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The Fruiting Habits and Pruning of the Campbell Early Grape

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Summary

The more vigorous the shoot growth, the more productive the shoot and the heavier its bunches. Not all shoots of the same diameter in the fall produced alike. Secondary thickening probably obscures the relative vigor of the early season growth which is the more important condition.

The fruiting canes with the largest diameters produced the largest shoots, the best yields and the heaviest bunches.

There was little correlation between the diameter of spurs and their production.

Comparatively little correlation was observed between the length of the sixth internode and productivity.

The point of maximum productivity on canes migrates away from the base as the diameter of the cane increases, or as the vine becomes more vigorous. In 1927, the region of highest production was from node five to node 10; in 1929, from node 10 to node 15.

The most productive cane length was 15 nodes. Both 10 and 20-node canes gave smaller nodal yields.

Vines pruned to 60 nodes gave the highest production throughout the experiment. They gave bunches of the smallest average weight and the largest percentage of scraggly bunches. The 40-node vines gave the best commercial crop.

Shoot growth was more vigorous the more severe the pruning.

The correlation between growth and yield is not pronounced. The correlation is more evident the more severe the pruning. The regression curves seemed to more nearly approximate a straight line the longer the experiment was continued.

There is very little correlation between number and average weight of bunches produced by the vines in this vineyard. The greater the number of nodes that break, the greater the number of bunches per vine. The vines which produced the heaviest bunches were vigorous and had produced but moderate crops the preceding harvest.

The average Brix reading increased with the severity of the pruning.

The Fruiting Habits and Pruning of the Campbell Early Grape

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A high quality grape that matures somewhat earlier than the Concord would be a desirable addition to the viticulture of Michigan. This is indicated by the ease with which the fruit of the very inferior Champion variety is marketed. Of course, Campbell Early can scarcely be classified as an early grape, but it does ripen a week or ten days earlier than Concord grown on similar soils. Its shorter season would permit the variety to be grown a little farther north than Concord. This variety seems especially adapted for sale in local or roadside markets, particularly if it is packed in uncovered, over-filled baskets which permit the display of its large bunches and berries. Owing to its large production of high quality fruit, the Campbell Early promises to be one of the most profitable grapes that can be grown. On the rich sandy and silt loam soils, to which it is especially adapted, its production exceeds that of adjacent blocks of Concord. Under the most satisfactory type of pruning, reported below, the production was more than four and one-quarter tons of high quality fruit per acre per year over a four year period.

The Campbell Early Grape has only been grown for a moderate length of time. It is a production of George W. Campbell of Delaware, Ohio, and was introduced by a nurseryman of Fredonia, New York. Its first fruit was harvested in 1892, and, in 1893, (Campbell, 1893) considerable emphasis was placed upon the high quality of its bunch and berry characteristics. Other articles followed (Campbell, 1894) in the same journal, all speaking highly of its qualities which were further emphasized by Campbell's willingness to name the variety after himself. By 1900, growers had planted these vines on soils of enough types for some of the defects of the variety to appear, especially a failure to develop good bunches. The introducer (Josselyn, 1900) pointed out that the variety was self-fertile and suggested winter-injury and previous over-production as causes for this undesirable characteristic. Shortly afterward, references to the Campbell Early grape became very scarce and the variety apparently lost much of its popularity.

However, as has been pointed out (Hedrick, 1912) there are few American bunch grapes that surpass this variety when it is grown under the most favorable conditions. It has proved to be adapted to the soils and regions of Oregon which produce American varieties (Schuster, 1923). In New York, (Gladwin, 1924) it has proved to be particular in its soil requirements and the introducers are quoted as reporting, "it requires frequent and heavy manuring," which statement is confirmed by Gladwin. In Ontario, (Palmer and van Haarlem, 1927) it is reported to be adapted to light, deep soils only. In general, there is agreement that this variety demands special soils for satisfactory production; otherwise the variety is characterized by low yields, poorly formed bunches, and irregular maturity. Although it is agreed that the variety does well on few soils, definite statements as to the kind of soil to which it is adapted are lacking in most instances.

The Campbell Early grape has probably proved disappointing in more instances than it has proved successful in Michigan. However, there are vineyards where the variety has proved very successful; the yields obtained exceeded those of Concord in adjacent blocks, and the bunches were large and compact. In these vineyards, bunches weighing a pound are not unusual and several have been weighed which exceeded a pound and a half in weight. The scraggly bunches, characteristic of the variety when it is grown in soil to which it is not well adapted, are associated with weak growth; and the large, compact bunches are most frequently found on strong growth. Two vines illustrating these two types of production are shown in Figures 1 and 2. In Michigan, those soils which are suited to the growth of the Campbell Early grape are high in fertility and have received frequent manuring with organic fertilizers as well as some ammonium sulphate or nitrate of soda. These soils are fertile, sandy or silt loams of the Fox or the Miami series. The Campbell Early grape demands a soil of greater fertility than the Concord, and does its best in a soil that is too rich to produce Concord to the best advantage. It is not established that Campbell Early will not produce well in a light sandy soil provided the vines are fertilized sufficiently, but it is not being grown successfully on any of the sand or loamy sand soils of Michigan at the present time.

It has been pointed out (Gladwin, 1924; Josselyn, 1900) that this variety is inclined to overproduce, and, when it does so, it takes several seasons to regain its former productivity. This same tendency has been observed in Michigan. Consequently, the pruning of the Campbell Early variety, which is the customary method of thinning the crop, is an operation of even greater importance than is the case with the Concord grape. This study was undertaken with the intention of securing some definite data on the fruiting habits and pruning of this variety.

Description of the Vineyard

This study was made in the Campbell Early vineyard of J. A. Richards, located just east of the village of Eau Claire in Berrien County. The vineyard was planted in the spring of 1916. The site is a fairly good one, although there has been some frost damage nearly every spring during the four years, 1926-1929, that observations have been made. The three rows used in the test consisted of 54 vines each, of which the center 48 were used, the end vines being discarded. The central portion of the vineyard is on a slight ridge with the north end of the rows considerably lower than the south end. Shoot killing by spring frost was largely confined to the northern ends of the rows. The vines are planted in rows about 10 feet apart with the vines about eight feet apart in the rows. The soil is partly a sandy loam and partly a silt loam, both of good fertility. The vineyard received three moderate applications of manure the first three years of the experiment, supplemented by applications of about 100 pounds per acre of ammonium sulphate. The result has been a gradual increase in the vigor of vine growth throughout the period of the test accompanied by very good yields of fruit.

The vineyard is much more vigorous now than at the beginning of the experiment. This vineyard produced an exceptionally large crop of fruit in 1923, more than 10 tons of fruit being sold from the vineyard which is just an acre in size. The crop of 1924 was considerably reduced and was followed by a very small crop in 1925, which was due partially to a severe spring frost. Many of the vines appeared to be very weak at that time. Owing to the heavy soil of the vineyard, the crop has matured somewhat later than the fruit in most Campbell Early vineyards in this region, the crop usually being harvested about the time that the first Concords mature on the lighter soils, or about a week to ten days before Concord on similar loams. Most of the vines have matured their crops well, although each year some vines have matured their fruit somewhat later than the others.

The pruning treatments were varied between the three rows in the experiment. The vines of the three rows were pruned to 60, 40, or 30 buds each. These treatments were considered to be light, moderate, and severe pruning for these vines. The same vines have received pruning of the same degree of severity throughout the four years of the experiment. During the first two seasons, 1926 and 1927, the type of training varied considerably from vine to vine. The last two years, 1928 and 1929, the pruning was standardized, each vine in the severely pruned row having four canes of 3, 4, 8, and 15 buds each; in the moderately pruned row having five canes of 3, 4, 8, 10, and 15 buds each; and in the lightly pruned row having five canes of 7, 8, 10, 15, and 20 buds each. There are advantages to both of these methods of conducting the experiment. Under the first system, it is possible to compare vines pruned to spurs with vines pruned to canes of moderate length and to make comparisons between vines pruned to canes of varying lengths. However, owing to the multiplicity of treatments there was a great variety of cane lengths, which reduced the number of canes in many groups to such a degree that comparisons between canes of different lengths were untrustworthy, owing to the small number of individuals available for study. It was also true in many cases that the canes of a given length came from a comparatively small number of vines.

There is a tendency for all canes on a given vine to yield in a somewhat similar manner. Further, too few vines received any particular treatment to furnish a really satisfactory basis of comparison between different styles of pruning. With standardized pruning, there were about 48 canes of each length available for study, one to each vine, which gave a reasonable number of individuals for study. At the close of each season, however, there were not 48 canes of each length on each row. Some had been broken off and lost in tying and each year a few vines had to be pruned somewhat differently from the rest because it was not always possible to select canes with the desired number of buds. However, there was a close approximation of the schedule of canes given above.

There were a few factors which caused some difficulty in getting comparable results. Each year some canes were broken in tying. The wind broke off a certain number of shoots which interfered with the distribution of fruiting shoots on the cane. The more rapid the rate of the spring growth the less wind it takes to snap off a fruiting shoot. It was impossible at harvest to determine just which shoots were lost in this way. As was mentioned above, a certain number of shoots were killed each season by frost. However, the relative fruitfulness of canes of similar growth types has proven to be so constant during each of the four seasons and for each of the three pruning treatments that the conclusions seem to be rather well established by the data.

The normal habit of growth on a grapevine is for all the buds on the cane to produce shoots except a few buds at the base of the cane. When a node well out on the cane is found without a shoot at harvesting time, something destroyed the shoot or bud in a large majority of instances. The bud may have been rubbed off on the wire, destroyed by a cutworm, killed by frost, or the shoot may have been broken off by the wind. In many instances where a shoot is lost, a second shoot that is produced from one of the growing points other than the strongest one which is called the first bud may be left at the node or grow in its stead. It is difficult or impossible at the harvest to tell definitely which shoots came from first, second, or third buds and no attempt has been made to so classify the shoots. Undoubtedly many of the low-producing or non-producing shoots were developed from second or third buds and so are not comparable to the higher producing first shoots on the same canes or those of other canes. However, this type of error largely compensates for itself when considerable numbers of canes are compared.

