud showing an embryonic shoot with embryonic leaves and blossom bunch.

piece of the current year's *fruit wood* from one and one half to six feet long.

Particular attention should be given that these canes consist of fruit wood, that is, of canes growing out of two-year-old wood. To leave



FIG. 8.—Longitudinal section of a sterile bud.

sterile wood, suckers or water-sprouts for this purpose is useless and fails to utilize the vine's possibilities of bearing. Canes less than two feet long are not advisable as they are difficult to attach to the stake or trellis without breaking. No advantage on the other hand is obtained

from fruit canes longer than six feet. Fruit canes six feet long will produce as many fruiting shoots as the vine can develop properly. Longer canes, indeed, usually fail to develop any more fruit as a larger proportion of the buds fail to start, and even when more start, the fruit is apt to be inferior in size and quality. Four six-foot fruit canes with five or six renewal spurs is about the maximum for the strongest vines with our methods of planting. More than this may sometimes increase the crop, but nearly always at the expense of quality and often with great danger of injuring the vine by over-bearing. This latter danger is particularly to be feared with vines grafted on resistant stock.

The buds on the canes are usually called *Eyes* by the pruner. This is a convenient term as they are more than simple buds, consisting of a main central bud with one or two smaller secondary buds within the same bud scales. (See Fig. 5.)

The external appearance of all the eyes on a vine is similar. They differ, however, in the important respect that some are capable of producing a fruit-bearing shoot and others are not. The former are called *Fruit Buds*, the latter sterile or *Wood Buds*. If a thin section of a bud is examined under a low power microscope it is possible to determine its character. The embryo blossom bunches can be seen in the fruit buds.

There is no external difference in appearance between fruitful and sterile buds, and the pruner has no means of determining with certainty whether an eye contains the possibility of fruiting or not. He can, however, tell what the relative probability of fruitfulness is with different eyes, which, for this purpose, is all that is necessary. This he determines by the position of the eye relative to the cane and the vine.

The greatest probability of fruitfulness occurs in the eyes of canes which have been produced by the spurs of the previous year. Or, as the pruner expresses it, the fruit buds are on the canes growing out of two-year-old wood. Canes produced by older wood, that is, which have grown from dormant or adventitious buds, are usually sterile. Water-sprout canes and suckers, therefore, are not suitable for fruit spurs or fruit canes.

The position of the eye on the cane is also of importance in judging of its probability of fruitfulness. The base bud is usually sterile. The first and second eyes are usually fruitful with most vinifera varieties. With some varieties, the probability of fruitfulness is not great until we reach the fourth or fifth eyes. From this point on the eyes are usually equally fruitful until we reach a point where the cane is imperfectly developed or badly matured. Sterility of the lower buds makes long pruning necessary.

A bud may be fruitful in varying degrees. A thoroughly fruitful

bud of most vinifera varieties will produce on the average two bunches of grapes of full normal size. The number may be one, two or three, according to variety. A less fruitful bud will produce fewer and smaller bunches. This reduction of fruitfulness may continue until we find buds producing bunches which are little more than tendrils with a few grapes. Such buds are practically sterile, producing few blossoms or grapes. Their bunches are easily distinguished from the loose bunches due to the dropping of the blossoms without setting.

Wood Buds are those which contain no rudiments of blossoms and are, therefore, incapable of yielding fruit. They are distinguished by their position, which can be inferred from what has been said regarding the position of fruit buds. They occur principally on water-sprouts and include usually also base, dormant and adventitious buds.

Some of the buds left on a vine do not develop the first year, or produce only a few small leaves. Such cases are particularly frequent in long pruning. These buds will often develop the second year, especially if shorter pruning is adopted. These buds are called *dormant* or *latent buds* and are usually sterile.

With the warm weather of spring, the bud commences to swell, then to elongate and finally produces a growing *shoot* which pushes through the bud scales. This shoot is produced by the main bud. If the vine is vigorous and the number of buds limited, one or both of the secondary buds may start and produce smaller shoots. Any injury to the main bud results in the starting of the secondary buds. Cut worms, or other gnawing insects, often kill the main bud without injuring the others. The same effect may be produced by a moderate frost after the shoots have started. A heavy spring frost will sometimes kill all the buds in a started eye.

The main buds on fruit wood usually produce *fruit bearing shoots*. The rudimentary blossom bunches can be seen after the shoot has grown a few inches. There are usually two, or more rarely one or three. They may occur at the second and third, the third and fourth or the fourth and fifth nodes. (See Fig. 9.) Shoots from the secondary buds may also produce fruit but the bunches are smaller and less numerous. Similar small bunches may be produced by shoots from the buds of suckers or water-sprouts. Other shoots are sterile, producing only tendrils in the place of fruit and are called *wood shoots*.

A shoot coming from a dormant or adventitious bud on the old wood is called a *water-sprout*, and is usually sterile. A *sucker* is a shoot coming from below the ground. On vines which are properly handled the suckers are removed carefully and completely every year so that few are produced, and, as these must come from adventitious buds, they are sterile. If the removal of suckers is neglected or imperfect, a

shoot from below ground may arise from the base of a sucker of the previous year in which case it may be fruitful.

As a shoot grows, it produces one leaf at each node on alternate sides. Opposite the second, third, fourth or fifth leaf is produced a blossom bunch on fruit shoots and a tendril on sterile shoots. The next one or two nodes may also produce bunches or tendrils. As the shoot elongates



FIG. 9.—Blossom-bearing shoot of Tokay vine.

further it produces more tendrils but not at all nodes in vinifera varieties.

In the axil of the leaf, that is, in the angle between the leaf stalk and the shoot, occurs a bud. Beside this bud very often arises a side shoot called a *lateral*. These laterals may be very short or may grow out and form large *lateral canes*. Any injury to the growing tip of the main shoot stimulates the production and growth of laterals. Laterals of some varieties may produce fruit like main canes. This fruit

is the so-called *second* crop and is usually about two weeks later than the main crop. Rarely these laterals may produce secondary laterals in their turn which in a few varieties may produce a *third* crop. (See Fig. 10.)

We have on a vine, therefore, *fruit wood* and *sterile wood*, but this distinction is not absolute. Some of the buds on the fruit wood may be sterile while some on the sterile wood may be fruitful. The probabilities of fruitfulness, however, are so much greater in one case than in the other that the pruner may safely proceed as though it were absolute. The difference between the two kinds of wood varies greatly



FIG. 10.—Fruit-bearing cane of Black Morocco, showing (I) first crop, (II) second crop, and (III) third crop.

with different varieties. On a Muscat or Alexandria most of the buds, even on water-sprout canes, contain rudiments of blossoms, while on a Sultanina they are almost always sterile. The fruitfulness of all kinds of wood moreover depends on weather, soil and cultural conditions. In some cases the conditions are so favorable to fruitfulness that even the water-sprouts bear. Hot summers, certain mechanical injuries to the vine and grafting on certain stocks have a tendency to increase the proportion of fruit buds on all kinds of canes. On the other hand, cool summers, excessive growth of vine due to over abundance of water or nitrogen in the soil may cause buds in all positions to be mostly sterile.

THE PRINCIPLES OF PRUNING.¹

Physiological Principles.—The correct pruning of the vine is based on certain facts regarding plant growth and nutrition which the pruner should understand. Some of these facts apply to all plants; others are peculiar to the vine.

1. The vine prepares its food by means of the green coloring matter (chlorophyll) of its leaves. All the sugar, starch and other substances which make up the body of the vine and of its crop are elaborated in the leaves by means of the chlorophyll under the influence of sunlight. The carbonic acid of the air and the water from the soil furnish the main bulk, while the mineral salts from the soil furnish a smaller but equally necessary part. A certain area of green leaf surface functioning for a certain time is necessary to produce sufficient nourishment for the vital needs of the vine and for the production of the crop. Those leaves most exposed to the direct rays of the sun are most active in absorbing and producing food. The youngest leaves take all their nourishment from the older parts of the plant; somewhat older leaves use up more nutrient material than they absorb from the air. A young shoot may thus be looked on as, in a sense, parasitic upon the rest of the vine. After a certain stage, the leaves produce more food material than they utilize, and the excess goes to support other parts. The true feeders of the vine and of its crop, therefore, are the *mature*, dark green leaves.

This principle shows that any method which forces an unnecessary growth of young shoots or removes mature leaves, while still active, limits the possibilities of production and if carried too far may result in starvation of the vine.

