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SOME RESPONSES OF VITIS VINIFERA TO PRUNING*

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The practice of pruning vines to develop a desired form and to influence fruitfulness is a very old one, and yet it is doubtful if, among the necessary operations of grape growing, there is one which is perhaps founded on more fallacies or on which so little progress has been made during the last century. With only minor modifications, such as the location of the desired spur or cane, vinifera vines are pruned today *much in the same manner as they were by the Romans.* The belief that was established among the grape growers of centuries past, that winter pruning invigorates the vine, still prevails.

In 1876 Dr. Guyot[1] noted the belief of the vine growers of France and elsewhere that "it is necessary to prune young vines in order to *repress the sap and strengthen the roots.*" This belief, however, was not limited to the grower, for in 1899 L. H. Bailey[2] stated that "pruning increases vigor."

Later[3] in 1916, he modified this statement, but added that "pruning must have something of the effect of manure." In other words, a

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† The writer wishes to acknowledge his indebtedness to Prof. F. T. Bioletti, who planned this investigation and directed the original plantings of Muscat and Monukka and who has given many helpful suggestions and criticisms as the work has progressed.

[1] GUYOT, Dr. J. Etudes des Vignobles de France, 2d. ed. 3:621. Paris, 1876.

[2] BAILEY, L. H. The *pruning book*, 2d ed., p. 15. The Macmillan Co., N. Y., 1899.

[3] BAILEY, L. H. The pruning manual, 18th ed., p. 12, 1916.

stimulating or invigorating effect. In 1924, Hedrick[4] recommends that "the weaker the plant the more the vine should be cut," and that "the severe pruning of the first two years of the vine's existence is an example of "*pruning for wood*," that is, of strengthening the vine.

On the other hand, Dr. Guyot[5] pointed out fifty years ago that "every cut . . . made with the pretense of strengthening the vine and its roots is contrary to the object in view and that "the greater and the more frequent this mutilation the more depressing on the present and future vitality of the vine." Foëx[6] also in 1895 stated that "the activity of vegetation in a plant is . . . all other conditions being the same, the greater, the larger the number of leaves it carries."

The cause of these inconsistencies seems to be a lack of clear definition and uniform use of terms, especially of the term vigor. This word is sometimes used *qualitatively* in the sense of "activity" and sometimes *quantitatively* in the sense of "capacity for action." A young vine may show great vigor in the qualitative sense of activity," and yet its vigor in the quantitative sense of "capacity for action," i.e., for growth and production, may be much less than that of an old and relatively inactive vine. Similarly if we prune a vine severely, we reduce the number of shoots the vine produces and these shoots may be more vigorous than the shoots of a lightly pruned vine. The vine will appear more vigorous, but in the quantitative sense, it has "less capacity for action."

In this paper the following definitions are understood:

Vigor.—The quality of making active growth.

Capacity.—The quantity of action in respect to growth and production of which the vine or part of the vine is capable.

Mass and *vigor* are therefore factors of *capacity.*

OBJECTS OF THE INVESTIGATION

The objects of this investigation are to determine (1) the effect of dormant pruning of the vine on vigor and capacity, (2) the effect of crop on vigor and capacity, and (3) the effect of dormant pruning on crop.

[4] HEDRICK, U. P. Manual of American grape growing, p. 112. Macmillan Co., N. Y., 1924.

[5] *Op. cit.* 3:620, 622.

[6] FOËX, G. Cours complet de viticulture, 4th ed., p. 379. Montpellier, 1895.

PLAN OF THE PLANTINGS

The plantings comprised three varieties—Muscat, Monukka, and Alicante Bouschet. With the Muscat and the Monukka the pruning treatments extend along the rows, and these rows are broken up into four plots by different distances of planting. In two plots planted 6 x 12 feet there are seven vines of Monukka and eight vines of Muscat, and in two plots planted 12 x 12 feet there are four vines of each variety under each type of pruning. This planting plan is shown in figure 1. The Alicante Bouschet plantings (12 x 12 feet) are divided into two plots with eight vines under each type of pruning in each plot.

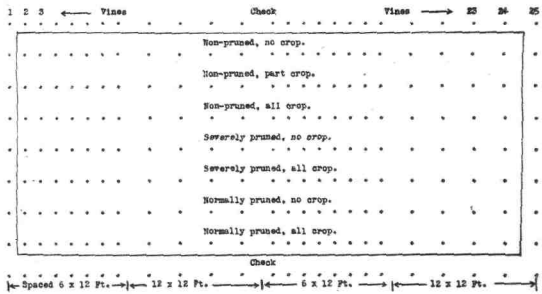

Fig. 1. The planting plan for Monukka and Muscat.