The Relation of Current Season's Growth to Productiveness

The amount of fruit produced by a grapevine is related both to the conditions of the previous season, which largely determine the number of cluster primordia which are present in the dormant buds of the vine (Goff, 1902) and also by the nutritional conditions the current season. The growth conditions in the spring may influence yield either through varying the number of blossoms differentiated in the cluster or by changing the percentage of blossoms that set berries. It has been shown previously (Partridge, 1930) that the number of blossoms differentiated from cluster primordia is influenced by the rate of growth of the young shoots previous to bloom, at least with Concord vines. Various investigators have demonstrated that very vigorous growth is detrimental to the setting of the blossoms of vinifera varieties (Mueller-Thurgau, 1898; Winkler, 1929), in extreme cases leading to the total abscission of the blossom clusters as has been observed occasionally on Concord in Michigan. Both of these effects are obviously confined to the early part of the growing season, up to and including the blossoming period.

Any relationship between total yield and any measurement of shoot diameter made at the close of the growing season includes the influence exerted by both of the phases mentioned above as well as any later influence that may affect the size of berry. The last mentioned factor is relatively of little importance, as the weight of the cluster is usually determined by the variations in the number of berries rather than by their individual weights (Colby and Tucker, 1929). In this same paper, for the Moore Early variety, a relationship was established between the total yield of shoots, their diameter and their total length.

In the Campbell Early grape, there is a marked positive correlation between the diameter of the shoot in the fall and the weight of fruit produced by that shoot during the season of its growth. Possibly, it should be mentioned that the term shoot in this discussion refers to the current season's growth on which the leaves and fruit are produced. At the close of the season, when the leaves fall, the shoots mature and become the canes on which next year's shoots will produce the

Fig. 1.—Fruit production on a weak vine, only a few scraggly bunches are developed. This vine is on an infertile sandy soil and has been habitually underpruned.

following crop. This condition was first studied at the close of the 1928 fruiting season. These data were obtained by measuring all the shoots on all the fruiting canes of nine vines in each pruning treatment. The relationship existing between the average total weight of fruit harvested from a shoot and its diameter extended to both the average number of bunches per shoot and the average weight of the bunches. These results are given in Table I. When shoots of the same diameter are compared, there is no consistent difference in the total yield or size of bunch between the different pruning treatments. Differences in the average production under the different pruning treatments given in this experiment appear to be related directly to the difference in

Table I.—Relation of Fruit Production to Diameter of Shoots. Crop of 1928, Canes of Various Lengths. Crop of 1929, 8 and 15-bud Canes.

Shoot Diameter	Crop of 1928				Crop of 1929							
	Number of shoots	Ounces per shoot	Bunches per shoot	Ounces per bunch	Number of shoots		Ounces per shoot		Bunches per shoot		Ounces per bunch	
					15-bud canes	8-bud canes	15-bud canes	8-bud canes	15-bud canes	8-bud canes	15-bud canes	8-bud canes
2/32	....	....	....	....	20	5	0.4	0	0.5	0	0.8	....
3/32	56	1.9	1.1	1.7	96	37	2.0	1.3	1.1	0.8	1.8	1.7
4/32	64	4.4	1.5	3.0	171	80	3.7	3.2	1.3	1.1	2.8	2.8
5/32	82	7.1	1.7	4.2	229	92	7.5	5.1	1.6	1.3	4.8	3.7
6/32	94	9.3	1.8	5.2	350	117	10.7	6.4	1.8	1.3	6.1	5.0
7/32	131	13.0	2.0	6.5	367	144	14.3	10.9	2.0	1.7	7.3	6.5
8/32	135	13.0	1.9	6.7	305	130	17.3	11.6	2.1	1.7	8.4	7.0
9/32	102	14.7	2.0	7.4	166	84	21.3	14.9	2.3	1.9	9.4	8.0
10/32	61	16.3	2.1	7.9	52	36	23.0	17.6	2.2	1.9	10.6	9.3
11/32	23	16.5	2.1	7.9	11	15	23.0	20.5	2.3	2.1	10.1	9.6
12/32	8	16.3	1.9	8.7	1	4	0.5	20.6	1.0	2.2	0.5	9.2
13/32	6	16.0	2.2	7.4	....	5	....	18.4	....	2.2	....	8.4
14/32	2	11.0	2.0	5.5	....	1	....	18.0	....	2.0	....	9.0
All	764	11.0	1.8	6.0	1,768	750	12.4	9.3	1.8	1.5	6.9	6.2

the vigor of the shoot growth produced. There appeared to be a slight increase in the number of bunches produced on the shoots of the lightly pruned vines.

These observations were continued with the 1929 crop, the data being secured from all the shoots produced on the 8 and the 15-bud canes on the three plots. These data are also given in Table I. In 1929, as in 1928, there was no significant consistent difference between the behavior of shoots of the same diameter under the three different pruning treatments. The variation in the average nodal production of the different rows is largely due to the differences in the numbers of shoots of different diameters, as is shown by the data from 15-bud canes given in Table II, there being a greater percentage of more vigorous shoots on the rows which received the more severe pruning treatment. The significance of the differences in the fruiting of shoots of weak, moderate, and vigorous growth is illustrated in Figs. 3, 4, and 5.

The outstanding point of interest is the marked difference in the production of shoots of the same diameter produced on canes of the two lengths. The shoots on the 8-bud canes are less productive than shoots of similar size on the 15-bud canes. This relationship extends to both the number of ounces per bunch and the average number of bunches per shoot as well as to the total yield per shoot. In order to make a more definite comparison between the difference in the behavior of the canes of these two lengths, Table III was compiled to show the fruiting of the shoots at nodes 6, 7, and 8 of each group. Here again the shoots produced on the 15-bud canes outyielded similar shoots on the 8-bud canes. On the 15-bud canes, these nodes are near the middle of the cane and they are the terminal ones on the 8-bud canes. Presumably, any difference in the behavior of these shoots of the same diameter at the end of the season produced by comparable groups of nodes must be due to differences in the response of the nodes to the different pruning treatments and cannot be due to any differences at pruning time. In this comparison, the difference was not due to the use of nodes on the longer canes which were not used in the shorter group. One element responsible for a portion of the difference in the average weight of fruit per shoot and the average num-

Table II.—Fruit Production of 15-bud Canes from the Three Pruning Plots, 1929.

Diameter	Ounces per shoot			Bunches per shoot			Ounces per bunch		
	Severe pruning	Medium pruning	Light pruning	Severe pruning	Medium pruning	Light pruning	Severe pruning	Medium pruning	Light pruning
2/32	0.5 (11)	0.4 (6)	0 (3)	0.4	0.8	0	1.5	0.5	....
3/32	1.7 (50)	1.8 (25)	2.7 (21)	1.0	1.0	1.3	1.6	1.8	2.0
4/32	3.5 (59)	3.6 (63)	4.1 (49)	1.3	1.2	1.5	2.7	3.0	2.7
5/32	7.5 (79)	6.7 (79)	8.3 (71)	1.6	1.4	1.7	4.8	4.7	5.0
6/32	10.8 (125)	11.4 (100)	10.1 (125)	1.8	1.7	1.7	5.9	6.6	5.9
7/32	13.3 (110)	13.9 (122)	15.5 (135)	2.0	1.9	2.0	6.6	7.4	7.9
8/32	15.4 (74)	18.0 (95)	17.9 (136)	2.0	2.1	2.1	7.7	8.6	8.6
9/32	17.5 (29)	20.2 (62)	23.7 (75)	2.1	2.3	2.3	8.2	8.9	10.2
10/32	27.2 (9)	23.8 (19)	20.9 (24)	2.6	2.2	2.0	10.7	10.8	10.4
11/32	7.5 (1)	23.0 (5)	26.2 (5)	1.0	2.4	2.4	7.5	9.6	10.9
12/32	....	....	0.5 (1)	....	....	1.0	....	....	0.5

Numbers in parentheses indicate number of shoots in each group.

Table III.—Production of Shoots Growing at Nodes 6, 7 and 8 on 8 and 15-bud Canes, 1929.

Diameter	Number of shoots		Ounces per shoot		Bunches per shoot		Ounces per bud		Per cent of barren shoots	
	15-bud canes	8-bud canes	15-bud canes	8-bud canes	15-bud canes	8-bud canes	15-bud canes	8-bud canes	15-bud canes	8-bud canes
2/32	2	2	0	0	0	0	....	....	100	100
3/32	24	13	1.8	0.6	1.0	0.3	1.8	2.0	25	69
4/32	41	37	3.8	2.2	1.3	0.8	3.0	2.9	15	35
5/32	48	49	7.6	3.8	1.6	1.0	4.9	3.7	2	27
6/32	78	60	10.4	5.4	1.8	1.1	5.9	4.9	3	25
7/32	87	74	13.7	10.7	1.9	1.6	7.1	6.7	0	12
8/32	68	88	14.6	10.8	1.9	1.6	7.6	6.8	1	7
9/32	34	48	16.5	15.4	2.1	1.8	8.0	8.6	0	8
10/32	11	28	17.8	17.4	1.8	1.8	9.8	9.6	9	7
11/32	2	10	25.0	21.2	2.5	2.1	10.0	10.1	0	0
12/32	....	4	....	16.5	....	2.0	....	8.2	....	0
13/32	....	4	....	15.9	....	2.2	....	7.1	....	0
14/32	....	1	....	18.0	....	2.0	....	9.0	....	0

Table IV.—Production of Basal and Terminal Nodes of 8-bud Canes, 1929.

Diameter	Ounces per shoot		Bunches per shoot		Ounces per bunch		Per cent of shoots barren	
Nodes	1-4	5-8	1-4	5-8	1-4	5-8	1-4	5-8
2/32	0 (1)	0 (4)	0	0	....	....	100	100
3/32	1.5 (20)	1.1 (17)	1.0	0.5	1.5	2.3	25	53
4/32	4.4 (34)	2.2 (46)	1.6	0.8	2.8	2.7	9	30
5/32	6.8 (32)	4.1 (60)	1.8	1.1	3.7	3.7	3	23
6/32	7.3 (41)	5.9 (76)	1.4	1.2	5.2	5.0	12	22
7/32	11.3 (43)	10.7 (101)	1.8	1.6	6.3	6.6	0	10
8/32	13.0 (25)	11.2 (105)	1.8	1.6	7.4	6.9	0	7
9/32	13.6 (20)	15.3 (64)	1.9	1.8	7.0	8.4	0	6
10/32	19.0 (4)	17.5 (32)	2.0	1.9	9.5	9.3	0	6
11/32	13.1 (4)	23.1 (11)	2.0	2.2	6.6	10.6	0	0
12/32	....	20.6 (4)	....	2.2	....	9.2	....	0
13/32	28.5 (1)	15.9 (4)	2.0	2.2	14.2	7.1	0	0
14/32	....	18.0 (1)	....	2.0	....	9.0	....	0

Numbers in parentheses indicate number of shoots in group.

ber of bunches per shoot was the larger percentage of barren shoots found on these nodes of the 8-bud canes than were recorded on the same nodes of the 15-bud canes, which amounted to 17 per cent and five per cent respectively. The barren shoots were of most frequent occurrence when the shoot diameter was small, few shoots one-fourth of an inch in diameter or larger being barren in either group of canes.

