THE CULTIVATION OF THE GRAPE-VINE.

By M. DAL PIAZ.

In cultivating grape-vines the first things to be considered are adaptability to climate and local conditions. An improvement in the quality of the fruit is also to be kept in view, for not in vain has man troubled himself through centuries to train the grape so that it should meet with his various requirements. That man has succeeded in bringing about the desired result is due, not so much to his own ingenuity, as to the extraordinary adaptability to changing conditions possessed by this hardy plant.

In order to exercise a favorable influence on the grape, the vine must be cultivated by methods that vary with the climate, soil, etc. By employing a suitable method of cultivation, the desired result can be obtained with more or less success. It is the purpose of this article to describe several of the methods commonly employed in northerly and southerly climates.

A classification of the methods employed would simplify this review, but since the various ways of growing the vine are numerous modified and com-

pruning has been introduced and variously modified. The heads are uncovered in the spring and the fruit-bearing canes are cut down to two eyes. The grapes hang very near the ground and are much exposed to the sun, a condition somewhat alleviated by the dense foliage. This method of pruning can be used with profit in vineyards subject to frosts in severe winters, since, by reason of their position, the undermost eyes can escape the danger of being frost bitten.

In Southern Austria the vines are usually supported by stakes, to which the canes are tied (Fig. 1 *a*). In the southern part of Hungary, however, the canes are allowed to grow without any support and are kept in place merely by tying them together so that the upper portions can be cut off at regular intervals, as shown in Fig. 1 *b*. The close pruning practiced in Banat and Syrmia can result only in producing a very short-lived vine. The pruning found in Charente (Aunis) and illustrated in Fig. 2 is interesting in so far as the wood is permitted to grow somewhat longer, but is, nevertheless, well pruned. Two or three eyes are usually retained, particularly in the variety Folle Blanche. The red grape variety Balsac is not cut so short. The vines are unsupported, but are kept in place by binding them together. During the summer the vines are not treated. Greater care, however, is given to the soil.

The heads are more often seen with longer wood, as illustrated in Fig. 3 *a*. As practiced in Rheingau this

described, are met with in Württemberg (Unter-Türkeim) and in Bavaria (Würzburg). In the Palatinate a like method is found which employs short arms tied up on wires (Fig. 4), so that the vines are brought within a yard of one another. The vines are, furthermore, pruned to two or three eyes. These eyes produce the fruit-bearing shoots of the next year. The green shoots are carefully tied up. In spite of the low position of the vines, shoots can be trained to a considerable length.

Many growers also train their canes horizontally, thus bringing the grapes very near the ground. This method has the disadvantage of requiring very long canes, in order that the latter may be tied up to the proper stake. In other respects the position of the fruit-bearing canes is good. Since the weight of the fruit, however, brings the vines very close to the earth, it would be advisable to cut the canes rather short and tie them to some short support in the manner shown in Fig. 5, to the right. Fig. 5, to the left, shows the first described method, in which all horizontal canes are tied in one direction, while in the second described method the canes are trained one on each side, and tied to a short stake.

In a method of propagation known as the "Hungarian" method, we find a head producing rather long canes, one of which is partially embedded in the soil, the emerging end virtually constituting a separate plant having two or three eyes (Fig. 6 *a*). The embedded

FIG. 1.—HEAD PRUNING WITH ACCESSORY BUDS.

FIG. 2.—A SPUR PRUNED HEAD IN CHARENTE.

FIG. 3.—HEAD PRUNED VINE SUPPORTED BY STAKES.

FIG. 4.—HEAD PRUNED VINES WITH CANES TIED TO WIRES.

FIG. 5.—SYSTEM EMPLOYING HORIZONTAL CANES.

FIG. 6.—HUNGARIAN AND STYRIAN SYSTEMS OF PROPAGATION.

FIG. 7.—GUYOT'S SYSTEM OF HEAD PRUNING.

bined, such a classification would result in obscurity. It would, however, be possible to select only those methods of cultivation which could be brought into a class, leaving the exceptions to be treated separately. In order, however, to avoid all confusion, a certain order will be maintained, beginning with those methods of cultivation that require very short mature wood and concluding with methods of propagation requiring longer mature wood.