The vines are planted in a Yolo–Fine–Sandy–Loam soil of unusual depth and uniformity. The land was leveled before planting to facilitate irrigation.

DEFINITION OF METHODS OR TYPES OF PRUNING USED

1. *Non-pruned, no crop.* No pruning. All bunches removed before blooming.

1*a*. *Non-pruned, part crop.* No pruning. All bunches in excess of the number of bunches on the *normally pruned, all crop* (2*b*) vines at the time of thinning removed before blooming.

1*b*. *Non-pruned, all crop.* No pruning. All bunches allowed to develop.

2. *Normally pruned, no crop.* Pruning as nearly as possible in accord with the best accepted commercial practices of pruning these varieties.[5] All bunches removed before blooming.

2*b*. *Normally pruned, all crop.* Pruned the same as the *normally pruned, no crop* (2). All bunches allowed to develop.

3. *Severely pruned, no crop.* Pruning similar to that of the normally pruned vines, but more severe, only the base buds being retained on the spurs. All bunches removed before blooming.

3*b*. *Severely pruned, all crop.* Pruned the same as the *severely-pruned, no crop* (3). All bunches allowed to develop.

THE EFFECT OF PRUNING ON VIGOR AND CAPACITY

Since the different types of pruning were started at the end of the first growing season, the Muscat and Monukka vines have passed through four seasons and the Alicante Bouschet through two seasons of growth. In order to start with vines as nearly uniform in shape as possible all plants were cut back to two buds at the end of the first growing season, and all growth of the second season was forced into one cane which was selected to form the permanent trunk of the vine. The vines were all treated alike during the first and second seasons, except that the canes selected for the trunk in the case of the *normally* and *severely pruned* vines during the second season were pinched back after their length had exceeded the desired length of trunk by 12 to 18 inches. The selected cane in the case of the *non-pruned* vines was not pinched.

At the present time none of the Muscat, Monukka or Alicante Bouschet vines have been removed; hence the differences in vigor and capacity here reported are of necessity represented by such measurements as can be made on the vine *in situ*. Data have been collected on the relative circumference increase of individual vines, the time of starting, the rate and the total length of cane growth and the number of leaves per vine for five representative vines in each of the Muscat and Monukka plots.

[5] Bioletti, F. T., and Jacob, H. E. Head, cane and cordon pruning of vines. California Agr. Exp. Sta. Circ. 277:1–32. 1924.

Trunk increase.—The effect of the different methods of pruning on the yearly relative increase in and total circumference of trunk are illustrated by table 1, which gives the figures for the Monukka. The graphs of figure 3 show the area of cross section of trunk at the end of each year for the Monukka and Muscat.*

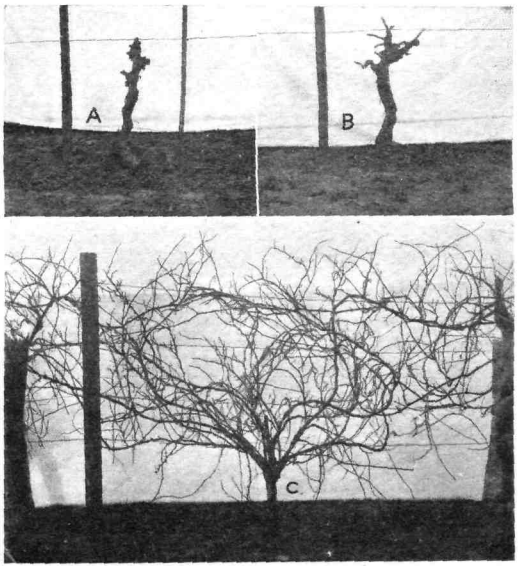

Fig. 2. Muscat vines showing the different types of pruning. A—Severely pruned. B—Normally pruned. C—Non-pruned.

The figures of table 1 indicate the influence of pruning on circumference increase and also show the consistent manner of the response. There has been no overlapping in the amount of increase under the

* Although the Monukka has shown a greater vigor each year since 1922 than the Muscat, the ratios of increase in circumference for each season and the ratio of length growth during 1923 have been so nearly the same that the direction of the graphs on figures 3, 4 and 6 are not altered by plotting the average for the two varieties.

different treatments in either of the varieties used. (See also table 3 for figures on Muscat.)