In view of the difference in the fruiting of shoots on the 8 and 15-bud canes, an examination was made of the basal and terminal portions of the 8-bud canes to determine whether this difference might not be due to the stimulating effect of the short pruning, which might affect the terminal nodes on the cane but not the basal ones more distant from the cut (Table IV). No consistent difference in weight of bunch was found in the two groups when shoots of the same size were compared. There was a marked difference in the number of bunches per shoot, however, the larger production being found on the basal half of the cane. There was a larger percentage of barren shoots on the terminal half of the cane, but this difference was not sufficient to account for the reduction in the number of bunches.

Table V gives similar data for the 15-bud canes which are very different from the 8-bud data. In this instance there was less consistent difference in the average number of bunches per shoot. In the case of shoots six thirty-seconds of an inch in diameter and smaller, the terminal third yielded fewer bunches per shoot than the basal or median portions. This appears to be due in large part to the greater percentage of barren shoots of the smaller diameters found on the terminal third

Fig. 2.—Fruit production on a vigorous vine. Many large compact bunches are developed. This vine is on a loamy soil, has been fertilized regularly, and was pruned to 40 nodes.

of the cane. The larger shoots, those seven thirty-seconds of an inch and above, showed a tendency for an increase in the average number of bunches from base to tip. The average weight of bunch showed little difference when shoots of the smaller diameters were compared, but showed a marked increase from base to tip when shoots above five thirty-seconds of an inch in diameter were compared.

It is evident that the final diameter achieved by the shoot at the close of the growing season is not the best measurement that can be obtained to bring out the relationship between shoot growth and fruit production. Those nutritional conditions which affect fruit production act early in the season. The relative diameter of the shoots may be

Table V.—Fruiting of the Basal, Median and Terminal Thirds of 15-bud Canes.

Diameter	Ounces per shoot			Bunches per shoot			Ounces per bunch			Per cent barren		
Nodes	1-5	6-10	11-15	1-5	6-10	11-15	1-5	6-10	11-15	1-5	6-10	11-15
2/32	0.5 (13)	0 (3)	0.2 (4)	0.7	0	0.2	0.7	....	1.0	29	100	75
3/32	2.1 (37)	1.6 (36)	2.2 (23)	1.2	0.9	1.2	1.7	1.7	1.9	11	28	29
4/32	4.0 (44)	4.0 (61)	3.2 (66)	1.5	1.4	1.2	2.7	2.9	2.6	7	10	21
5/32	7.7 (44)	8.5 (81)	6.6 (104)	1.7	1.7	1.4	4.5	5.0	4.8	2	1	14
6/32	9.3 (67)	11.1 (149)	11.0 (134)	1.7	1.8	1.7	5.5	6.2	6.3	0	2	5
7/32	12.2 (63)	14.2 (137)	15.2 (167)	1.8	2.0	2.0	6.7	7.1	7.7	2	0	5
8/32	13.8 (54)	16.1 (110)	20.2 (141)	1.9	2.0	2.2	7.2	8.1	9.3	0	2	1
9/32	16.1 (29)	18.8 (52)	24.9 (85)	2.1	2.1	2.4	7.7	8.8	10.2	0	0	0
10/32	17.0 (6)	20.1 (17)	26.8 (29)	1.8	2.1	2.4	9.3	9.8	11.3	0	6	0
11/32	16.5 (3)	19.3 (3)	26.1 (5)	2.0	2.0	2.5	8.2	9.7	10.4	0	0	0
12/32	0.5 (1)	....	....	1.0	....	....	0.5	....	....	0	....	....
All	9.3	12.0	14.4	1.7	1.8	1.9	5.6	6.6	7.7	4	4	7

Numbers in parentheses indicate the number of shoots in each group.

Table VI.—Fruit Production of the Smallest and Largest 15-bud Canes, Diameters Taken in the Winter of 1928-1929.

Diameter of shoot	Nodes 1-5								Nodes 6-10								Nodes 11-15							
	Cane diameter 6/32-8/32				Cane diameter 12/32-15/32				Cane diameter 6/32-8/32				Cane diameter 12/32-15/32				Cane diameter 6/32-8/32				Cane diameter 12/32-15/32			
	No. shoots	Oz. per node	Bun. per node	Oz. per bunch	No. shoots	Oz. per node	Bun. per node	Oz. per bunch	No. shoots	Oz. per node	Bun. per node	Oz. per bunch	No. shoots	Oz. per node	Bun. per node	Oz. per bunch	No. shoots	Oz. per node	Bun. per node	Oz. per bunch	No. shoots	Oz. per node	Bun. per node	Oz. per bunch
2/32	6	0.9	0.7	1.4	2	0	1.0	0	3	0	0	......	......	......	......	......	4	0.2	0.2	1.0	......	......	......	......
3/32	10	2.1	1.3	1.7	5	1.3	0.8	1.6	19	1.9	1.0	1.9	......	......	......	......	5	0.6	0.6	1.0	1	2.0	1.0	2.0
4/32	11	4.3	1.5	2.8	6	3.3	1.5	2.2	19	4.3	1.5	2.9	6	6.1	1.3	4.6	18	3.4	1.3	2.5	9	3.0	1.3	2.2
5/32	9	7.4	1.6	4.7	7	6.4	1.6	4.1	34	9.6	1.8	5.3	4	14.7	2.2	6.6	33	8.1	1.6	5.1	12	4.6	1.2	3.9
6/32	17	10.1	1.8	5.7	12	9.4	1.6	5.9	56	12.3	2.1	6.0	12	10.2	1.6	6.5	41	11.7	1.9	6.1	21	9.9	1.5	6.5
7/32	21	10.8	1.8	6.1	9	9.0	1.3	6.7	33	14.4	2.1	6.9	23	13.9	1.9	7.5	48	14.9	2.0	7.6	28	15.3	1.9	8.1
8/32	14	14.1	1.8	7.9	11	12.7	1.9	6.6	13	15.1	1.8	8.2	22	15.8	2.1	7.6	21	16.7	2.2	7.5	25	20.7	2.0	10.1
9/32	3	10.7	1.7	6.4	7	19.4	2.1	9.1	3	24.5	2.3	10.5	16	19.4	2.1	9.1	10	19.7	2.6	7.6	19	24.7	2.3	10.9
10/32	......	......	......	......	1	20.5	2.0	10.2	1	7.0	1.0	7.0	9	20.9	2.0	10.5	3	25.8	2.3	11.1	11	29.5	2.4	12.5
11/32	......	......	......	......	......	......	......	......	......	......	......	......	1	28.0	2.0	14.0	......	......	......	......	1	33.0	3.0	11.0
All	91	8.4	1.6	5.3	60	9.4	1.6	5.9	181	10.4	1.8	5.8	93	15.2	1.9	7.9	183	11.8	1.8	6.5	127	16.3	1.9	8.8

altered materially by their secondary thickening, which undoubtedly varies in amount due to the conditions in the individual shoots later in the season. However, the evident correlation shown in the tables indicates that there is a tendency for the slowly growing shoots to be less productive and the rapidly growing shoots to be more fruitful in spite of the somewhat obscuring effect of the secondary thickening.

The effect of cane diameter on the growth of the shoots on the cane is shown in Table VI in which the 43 canes ranging in size from six thirty-seconds to one-fourth of an inch were grouped together and the 19 canes ranging from twelve thirty-seconds to fifteen thirty-seconds in another group. In general, the shoots on the smaller canes proved to be more fruitful than shoots of similar size at the close of the season on the larger canes. This condition is more marked when the basal thirds of the canes are compared and is much less apparent in the median thirds of the canes. In the terminal third of the canes, there is a marked superiority of the larger shoots growing on the larger canes, although the smaller shoots on the smaller canes are more fruitful than similar shoots on the large canes. The larger canes are more productive than the smaller ones. This condition is possible because the larger canes produce more vigorous shoots, thus counterbalancing the smaller production of shoots of equal size, even in the basal third of the cane.

Sufficient attention has not been devoted to the effect of current season's growth on the fruiting of the Campbell Early grape to warrant very definite conclusions as to the method by which this superiority in fruiting has been attained. An examination of Table VI which also gives the average number of bunches and the average weight of bunches per shoot shows that the larger production is more closely related to weight of bunch than to number of bunches. Owing to the fact that most, if not all, inflorescences which will yield bunches of good size have already been differentiated and are present in the buds during the dormant season, the conditions found are probably related to differences in the production, translocation or utilization of organic food materials in the spring between the time that the buds swell and the time that the setting of the berries is completed. These nutritional conditions influence the differentiation of the individual flowers which have made little, if any, previous separate development, and also affect the setting of the berries. There are some differences in the weight of berries at harvest that may contribute somewhat to the differences observed. The possible effect of differences in berry weight is not large enough to account for the differences recorded. No large amount of coulure, following the blossom drop, has occurred in this vineyard during the progress of the experiment.

No matter what may be the fundamental cause of this variation in the fruitfulness of shoots of different degrees of vigor, a very practical application of the results may be made. Vigor is essential for the production of canes of the most fruitful type and is equally essential for the growth of shoots of sufficient strength to utilize the full potentialities of the nodes which produce them. The Campbell Early, like the Concord, no doubt has an optimum vigor of growth which is followed by decreased yields if vegetation is too great. However, this vigorous vineyard has failed to offer definite proof of such a point.

Although there are indications that the optimum shoot diameter is eleven thirty-seconds of an inch, the number of shoots that were more vigorous was so small that it hardly seems safe to assume that this is the exact point. The evidence secured explains why it is necessary to fertilize a Campbell Early vineyard well and to prune it rather severely, and it also indicates the reason that this variety succeeds best on fertile soils, for these are the only conditions which will secure the requisite vigor of cane and shoot growth. Concord, whose best canes are about a quarter of an inch in diameter, is in marked contrast to this variety and will not do well on soils of the highest fertility.