In training vines with short mature wood, the "heads" are formed by cutting the wood very short. These "heads" usually make their appearance during the first year, the shoots being cut close to the ground. One or two eyes only are retained, so that in the fourth year, each vine has grown a rather stout head.

The closest pruning known is practiced in Austria. In the method here in vogue the fruit-bearing canes of the previous year are cut away as far as the old wood. In order to produce a suitable form of head the laterals should be cut down to eyes, while the uprights growing in the center are cut entirely away, care being also taken to remove the shoots. This method of pruning is not suited to all varieties of grapes.

In many parts of Austria and Hungary "spur"

system of propagation provides for two canes having from six to ten eyes, the canes being tied up obliquely. The vine itself is supported by a long stake to which are vertically tied the shoots that are to bear fruit during the following year. The bearing vines are tied to short pegs in such a manner that they shall be inclined at an angle of forty degrees; by this means, the grapes are carried away from the wood-producing shoots and yet are kept rather near the soil. Riesling wine is produced from Rheingau grapes cultivated in this manner.

In a method (Fig. 3 *b*) which has been generally discarded for the one illustrated in Fig. 3 *a*, three vines were planted at a distance of about three feet from one another and provided with rather long stakes. Two vines were then pruned down to laterals, bent down, and tied each to a stake. Of these stakes, each had to support the bearing vines of two plants. The vine was pruned down to two or three eyes which were trained so as to produce a stout wood growth. This method of culture has many shortcomings and is, consequently, no longer used in newly planted vines.

"Head" pruned vines, with canes or bows somewhat similar in appearance to the Rheingau vines already

cane takes root in the course of the spring and summer, the shoots at the end of the buried cane being, in addition, nourished by the mother-plant. Fine grapes can be produced by this method, but the fruit on the end of the embedded cane is never so good as that of the main plant.

In Styria the vine is trained in a way somewhat different from the "Hungarian" mode. The cane is also embedded in the soil (Fig. 6 *b*), but does not emerge again to form a new plant. This method has an advantage over its "Hungarian" rival in not weakening the main plant or exhausting the fertility of the soil. In the "Hungarian" method, moreover, the vineyard will require considerable fertilizing after a time, if the productive power of the soil is to be kept undiminished in vigor. The Styrian culture, moreover, has the further advantage of keeping the fruit near the ground and yet at such a distance therefrom as to permit a ready cultivation of the soil.

A method of culture first tried by I. Guyot has been applied with some success. This method is chiefly adapted to regions in which the fruit-bearing wood is not likely to freeze, and in which frequent pruning must be resorted to in order to curb the rapid growth of the vines. Care must be taken to keep the fruit at

a proper distance from the ground. The vines are set in squares one yard apart and closely "head" pruned. Each plant is supported by a long stake, while in the spaces between the plants stakes are located, one-half the size of the larger ones (Fig. 7). The summer shoots are tied to horizontal wires sufficiently strong to hold all the stakes firmly in position.

A method of cultivation common in Beaujolais (Fig. 8 *a*) consists in training a tall head with old mature wood cut down to three spurs, which spurs during the course of the year become arms. This method is somewhat similar to the stem-training (shown in Fig. 8 *b*) usually practiced in Bas-Languedoc (Herauld). The vines are placed rather closely together (less than three

large crops. But little cultivation of the soil and but little pruning of the vines are required. "Spur" pruning of this kind is, however, applicable only to those varieties of grapes that bring forth fruit-bearing shoots on the first eyes of the vine. It is this very condition which has prohibited the general use of the preceding methods of pruning in Italy, because the varieties of grape there cultivated absolutely require long wood in order to bear fruit. If, however, it is desired to cultivate such varieties of grapes by the methods already indicated, then the long, fruit-bearing wood must be cut, as shown in Fig. 9. Should it not be desired to allow the canes to hang freely, they can be tied to one another in the manner illustrated.

ployed. The "bow" system is also found near Heidelberg, Neustadt, and Edenkoben. This method of training the canes can be used to good effect on wire frames. When growing on a large scale, the canes should be bent to half-bows in order to attain a uniform growth of the individual eyes. Fig. 12 illustrates a method of this nature which has given good results. According to this system, the stems are pruned very short, only two arms on a side being allowed to grow. From fifteen to thirty eyes are retained and evenly distributed between two long canes and two arms held in reserve for renewal. The undermost wire is about a foot from the ground, and to it are tied the fruit-bearing canes. These canes are so arched that the most

FIG. 8.—METHODS EMPLOYED IN BEAUJOLAIS AND BAS-LANGUEDOC.