2. Within certain limits the *tendency* to fruitfulness of a vine or a part of a vine is inversely proportionate to its vegetative vigor. Within these limits, methods which increase the vegetative vigor diminish bearing, and, vice versa, methods which diminish vigor increase bearing. Failure to reckon with this fact and to maintain a proper mean between the two extremes lead, on the one hand, to comparatively sterility and, on the other, to over-bearing and premature exhaustion of the vine.

The correct treatment of a vine is that which invigorates it as much as is possible without diminishing the crop.

3. Other conditions being equal, an excess of foliage is accompanied by a small amount of fruit; an excess of fruit by diminished foliage. This and No. 4 are corollaries of Principle No. 2.

4. Bending, twisting or otherwise injuring the tissues of the vines or of its parts tend to diminish its vegetative vigor and, therefore, unless excessive, to increase its fruitfulness.

¹The second part of this bulletin, entitled "The Practice of Pruning," is prepared and will be published shortly.

5. The vine tends to force out terminal buds and to expend most of its energy on the shoots farthest from the trunk. To keep the vine within practical limits, this tendency must be controlled by the removal of terminal buds or by measures which check the flow of sap and force the growth of buds nearer the stock.

Certain defective styles of pruning fail to recognize this tendency and are, therefore, impracticable and can not be continued indefinitely. One of the commonest of these is the tying of fruit canes vertically to a stake.

6. The nearer a shoot or cane approaches the vertical the more vigorous it will be.

This principle is made use of in the Guyot and similar systems of pruning. The shoots from renewal spurs are tied up vertically to a stake and are thus rendered vigorous. On the other hand, the fruit canes are tied horizontally to wires, thus moderating the vigor and increasing fruitfulness.

7. The size of vines or parts of vines are inversely as their number, if other conditions remain the same.

Thus, for example, the fewer vines to the acre, the larger each will grow; the fewer shoots allowed to grow on a vine or the arm of a vine the larger each individual shoot. This principle extends to the fruit. If we want large bunches we must limit their number; if we want large berries there must not be too many on a bunch.

Winter Pruning.—The principal pruning of the vine is done while the plant is dormant, between the fall of the leaves at the beginning of winter and the starting of the buds at the beginning of spring. In large vineyards the pruning may have to be spread over most of this period; in smaller vineyards it is usually possible to prune in the month which is judged most favorable.

Season.—In deciding on the best time for pruning we must consider the convenience of other cultural operations and the effect of the period on the health and bearing of the vine.

For convenience, the earlier the pruning is done the better. Pruning in November or December gives abundant time to gather and to remove the prunings, to apply fertilizers, to plow, irrigate and sucker and to tie up the fruit canes before the starting of the buds.

The effects of the time of pruning on the vigor and fruitfulness of the vine bear a close relation to the location and amount of reserve food material in the various parts of the plant.

During the summer the leaves feed the canes, trunk and roots. Just before the natural fall of the leaves the canes contain the maximum amount of food material, viz, starch, sugar, cellulose and other carbohydrates. For two or three weeks, immediately following the fall of the leaves much of these substances passes rapidly downwards to

accumulate as reserves in the roots. Later these reserves ascend again slowly, to supply the above ground portions of the vine which, though dormant, still require nutrition. In spring, during the period just before and just after the starting of the buds, this upward migration of reserves is more rapid and continues until the young leaves are sufficiently developed to supply the vine with its carbohydrate food.¹

If we prune a vine, therefore, immediately after the fall of the leaves the cuttings contain the largest amount of reserves and are in the best condition for use for grafting or planting. Three or four weeks later the roots contain the largest amount of reserves, and if pruning is done then they will be in the best condition to promote a vigorous growth in the spring. When the buds start in the spring, the root has lost some of its reserves, used up by the canes during the winter. Pruning at this time, therefore, results in a less vigorous growth of shoots, but also, usually, in a better "setting" of the crop.

The effects of the time of pruning on the vigor and crop of the vine have been investigated by Professor Ravaz² in a series of experiments extending over seven years with results which have been in the main corroborated by tests at Davis of shorter duration.

Vines pruned immediately after the fall of the leaves were the earliest to start in the spring. Those pruned when the vines were most dormant (end of December and beginning of January) started on the average four days later. Those pruned at the time vines commence to bleed (about February 20th in the south of France) started about six days later. Pruning when the terminal buds commenced to swell (March) retarded the lower buds eleven days, and, when the terminal buds had grown two or three inches, twenty days.

The starting of the buds was late, therefore, in proportion to the lateness of the pruning. One exception, however, was noticed. Vines pruned soon after the vintage and while still covered with green leaves started on the average ten days later than those pruned after the fall of the leaves.

The retardation of the starting of the shoots in the spring may be a valuable means of escaping the injurious effects of spring frosts. In one of our tests, the crop on nine rows pruned March 13th was saved, while that of twelve rows pruned November 19th and December 21st was completely ruined by a frost on April 21st. Late pruning also retards the blossoming though somewhat less than it does the starting. Pruning as late as March may retard the blossoming ten days. The time of ripening is also influenced slightly in the same direction. When spring frosts occur, this influence appears to be reversed. The vines pruned early may blossom and ripen their fruit later. This is because

¹Vidal, J. L. "Les reserves de la Vigne." *Revue de Viticulture* I, pp. 895 to 903.

²Ravaz, L. "Taille hative ou Taille tardive," 1912.

the frost having destroyed the first shoots, the only flowers and fruit which appear are on buds which have started after the frost.

Vines pruned before the fall of the leaves are weakened. Otherwise the time of winter pruning has little direct effect on the vigor of the vines. Professor Ravaz notes somewhat greater vigor in vines pruned earliest in the dormant season. On these vines the crop was diminished by frost. The extra vigor was due, therefore, probably not to the time of pruning but to the lack of crop.

Late pruned vines gave on the average larger crops. Professor Ravaz accounts for this by their escape from frost. The later blossoming may also be a factor. At Davis, Muscat vines pruned in the middle of April produced 22.6 pounds per vine, while vines pruned in December produced only 10.1 pounds, with no injury from frost in either case.

Pruning may be done, therefore, in frostless locations and with varieties which set their fruit well, at any time when the vines are without leaves. Where spring frosts are common the pruning should be as near the time of the swelling of the buds as possible. The benefits of late pruning without its inconveniences can be obtained by the system of "double" or "clean" pruning practiced in some regions. This may be applied in various ways. The simplest is to shear off all the canes to a length of 15 to 18 inches at any time during the winter that is convenient. This permits plowing and other cultural operations, and the final pruning is done in April. A better method is to prune the vines as usual but to leave the spurs with four or five extra buds. These spurs are then shortened back to the proper length as late as practicable. In some cases the method practiced in the Medoc may be used. This consists in leaving a foot or fifteen inches of cane beyond the last bud needed and removing all the extra buds at the time of pruning. The base buds are said to be retarded by the length of cane above them the presence of buds on the cane having no effect.

Early pruning (December) promotes the vigor of the vine and results in early starting of the buds. Late pruning (March, April) promotes fruiting, may slightly weaken the vines and results in late starting of the buds. Weak vines, those which have borne too much or which have been injured by insects or diseases are better pruned early. Very vigorous vines, especially in frosty locations, should be pruned late.

Amount of Pruning.—An average vine before pruning may have twenty-five canes with an average of fifteen buds on each or three hundred and seventy-five buds in all. If the vine is not pruned, all these buds will not start or produce shoots. Probably not more than fifty or one hundred will do so. If we pruned the canes back so that we leave only fifty or one hundred buds the same number of shoots will be produced. The only effect will be that buds nearer the bases of the canes will start instead of buds near the ends. (See Physiological Principle No. 5, page 25.) The quality and quantity of the crop and the vigor of the vine and its shoots will be influenced little, if at all.

If we prune the vine more severely and leave only half this number of buds, a smaller number of shoots will be produced. As this smaller number has the same store of reserve material in trunk and root to draw on and the same root system to supply water and soil nutrients, each shoot will grow larger and more vigorously. (See Principle No. 7, page 25.) This smaller number of large shoots will produce as much foliage as the larger number of small shoots on the unpruned vine and the vigor of the vine is therefore not diminished.

There will also be a smaller number of bunches produced, but each of these will be larger and have larger berries so that the total weight of crop will be as large as on an unpruned vine. In fact, the weight of crop will probably be larger, as it is easier for the vine to supply the water and sugar which constitute the main bulk of large berries than the stems, seeds and skin which form a larger part of small berries.