The Relation of Cane Diameter to Productiveness

It has been shown previously (Partridge, 1922 and 1925) that there is an association between the diameter of Concord grape canes and their productiveness. Similar results were secured with this variety

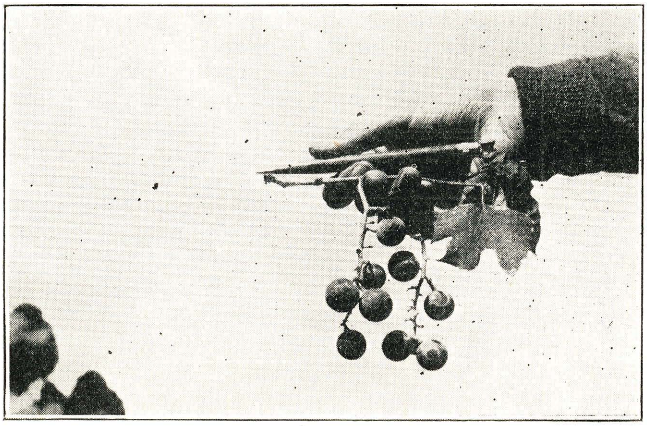

Fig. 3.—Fruit production on a weak shoot. Shoot diameter, 1/16 inch. First six internodes, 4¼ inches. Cluster weights: 1, 0.5 oz., 2, 0.5 oz.

by others (Colby and Vogele, 1924; Clark, 1925; Angelo, 1927). The conclusions reached by these observers were that the moderate-sized cane whose diameter was not far from a quarter of an inch was potentially the most productive. The largest as well as the smallest canes proved to be less productive than those of moderate size. Data have been presented for the Worden variety (Pickett, 1926 and 1927) which indicate that cane diameter is not an important factor in assisting in the selection of productive canes. These results were obtained in Kansas where the climatic conditions are very different from those prevailing in the more important regions where American bunch grapes are grown, and it is not impossible that further investigation of the fruiting habits of the Worden may yield different results in other regions. In the second report (1927), data are also included for Concord which do not show as marked a correlation between cane diameter and

Table VII.—The Average Nodal Production of Canes of Different Diameters.

Cane diameter	1926					1927					1928					1929				
	No. of canes	Oz. per node	Oz. per bunch	% of nodes fruiting	% with multiple shoots	No. of canes	Oz. per node	Oz. per bunch	% of nodes fruiting	% with multiple shoots	No. of canes	Oz. per node	Oz. per bunch	% of nodes fruiting	% with multiple shoots	No. of canes	Oz. per node	Oz. per bunch	% of nodes fruiting	% with multiple shoots
4/32	4	2.6	4.3	28	4	3	1.5	4.4	21	8	1	5.1	5.9	43	0	......	......	......	......	......
5/32	22	4.4	4.4	51	2	10	3.2	4.5	45	4	16	3.8	4.5	46	1	6	4.1	4.4	50	0
6/32	88	5.1	4.8	52	4	65	3.4	5.0	44	3	33	5.9	5.2	54	2	33	5.8	5.4	55	1
7/32	131	6.8	5.6	57	6	160	3.5	5.1	44	4	93	6.6	5.7	55	4	77	6.4	5.5	60	3
8/32	105	8.0	6.3	56	10	151	3.5	5.2	43	7	110	7.5	5.8	59	6	87	6.9	5.7	61	7
9/32	61	7.2	6.1	53	12	100	3.9	5.0	45	11	96	8.9	6.3	62	10	106	7.5	5.8	64	8
10/32	22	8.9	6.8	57	13	64	3.9	5.2	44	13	74	10.3	6.5	64	17	82	8.7	6.6	62	15
11/32	3	11.1	6.9	54	25	18	3.6	4.6	44	20	33	12.1	7.2	69	18	40	10.2	6.9	66	18
12/32	......	......	......	......	......	5	3.5	5.1	33	21	8	12.8	6.7	70	23	21	11.0	7.0	72	22
13/32	1	11.0	6.7	73	27	7	3.3	5.2	36	16	3	11.2	6.1	77	23	14	11.8	7.9	68	15
14/32	......	......	......	......	......	2	3.6	3.8	47	27	......	......	......	......	......	4	16.5	7.7	87	30
15/32	......	......	......	......	......	......	......	......	......	......	1	1.0	2.0	25	12	1	18.9	9.1	87	20
16/32	......	......	......	......	......	......	......	......	......	......	1	8.7	7.2	60	20	......	......	......	......	......

yield as were obtained in Michigan. Differences in environment appear to exert a marked effect on the fruiting habits of the grape.

Measurements of the diameter of the fruiting canes of the Campbell Early vines used in this experiment were made each year after pruning and before growth commenced in the spring. The measurement recorded was the average of the largest and smallest measurements obtained at a point midway between the fifth and sixth nodes of each cane and was made to the nearest thirty-second of an inch. At harvest, the fruit from each shoot was weighted to the nearest half ounce and the number of bunches was recorded. The average weight of fruit harvested per node was calculated for each group of canes of each diameter and the data are presented in Table VII. All canes pruned to all the different numbers of nodes used are grouped together in this table, although the spurs were omitted.

The data offer little definite indication of an optimum cane diameter such as has been found in Concord, but rather show a tendency toward increased production as the size of the cane is increased, at least within the limits studied in this vineyard. In 1927, a year when production was low on canes of all diameters, there is an indication of an optimum with canes of nine thirty-seconds and ten thirty-seconds of an inch giving the best yields and, again in 1928 the three groups of largest diameter, exceeding twelve thirty-seconds of an inch, gave smaller yields than canes eleven thirty-seconds and twelve thirty-seconds of an inch in diameter. In general, the data do not give conclusive proof or disproof of an optimum cane diameter, owing to the small number of canes larger than twelve thirty-seconds inch in diameter. However, these data do show that the best fruiting canes of Campbell Early are considerably larger than those of Concord. Also, there can be no doubt that in most years there is little probability that yields will be reduced even though the largest canes available be chosen, because there are so few that exceed the most productive ones in size in any of the seasons included in the data. It seems safe to recommend using the largest canes on the vine for fruiting without further qualification.

The average size of bunches also increases with the diameter of the cane as is illustrated by the data presented in Table VII. There are a few more irregularities to be observed in this column of the table than in the preceding one. The largest bunches are found as a rule, on the most productive canes. The largest number of bunches per node is also found on the largest canes, with about the same exceptions as have been noted. The percentage of nodes producing fruiting shoots, the data being given in Table VII, shows a marked increase with the diameter of the cane. This increase in percentage is nearly sufficient to account for the increase in the number of bunches produced on the nodes of the larger canes. The last column of Table VII, giving the percentage of multiple shoots from the nodes of the canes, shows that the production of more than one shoot per bud is a characteristic of the more vigorous canes. The additional shoots probably account for nearly all the rest of the increase in number of bunches per node.

Both the percentage of nodes producing fruit and the percentage of nodes producing multiple shoots depend upon the vigor of the cane; the greater the size of the cane the more shoots will be produced by its

Table VIII.—The Average Nodal Production of 15-bud Canes of Various Diameters on Vines Receiving the Different Pruning Treatments; Seasons of 1928 and 1929.

Cane diameter	Crop of 1928						Crop of 1929								
	Severe pruning		Moderate pruning		Light pruning		Severe pruning			Moderate pruning			Light pruning		
	No. canes	Oz. per node	No. canes	Oz. per node	No. canes	Oz. per node	No. canes	Oz. per node	Shoot diam.	No. canes	Oz. per node	Shoot diam.	No. canes	Oz. per node	Shoot diam.
6/32	1	12.4	4	5.4	2	6.0	1	15.9	0.20						
7/32	3	6.9	8	7.9	10	6.0	3	8.1	0.19	5	7.4	0.19	8	7.4	0.18
8/32	7	9.5	10	9.3	16	6.6	4	9.3	0.20	6	9.0	0.19	16	6.0	0.17
9/32	13	12.6	11	13.1	10	6.0	11	11.7	0.21	10	9.0	0.20	11	8.8	0.19
10/32	9	11.0	8	13.9	8	10.1	7	11.8	0.21	14	11.1	0.20	6	9.4	0.19
11/32	11	12.6	6	14.4	1	4.4	8	13.1	0.21	9	11.2	0.22	7	10.4	0.20
12/32	1	15.6	1	26.5	1	7.9	5	13.5	0.21	3	11.2	0.22	1	10.3	0.21
13/32					1	9.3	4	15.1	0.22	1	15.6	0.25			
14/32							4	16.5	0.23						
15/32							1	18.9	0.25						
16/32	1	8.7													

nodes. The bunches are also larger on the shoots produced on these canes.

The production records of the vines receiving the different pruning treatments have constantly shown light pruning to give the greatest total yield. However, the nodal yields have been smallest on this row. When a comparison is made of the diameters of canes pruned to equal numbers of nodes, it is observed that the vines pruned most severely show a larger average diameter than canes on vines pruned more lightly. For example, in 1929, the 15-bud canes on the lightly pruned vines averaged 0.275 inches in diameter; those on the moderately pruned vines were 0.300 inches and those on the severely pruned vines averaged 0.325 inches. This difference in the diameter of the canes under the three pruning treatments accounts for some of their variation in nodal yields as is shown in Table VIII. In 1929, with scarcely an exception, the canes of the same diameter produced more when they grew on vines receiving more severe pruning. Although the canes on the lightly pruned vines generally produced less than those on the more severely pruned vines, the canes on the moderately pruned vines produced somewhat more fruit. However, the average nodal production of the two groups of canes was the same, 11.4 ounces, owing to the difference in the diameters of the canes.

Part of the difference in the nodal yields reported for canes of different diameters and of similar length under different pruning treatments is due to the more vigorous shoot growth found on the larger canes and with the more severe pruning. Table VIII also gives the average diameter of the shoots produced on the canes of different sizes. With the exception of the six thirty-seconds inch cane receiving severe pruning and the group of seven thirty-seconds inch canes on the lightly pruned vines, each increment in cane diameter is accompanied by an increase in shoot diameter, although this increase is sometimes less than 0.01 of an inch. The average shoot diameters on the larger sized canes would be somewhat greater if the additional shoots produced by nodes with more than one shoot were omitted. This increase, obtained by omitting "second" shoots from the average, which are assumed to be the shoots with the smaller production, is not large, however, amounting to 0.01 of an inch for each diameter group larger than eight thirty-seconds of an inch on the severely pruned vines.