When treated statistically as, e.g., by *Student's Method*, the *non-pruned no crop* Monukka and Muscat vines show odds of 30.4:1, 17.5:1, and 70.4:1, 21.9:1 respectively that the smaller circumference increase of the *normally* and *severely pruned no crop* vines is a result of the pruning. No doubt some of these odds, as such, may be considered as barely significant. However, since the indicated response to pruning as shown by the circumference increase has in all cases been in the same direction it is fair to conclude that all of these data may be considered as significant.

TABLE 1

THE EFFECT OF PRUNING ON THE YEARLY AND TOTAL CIRCUMFERENCE INCREASE OF MONUKKA. (In centimeters.)

Measurements	Severely pruned No crop	Normally pruned No crop	Non-pruned No crop
Circumference at end of 1921*	2.9±.12	2.9±.13	2.9±.15
Circumference increase during 1922	3.9±.15	4.0±.12	4.2±.28
Circumference increase during 1923	4.7±.16	5.6±.09	6.3±.17
Circumference increase during 1924	3.5±.21	3.8±.12	5.0±.26
Circumference increase during 1925	2.5±.19	2.8±.17	3.2±.21
Circumference at end of 1925	17.5±.32	19.1±.56	21.6±.38

* Before the different types of pruning were used on any vines.

The regularity of the response to pruning is further shown in the graphs of figure 3. The average total circumference at the end of the years 1923, 1924 and 1925 for the several varieties under test which are plotted in figure 3 show an increase in favor of the *non-pruned* vines of 16.3, 16 and 16.8 per cent respectively over that of the *severely pruned*, and of 5.7, 8.4 and 12.3 per cent respectively over that of the *normally pruned* vines.

Length growth.—The effect of method of pruning on the time or rate of growth and on the total length growth during an entire season is indicated by figure 4. These graphs indicate the average total length of growth of both canes and laterals at four periods during the season of 1923 for five vines each of Muscat and Monukka.

The graphs of figure 4 indicate that the method of pruning not only influences the amount of total length growth that a vine will make but that it also modifies both the time of leafing out and the rate of growth. The importance of this influence is seen when the amount of

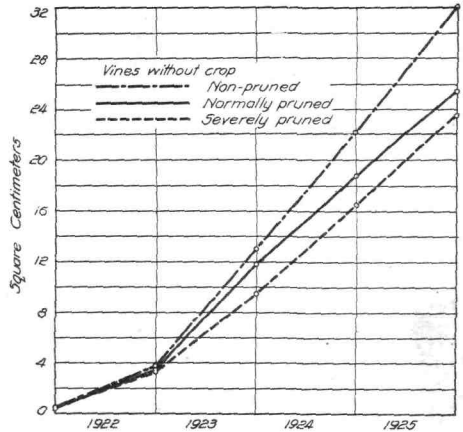

Fig. 3. The effect of pruning on the increase of area of cross section of trunk.

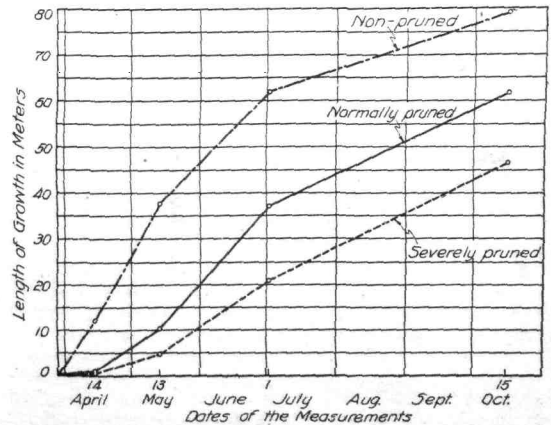

Fig. 4. The effect of pruning on the start, rate and length of cane growth.

length growth found at the several dates of measurement is taken into account. On May 13th the *non-pruned* vines had made 53 per cent of the total season's length growth, while the *normally pruned* and *severely pruned* vines had made only 17.5 and 10.9 per cent respectively. Then again, by May 13th the *non-pruned* vines had made as much length growth as the *normally pruned* vines made by July 1st and 81 per cent as much length growth as the *severely pruned* vines made during the entire season.

Number of leaves.—During the season of 1925 the leaves on five representative Muscat vines under each of the pruning treatments were counted on May 15th, June 24th and October 15th. These counts together with the relative total weight of leaves are plotted in figure 5.