We can increase the severity of the pruning, that is, diminish the number of buds left, still further, without materially influencing either the vigor of the vine, the amount of foliage or the weight of crop. Beyond a certain point, however, the crop is diminished. There are two causes for this. One is that there is a certain maximum size for the bunches and berries of any particular vine. When we have reached this maximum, any further decrease of fruit bunches results in a diminished crop. The other is that the excessive vigor given to the shoots is unfavorable to fruiting (see Physiological Principle No. 2, page 24), often causing "coulure" or dropping of the blossoms without "setting." The pruner should endeavor, therefore, to leave just enough fruit buds to furnish the number of bunches that the vine can bring to perfection.

Beyond this point the crop is diminished and the vigor of the vine correspondingly increased. If we prune the vine so severely that no crop is produced, the vigor of the vine attains its maximum. Even though we prune off all the growth of the season the vine is not weakened, as it produces shoots from dormant and adventitious buds with so much facility that the foliage produced is as great as when we leave spurs with well formed buds.

Heavy winter pruning, therefore, invigorates the vine by diminishing the crop. Light winter pruning increases the crop. If this increase is represented by a larger number of bunches than the vine can properly nourish, the crop will be inferior in quality and the vine weakened by overbearing. On a mature vine of normal vigor, the pruner should leave the same number of spurs and fruit buds as were left the year before. If the vine appears abnormally vigorous more fruit buds should be left in order to utilize this vigor in the production of crop. On the other hand, if the vine appears weak it should be pruned more severely

than the previous year, that is, fewer fruit buds should be left, in order to strengthen the vine by diverting its activities from crop production into building up tissues and replenishing its store of reserve food materials. Any attempt to make a weak vine bear a normal crop can succeed only in further weakening of the vine and in the production of inferior grapes. By pruning such a vine for a small crop, the grapes obtained will be of good quality and the vine invigorated so that it can produce normal crops in subsequent years.

These arguments apply not only to individual vines, but to individual arms or canes of a vine. The number of fruit canes, spurs or buds should be in proportion to the strength of the arm. A fruit cane or fruit spur should be the longer the more vigorous it is.

The vigor of a vine is determined not only by the growth it has made but by the amount of reserves contained in its canes and body. Its condition in this respect can be determined by an inspection of the canes. These should be firm and heavy. Soft, pithy canes indicate weakness and should never be left for fruit canes. If all or most of the canes on a vine are of this character the vine should be pruned very short; in extreme cases, sufficiently short to prevent any attempt to bear. On the other hand, long, firm canes should be made to produce fruit by being left longer whether as fruit spurs or fruit canes.

The iodine test is useful in determining the condition of canes or vines in respect to reserves. For this test a solution of iodine in 75 per cent alcohol is used—100 parts by weight of alcohol to one part by weight of iodine.

A clean, slanting cut is made through the cane and a few drops of the solution placed on the cut. In three to five minutes a well nourished cane, containing abundance of starch (reserves) turns black all over the cut. An imperfectly nourished cane will turn black only on the medullary rays which will show like the spokes of a wheel. If only a few black specks are produced by the iodine, reserves are lacking. In the first case the canes are good for use as cuttings or grafts and indicate that the vine is capable of producing a good crop. The pruning should be correspondingly generous. In the last case the cuttings are useless and the vine should be pruned very short. A few tests of this kind in a vineyard will give a very fair idea of the amount of reserves in the vines and is a valuable aid in determining the amount of pruning to give.

Young and Old Vines.—During the first part of the life of the vine, the main, if not the only, object of the pruner is to develop a framework of proper form. The methods of doing this and the time required will depend on the form aimed at and on the more or less favorable conditions for rapid growth. The crop during this formative period should be a secondary object. In fact, nothing is lost, if it is left out

of consideration altogether except in so far as it affects the attainment of the desired form. Vines which are so pruned as to reach most rapidly and perfectly a desirable shape will not only bear more when they reach adult size, but will practically always bear more fruit during the formative period than if the fruit alone were in view.

In pruning an adult vine, two objects must be kept in view; first, the production of the crop of the current year, and second, the maintenance of the proper form of the vine. Each of these objects is perhaps of equal importance. On the attainment of the first depends the current crop, on that of the second all future crops.

Units of Pruning.—When a vine has reached the stage of full bearing, pruning consists in leaving certain parts of the new wood for fruiting, other parts for renewal or the production of wood for the next year and finally other parts for the replacing or shortening of arms.

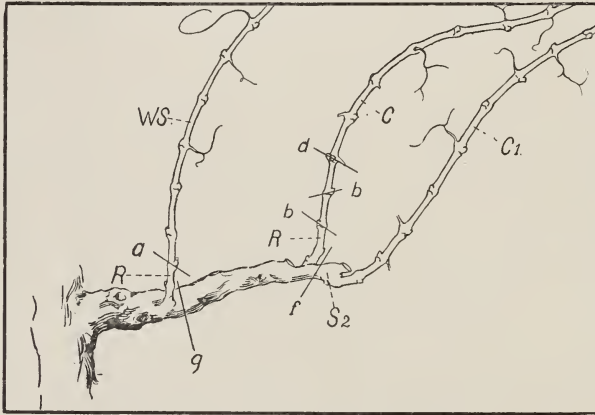


FIG. 11.—Unit of short pruning.

All new wood not needed for these purposes and all arms to be replaced are removed.

Whatever the system of pruning adopted, in all our Californian systems, each arm of each vine is treated by the same method, modified only by the vigor of the individual cane, arm or vine. There are two general methods used, viz, *spur pruning* and *cane pruning*. The treatment of a single arm by either of these methods may be called the “unit of pruning.”

The unit of pruning in spur pruning is illustrated in Fig. 11, representing a long arm about seven years old. At the end of the arm is shown the two-eye spur (S_2) of the previous year bearing two canes, (C and C_1). Near the base of the arm is shown a single water-sprout (WS) growing out of old wood. Such an arm would normally bear other canes, but as they would all be removed entirely at pruning they are omitted to simplify the figure.

In pruning such an arm, one of the canes growing out of the spur of the previous year (S_2) is cut back to form a new spur and the other removed entirely. In deciding on which cane to use for the new spur, we must choose one that is suitable for fruiting, viz, well ripened, of moderate thickness and with well formed buds. Of those which fulfill this condition, we must choose that which is in the best position to preserve the form of the vine. This, in most cases, will be the lowest (C in the figure), because it increases the length of the arm the least. If the lowest, however, is weak, broken or otherwise unsuitable, we are obliged to take one higher up.

When a cane arising from the base bud of the spur of the previous year is chosen for the new spur, the length of the arm is lengthened imperceptibly. A spur from the first bud (C) will lengthen it usually little over an inch, one from the second bud (C) three or four inches.

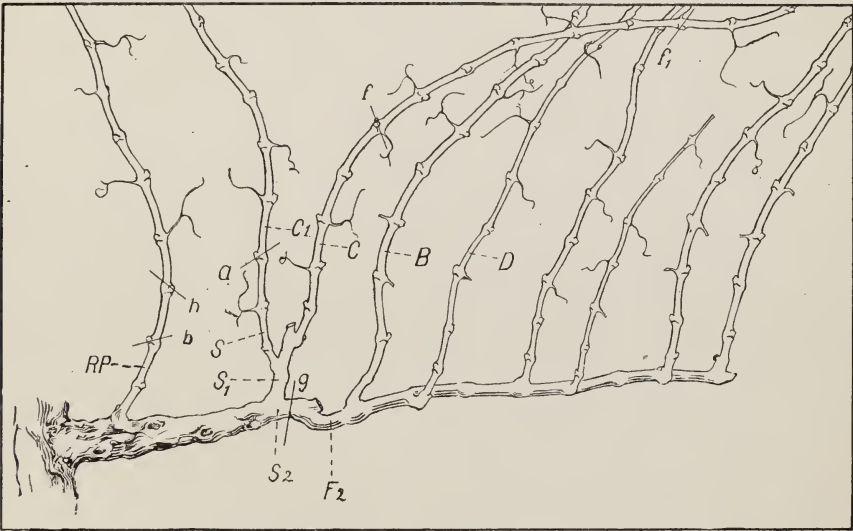


FIG. 12.—Unit of long pruning.