Nodal yields of the canes of the Campbell increase with their diameter. The manner in which the larger yields are obtained is partially through the production of more vigorous shoots which produce more and larger bunches than less vigorous ones, partially through a greater percentage of the buds producing fruiting shoots and partially through a larger percentage of the nodes producing more than one shoot. There are, of course, a few exceptions to the regular increase in productivity as cane diameter increases; but when they occur, the higher yielding group achieves its greater yield by excelling the lower in the greater vigor that is shown. An example may be cited in the difference shown in the data for the severely pruned plot in 1929 when a single 15-bud cane six thirty-seconds of an inch in diameter yielded 15.9 ounces per node and the average of a group of these seven thirty-seconds inch canes was only 8.1 ounces. The six thirty-seconds inch cane has 80 per cent of its nodes fruitful, the seven thirty-seconds inch cane but 71 per cent. The six thirty-seconds inch cane had no nodes with multiple shoots, the seven thirty-seconds inch canes had two per cent. The six thirty-seconds inch cane produced shoots averaging 0.20 inch in diameter, the seven thirty-seconds inch canes 0.19 inch in diameter.

There is no need to choose canes of different diameters if the length of the cane is to be varied. Table IX has been prepared showing the nodal yields of canes of different diameters pruned to different numbers of nodes. There are numerous instances in which exceptions occur, but, in general, there is an increase in the nodal yield as the cane diameter becomes larger, no matter to what length the canes may be pruned. The data are quite similar when results from other pruning treatments and other years are examined, the exceptions to the regular increases merely occurring at different points in the table.

Table IX.—The Nodal Production of Canes of Different Numbers of Nodes and Diameters, Light Pruning, 1929.

Diameter of cane	Number of nodes on cane				
	7	8	10	15	20
5/32	4.6 (2)	4.2 (2)	4.8 (1)	....	....
6/32	5.8 (13)	5.0 (4)	3.4 (7)	....	5.0 (1)
7/32	5.0 (16)	5.5 (14)	5.2 (9)	7.4 (8)	6.4 (7)
8/32	5.7 (3)	4.7 (10)	6.3 (12)	6.0 (16)	7.6 (8)
9/32	4.6 (4)	4.7 (7)	5.5 (13)	8.8 (11)	7.3 (17)
10/32	7.0 (5)	7.0 (5)	6.8 (5)	9.4 (6)	6.5 (8)
11/32	....	11.9 (1)	6.2 (4)	10.4 (7)	7.8 (2)
12/32	....	8.6 (1)	1.3 (1)	10.3 (1)	8.6 (1)
13/32	6.0 (1)	....	....	....	13.5 (1)

Numbers in parentheses indicate number of canes in each group.

The preceding data have all dealt with canes of a length of six or more nodes. The nodal yields of spurs have been arranged in Table X. The diameters were measured at the center of the last internode in

Table X.—Average Nodal Production of Three and Four-bud Spurs of Various Diameters.

Diameter of spur	3-bud spurs				4-bud spurs	
	1926	1927	1928	1929	1928	1929
4/32	4.4 (3)	....	....	0.3 (2)	....	....
5/32	5.0 (5)	0.9 (2)	2.6 (6)	4.7 (4)	5.0 (2)	3.6 (2)
6/32	2.8 (7)	3.9 (11)	2.9 (13)	4.5 (9)	3.5 (12)	4.2 (9)
7/32	3.8 (8)	4.4 (6)	3.2 (20)	4.9 (13)	5.1 (19)	5.0 (11)
8/32	2.2 (12)	3.1 (8)	4.1 (26)	5.2 (25)	2.7 (23)	5.1 (21)
9/32	2.5 (7)	3.2 (4)	3.1 (8)	4.7 (15)	3.9 (19)	5.3 (19)
10/32	0 (2)	3.7 (6)	2.8 (12)	5.5 (12)	6.0 (14)	4.4 (18)
11/32	0 (1)	3.3 (3)	2.3 (6)	3.0 (9)	3.0 (5)	5.7 (12)
12/32	....	2.8 (1)	2.6 (2)	9.1 (4)	....	4.0 (1)
13/32	0.5 (1)	....	0.7 (1)	....	....	12.4 (2)
14/32	....	....	....	....	....	....
15/32	....	0.8 (1)	....	....	....	....

Numbers in parentheses indicate number of spurs in each group.

each case, and so are not strictly comparable with the diameters of canes measured farther out on the cane because grape canes increase in diameter toward their bases. The groups tabulated are those groups which contained the largest numbers of individuals. It will be observed that there are marked irregularities in the yield of spurs of various sizes, so great in amount that no conclusion as to the relative fruitfulness of spurs of different sizes is justified. The differences in the means obtained by averaging the figures for each diameter in the table are small. It is evident that the large spurs are able to yield about as well as the small ones. There is, however, a positive correlation between the size of shoots produced on a spur and its diameter. In view of the smaller nodal yields of spurs, they should not be used for fruit production, but only to furnish necessary renewal. Consequently, the spurs to be retained should be the largest ones so that large fruiting canes may be produced for fruiting the following season.

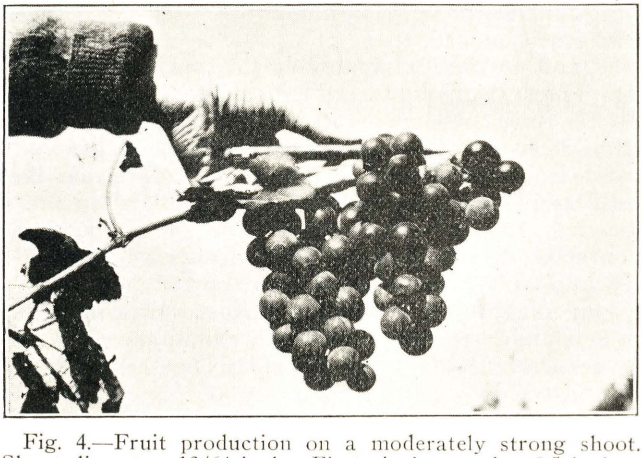

Fig. 4.—Fruit production on a moderately strong shoot. Shoot diameter, 13/64 inch. First six internodes, 9.5 inches. Cluster weights: 1, 7.5 oz., 2, 8 oz.

The Relation of Internodal Length to Productiveness

It has been shown (Partridge, 1925) that the productiveness of Concord canes is associated with the internodal length as measured between the fifth and sixth buds. The canes with this internode measuring from five to eight inches in length produced the largest yields. Clark (1925) has shown that there is a positive correlation between total cane length and internodal length. Concord canes of moderate length, from five to nine feet, were found most productive by Schrader (1923) and Clark (1925). It seemed advisable to determine whether there was any association between internodal length and productiveness in the Campbell Early grape. Internodal length measurements were taken of all the canes. These results have been tabulated and are presented in Table XI. These data show that the canes with the shorter internodal lengths are not as productive as those with moderate lengths.

Table XI.—Nodal Yields of Canes of Different Internodal Lengths from all Pruning Treatments and of all Cane Lengths.

Internodal length, inches	1926	1927	1928	1929
1	5.6 (70)	3.1 (10)	5.4 (6)	4.5 (1)
2	6.6 (237)	3.8 (121)	6.0 (52)	6.2 (29)
3	7.8 (112)	3.4 (257)	7.8 (200)	7.7 (131)
4	8.5 (14)	3.7 (161)	9.6 (161)	8.0 (183)
5	3.9 (2)	3.6 (307)	10.0 (6)	9.1 (96)
6	....	3.4 (1)	4.2 (1)	7.7 (27)
7	....	....	....	7.2 (4)

Numbers in parentheses indicate number of canes in each group.

At the same time, the canes with the longest internodal lengths, those with greater lengths than five inches, are somewhat less productive than those of more moderate length. The number of canes of the longest internodal lengths are relatively few in number, and these results are not considered very significant.

As in the case of Concord, there is a positive correlation between the cane diameter and internodal length measurements which are given in Table XII. These coefficients indicate a moderately strong correlation between the two measurements. As in the case of the Concord, the correlation between cane performance and internodal length is smaller than it is between cane productivity and cane diameter. In view of the differences encountered in nodal yield when the severity of pruning is varied, either of the whole vine or of the cane, the coefficient of correlation was determined for only the groups of 15-bud canes in 1928 and 1929. The data are presented in Table XIII which shows that four of the six coefficients of correlation between internodal length and yield are very small. In every group of canes the coefficient between cane diameter and yield exceeds that between internodal length and yield.

Table XII.—The Relationship Between Internodal Length and Cane Diameter.

Type of pruning	1926	1927	1928	1929
Light	+.55±.04	+.55±.03	+.71±.02	+.59±.03
Moderate	+.38±.05	+.65±.03	+.47±.04	+.59±.04
Severe	+.54±.05	+.65±.03	+.32±.06	+.52±.05
All types	+.48. ±02	+.54±.02	+.57±.02	+.59±.02

In pruning the Campbell Early, little attention need be given the internodal length of the fruiting canes. If the most vigorous canes are selected on the basis of diameter, little difference in productiveness need be expected from a further selection on a basis of internodal length.

Table XIII.—Coefficients of Correlation Between Diameter and Yield and Internodal Length and Yield for 15-bud Canes.

Type of pruning	Coefficient of correlation for diameter and yield	Coefficient of correlation for internodal length and yield
	1929	
Light pruning	+.55±.07	+.13±.09
Medium pruning	+.37±.08	+.11±.10
Severe pruning	+.53±.07	+.31±.09
	1928	
Light pruning	+.37±.08	+.16±.09
Medium pruning	+.74±.04	+.32±.09
Severe pruning	+.20±.09	+.13±.09

The Location of the Most Fruitful Portion of the Cane

There are varietal differences in the location of the most fruitful nodes on pruned grape canes, as has been shown by Keffer (1906) in his study of the fruiting habits of the Concord, Niagara, Delaware, and Brighton varieties in Tennessee.

Data have been presented which show the marked influence of current season's growth on the performance of the fruiting shoots. The severity of the pruning of either the vine or the cane exerts a marked influence upon the amount of growth which any particular shoot will make. Consequently, any grouping of canes or nodes which includes canes which are pruned to various lengths or which are growing on vines of differing vigor or which have received pruning of varying severity, are likely to be more or less misleading. An examination of the data will reveal some of the irregularities which occur. It is thought worth while, however, to present data showing the yield of all the nodes of these vines, since such a miscellaneous grouping of canes is more or less characteristic of the conditions found in the ordinary Campbell Early vineyard.