In view of the importance of the total leaf area of a plant and the time during which the leaves function, the differences in the number of leaves per vine and the date of their appearance as shown in figure 5 is of considerable interest. As illustrated by the graphs, the *non-pruned* vines had produced more leaves at the time of the first count, on May 15th, than the *normally* or *severely pruned* vines produced during the entire growing season. The rate of increase in the number of leaves per vine for the remainder of the season was also greater for the *non-pruned* than for the *normally* or *severely pruned* vines.

A question which arises as a result of the great differences in the number of leaves per vine obtained under the several treatments is that of relative area or weight of the individual leaves. No leaf area measurements have been made, but the weight of a considerable number of leaves taken from similar positions on vines under the different treatments were determined during 1925. The relative weight of leaves perhaps give a better comparison than the number. This is well shown by the graphs on figure 5. The weight and number of the leaves of the *normally pruned* vines was used as a basis for the comparison. The difference in weight is somewhat less than the difference in number, but the great importance of the influence of pruning on the production of leaves is still evident.

Young vines.—Since all the Muscat, Monukka and Alicante Bouschet vines were treated alike during the first two years in the vineyard, they offered no information as to how newly established rooted vines respond to pruning. To determine this, four hundred selected cuttings each of Petite Sirah and Gros Colman were planted in parallel rows in a uniform soil. Practically every one of the cuttings rooted; hence by removing every other rooting at the end of the first season a uniform spacing of eighteen inches by six feet was obtained. The rootings of

each variety were then divided into twenty plots of ten vines each. The vines of one-half of the plots were pruned back to two buds while those of the others were not pruned. Circumference measurements of all the vines and weighing of the prunings of the vines cut back to two buds were made at the end of the first season. At the end of the second season all the vines were removed and final weighings and measurements made. The data collected during the two seasons are given in table 2.

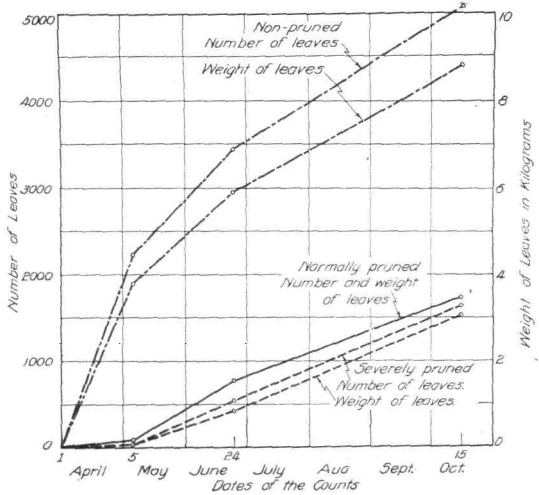

Fig. 5. The effect of pruning on the number and weight of leaves.

The figures of table 2 show that the omission of pruning of one year old Petite Sirah and Gros Colman vines resulted in a relative circumference increase of 19.0 and 35 per cent respectively greater than that of vines pruned back to two buds. Likewise, the average diameter of the roots of the *non-pruned* vines was 16 per cent greater than those of *pruned* vines in case of Petite Sirah and 22 per cent in that of Gros Colman. The number of roots per vine was only slightly influenced by the pruning treatment.

The total top growth for the *non-pruned* vines was 35 per cent greater than that for the pruned vines in case of Petite Sirah and 79 per cent in that of Gros Colman. There was also an increase in the production of reducing substances and starch by the *non-pruned* vines of 56 per cent in Petite Sirah and of 99 per cent in Gros Colman.

TABLE 2

THE EFFECT OF PRUNING ON THE VIGOR OF YOUNG VINES.

Measurements	Gros Colman		Petite Sirah	
	Pruned back to two buds	Non-pruned	Pruned back to two buds	Non-pruned
Circumference of trunk at end of first year*	4.2 cm.	4.1 cm.	3.8 cm.	3.9 cm.
Circumference of trunk at end of second year	5.9 cm.	7.2 cm.	5.5 cm.	6.4 cm.
Per cent of increase in circumference of trunk	40.5	75.5	45.0	64.0
Average number of roots at end of second year	10.8	11.3	10.0	10.4
Average diameter of roots 2–3 centimeters from base	4.5 mm.	5.5 mm.	5.6 mm.	6.5 mm.
Average weight of top at end of first year	29.1 gr.		27.2 gr.	
Average weight of total top growth at end of second year	214.0 gr.	434.0 gr.	269.0 gr.	400.0 gr.
Average weight of reducing substances and starch at end of second year†	34.9 gr.	69.4 gr.	33.3 gr.	52.0 gr.