FIG. 13.—CÔTE-RÔTIE SYSTEM.

FIG. 10.—SYSTEMS EMPLOYED IN LA GIRONDE, NEAR BORDEAUX.

FIG. 11.—SYSTEM OF TRAINING VINES IN MÉDOC.

FIG. 12.—VINES WITH BOWS, TRAINED ON WIRES.

FIG. 14.—VINES TRAINED WITH BOWS.

FIG. 15.—SYSTEM EMPLOYED IN LA CHAMPAGNE.

feet) and pruned down to two or three eyes. Sometimes the superfluous shoots are disbudded. Up to the twelfth year the vines are supported by stakes. After the twelfth year the stakes are totally discarded and the shoots of adjacent plants are tied together so as to form a bow to support one another.

In Bas-Languedoc, the vines are trained in a way well adapted to the conditions usually met with in southern countries. The vines are planted $1\frac{1}{2}$ to $1\frac{3}{4}$ yards apart, in squares, or in rows, 2 yards apart. The stems are trained with six to ten arms, each of which is pruned with spurs having two eyes. The summer shoots are untreated and unsupported and shade the ground. The soil is usually cultivated with the plow.

These and similar methods of propagation are to be commended to growers who are usually favored with

In La Gironde, shorter stems having long arms are trained. The vines, as shown in Fig. 10 *a*, are bound to stakes or wires, a custom generally practiced in the vicinity of Bordeaux. In the method illustrated in Fig. 10 *b*, frequently met with on the banks of the Gironde, the vines are tied to three short stakes.

A method more frequently seen is the "half-bow" system of training the canes—a system which has been subjected to many modifications. In Médoc, the vine-growers usually train two arms on a short stem, the canes being bent down and tied to a frame as shown in Fig. 11. In this, as well as in other methods, the lowermost arms are cut back so as to produce fruit-bearing canes for the next season. Exactly similar to the Médoc system is that practiced in Nackenheim, in which, however, a double supporting frame is em-

pronounced bend shall be near the old wood. By this means the first eyes receive considerable nourishment and can be used in the next year as fruit-bearing wood without providing too long a stem. If, however, the old wood already extends above the first wire, then, with the assistance of the arms held for renewal, a new growth of wood can be undertaken. The shoots are fastened to the second and third wires. If the third wire be discarded, then each wire must be further supported by a thin stake, upon which are bound the bearing canes of the following year.

Another "bow" system is found on the banks of the Rhone (Côte-Rôtie) and is illustrated in Fig. 13. The vines are planted in the manner shown, and are supported by stakes bound together to form a pyramid. Each of the stakes is provided at its base with a smaller

stake, to which the downwardly bent canes are tied. The shoots are tied up to the larger stakes, and with their leaves shelter the fruit from the rays of the sun. This system is one of the best now in use. The bows are well placed and the grapes hang near the soil. The position of the shoots, however, is not so favorable as it might be. Half-bows of this variety are also met in Alsace. In the vicinity of Wolzheim, but a single stem is used, cut down to two canes bent as shown in Fig. 14 a. The stakes used in training the vines must be at least six feet in length. The vines must be placed about five feet from one another, so as to permit the entrance of light and the circulation of air.

In the valley of the Main, near Würzburg, a method is practiced in which only two bows are formed. In the upper part of Baden, in Switzerland, and in Siebenbürgen, the old wood is more closely pruned and two bows are grown from a single arm, as illustrated in

from 7 to 9 feet in length. Of these canes, the strongest alone is retained and tied to a wire running parallel with the soil at a distance of 20 inches therefrom. At intervals of 10 feet the wire and arm are supported by a stake, since the wire alone could not support the fruit. Only those buds are retained which stand erect, the lateral buds being rubbed off. The canes growing from the buds which have been retained are tied to the second wire. Vines trained in this manner will produce grapes at first of inferior quality. Not until the third year will the vine have sufficiently recovered from its rapid growth to produce a better grape. In this year the canes are cut down to six or eight eyes and tied obliquely to the wire, as shown in Fig. 18. The third wire, which up to the present may have appeared somewhat superfluous, receives the shoots that are to bring forth the bearing wood of the following season. The other

America is an entertaining and instructive chapter in the history of science.