The average production obtained from each node during the four year test is given in Table XIV. The most marked characteristic is the low yield of the basal nodes, which is similar to the results previously reported for all four of the varieties studied by Keffer. The results for 1926 alone show an increasing yield from the base to the tip of the cane. In 1927 the high yielding section extended from node five to node 10, in 1928 from node six to node 15 and in 1929 from node 10 to node 15. The marked reduction in yield reported for 1928 and 1929 for the last five nodes is largely due to the fact that the only 20-bud canes were on the vines which received light pruning and which had smaller nodal yields than the vines receiving more severe pruning. It is true, however, that the distal five nodes had somewhat smaller nodal yields than the central section of these 20-bud canes but the

Table XIV.—Average Production of Nodes on Canes of All Lengths.

Node number	Crop of 1926					Crop of 1927					Crop of 1928					Crop of 1929				
	No. nodes	Oz. per node	Oz. per bunch	Bun. per node	Oz. per fruit-ing node	No. nodes	Oz. per node	Oz. per bunch	Bun. per node	Oz. per fruit-ing node	No. nodes	Oz. per node	Oz. per bunch	Bun. per node	Oz. per fruit-ing node	No. nodes	Oz. per node	Oz. per bunch	Bun. per node	Oz. per fruit-ing node
1	569	1.3	3.7	0.3	6.3	683	1.5	4.6	0.3	7.4	656	0.8	4.0	0.2	7.5	659	0.8	3.9	0.2	5.7
2	569	5.2	4.8	1.1	9.3	683	3.8	4.6	0.8	7.7	656	3.1	4.5	0.7	8.6	659	3.4	5.1	0.7	8.7
3	569	6.4	5.1	1.2	10.2	680	3.4	4.3	0.8	6.9	656	4.1	4.6	0.9	8.3	659	5.3	5.7	0.9	10.4
4	523	6.4	5.4	1.2	11.1	638	3.5	4.6	0.7	7.5	562	6.4	5.0	1.3	9.8	566	6.5	5.4	1.2	10.3
5	503	6.5	5.7	1.1	11.8	622	4.1	5.3	0.8	8.5	469	8.5	5.6	1.5	12.4	471	8.0	6.1	1.3	11.7
6	437	7.4	5.9	1.2	12.7	585	3.9	5.1	0.8	8.0	469	10.2	6.1	1.7	14.1	471	9.0	6.2	1.4	12.5
7	417	8.4	6.4	1.3	14.8	542	4.1	5.4	0.8	8.9	469	10.6	6.2	1.7	14.6	471	9.3	6.2	1.5	12.1
8	361	8.2	6.3	1.3	14.0	478	4.0	5.7	0.7	9.0	424	12.5	6.6	1.9	16.2	427	9.6	6.2	1.6	13.1
9	286	8.2	6.2	1.3	14.3	368	4.0	5.9	0.7	9.1	278	12.5	6.9	1.8	16.7	288	10.2	6.2	1.6	13.5
10	248	9.2	6.0	1.5	14.7	325	4.4	5.6	0.8	9.3	278	11.9	6.7	1.8	16.5	288	10.9	6.5	1.7	13.7
11	131	9.5	6.0	1.6	15.6	167	3.6	5.8	0.6	9.2	189	12.6	6.7	1.9	16.3	190	13.0	6.7	1.9	15.7
12	99	7.9	6.3	1.2	15.0	131	3.4	5.8	0.6	9.4	189	13.3	7.2	1.8	17.4	190	14.2	7.0	2.0	16.7
13	65	8.4	6.4	1.3	16.6	78	3.2	5.8	0.6	8.4	189	11.6	7.2	1.6	17.3	190	13.8	6.9	2.0	16.3
14	52	9.1	6.7	1.4	14.3	68	2.6	4.7	0.6	8.5	189	10.5	7.2	1.5	17.1	190	15.3	7.6	2.0	18.8
15	38	9.8	6.8	1.4	17.7	61	3.6	4.9	0.7	8.4	189	10.9	6.6	1.7	16.0	190	13.0	7.1	1.8	17.1
16	8	12.4	7.9	1.4	17.4	14	1.4	3.3	0.4	6.7	46	8.4	5.8	1.4	12.9	45	7.2	4.8	1.5	10.4
17	....	....	....	....	....	4	1.2	5.0	0.2	5.0	46	9.1	6.1	1.5	14.4	45	9.2	5.1	1.8	11.2
18	....	....	....	....	....	2	6.2	12.5	0.5	12.5	46	8.5	6.3	1.3	13.0	45	8.1	5.3	1.5	10.4
19	....	....	....	....	....	2	0	....	0	....	46	8.0	5.8	1.4	12.2	45	6.8	4.6	1.5	8.8
20	....	....	....	....	....	2	10.0	10.0	1.0	20.0	46	9.5	6.2	1.5	12.5	45	6.6	4.7	1.4	9.6
21	....	....	....	....	....	1	0	....	0	....	....	....	....	....	....	....	....	....	....	....
All	4,875	6.5	5.7	1.1	12.1	6,134	3.6	5.1	0.7	8.2	6,092	7.8	6.0	1.3	13.5	6,134	7.7	6.1	1.3	12.6

actual difference in productivity is much less than is indicated by the table. With the exception of the 1926 results, there is a marked tendency for the high-yielding nodes each year to be further removed from the base of the cane. The vines have been increasing in vigor during this period, which is the probable reason for this change.

The relative fruitfulness of the nodes depends upon the vigor of the fruiting cane to a certain degree. There is much less difference between the productivity of the basal and terminal nodes on the canes of small diameter than is found with canes of the larger diameters. Table XV has been prepared from the 1929 data obtained from the 15-bud canes on the moderately pruned vines. These data are quite similar in general character to those obtained under the other pruning treatments. There are many irregularities in the table, but the tendency of the nodes of the terminal third of the cane to increase in productivity most rapidly as the diameter of the cane increases in size is very apparent. There is a tendency for the center of productivity to swing away from the base of the cane as vigor increases. This is not due to a decrease in the productivity of the basal nodes but is primarily caused by the greater yield secured from the terminal third of the cane. When similar data were compiled for the 20-bud canes, which were divided into quarters, very similar results were secured for the three basal quarters. There is the same tendency for the center of productivity to move away from the base of the cane as the diameter is increased. The yield of the terminal quarter, however, does not show much tendency to increase with the diameter of the cane. The fluctuations in the data for this quarter are very marked and so irregular that no definite tendency toward increase or decrease in productivity can be established.

Table XV.—Average Number of Ounces of Fruit Produced Per Node on the Basal, Median and Terminal Thirds of the 15-bud Canes, Moderately Pruned Vines, Crops of 1928 and 1929.

Cane diameter	No. of canes	Average number of ounces harvested per node		
		Nodes 1-5	Nodes 6-10	Nodes 11-15
Crop of 1928				
6/32	4	3.3	7.5	5.4
7/32	8	5.3	9.5	8.9
8/32	10	3.7	11.1	13.2
9/32	11	5.6	17.2	16.5
10/32	8	5.5	17.6	18.7
11/32	6	3.5	19.3	20.6
12/32	1	11.5	33.7	34.2
Crop of 1929				
7/32	5	3.6	8.5	10.2
8/32	6	3.9	11.2	12.0
9/32	10	4.8	7.3	14.9
10/32	14	4.3	12.2	16.9
11/32	9	6.4	10.4	16.7
12/32	3	3.7	9.7	20.3
13/32	1	14.6	9.6	22.7

The total yield of a node depends upon the number of the bunches produced and upon the weight of the bunches. Table XIV gives the average weight of bunches produced at each node and the average number of bunches produced per node. It will be observed that, in general, the portions of the cane with the heaviest bunches are those on which the greatest yields were reported. Those regions which are characterized by the largest total production are also found to show the greatest number of bunches per node. High yields are dependent in the Campbell Early, as well as in the Concord, on the production of many as well as large bunches. With the larger bunch, characteristic of this variety, the weight of the bunch is more influential in determining the weight of fruit per node than is the case with Concord.

The average yield per node is affected by the proportion of the nodes that are unfruitful as well as by the production of more than one fruitful shoot from the node. The basal portion of the cane is characterized by the failure of some of the buds to break. Those unfruitful nodes that are located more distantly from the base of the cane usually fail to produce fruit because of some accident to the bud, although a few dormant buds are found on all portions of the cane. Barren shoots are occasionally produced, usually following an accident to the first shoot, although they may often be found with the fruitful first shoot still present on the node. The more vigorous first shoots are more brittle and are lost more frequently than the slower growing second shoots. Table XVI shows the percentage of nodes producing fruitful shoots. Here as in Table XIV, which shows the average weight of the fruit of the productive nodes, the region of highest production of fruitful shoots occurs close to the region of high yield.

The percentage increase in yield due to the development of multiple shoots from the nodes is something less than the percentage of the nodes with extra shoots since the primary bud usually produces the most fruitful shoot of the group. This has been shown to be the case with Concord by Wiggans (1926). In most cases where multiple shoots grow from a single node but two are found, but sometimes three shoots are recorded and very rarely four. Nodes with multiple shoots are usually on vigorous canes. They are more frequently found on the distal portion of the cane and are seldom observed on the basal portion of canes of any considerable number of nodes but are found on spurs. The more severe the pruning of the vine or cane, the greater is the tendency for multiple shoots to develop.

The data show that the heaviest bunches, the greatest number of bunches per node, the smallest percentage of unfruitful nodes, the largest percentage of nodes with multiple shoots, the most productive shoots, and the largest yield of fruit are found in the same general region of the cane. It is shown further that this most productive region varies rather markedly from year to year, apparently tending to move away from the base of the cane as the vines become more vigorous.

The Number of Buds Desirable on the Different Canes

The number of buds to be left on the different canes is a matter of considerable importance with Campbell Early vines. It is much more important to retain canes that will give the greatest yield of high

Table XVI.—Average Percentages of Nodes Producing Fruit and Multiple Shoots; Canes of All Lengths.