* Before pruning had been used on any vines.

† The samples (wood taken from all the vines under a single treatment) were collected and immediately dried in a forced draught oven at 70° C. The collected material was then ground and a 5-gram sample used for analysis. For the reducing substances the extraction was made with 95 per cent alcohol, while the starch was hydralized with taka-diastase. The reductions were carried out according to the Shaffer-Hartmann method.

THE EFFECT OF BEARING ON VIGOR AND CAPACITY

In the past it has been the conviction of grape growers that overbearing was solely responsible for the weakening of healthy vines. For this reason a weak vine has always been severely pruned to revive its vigor by diminishing the crop and by the supposed invigorating influence of the heavy pruning.

It may be assumed that fruit bearing, at least beyond some limit, is weakening. It is therefore interesting to inquire how this weakening effect compares with that just shown to follow pruning. To determine

this effect measurements have been made of the relative circumference increase of vines with and without crop under the different methods of pruning. The yearly relative increase in circumference for the *normally* and *non-pruned* Muscat vines with and without crop is given in table 3.

TABLE 3

THE EFFECT OF CROP PRODUCTION ON THE YEARLY AND TOTAL CIRCUMFERENCE INCREASE OF MUSCAT. (In centimeters.)

Measurements	Normally pruned		Non-pruned		
	No crop	All crop	No crop	Part crop	All crop
Circumference at end of 1921*	2.1±.15	2.0±.12	2.0±.11	2.1±.10	2.2±.12
Circumference increase during 1922	4.1±.26	4.2±.12	4.7±.23	4.2±.24	4.4±.16
Circumference increase during 1923	4.5±.18	3.6±.13	5.1±.13	3.9±.11	3.2±.16
Circumference increase during 1924	3.3±.22	2.8±.13	4.2±.24	3.1±.18	1.9±.12
Circumference increase during 1925	2.7±.13	2.1±.17	2.9±.15	2.4±.12	2.2±.15
Circumference at end of 1925	16.7±.53	14.7±.36	18.9±.29	15.7±.36	13.9±.22

* Before the different types of pruning were used on any vines.

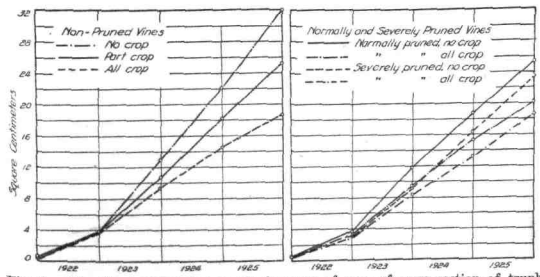

Fig. 6. The effect of bearing on the increase of area of cross section of trunk.

The average circumference at the end of each year for all of the pruning treatments on the Muscat and Monukka vines with and without crop are illustrated by the graphs in figure 6.

The figures of table 3 show a regular falling off in the relative circumference increase of the vines with crop as compared with the

vines under the same method of pruning without crop. It might also be stated that the data indicate a rather direct dropping off in proportion to the amount of crop produced where the pruning is identical, as under the non-pruned vines. The depressing effect of bearing on circumference increase, however, has not been the same with the different pruning treatments. This is shown by a comparison of the figures for the *normally pruned* vines *with* and *without crop* and the *non-pruned part crop* vines in the above table and more clearly by the graphs of figure 6 and the ratios shown in table 4.

TABLE 4

THE RATIOS OF CIRCUMFERENCE INCREASE AND OF CROP OF THE *Severely Pruned All Crop* AND THE *Normally Pruned All Crop* TO THE *Non-pruned Part Crop* VINES

Year	Severely pruned to non-pruned		Normally pruned to non-pruned	
	Circumference increase	Crop	Circumference increase	Crop
Muscat 1923	1:1.04	1:3.60	1:1.07	1:2.16
1924	1:1.22	1:4.38	1:1.09	1:1.86
1925	1:0.95	1:3.69	1:1.16	1:2.55
Average	1:1.07	1:3.89	1:1.11	1:2.19
Monukka 1923	1:1.3	1:10.7	1:1.16	1:1.06
1924	1:1.4	1:63.2	1:1.36	1:2.75
1925	1:0.9	1:59.0	1:1.20	1:0.95
Average	1:1.2	1:44.3	1:1.24	1:1.59