The reports of the early State Geological Surveys, the transactions of learned societies, and the volumes of Silliman's Journal down to about 1850 contain frequent references to "diluvial drift," "diluvial scratches," "tremendous currents of water" and terms of similar import. The first suggestion of ice as a contributory agent in the genesis of the drift, in the form of icebergs or icefloes, was made by Peter Dobson, of Connecticut, in a letter to Silliman,* dated November 21, 1825. Murchison gives to this letter of Dobson the credit of suggesting to him the iceberg hypothesis, while Edward Hitchcock obtained his similar idea from Sir James Hall, of Scotland.

So far as the writer has discovered in print, no American geologist suggested land or glacier ice as a possible cause of the drift phenomena until 1837, when

FIG. 16.—TRAINING THE STEM WITH ARMS AND BOWS.

FIG. 17.—BUCK PRUNING.

Fig. 14b. The other arm is pruned down to two or four buds and produces the bows of the following season. This, therefore, constitutes an "alternate renewal system." The bows, on account of the peculiar method of tying, can produce only short shoots. The system cannot be used for producing a fine quality of fruit.

It may not be uninteresting to give here a brief description of the methods practiced in La Champagne. The vines in this fertile province are set so closely together that sometimes 60,000 vines may be counted upon a single hectare (2.47 acres). The vines are kept well down, and are always supported by stakes, as indicated in Fig. 15. In February the old wood is partly buried in the soil, and the longest spur cut down to three eyes. The other spurs are cut entirely away. After pruning in February, the soil is cultivated in March to a depth of eight inches. At the same time each plant is uncovered, and the two-year-old wood so embedded in the soil that only a few spurs emerge. Such a system naturally produces a mass of superficial roots. The grapes hang very near the soil, and, being rich in sugar, are best adapted to the making of champagne.

A system not infrequently employed in Jura, France, is illustrated in Fig. 16. The stem, as seen in the engraving, is trained obliquely. In the center another arm is trained, which during the course of time lengthens and becomes stouter. The Jura growers sometimes use two supporting stakes, one for the unbent canes and the other for the bows. As illustrated in Fig. 16, however, a single inclined stake may be employed, which serves to support both canes and bow. The green shoots of the bow are allowed to grow freely and the grapes are but little shaded. In the following year the bow is grown on the other arm. If the canes on the bows have not developed

shoots grow freely, and are afterward pruned down. Spurs should always be provided for a renewal of the arm. It is said that vines trained according to this system and grown in well fertilized and cultivated soil will yield in a favorable southern climate 1600 gallons to the acre without exhausting the strength of the vines.—Der Stein der Weisen.

GLACIAL GEOLOGY IN AMERICA.*

By HERMAN L. FAIRCHILD.

INTRODUCTION.

THE life of this Association, with that of its predecessor, covers precisely the period since the glacial theory was introduced to American geologists. It seems highly appropriate, upon the occasion of this jubilee meeting of the Society, to review briefly the history and growth of glacial geology in America and to give credit to the men who were pioneers or who have been most influential in the development of this young and vigorous branch of earth-study.

In the limits of this paper it is impossible to call the roll of all the investigators in American glaciology, and apology is here offered for many omissions and possible errors.†

THE GLACIAL THEORY.

Announcement.—The "drift" of the northern United States and Canada was not neglected by the self-taught geologists of the early part of this century. Frequent references occur in the writings of those years to the striae and polished rocks, the stony clay, the deposits of sand and gravel, and particularly to the conspicuous erratics and perched boulders. These phenomena were commonly attributed to the agency of violent floods, and were called "diluvial." They

T. A. Conrad asserted his belief in such agency in the following words:

"Whence then this immense body of ice which has scattered bowlders over so vast a tract of country, appearing, too, at an epoch subsequent to the extinction of the mastodon and other mammalia, which evidently lived in this region and enjoyed equatorial climate anterior to the icy period? Nothing can reconcile this apparent contradiction but the admission of a fall of temperature far below that which prevails in our day, freezing the enormous lakes of that period and converting them into immense glaciers, which probably continued undiminished during a long series of years."