Node number	Crop of 1926			Crop of 1927			Crop of 1928			Crop of 1929		
	Number nodes	Per cent nodes fruiting	Per cent nodes multiple	Number nodes	Per cent nodes fruiting	Per cent nodes multiple	Number nodes	Per cent nodes fruiting	Per cent nodes multiple	Number nodes	Per cent nodes fruiting	Per cent nodes multiple
1	569	20	2	683	20	3	656	10	2	659	13	2
2	569	56	2	683	50	2	656	36	2	659	39	1
3	569	62	5	680	50	5	656	49	3	659	51	3
4	523	58	6	638	46	9	562	65	8	566	63	7
5	503	55	6	622	49	9	469	69	13	471	68	8
6	437	59	9	585	49	10	469	72	15	471	71	10
7	417	57	13	542	46	12	469	72	16	471	76	15
8	361	59	9	478	44	12	424	78	19	427	74	19
9	286	57	12	368	44	12	278	75	14	288	76	13
10	248	63	14	325	47	12	278	72	13	288	80	11
11	131	61	16	167	40	10	189	77	12	190	83	15
12	99	53	9	131	36	10	189	76	8	190	85	17
13	65	51	12	78	38	13	189	67	10	190	85	19
14	52	63	19	68	31	10	189	61	8	190	82	16
15	38	55	13	61	43	7	189	68	12	190	76	19
16	8	71	14	14	21	14	46	65	2	45	69	2
17	....	....	....	4	25	25	46	63	2	45	82	0
18	....	....	....	2	50	0	46	65	0	45	78	0
19	....	....	....	2	0	0	46	65	0	45	78	4
20	....	....	....	2	50	0	46	76	2	45	69	2
21	....	....	....	1	0	0	....	....	....	....	....	....
All	4,875	54	7	6,134	44	8	6,092	58	9	6,134	61	9

quality, large-sized bunches, than it is to follow any definite training system with a definite number of canes. Many growers seem to believe that four canes should be used on every grape vine, no matter what its condition may be. An examination of the data presented seems to show the fallacy of this opinion, at least with the Campbell Early.

Table XVII shows the yield of the average node on the canes pruned to different numbers of nodes in each of the four years of the test. During the first two years, the canes were pruned to various lengths, with the result that in many instances the numbers of canes of any length were few in number. In consolidating the results from the three pruning treatments into a single table the group was often more or less dominated by a group of canes from one pruning treatment while another group was dominated by canes from another treatment.

Fig. 5.—Fruit production on a vigorous shoot. Shoot diameter, 9/32 inch. First six internodes, 15 inches. Cluster weights: 1, 10 oz., 2, 16 oz., 3, 6.5 oz.

Thus the data in the table are not strictly comparable. During the last two years of the experiment, the same length canes were left on all vines receiving the same pruning treatment. The comparative value of canes of different lengths is much more apparent, particularly when the source of the canes is noted. The three-and four-bud spurs were on vines pruned moderately and severely. The 7 and 20-bud canes were all on lightly pruned vines. Eight and 15-bud canes were left on all vines. The 10-bud canes were on the moderately and lightly pruned vines.

The data show that spur pruning does not lead to as large nodal production, under the conditions of this experiment, as does cane pruning. In 1927, however, when the production was not large on any type of cane, the spurs produced about as well as the canes. It should

Table XVII.—Average Nodal Production of Canes Pruned to Various Numbers of Nodes.

No. nodes on cane	Crop of 1926					Crop of 1927					Crop of 1928					Crop of 1929				
	No. canes	Oz. per node	Oz. per bunch	Bun. per node	Oz. per fruiting node	No. canes	Oz. per node	Oz. per bunch	Bun. per node	Oz. per fruiting node	No. canes	Oz. per node	Oz. per bunch	Bun. per node	Oz. per fruiting node	No. canes	Oz. per node	Oz. per bunch	Bun. per node	Oz. per fruiting node
2	...	...	...	...	...	3	11.7	8.8	1.3	23.5	...	...	...	...	...	...	...	...	...	...
3	46	2.9	4.0	0.7	6.6	42	3.4	4.2	0.8	7.3	94	3.2	4.5	0.7	8.1	93	4.9	6.4	0.8	10.4
4	20	4.4	4.8	0.9	8.8	16	2.0	4.1	0.5	5.7	93	4.1	5.0	0.8	9.6	95	5.1	5.9	0.9	10.5
5	66	4.4	5.2	0.8	10.0	37	3.2	5.1	0.6	8.0	...	...	...	...	...	...	...	...	...	...
6	20	5.8	5.3	1.1	11.2	43	3.2	4.7	0.7	7.1	...	...	...	...	...	...	...	...	...	...
7	56	6.5	5.7	1.1	11.8	64	3.5	5.0	0.7	8.2	45	5.1	5.1	1.0	10.7	44	5.4	5.3	1.0	10.0
8	75	6.5	5.9	1.1	12.4	110	3.4	5.0	0.7	8.3	146	7.0	5.8	1.2	13.1	139	6.4	6.1	1.1	11.9
9	38	7.4	5.8	1.3	12.8	43	4.3	5.3	0.8	9.1	...	...	...	...	...	...	...	...	...	...
10	117	7.0	5.8	1.2	12.6	158	3.6	5.2	0.7	8.2	89	7.7	6.2	1.2	13.5	98	6.5	6.0	1.1	11.9
11	32	6.4	5.6	1.1	11.8	36	3.7	5.1	0.7	7.9	...	...	...	...	...	...	...	...	...	...
12	34	6.9	5.6	1.2	12.5	53	3.5	5.0	0.7	7.9	...	...	...	...	...	...	...	...	...	...
13	13	6.3	5.6	1.1	12.4	10	3.9	5.4	0.7	9.2	...	...	...	...	...	...	...	...	...	...
14	14	8.0	6.2	1.3	13.9	7	4.2	5.2	0.8	8.6	...	...	...	...	...	...	...	...	...	...
15	31	7.2	5.9	1.2	13.1	47	3.7	5.1	0.7	8.5	143	9.9	6.5	1.5	15.3	145	10.2	6.8	1.5	14.8
16	7	6.7	5.5	1.2	11.4	10	3.1	4.2	0.7	6.7	...	...	...	...	...	...	...	...	...	...
17	...	...	...	...	...	2	3.1	5.5	0.6	8.7	...	...	...	...	...	...	...	...	...	...
20	...	...	...	...	...	1	5.6	8.7	0.6	14.1	46	8.2	5.7	1.4	12.4	45	7.2	4.9	1.5	10.3
21	...	...	...	...	...	1	0.5	3.8	0.1	3.8	...	...	...	...	...	...	...	...	...	...
All	569	6.5	5.7	1.1	12.1	683	3.6	5.1	0.7	8.2	656	7.8	6.0	1.3	13.5	659	7.7	6.1	1.3	12.6

be mentioned in this connection that this vineyard was originally trained on the spur system and that it was able to produce enough fruit on spurs to overbear in 1923 and throw the vineyard out of bearing. The best number of nodes that were left in 1926 were 14, 9, 15, and 10 and in 1927 were 2, 20, 9, and 14. It is difficult to draw very definite conclusions from the data for these years. In 1928 and 1929, however, the 15-bud canes were much more productive than those of any other length. This same cane length was associated with the heaviest bunches and the greatest number of bunches per node and with the largest production from fruitful nodes. The data presented in Table XVIII show that there was a smaller percentage of unfruitful nodes on the 20-bud canes both years than on the 15-bud canes, while the shorter canes had larger percentages, the greater the number of buds on the cane the greater the percentage of fruitful nodes. There was a larger percentage of nodes with multiple shoots on the 8-bud canes in 1928 but the maximum percentage was found on the 15-bud canes in 1929.

With one exception, the 15-bud canes gave the greatest nodal yield of any cane length under all three pruning treatments in 1928 and 1929. This exception was the 20-bud canes on the lightly pruned vines in 1928. The largest bunches and the greatest yields of fruiting nodes were on the 15-bud canes with the same exception. The 10-bud canes on the lightly pruned vines in 1928 also surpassed the 15-bud canes in average weight of bunch. The average number of bunches per node increased with the length of the cane with all three pruning treatments both in 1928 and 1929, as did the percentage of nodes producing fruit, with a few minor exceptions.

Table XIX was prepared to show the differences in yield of canes pruned to the same length, but growing on vines receiving different pruning treatments. The data for the years 1926 and 1927 are somewhat obscure, owing to the presence of but few individuals in the various groups. The results secured in 1928 and 1929 are quite regular, showing a marked increase both in number of bunches produced per node and in the average weight of bunch as the pruning treatment became more severe. The percentage of increase in the productiveness of the nodes as the pruning treatment became more severe was greater with the longer than the shorter canes.

From the data shown, it appears better practice to use rather long canes for fruiting the Campbell Early. If the vines require about 30 buds, it would probably be better to leave but two canes instead of the four that are usually used. With somewhat stronger vines, three canes might be left but it would be necessary to have a very vigorous vine before it would be advisable to leave four fruiting canes. In order to secure the best exposure to light and to avoid some of the danger of early spring frosts, the canes should be trained on the upper wire rather than on the lower one.

When long canes are used for fruiting it is usually a good plan to use spurs to secure good renewal for the following crop. While satisfactory renewal may be secured easily when the canes are pruned short, it is frequently difficult to find large enough canes the following season close to the vine trunk on the longer canes. The shoots that grow from the basal nodes of long canes are usually rather weak.

Table XVIII.—Average Percentages of Nodes Producing Fruit and Multiple Shoots, Canes of Various Lengths.

Number nodes on cane	Crop of 1926			Crop of 1927			Crop of 1928			Crop of 1929		
	Number canes	Per cent nodes fruiting	Per cent nodes multiple	Number canes	Per cent nodes fruiting	Per cent nodes multiple	Number canes	Per cent nodes fruiting	Per cent nodes multiple	Number canes	Per cent nodes fruiting	Per cent nodes multiple
2				3	50	0						
3	46	43	8	42	47	15	94	40	5	93	47	8
4	20	50	2	16	36	11	93	43	7	95	49	4
5	66	44	7	37	41	9						
6	20	52	8	43	45	8						
7	56	55	10	64	43	9	45	48	8	44	54	5
8	75	52	8	110	41	10	146	54	13	139	54	11
9	38	58	9	43	48	14						
10	117	55	8	158	44	7	89	57	9	98	54	10
11	32	54	6	36	46	7						
12	34	55	7	53	44	5						
13	13	51	5	10	42	12						
14	14	58	6	7	49	9						
15	31	55	7	47	44	6	143	64	10	145	69	12
16	7	59	8	10	47	7						
17				2	35	6						
20				1	40	0	46	66	4	45	70	5
21				1	14	10						
All	569	54	7	683	44	8	656	58	9	659	61	10

Table XIX.—Comparative Fruiting of 8 and 15-bud Canes on Vines Receiving Different Pruning Treatments.