The graphs of figure 6 show that by the end of the 1925 season the *non-pruned part crop* vines had made almost the same amount of total circumference increase as the *normally pruned no crop*, and 11.9 per cent more increase than the *normally pruned all crop* vines, despite the fact that they had each year (1923, 1924 and 1925) produced average crops of from 40 to 138 per cent greater weight than the latter. By comparing the *non-pruned part crop* vines with the *severely pruned*, where there is still a greater difference in the amount of crop produced, the figures show a relative circumference increase of 3.5 per cent for the *non-pruned part crop* over that of the *severely pruned no crop* vines and an increase of 16.7 per cent over that of the *severely pruned with crop vines*. Even the *non-pruned all crop* vines which have borne from 10.4 to 20.7 times more crop each year have made as great a yearly circumference increase as the *severely pruned all crop* vines

The ratios of table 4 appear to further emphasize the greater capacity of the *non-pruned* as compared to the *pruned* vines. Despite an average yearly production in Muscat of 3.89 and 2.19 times more crop respectively than the *severely* and *normally pruned* vines, the *non-pruned part crop* vines made a greater yearly average circumference increase. In Monukka the ratio of crop production between the *non-pruned part crop* vines and the *normally pruned* is comparatively small (1.59:1), but it is much greater when the comparison is made with the *severely pruned* vines (44.3:1), while the ratio for circumference increase is still in favor of the *non-pruned* vines.

THE EFFECT OF PRUNING ON CROP

The Muscat and Monukka vines produced their third and the Alicante Bouschet vines their first crop of fruit during 1925. In recording the influence of pruning on production of crop, account has been taken of yield, weight of bunch, length of bunch, number of normal berries to a bunch, per cent of normal berries to a bunch, and the germination of pollen.

Yield.—Records of crop have been kept for each vine. The average crop per vine for each year is given in table 5.

TABLE 5

THE EFFECT OF PRUNING ON YIELD. (Crop in kilograms.)

Variety	Year	Severely pruned	Normally pruned	Non-pruned part crop	Non-pruned all crop
Monukka	1923	.75	7.58±.58	8.05±1.01	7.49±.50
	1924	.12	2.76±.67	7.58±.53	21.60±.87
	1925	.27±.16	16.75±1.4	15.92±.52	35.52±.58
Muscat	1923	2.51±.27	3.56±.37	7.68±.41	15.84±.54
	1924	1.68±.23	3.96±.64	7.36±.32	15.72±.65
	1925	5.15±.56	7.44±.85	18.99±.84	35.45±1.1
Alicante Bouschet	1925	2.36±.25	7.9 ±.76	18.05±.93	22.5 ±.55

The influence of pruning on yield of fruit has been very consistent. The only apparent exception is the Monukka in 1924 when frost injury was responsible for the very small crop on the *normally pruned* vines and perhaps indirectly responsible for the rather large yield of these vines in 1925, which is in sharp contrast with the Muscat in the same year when the *non-pruned part crop* vines bore more than

twice as much as the *normally pruned* vines. Although the Monukka has not responded to pruning so much as the Muscat and Alicante Bouschet, the difference in yield in favor of the *non-pruned* vines has been considerable. In the case of the Muscat the *non-pruned part crop* and the *non-pruned all crop* vines have produced approximately two and four times respectively more crop each year than the *normally pruned* vines. The response of the Alicante Bouschet has been even more pronounced than that of the Muscat.

In spite of the greater yield, the fruit of the *non-pruned part crop* vines for each of the varieties under test has shown a slightly higher sugar content (by Balling hydrometer) than that of the *normally pruned* vines. In case of the *non-pruned all crop* vines where the crops have been very heavy, as might be expected, the sugar content has been lower. However, a four-fold increase in the crop on these vines over that of the *normally pruned* vines has resulted in a lower sugar content of only two to four degrees Balling.

Weight of bunch.—At harvesting, all the bunches on six of the Muscat and eight of the Alicante Bouschet vines under each type of pruning were weighed. The average weight of a bunch on the Monukka vines was also determined. The figures on weight of bunch are shown in table 6.

TABLE 6

THE EFFECT OF PRUNING ON THE WEIGHT OF BUNCH. (In grams.)