In any case, the arm finally becomes too long like the one in the figure. It must then be shortened or replaced. This can be done by using a conveniently placed water-sprout for a replacing spur as at R in the figure, and cutting back the arm in the place indicated by the line g .

This cutting back of an arm should be deferred until the following year as the replacing spur will produce little or no fruit. In the mean while the fruit spur from cane C will bear a crop and the replacing spur R will produce fruit wood for the following year.

The cane chosen (C) is cut at a , b , or d , leaving a fruit spur of one, two or three fruit buds and the cane, C_1 , removed entirely by a cut at f . The more vigorous the variety and the particular cane, the more buds

should be left. The water-sprout is cut back at *a*, leaving a replacing spur of one eye. Of course a replacing spur is left only in case the arm is too long and will require shortening the next year.

The unit in short pruning consists then of a single fruit spur of one, two or three fruit buds.

The unit of pruning in long and half long systems is shown in Fig. 12 and consists of a fruit cane, *F*₂, with its renewal spur, *S*₁.

In the illustration, *S*₂ represents the renewal spur of two years previous. On it was left a fruit cane *F*₂, which has produced the crop of the previous season and a renewal spur, *S*₁, which has produced fruit wood for the present season.

In pruning, the fruit cane, *F*₂, is removed entirely at *g*. The upper cane, *C*, of the renewal spur, *S*₁, is used for a new fruit cane and shortened to about *f* for half long and to about *f*₁ for long pruning. The lower cane, *C*₁, is cut back at *a* to form a renewal spur, *S*, which will produce the new wood for the next winter pruning.

This is the normal method of procedure, but various modifications are often necessary. If the cane, *C*, is unsuitable on account of lack of vigor, other canes such as *C*₁, or even *B*, *D*, near the base of the old fruit cane, may be used for a new fruit cane. The essential point is that the cane used for this purpose shall originate from *two-year-old* wood. In the same way, any suitably placed cane may be used for a renewal spur. Water-sprouts from three-year, four-year or older wood being available (*RP*). The essential point in this case is that the renewal spur shall be below the fruit cane, that is, nearer the trunk.

Replacing spurs for shortening the arms are occasionally needed as in spur pruning, but usually the same spur can be used both for renewal and replacing. The water-sprout, *RP*, may be used for this purpose, cutting it at *h* or *b*, according to its vigor.

Summer or Herbaceous Pruning.—Summer pruning, of which there are many forms, consists in the removal of buds, shoots or leaves while they are green or herbaceous, and is done therefore while the vine is growing or active.

Weakening Effect.—The effects of summer pruning are in some respects very different from those of winter pruning and in some quite the opposite. If we remove a part of a cane in the winter, we do not weaken the vine at all, in fact, we may strengthen it indirectly by diminishing bearing. If we remove a growing cane in the summer, on the contrary, we weaken the vine because we remove leaves which are its principal feeding organs and to which it owes its vigor. See Principle No. 1, page 24.

This weakening effect is greatest in the middle of summer when the vine is most active and most in need of the food supplied by the leaves.

The removal of all the leaves by defoliating insects at this time may kill the vine. It is not so great early in the spring, when we can remove a certain number of small shoots without serious injury. In fact, vines struck by spring frosts are often more vigorous the following year because the weakness due to removal of leaves is more than counter-balanced by the strengthening due to lack of crop. It is least harmful late in the autumn after the canes have matured and the leaves commence to turn yellow.

Concentrating Effect.—The removal of growing shoots or parts of shoots has also an effect similar to that of winter pruning, viz, the concentration of the growth of the vine on the parts which remain. This concentrating effect and the weakening effect occur in inverse ratio and vary according to the time and method of operation. In early spring, at the starting of the shoots, the weakening effect is very slight and the concentrating effect almost as marked as that of winter pruning. In early summer, with the vines in full growth, the weakening effect may be sufficient to completely neutralize the concentrating effect, *i. e.*, the removal of some of the shoots may so weaken the vine that there will be no increase of growth in those which are left. Still later the weakening effect may exceed the concentrating effect, *i. e.*, the shoots which are left will make less growth than if none had been removed.

Uses of Summer Pruning.—Summer pruning has various uses, of which the principal are:

1. To direct the growth into useful parts of the vine: disbudding, thinning of shoots and topping of young vines; suckering; water-sprouting.
2. To moderate the vigor of the vine and so increase its bearing: pinching, topping.
3. To increase the size of fruit (at expense of sweetness): topping.
4. To increase the shade on the fruit: topping or pinching to promote upright position of shoots and growth of laterals.
5. To decrease the shade on the fruit: defoliating.

Three other operations performed in the summer may be considered as forms of summer pruning, viz:

6. Thinning of the fruit.
7. Ringing.
8. Removal of scion and surface roots.

Disbudding is practiced on young vines during the second and third years. It consists in removing the buds on the lower part of the stem of the vine in order to concentrate the growth in the shoots above and to avoid the production of canes low down where they would have to be cut off later. The buds are not removed until they have grown an inch or two. Many of them are dormant or adventitious and the

attempt to remove them earlier would make it necessary to go over the vineyard too often. The sooner they are removed, however, the better, before they have used up much of the reserves of the vine and when the concentrating effect of their removal is at its maximum. On younger vines which have not yet formed a stem, it consists in removing all the buds but one in order to concentrate all the growth into a single shoot from which the following year the stem will be formed.

Thinning of Shoots.—The purpose of this operation is the same as that of disbudding. It is done after the shoots have grown several inches or more. It is inferior to early disbudding as it is more weakening to the vine and the concentrating effect is correspondingly less. It is simpler than disbudding, as it necessitates going over the vineyard only once. It is used principally during the second year for vines which have been cut back to two buds at the end of the first season's growth.

Topping the Young Vines.—When by disbudding or thinning of shoots during the second year, all the growth has been concentrated into a single shoot, this shoot will grow with great vigor. When it has grown about twelve inches above the top of the stake, that is, above the height at which it is intended to develop the head, it should be topped. This topping has the effect of forcing the growth of laterals. These laterals can be used at the following winter pruning as fruit spurs and as the commencement of permanent arms. If this topping is not done, there may be very few buds on the cane when mature at the height at which it is desired to make a head. It will, therefore, be difficult to find buds in the proper place for the development of the arms and to produce the crop of grapes which the vine should yield the third year.

During the third summer, the number of shoots will be small for the vigor of the young vine. They will grow rapidly and be very liable to be broken off by the wind while tender and succulent. If topped before they are long enough to afford sufficient leverage to the force of the wind, they will have time to lignify their tissues and become tough enough to withstand the pressure of the wind. Topping at this time helps to keep the shoots upright and makes it easier to give the arms the proper direction at the following winter pruning.

Suckering.—This is the removal of all shoots which originate at or below the surface of the ground. Neglect of suckering results in diminished vigor of the whole above ground portion of the vine. The suckers bear little or no fruit, hence growing vigorously, they appropriate the sap which should nourish the whole vine. Finally, the top may die, the whole growth go into the suckers, and all the benefits of a properly shaped vine will be lost. Such a vine can be renovated only by cutting off the old stump and building up a new vine from a vigorous sucker.

With grafted vines, the consequences are even more serious. The suckers, coming from the stock, take the sap even more easily from the top which is connected to the root by the union which impedes somewhat the passage of water and food materials. A grafted vine which has been seriously weakened by the prolonged growth of suckers is useless and can not be renovated.

Suckering should be done with the greatest care and thoroughness during the first four or five years. This will save a great deal of expensive and troublesome work later. Very few suckers will be produced by vines which have been properly cared for in this respect during the first three years and such vines will usually cease to produce any after five or six years. Vines on which the suckering has been imperfectly done during the first three years, on the contrary, will always produce an abundant crop of underground shoots every year.

Suckering, like disbudding, should be done as early in the season as possible for the reasons already given. Another and even more important reason is that suckers which are removed late, and especially those which are allowed to grow the whole summer, promote the formation of dormant buds and of tissue which readily forms adventitious buds below ground.

It is necessary to sucker young vines two or three times during the spring. This is done every time the vines are visited for hoeing or tying up. When the suckers are soft and succulent they are easily pulled off without cutting. They must be removed completely from the base. When they get a little tough it is necessary to dig down to their point of origin for this purpose. It is worse than useless to remove a sucker partially. The part which remains forms an underground spur or arm which will be a source of perennial trouble.