We cannot, however, regard Conrad's suggestion as a fair presentation of the glacial theory. It was made only incidentally, as an argument for his hypothesis of epochs of cold climate, and without any attempt to give a full statement or to marshal the facts as bearing upon the genesis of the drift. It is significant, however, as indicating, by the casual way in which he introduces the argument, that the conception of great bodies of land ice might not have been, even at that time, an entirely new idea to American geologists. The work which then had been prosecuted for some years upon the Alpine glaciers was probably not entirely unnoticed by Americans.

The American geologist who first gave a favorable reception to the glacial theory of Agassiz, as far as printed records show, was Edward Hitchcock. In his address as retiring president at the second annual meeting of the Association of American Geologists and Naturalists, held at Philadelphia, April, 1841, he described the characters of the drift and the various phenomena which we now call glacial with great accuracy and appreciation. After discussing several hypotheses of the drift, he writes as follows:

"But the recent work of Agassiz, entitled 'Etudes sur les Glaciers,' gives a new aspect to the subject. . . . Henceforth, however, glacial action must form an important chapter in geology. While reading this work and the abstracts of some papers by Agassiz, Buckland, and Lyell, on the evidence of ancient glaciers in Scotland and England, I seemed to be acquiring a new geological sense; and I now look upon our smoothed and striated rocks, our accumulations of gravel, and the tout ensemble of diluvial phenomena with new eyes."

"I do not mention these difficulties (to which I might add more) as any strong evidence against this theory. For so remarkably does it solve most of the phenomena of diluvial action, that I am constrained to believe its fundamental principles to be founded in truth."

In the application of the hypothesis to American drift he stated his chief difficulties to be: (1) The general southerly direction of the striae and drift transportation over New England and New York, instead of radiating from the highlands as in the Alps; (2) the lifting of the erratics from lower to higher levels, although for this work he regarded ice as more efficient than water; and (3) the localized drift masses which we now call "drumlins." At that time, with only Alpine glacier phenomena as the foundation of the theory, these were valid and forcible objections. Indeed, his presentation of the argument for and against glacial agency showed excellent appreciation and grasp of the subject, and to-day can be read with profit. This is also true of his "postscript," discussing the glacier hypothesis and moraines in the introduction to his *Geology of Massachusetts*, 1841.

In these writings Prof. Hitchcock seemed to declare his adherence to the glacial hypothesis, as applied to

FIG. 18.—GUYOT'S SYSTEM.

sufficiently, the bow is grown at some portion of the arm where strong wood has been produced. The bow is then tied to the stem. The shoots growing from eyes on the stem are then tied to the stake perpendicularly. By this means strong canes are obtained, which can be used to form the bows of the next season.

A singular method of training the arms is found in the "Würzburg System." According to this system, three arms are trained on a single stem, as shown in Fig. 17 b. The arms with their ends form a triangle. Each arm is supported by a stake six feet long, to which stake the bearing canes of the following season are tied, the ends of the bows being always tied to the stake of an adjacent arm.

A system productive of good hardy vines is the Guyot system, shown in Fig. 18. The trenches in which the vines are planted should be eight feet distant from one another and should be well fertilized. In the second or third year strong canes are produced

were, however, so unlike any products of observable aqueous action that the conditions of their formation were a subject of imagination rather than of scientific inquiry. But this conception of water as the chief or only agent concerned in the production of the drift and striae gained such general assent and so bound the minds of the older American geologists that the glacial theory was not given at first even a respectful hearing, and it was not accepted until long after a majority of foreign geologists had adopted it for western Europe and the British Islands, not, indeed, until a new generation of workers had possession of the field. The story of the introduction, discussion, and final acceptance of the glacial theory in

* Address before the Boston meeting American Association Advancement of Science, Section E.

† The writer hopes to insert in the record of Section E for the next meeting (1899) a notice of any important additions or corrections which are brought to his attention.

* It is not desirable to encumber these pages with a great number of bibliographic references. These can be found in chronological order under authors' names in United States Geological Survey Bulletin No. 127—"Catalogue and Index of Contributions to North American Geology, 1732-1891," by N. H. Darton. (See "Glaciology," page 417 and "Pleistocene," page 756.) Bulletins Nos. 130 and 135 contain the bibliography from 1891 to the close of 1895.