Variety	Year	Severely pruned	Normally pruned	Non-pruned part crop	Non-pruned all crop
Monukka	1923	640	660	610	490
	1924	113	291	364	177
	1925	40	257	398	170
Muscat	1923	203±8.1	213±8.8	520±10.8	175±6.0
	1924	116±5.9	140±4.6	523± 9.3	179±6.8
	1925	166±8.5	143±6.9	554± 7.9	152±8.6
Alicante Bouschet	1925	163±8.9	203±19	316±10.5	.....

The figures of table 6 indicate a very striking increase in size of bunch on the *non-pruned* vines where the crop was controlled by thinning. This increase is greatest in the Muscat where the average weight of bunches of the *non-pruned part crop* vines averaged 224 per cent greater than those from the *normally pruned* vines. It is of interest to note that this increase in weight of bunch in the *non-pruned part crop* Muscat vines was obtained despite the fact that the average crop on these vines for the three years has been from 85 to 155 per cent

greater than that of the *normally pruned* vines. A similar though less marked increase in the weight of the bunches of the *non-pruned part crop* vines is shown for the Monukka and the Alicante Bouschet. The mean weight of the bunches for all of the crops on the *non-pruned all crop* vines has been greater for each variety than that of the bunches of the *severely pruned* and almost as great as that of the *normally pruned* vines. There is evidently an inverse relation between size of crop and size of bunch as shown by comparing the *non-pruned all crop* vines with the *non-pruned part crop* vines. Yet in spite of the fact that the *non-pruned all crop* Muscat and Monukka vines produced more crop each year (410 per cent for the whole period) than the pruned vines, the size of bunch was redueed only 10 per cent.

Length of bunch.—The length of the individual bunches on six of the Muscat and eight of the Alicante Bouschet vines in each plot was measured. The length taken was from the tip of the bunch to the attachment of the peduncle with the cane. The data on length of bunch are given in table 7.

TABLE 7

THE EFFECT OF PRUNING ON LENGTH OF BUNCH. (In centimeters.)

Variety	Year	Severely pruned	Normally pruned	Non-pruned part crop	Non-pruned all crop
Muscat	1924	19.3±.05	19.8±.04	28.7±.02	18.0±.02
	1925	18.5±.07	18.0±.02	27.7±.01	17.0±.02
Alicante Bouschet	1925	12.2±.03	13.0±.02	18.3±.01	.....

The figures of table 7 show 50 per cent greater length of bunch on the *non-pruned part crop* Muscat vines than on the *normally or severely pruned* vines. The corresponding difference for the Alicante Bouschet was 40 per cent. The bunches of the *non-pruned all crop* Muscat vines were slightly shorter than those of the normally pruned vines.

The importance of this increase in length of bunch on the *non-pruned part crop* vines becomes significant when it is considered that the bunches of these vines were no more compact than the average bunches of the *normally pruned* vines, although they contained more and larger berries.

Number and per cent of normal berries.—It is an observation of long standing in all countries where the Muscat of Alexandria is grown that this variety is very subject to *coulure* (shelling) and

millerandage, the production of small seedless (shot) berries. Although this defect varies greatly in different sections of the state and in different seasons, its economic importance as a factor in grape production was among the first to receive the attention of the Experiment Station. Its appearance in serious proportions among the plantings of Muscat in the early days of grape planting on the Southern Mesas was brought to the attention of Professor Hilgard.[6] He recommended the use of fertilizers to ameliorate the trouble, but this proved ineffective, and at present there are few Muscats grown in these particular localities.

In following up the effect of pruning on the number of normal berries to a bunch, counts of the normal and of the total number of berries were made on all the bunches of six of the Muscat vines under each treatment. The average percentage of normal berries to a bunch was then calculated from the number of normal and total berries. The counts of normal berries to a bunch and the per cent of normal berries are given in table 8.

TABLE 8

THE EFFECT OF PRUNING ON NUMBER PER BUNCH AND PER CENT OF NORMAL BERRIES IN MUSCAT.

Normal berries	Year	Severely pruned	Normally pruned	Non-pruned part crop	Non-pruned all crop
Number to a bunch	1924	32±1.6	37±1.1	119±2.1	58±1.9
	1925	42±1.8	34±1.4	140±2.4	57±2.9
Per cent of total	1924	47	68	95	78
	1925	65	69	96	93

The data indicate an increase of 221 and 311 per cent respectively for the years 1924 and 1925 in the number of normal berries to a bunch on the *non-pruned part crop* vines over that of the *normally pruned* vines. These differences are just as great when comparisons are drawn between the *non-pruned part crop* and the *severely pruned* vines. A similar but somewhat less marked increase is shown for the *non-pruned all crop* vines.