Water-sprouting.—This is the removal of sterile shoots. When it is done to prevent growth in places where growth is not wanted, or to concentrate growth in parts where it is wanted, it is advisable. The removal of all sterile shoots in all cases on the theory that they are useless, however, is mistaken practice.

The growth of a large number of water-sprouts is usually a sign that the full vigor of the vine is not being used for the production of crop. The cure for this is longer or a different style of winter pruning. The production of sterile shoots on what ought to be fruit wood often indicates some cultural error, such as excess of water, nitrogen or humus, too late growth of the vine in autumn or excessive vigor.

Water-sprouts may be removed with good results in certain cases. If the vines are weak, the growth may by this means be concentrated in the bearing shoots which will thus be able to nourish their crop better. In this case the water-sprouts must be removed early, before they have grown more than a few inches. Otherwise, the vine will be still further

weakened, and the trouble increased the following year. If the vines are excessively vigorous, diminishing the foliage by the late removal of water-sprouts may correct this defect. It is more reasonable, however, to utilize this vigor for crop production by a change in the winter pruning. Water-sprouts are sometimes troublesome by growing through the bunches, making it impossible to gather the crop without injury. This is particularly harmful with shipping grapes. Where much of this trouble exists, it indicates that the vine has an unsuitable shape. This can be modified in the winter pruning by spreading the vine sufficiently to allow all the bunches to hang free.

Sterile shoots are by no means completely useless. The foliage they produce nourishes the vine and makes it more capable of bearing fruit. They are needed for use as renewal and replacing spurs, for which purpose they are better than fruitful shoots, being more vigorous.

Pinching.—This consists of the removal of the growing tip of a shoot with thumb and finger. Its weakening effect is very slight, as no expanded leaves and a very small amount of material are sacrificed.

Its immediate effect is to arrest the elongation of the shoot. If this is done when the shoot is 15 inches to 18 inches long the shoot has time to become tough enough to resist the wind before it gets long enough to afford the wind much pressure surface. Shoots pinched as early as this usually produce a new growing tip from a lateral which later can not be distinguished from an original growing tip. Later pinching usually causes the growth of several strong laterals.

Pinching fruit shoots, just before blossoming, tends to make the fruit "set" better. It is, therefore, a remedy for "coulure." Pinching the first shoots on a fruit cane tends to promote the starting of other buds, and therefore the production of more bunches. By pinching we can accomplish most of the objects of topping with a minimum weakening effect on the vine. Figure 9 shows a fruiting shoot at the proper stage for the first pinching.

Topping.—This consists in removing one, two, or more feet of the end of a growing shoot, usually in June and July or later. In some regions topping is practiced regularly twice or even three times during the season. In general, it is more used in the cooler districts than in the hotter.

If practiced early, it has much the same effect as pinching. It tends to keep the canes upright and to cause the development of laterals. It involves the removal of leaves and is therefore weakening, which may be an advantage with extra vigorous vines. In very windy districts it is necessary to prevent the shoots being broken off entirely by the wind. The later the topping is done the more leaves are removed and the more weakening the practice is to the vine. Constant severe topping may have a serious effect on the vigor of even the strongest vines.

In general, topping tends to increase the size of the grapes and to decrease their quality. For table grapes on vigorous vines it is sometimes an advantage if not carried too far. At least, three or four leaves should be left above the fruit when the topping is done early, and seven or eight when the topping is done late. For wine or raisin grapes it is seldom advisable as it decreases the sugar and flavor of the grapes. With long pruned vines, especially when trellised, it is often possible to obtain the benefits of the practice without its defects by topping only the shoots on the fruit canes and allowing the shoots on the replacing spurs to grow normally.

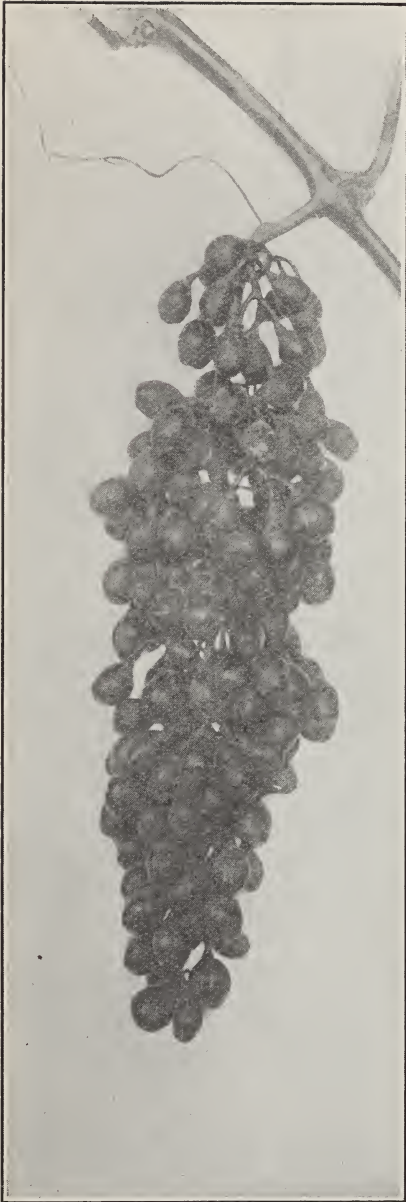
Both pinching and topping are used frequently with the object of protecting the fruit from sunburn by increasing the shade on the grapes. For this purpose pinching is much superior to topping.

When a shoot is allowed to grow without interference, it takes at first a more or less upright direction. As it increases in length, the weight of the shoot tends to bend it over to a more or less horizontal or downward direction. With some rapidly elongating varieties, the shoots bend over and take a reclining position, resting for a considerable portion of their length on the soil. With nearly all varieties they will finally bend outwards and downwards sufficiently to open up the center of the vine to the sun.

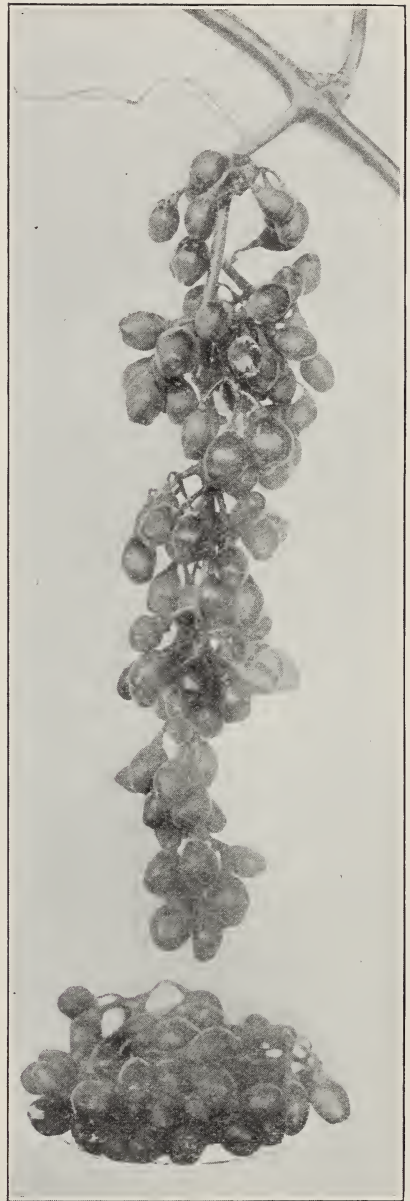
In many cases, this opening up of the center is an advantage, promoting the coloring of the grapes and the control of mildew. In some, it encourages sunburn of the grapes. Sunburn, however, is not due alone to the direct rays of the sun. This is proved by the fact that some bunches completely exposed do not sunburn and others much shaded do. Sunburn occurs in vineyards where the shade temperature seldom goes above 100° F. and may not occur in others where it often rises to 110° F.

The commonest form of sunburn is due to an excess of evaporation over sap supply. If more water is lost through the skin of the grape than is supplied through the stem, it will dry up. An excess or a deficiency of water in the soil may curtail the sap supply and sunburn result. Defective or diseased roots, wounds or fungus in stem or arms, may have the same effect. Increasing the shade, therefore, is merely a palliative, and any method which weakens the vine will increase the trouble.

If we pinch the growing shoots once or twice before they are three feet long we increase the shade in two ways. First, they grow more upright as they are relieved from the weight of the growing top until they are sufficiently lignified to retain their upright position. Second, they produce laterals which increase the number of leaves near their bases and over the head of the vine. Topping being done later is less effective in these respects, and moreover, involving the removal of feeding leaves, may weaken the vine so much as to increase the trouble.



A



B

FIG 13.—Bunch of green grapes before (A) and after (B) thinning.

Defoliating.—The development of the color of the grapes is influenced more by the light than by the heat of the sun. The coloring of Tokay grapes can sometimes be facilitated in the cooler districts by means which expose the bunches to more sunlight. One of these means is the removal of leaves. This of course will tend to weaken the vine. If the vines are excessively vigorous, this may not be a disadvantage. If only the leaves in the center of the vine, which have already commenced to turn yellow, are removed, the weakening effect may be very slight. Better insolation, however, can usually be obtained more profitably by changing the form of the vine or by thinning the bunches.

Removal of the interior leaves may be useful in some cases, with very late varieties, to protect them from molding after rains. It allows sun and air to reach the grapes freely and to evaporate the moisture from their surfaces quickly.

“Sheeping” the vineyard or allowing sheep to eat the leaves immediately or soon after gathering the crop is undoubtedly a bad practice. It removes the leaves before they have fulfilled their important duty of providing the reserve food to be stored up in cane, trunk and roots for the growth of the following spring.

Thinning the Fruit.—Many otherwise suitable grapes do not ship well on account of the excessive compactness of the bunch. A compact bunch is difficult to pack without injury and can not be freed from imperfect berries without spoiling good berries.

This excessive compactness can be prevented by thinning before the berries are one third grown. Thinning, moreover, increases the size of the berries, hastens ripening, promotes coloring, and lessens some forms of sunburn. The practice is regularly followed with success by many growers of Tokay, Black Morocco, Luglienga and other grapes, where bunches are usually too compact. While apparently costly, the expense is often more than counterbalanced by the saving in trimming of the ripe grapes. The increase of quality thus becomes a net gain.

The bunches are thinned at any time after the berries have set and before they have reached one third their mature size.

No bunches are removed, but only a certain proportion of the berries of each bunch. The number of berries to be removed will depend upon how compact the unthinned bunches usually become. In general, it will vary from one third to one half of the total number. The thinning is effected by cutting out several of the side branchlets of the bunch. The branchlets should be removed principally from the part of the bunch which has most tendency to compactness, usually the upper part. The work can be done very rapidly, as no great care is necessary in preserving the shape of the bunch. However irregular or one-sided the bunch looks immediately after thinning, it will round out and become regular before ripening.

A long, narrow-bladed knife or a pair of grape-trimming scissors can be used conveniently for this work.

Ringing.—This consists in the removal of a ring of bark from a growing shoot or from a cane of the previous year. The ring removed

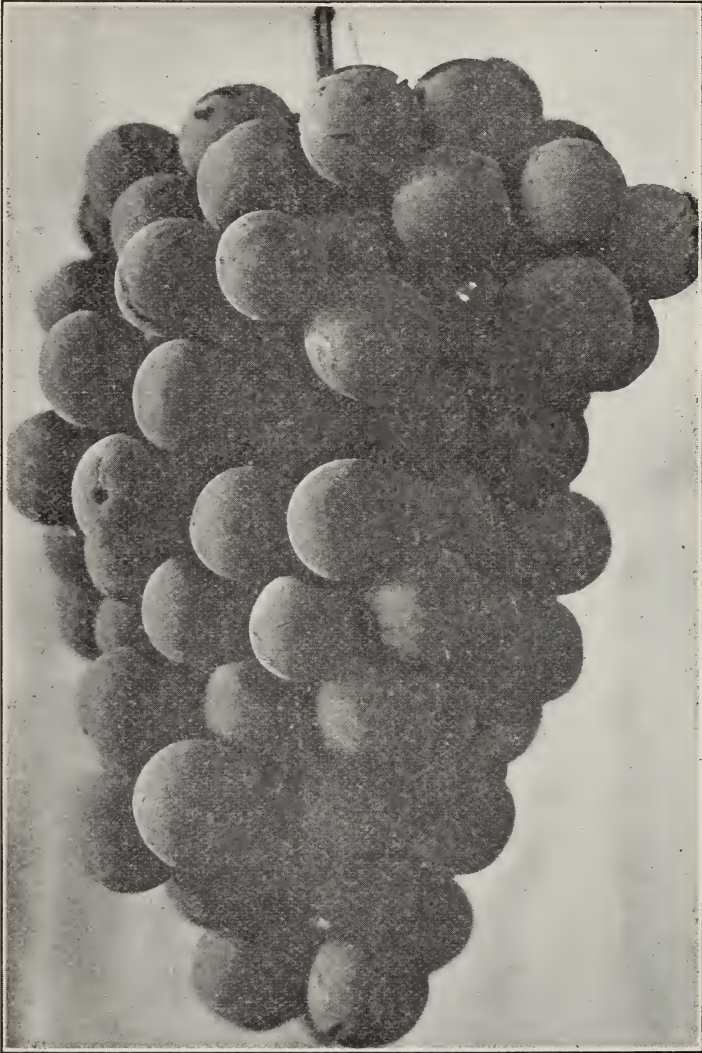


FIG. 14.—Black Morocco improved by thinning.

varies in width from one fourth to one third of an inch. If it is too narrow, the wound heals too quickly and the full effect of the operation is not obtained; if too wide, the shoot may die before the ripening of the fruit. The ring is removed from a part of the shoot or cane just below the fruit. This prevents the passage of the food material to the

lower parts of the vine and causes its accumulation in the parts above the incision and consequently in the fruit.

The result on the vines is weakening as in all kinds of summer pruning. It can be used therefore only on vigorous vines, and usually only on those parts which are to be removed at the following winter pruning.

Shoots may be ringed as soon as they commence to become woody at the base, that is, a little before blossoming and until the time when they commence to turn yellow or mature. The canes or spurs of the previous winter pruning may be "ringed" from three weeks before blossoming to a month before the ripening of the fruit.

Early ringing tends to cause the blossoms to set better and to combat "coulure." It causes the fruit to ripen two or three weeks earlier and often to increase the size of both berries and bunches.

Its weakening effects are greatest in hot climates and it is not used in California. In Australia it is used regularly with the Black Corinth, the vine which produces the small seedless grapes from which the currants of commerce are made. This vine is of such extraordinary vigor that ringing may be practiced every year without injury. It is even possible to ring the main trunk of the vine with good results.

The ringing may be done with an ordinary budding knife, but can be done quickly and well only with one of the special instruments made for the purpose.

Removal of Surface Roots.—As has already been pointed out, the final position of the feeding roots depends on the soil conditions and can not be influenced by pruning. The position of the main roots can, however, be modified to some extent in certain cases.

Young vines in some soils tend to start roots at or very close to the surface of the ground. This is especially frequent where summer irrigation is practiced. If these roots are allowed to grow, they will form main roots and are liable to injury in cultivation. During the first and second year, therefore, it is advisable to cut off any roots which form within three or four inches of the surface. This can be done at the same time that the vines are hoed and suckered. When grafted vines are planted, the union is placed above ground but is covered by "hilling" up the soil. This may cause roots to start from the scion. These roots must be carefully cut off before they become large or the vine will fail to nourish its resistant roots.

Restriction and Treatment of Wounds.—The possible length of life of a vine so far as we know is unlimited. The actual profitable life varies from a few years to fifty or more. Vines are sometimes killed by some disease or unusually unfavorable conditions such as severe frosts, prolonged drought, etc. Most vines fail and become unprofitable from the effects of an accumulation of small injuries. Among the chief of these

are pruning wounds. Wounds are not only harmful in themselves by destroying wood, bark and other conducting tissues, but they allow the

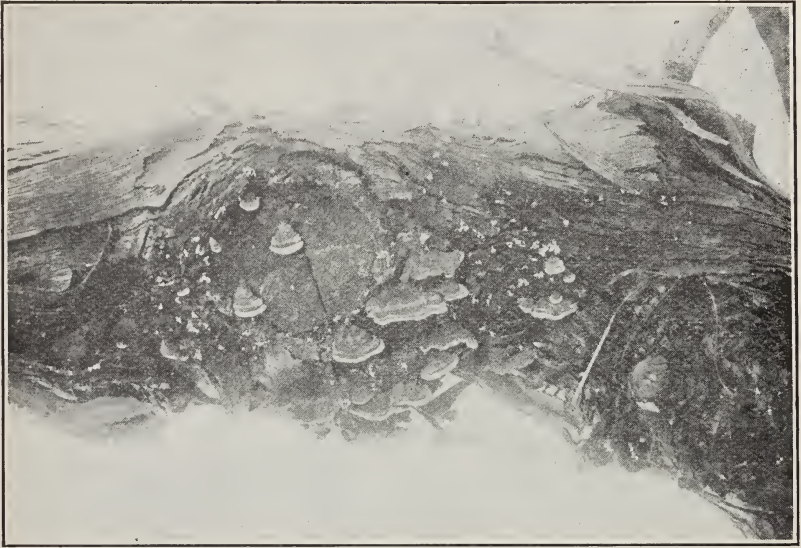


FIG. 15.—Spore bearing bodies of an "oyster-shell fungus" showing fungous decay of the trunk due to large pruning wounds.

entrance of boring insects and wood destroying fungi whose effects are even more destructive.