The data of table 8 appear to substantiate Professor Hilgard's belief that the setting of shot berries is the result of an unbalanced nutrition. What he had hoped to do with mineral fertilizers, but

[6] HILGARD, E. W. The Muscat Grape on the Southern Mesas. California Agr. Exp. Sta. Bull. 17, 1884.

failed, is possibly accomplished by an increase in the carbon assimilation due to the larger leaf area of the *non-pruned* vines. This indication is further substantiated by the fact that the second crop, the bloom for which develops in mid-season when the vine is in full leaf, usually sets normal berries, however prone the variety may be to set shot berries in the primary crop.

Germination of pollen.—The germination tests were made in hanging drops and on sugar agar agar media. The best germination was obtained in 15 and 20 per cent sucrose solutions. The figures of table 9 represent the average of a number of tests in both 15 and 20 per cent sucrose at 27° to 30° C.

TABLE 9

THE EFFECT OF PRUNING ON THE GERMINATION OF POLLEN. (In per cent.)

Variety	Severely pruned	Normally pruned	Non-pruned part crop	Non-pruned all crop
Muscat	7.8	8.0	54.6	42.0
Monukka	17.3	17.6	58.2	47.6

The data of table 9 indicate that both severe and normal pruning decreased the germinative power of pollen of Muscat 81 per cent, and that of Monukka 63.5 per cent, if we take the pollen of the *non-pruned all crop* vines as a standard. The removal of part of the blossom bunches before blooming on the *non-pruned part crop* vines further increased the germinability of the pollen so that the pollen from these vines gave a germination of 30 per cent for Muscat and 22 per cent for Monukka greater than the standard taken.

SUMMARY AND CONCLUSIONS

Dormant pruning reduces capacity.—

1. A depressing effect on capacity made itself manifest in a smaller circumference increase, total length growth and production of leaves by the pruned vines than by the unpruned.

2. The total top growth of one year old vines was decreased by pruning from 25 to 50 per cent. The percentage of reducing substances and starch was not altered in the dormant wood of one year old vines by the omission of pruning.

Bearing reduces capacity less than pruning.—

3. The retardation of circumference increase as a result of bearing, as shown by the production of three crops, was less than that of normal or severe pruning.

4. The data indicate a retardation of circumference increase somewhat in proportion to the amount of crop where the pruning was the same. This retardation in circumference increase, however, has not been the same with the different pruning treatments.

Non-pruned vines produce more fruit.—

5. The *non-pruned part crop* and the *non-pruned all crop* Muscat vines have produced from two to four times more crop, respectively, than the *normally pruned all crop* vines. This difference in yield with the Monukka has been less marked, while with the Alicante Bouschet the difference has been even greater than with the Muscat.

Non-pruned part crop vines produced better fruit.—

6. The *non-pruned part crop* vines produced grapes of normal sugar content. The increase in the weight of crop has decreased the sugar content of the fruit in the *non-pruned all crop* vines.

7. Despite the great increase in yield, the weight of bunch from the *non-pruned part crop* vines was increased from 16 to 224 per cent respectively for Monukka and Muscat over that of the *normally* and *severely pruned* vines. The weight of the bunch from *non-pruned all crop* vines has been only slightly less than that of the bunches from the *normally* and *severely pruned* vines.

8. The bunches from *non-pruned part crop* Alicante Bouschet and Muscat vines have averaged 40 to 50 per cent respectively longer than those from the *normally pruned* vines.

9. In Muscat there was an increase of 220 and 310 per cent respectively for the years 1924 and 1925 in the number of normal berries to a bunch on the *non-pruned part crop* vines over that of the *normally pruned* vines. The increase shown is just as great when the comparison is made with the *severely pruned* vines.

10. During the same seasons (1924 and 1925) the normal berries to a bunch was 68 and 69 per cent on the *normally pruned* vines and 95 and 96 per cent on the *non-pruned part crop* vines.

11. The increase in the number and per cent of normal berries has been similar with the *non-pruned all crop* vines, but the differences have not been so great.

Pruning decreases germinability of pollen.—

12. If we take the pollen from the *non-pruned all crop* vines as a standard, both *severe* and *normal pruning* decreased the power of germination of the pollen of Muscat 81 per cent and that of Monukka 63 per cent. *Non-pruning* with thinning of the blossom bunches before blooming has increased the germinability of the pollen.