All pruning wounds, therefore, should be made as small as possible, especially in the main body and other permanent parts of the vine. The necessity of making large wounds can be avoided to a great extent by using foresight.

Useless shoots and canes should be removed while they are small and young, necessary renewals of arms or branches should be made before the part to be suppressed becomes too large. Where large wounds are unavoidable, they should be made as smooth as possible and protected by an antiseptic swabbing with 2 per cent copper sulfate solution and covered with a good white lead paint. The vine heals its wounds from



FIG. 16.—Proper position of pruning shears with relation to the vine when making a cut.

the inside by the production of gummy matters or thyloses which fill up the cells and tissue and so prevent loss of sap. It does not cover the wounds with healing tissue from the outside with the facility of many fruit trees. Wounds much over an inch in diameter seldom heal over completely.

By careful and skillful use of the pruning tools the harm of necessary wounds can be reduced to a minimum.

All cuts should be made clean and smooth. This requires that the shears should be of good quality and kept sharp. The cuts should be made in such a way that there is no splitting or cracking of the wood. This is accomplished by holding the shears in the proper way at the proper angle and by avoiding any undue bending of the portion of the

vine to be removed. Canes for spurs should be cut at a slight angle, and not at a right angle to the grain. In cutting off a cane or spur entirely the blade of the shear should be placed against the vine, and should cut upwards as shown in Fig. 16. This will insure a clean, close cut without splitting. Any cut on the body of the vine should be made in such a way as to leave as small a wound as possible and at the same time to leave no projecting stub. Stubs of dead wood prevent healing over and interfere considerably with future pruning.

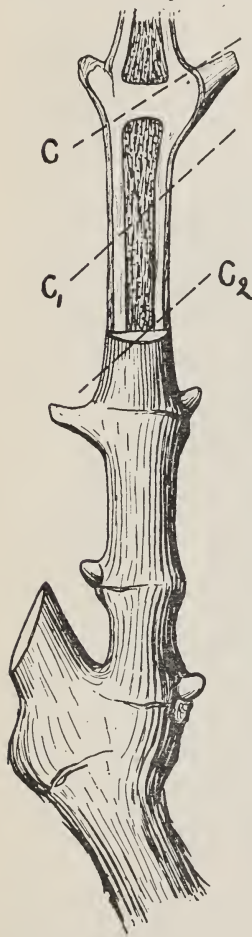


FIG. 17.—Methods of cutting the end of a spur.

In spur pruning it is considered best to cut through the bud above the last one that it is desired to have grow as at *C* in Fig. 17. This leaves the woody diaphragm intact and protects the spur from injury. If the spur is cut at *C*₁ a long piece of internode is left exposing the pith. As this pith dries and shrinks it allows water to enter and forms an excellent place for molds to grow which may destroy the bud below. It requires some skill and practice to cut exactly in the right place and if by mistake the cut is made just below the diaphragm the breeding place for molds has its maximum size. For this reason most pruners make the cut at *C*₂ about half an inch above the last bud. If the shears are sharp and the cut made at an angle of about 45 degrees behind the bud, no injury results.

In removing a piece of old wood at the base of a spur or fruit cane it is best to leave a little projecting stub. Too close cutting in this case is apt to injure the spur or cane. The projecting stub can be removed the following year, when the spur has grown larger, without danger of injury.

Supports.—With most systems of pruning, after the vine has reached a certain stage of development and its framework is complete, it will support itself after the manner of a small tree. Where the trunk is elongated, as in the Cordon systems, the trunk requires a permanent support.

Young vines in all systems require support for at least three or four years and usually longer. A skillful pruner can build up a low vine without a support, but the results are imperfect at best and the method requires so much skill and care that there is no economic gain.

In long or cane pruning, there must always be some support furnished for the fruit canes.

The supports needed then are of two kinds: (1) Temporary supports to keep young vines in place until their trunks become large and strong enough to support themselves, and (2) Permanent supports for long trunks or for the annual fruit canes.

Staking.—As temporary supports, some form of stake is always used. Nearly all vine stakes in California are made of redwood, which is remarkably adapted to the purpose. It is light, easy to work, and very resistant to decay unless made from sap wood. Split stakes are the best, as sawn stakes may be cut diagonally across the grain and many may break in driving.

Pine, spruce, poplar, willow or any available wood may be used for temporary stakes if redwood is unavailable. Most of these woods will last two years and can be made to last four or five if treated with copper sulfate. Saplings and small branches can sometimes be used conveniently. These should be peeled and pointed as soon as cut and then stood for twenty-four hours in a tub containing a few inches of a 5 per cent solution of copper sulfate (bluestone). At the end of this time, the copper sulfate will have penetrated the whole stake and can usually be seen at the upper end. If the saplings are allowed to dry even for a few days, it will require a very much longer time to impregnate them with the antiseptic.

Other materials may sometimes be conveniently used for temporary stakes. The commonest of these is the Spanish reed or bamboo, *Arundo donax*, used in many places as a wind-break. These are somewhat slender for the purpose and require much readjusting, but will serve when better is not available.

The length of the stake depends principally on the height at which it is desired to head the vine and on the character of the soil. It should be of such length, that after being driven into the ground, sufficient will be below the surface to keep it firm and prevent its being loosened by the force of the wind acting on the vine which is tied to it, and sufficient above the surface to extend for two inches above the height at which it is intended to head the vines. Its thickness should be in proportion to its height.

When redwood is used a stake thirty inches long and one and one fourth inches square will be sufficient in firm ground for small growing vines like the Zinfandel. This will allow fifteen inches to be driven into the ground and leave fifteen inches above, which is sufficient for vines to be headed at twelve inches. If the ground is loose or sandy, a slightly longer stake is advisable. For strong-growing varieties such as Carignan or Tokay, especially when growing in rich soil, a stake two inches square and thirty-six to forty-two inches long is necessary. This will permit the heading of the vine at eighteen to twenty-four inches.

When a stake is used as a permanent support for fruit canes it is usually made six feet long and two or two and one quarter inches in diameter. A somewhat shorter stake, four to five feet, will suffice if the canes are bowed. A similar stake is needed for a vertical cordon.

Trellising.—A trellis consists of one, two or rarely three wires stretched horizontally along the rows. The wires are held at the ends by heavy stakes or fence posts braced firmly. These wires are supported at intervals along the row by stakes of appropriate height. A tall stake at each vine is convenient for this purpose as it serves also for tying up the yearly replacing shoots. This stake, however, is expensive and not indispensable. It is usually sufficient to place stakes at intervals of two or even three vines. Such stakes should be placed *between* the vines and need be long enough only to reach to the top wire.

Some growers dispense with these intermediate stakes altogether.



FIG. 18.—Pruning tools: (a) one-hand shears; (b) two-hand shears; (c) curved saw.

A temporary stake is used with each vine until it has developed a self-supporting trunk. The wire is then allowed to rest on the head of each vine. If the vines are even and well formed this is a convenient arrangement as it facilitates the tightening of loose wires and the repair of those which break.

The height of the first or only wire is usually about thirty inches, that of the second forty-five inches and that of the third fifty-seven inches when three are used. In many cases one wire is sufficient to support the fruit canes. In windy locations the second wire is useful to support the growing shoots. With very vigorous vines the second wire may be used also for fruit canes. A third wire may be used in this case to support the fruit shoots, but is seldom or never really needed, and adds much to the cost of both installation and maintenance. The wire most used is No. 12 galvanized fencing wire. No. 10 or No. 11 are a little better as No. 12 will frequently break,

For the horizontal cordon system the same method of trellising is used.

For attaching the vines, canes and shoots to stakes and trellises some form of rope or string is commonly used. The balls of twine used on self-binders are convenient and preferred by some. This twine, however, is not quite strong enough for the main body of the vine, especially in windy locations, unless doubled, though it is excellent for tying fruit canes to stake or trellis. Old ropes, such as discarded ship cables, can sometimes be obtained cheaply, and, if cut into suitable lengths, the single strands are easily separated and form very good tying material.

It is false economy to use material for tying of insufficient strength or durability. It results in much troublesome extra work in retying or in defective vines.

In the hands of very careful workmen, nothing is better than wire



FIG. 19.—Burning the brush in the vineyard after pruning.

for tying up young vines at the winter pruning. It holds the vine permanently and securely. Used carelessly, however, it may cut the bark and unless discretion is used in the placing of the tie and care in its removal when necessary, the vines may be girdled and killed. The wire from hay bales is suitable for this purpose though it is a little unnecessarily heavy. No. 16 galvanized fencing wire is about the right weight.

Other materials used are raffia for the fruit canes and osier willows for the body of the vine. Raffia is unreliable in strength and inferior for this purpose to binding twine. Nothing is better than osier willow to attach the trunk of a young vine to the stake but it is rarely obtainable and requires some special skill to use.

Pruning Tools.—The best tool for pruning vines is a pair of shears of the Swiss form (see Fig. 18). If vines are properly pruned every year, it will seldom be necessary to make cuts too large for these shears except when arms have to be replaced or last year's fruit canes removed.

For this purpose a curved saw should be carried by the pruner. For vines which make a very heavy growth or which have been unskillfully pruned, a pair of two-handed pruning shears similar to those used for tree pruning may be used. If these are of good form, kept sharp, and carefully used so as to avoid splitting the arms or cutting too deeply into the old wood, good work may be done with them.

Disposal of Prunings.—After the pruning is finished, the “brush” or cuttings must be removed. This is much facilitated if the pruners are careful in placing the wood they remove. The usual method is to place the wood from two adjoining rows in the space between them, either in a long line or in piles between four vines.

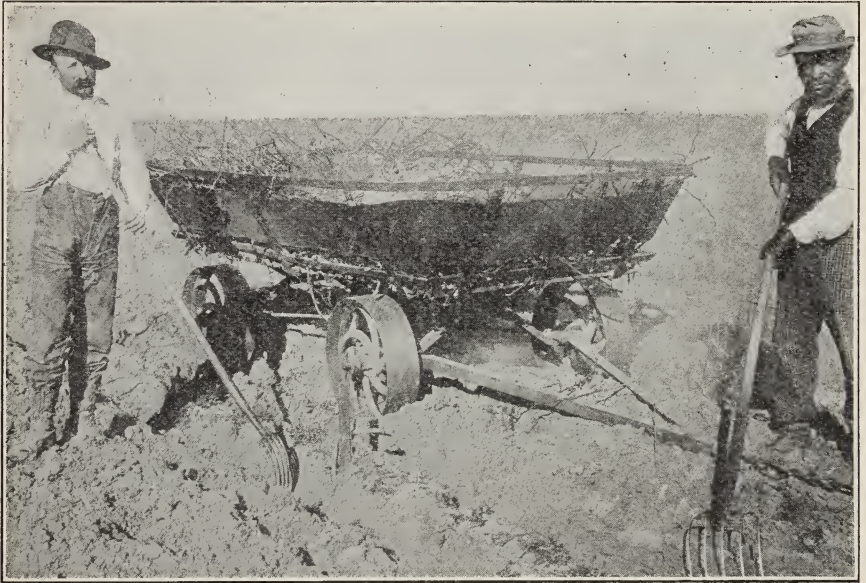


FIG. 20.—Vineyard brush burner.

These rows or piles can then be carried by hand or with a hay fork and concentrated in large piles in the avenues or on the borders of the vineyard where they are burned as soon as they are sufficiently dry. The heat from these fires is so great that it sometimes injures neighboring vines, especially if the burning is deferred until the starting of the buds.

A better method is to use a brush burner. One form of brush burner is shown in Fig. 20.

This consists of an iron truck with a perforated bottom. A fire is started in the truck which is then drawn slowly down a free row by a quiet horse trained to the work. Two men collect the “brush” in the adjoining rows and throw it into the moving truck where it burns without danger of injuring the vines, and at a lower temperature than

in the large piles. The ashes are distributed equally over the vineyard. The method is difficult to adapt to trellised vineyards or to vines with fruit canes.

Gathering the brush with a hay rake is sometimes done, but is not satisfactory and is apt to injure the vines. In some countries the vine prunings are used for fuel, for manure, and even for cattle feed, after cutting and crushing. The labor cost in California seems at present to prevent economical utilization in any of these ways.

Principle of Economy.—The skillful pruner directs as much as possible of the energy and growth of the plant into the permanent framework of the vine and into its fruit. The unskillful pruner allows the vine to grow canes, arms or branches where they are not wanted and which must be cut off later. This is not only a complete loss to the vine, which is deprived of all the removed material which ought to have gone into its permanent framework, but the large wounds made are a source of weakness and shorten the life of the vine. The skillful pruner makes use of the vigor of the vine by making it bear all the fruit it is capable of bringing to perfection. He properly distributes the fruit buds, leaving on each cane, arm, or vine, just the number needed, without running the risk on the one hand of weakening the vine with an over-supply of poor fruit, or, on the other, of forcing it to excessive vigor and sterility.

To avoid waste in the development of a young vine, the pruner must have a clear idea of the form he wishes to give it. He must then, by appropriate and timely removal of buds and shoots, force the growth into those parts which are to form the permanent framework of his ideal vine. No cane, arm or division should be allowed to grow more than one season which is not destined to be part of the final skeleton of the mature plant. In this way the vine will not only attain the desired form but will quickly reach bearing stature and be free from the large wounds which are one of the main causes of premature aging. Part II of this bulletin will contain specific directions for applying these principles to the principal vines and regions of California.

TABLE OF CONTENTS.

PART I.

A. Introduction.

	PAGE.
LITERATURE: Need of the Bulletin -----	3
DEFINITION: Objects; Scope -----	3
SOME RESULTS OF DEFECTIVE PRUNING -----	4

B. Habit and Characteristics of the Vine.

VITIS VINIFERA: Structure of a Cultivated Vine -----	7
PRUNING AND DESCRIPTIVE TERMS -----	9
Roots; Trunk; Head; Branches; Arms; Spurs; Fruit Canes; Buds; Shoots; Water-sprouts; Suckers; Laterals; Fruit Wood; Sterile Wood.	

C. The Principles of Pruning.

PHYSIOLOGICAL PRINCIPLES -----	22
WINTER PRUNING -----	23
Season; Amount; Young and Old Vines; Units of Pruning.	
SUMMER PRUNING -----	30
Weakening effect; Concentrating effect; Uses; Disbudding; Thinning of Shoots; Topping Young Vines; Suckering; Water-sprouting; Pinching; Topping; Defoliating; Thinning the Fruit; Ringing; Cutting Surface Roots.	
RESTRICTION AND TREATMENT OF WOUNDS -----	39
SUPPORTS: Staking; Trellising -----	42
PRUNING TOOLS: Disposal of Prunings -----	45
PRINCIPLE OF ECONOMY -----	47

ILLUSTRATIONS.

Cover Cut, Wild Vine of California (*Vitis Californica*).

- Fig. 1. Trunks of *V. Californica*.
- Fig. 2. Root crown of four-year-old vine.
- Fig. 3. Typical cultivated vine with short arms.
- Fig. 4. Typical cultivated vine with long arms.
- Fig. 5. Vine "eye"—cross section.
- Fig. 6. Fruit bud—cross section.
- Fig. 7. Fruit bud—longitudinal section.
- Fig. 8. Sterile bud—longitudinal section.
- Fig. 9. Shoot showing position of blossom bunches.
- Fig. 10. Shoot showing laterals and second crop.
- Fig. 11. Unit of short pruning.
- Fig. 12. Unit of long pruning.
- Fig. 13. Tokay bunch before and after thinning.
- Fig. 14. Black Morocco bunch improved by thinning.
- Fig. 15. Fungous decay due to large pruning wounds.
- Fig. 16. Position of pruning shears.
- Fig. 17. Method of cutting the end of a spur.
- Fig. 18. Pruning tools.
- Fig. 19. Burning the "brush" after pruning.
- Fig. 20. Brush burner.