Kind of pruning	8-bud canes			15-bud canes		
	Oz. per node	Bunches per node	Oz. per node	Oz. per node	Bunches per node	Oz. per node
1926						
Severe	5.6 (24)	1.0 (24)	5.6 (24)	....	....	....
Moderate	6.8 (47)	1.1 (47)	6.1 (47)	9.4 (6)	1.4 (6)	6.9 (6)
Light	7.9 (4)	1.7 (4)	4.8 (4)	6.7 (25)	1.2 (25)	5.6 (25)
1927						
Severe	3.5 (33)	0.7 (33)	4.7 (33)	....	....	....
Moderate	3.5 (70)	0.7 (70)	5.0 (70)	3.4 (6)	0.7 (6)	4.9 (6)
Light	2.8 (7)	0.4 (7)	6.2 (7)	3.8 (41)	0.7 (41)	5.2 (41)
1928						
Severe	8.2 (48)	1.3 (48)	6.3 (48)	11.4 (46)	1.6 (46)	7.0 (46)
Moderate	7.0 (47)	1.2 (47)	6.0 (47)	11.4 (48)	1.6 (48)	7.0 (48)
Light	5.9 (51)	1.1 (51)	5.3 (51)	6.9 (46)	1.3 (46)	5.3 (46)
1929						
Severe	7.2 (47)	1.1 (47)	6.3 (47)	12.6 (48)	1.7 (48)	7.4 (48)
Moderate	6.6 (48)	1.0 (48)	6.4 (48)	10.2 (48)	1.5 (48)	7.0 (48)
Light	5.5 (44)	1.0 (44)	5.5 (44)	8.0 (45)	1.3 (45)	5.9 (45)

Numbers in parentheses indicate number of canes in each group.

Severity of Pruning and Fruit Production

In varying the number of buds by different pruning treatments, the potential fruiting capacity of the vines is directly affected by the treatment, as was suggested by Keffer (1906). The greater the number of fruiting shoots available for crop production, the larger the crop produced, unless there is a marked difference in the potential fruitfulness of the buds left upon the vines. In this block of Campbell Early vines, the greater the number of buds left on the vines the greater the total weight of fruit produced, as is shown by the data in Table XX. However, the average weight of the bunches produced has not followed the same course as fruit production.

In Campbell Early, one of the characteristics of the variety is the production of scraggly bunches. These bunches do not have the weight of the compact bunches and are of very inferior character since they do not present a pleasing appearance. The pruning treatments which have given the lowest average weight for the bunches have given the largest percentage of scraggly bunches. The data in Table XX show that the light pruning treatment has given the lightest bunches each year of the test except 1927 and each year there has been a large enough percentage of these bunches to affect the grade of the fruit quite noticeably. In 1927, the quality of fruit under the severe prun-

Table XX.—The Relation Between Severity of Pruning and Fruit Production.

	1926		1927		1928		1929		4-year average	
	Lbs. fruit	Oz. per bunch	Lbs. fruit	Oz. per bunch	Lbs. fruit	Oz. per bunch	Lbs. fruit	Oz. per bunch	Lbs. fruit	Oz. per bunch
Severe pruning	10.6±.58	4.9±.2	8.7±.34	4.6±.1	16.6±.45	6.3±.1	18.3±.44	6.8±.1	13.5	5.6
Moderate pruning	16.9±.65	5.7±.1	10.1±.41	5.1±.1	21.2±.44	6.4±.1	19.8±.56	6.5±.1	17.0	5.9
Light pruning	22.5±.65	5.3±.1	13.7±.41	4.8±.1	26.3±.52	5.4±.1	25.1±.50	5.3±.1	21.9	5.2

Table XXI.—The Relation Between Severity of Pruning and the Production of the Average Bud.

	1926		1927		1928		1929		4-year average	
	Oz. per bud	Per cent of buds fruiting	Oz. per bud	Per cent of buds fruiting	Oz. per bud	Per cent of buds fruiting	Oz. per bud	Per cent of buds fruiting	Oz. per bud	Per cent of buds fruiting
Severe pruning	6.3±.3	54±1.4	3.8±.1	46±1.1	8.8±.2	57±.9	9.9±.2	64±1.0	7.2	55
Moderate pruning	7.5±.3	56±1.1	3.6±.1	43±1.1	8.9±.2	57±.8	8.0±.2	58±1.0	7.0	53
Light pruning	6.3±.2	54±1.1	3.4±.1	43±.9	7.0±.1	59±.6	6.7±.1	62±.8	5.8	54

ing treatment was also lowered somewhat by the presence of scraggly bunches. During the remainder of the experiment, the vines which have been pruned either moderately or severely have had no considerable proportion of scraggly bunches. From the point of view of the production of a large tonnage of fruit of high quality from this particular vineyard, the moderate treatment which left 40 buds per vine has been the best treatment throughout the four year period. From the point of view of maximum fruit production the light pruning treatment of 60 buds per vine has been the most successful. Which treatment would prove the more profitable would depend upon the demands of the particular market supplied, but in most instances it is believed the higher quality fruit would yield the largest income. At any rate, it requires much less time and trouble to harvest the crop.

Table XXI presents some data which show the effect of pruning on the individual buds of these vines. It is interesting to note that there is no consistent difference between the percentage of nodes which actually produce fruiting shoots under different pruning treatments. There is a marked difference in the fruitfulness of the nodes on the vines receiving the different pruning treatments. Comparing the vines receiving moderate and severe pruning treatments the nodes of the former outyielded the latter in 1926, with the reverse condition occurring in 1929. Each year since 1926, the nodes on the vines pruned lightly have produced less fruit than have those on the other two treatments.

Any differences in fruitfulness observed in 1926 could only be due to the difference in the numbers of shoots and blossom clusters carried by the vines or possibly to differences in the behavior of the vines previous to the commencement of the experiment. Those vines which received moderate pruning produced considerably more fruit per node than either of the other rows, but the reason for this difference has not been determined.

Differences in pruning treatment affect the behavior of the vines the following year. The less severe the pruning treatment the greater the number of shoots and amount of fruit that develop that season, as has been observed by Keffer (1906). If the vines overproduce, the quality of the fruit is poorer both in bunch characteristics and in sugar content. In the Concord grape (Partridge, 1925), it has been shown that production is markedly decreased the year following the first full crop of fruit harvested after the commencement of light pruning. With vineyards of weak and moderate vigor, the vines receiving the consistently severe pruning treatments actually overyielded those receiving less severe pruning the following year. The yields from the vines in the very vigorous vineyard did not show this complete reversal of yield, although there was comparatively little difference in their yields after the first harvest. Colby (1925) reports results quite similar to those obtained in the very vigorous vineyard. The total growth of the lightly pruned vines, as measured by the weight of fresh prunings, was very materially reduced during the first season's growth. The behavior of the Muscat (of Alexandria), as reported by Winkler (1927), is very different. Here, there is an increase in vine growth as well as in yield, with no pruning and all the bunches permitted to mature. Here, the depression of growth due to heavy fruiting is less than the depression due to severe pruning. This condition is reversed with most varieties of American bunch grapes, as shown by Keffer (1906) in Tennessee and in Michigan (Partridge, 1925). Heavy fruit production reduces total growth but severe pruning increases total growth because of the reduced fruit production. The Campbell Early seems to be intermediate between these two types of vines. The weight of prunings increased from 2.0 pounds in 1925-1926 to 2.9 pounds in 1928-1929 with the light pruning treatment; from 2.1 to 3.1 pounds with moderate pruning and from 2.1 to 2.8 pounds with severe pruning. The vines receiving all types of pruning increased in vigor under the fertilization that they received. The severely pruned vines increased the least and the moderately pruned vines increased the most in vigor of growth. This does not correspond with the marked increase in vigor of lightly pruned vines observed by Winkler nor does it follow the course of change found in Concord. The depression of growth following severe pruning seems to about equal the depression of growth which results from fruit production. In case of marked over-production of fruit, a depression of growth is to be expected from the results reported by Michigan growers.

Table XXII.—Fruitfulness of Vines Pruned to Long and Short Canes.

Kind of canes	Number of vines	Year	Lbs. per vine	Oz. per bunch
Severe Pruning				
3-bud	4	1926	6.7	3.4
7 and 8-bud	15	1926	10.6	5.0
10-bud	11	1926	16.0	6.0
3-bud	4	1927	6.9	3.2
7 and 8-bud	17	1927	7.8	3.6
10-bud	14	1927	10.1	4.6
Moderate Pruning				
8-bud	8	1926	18.4	5.9
10-bud	10	1926	18.3	5.7
1, 10 and 2 15-bud	6	1926	23.9	6.5
8-bud	12	1927	10.1	4.8
10-bud	12	1927	10.6	5.1
Light Pruning				
10-bud	9	1926	22.7	4.8
12-bud	9	1926	25.8	5.2
15-bud	7	1926	23.3	5.2
10-bud	14	1927	14.1	4.8
12-bud	9	1927	14.0	5.0
15-bud	8	1927	15.6	4.7

The Relative Productiveness of Vines Pruned to Long and Short Canes

All the vines were pruned to a few schedules of canes of different lengths in 1926 and 1927, but there were scarcely enough vines available in the various groups to give consistent results when the different types were compared. However, the data were consistent enough to warrant the conclusion that vines pruned to spurs are less productive than similar vines on which short canes are left, and, further, that vines pruned to long canes are more productive than those pruned to short canes. These data are given in Table XXII. Little difference is shown between the productiveness of the vines pruned to 8 and 10-bud canes with moderate pruning and there are some inconsistencies each year with the lightly pruned vines. There is a greater difference in productiveness between vines pruned to spurs and those pruned to short canes than there is between vines pruned to short canes and those pruned to longer ones.

In general, bunch size follows the course of total yield in the data. The vines pruned to the longer canes averaged larger bunches as well as a greater total yield.

It might be thought that these differences in yield and bunch size might be due to differences in the vigor of the vines of the various groups. While such differences in vigor do occur, owing to the small number of vines in these groups, the results are similar when the vines are subdivided according to their pruning weights the preceding winter. The consistency of the results is about the same as when the vines are lumped together.

Growth and Yield

It has been shown by many that there is a relationship between the total growth that a plant makes and its fruiting capacity. What form a growth-yield curve will take depends upon the amount of growth being made by the individuals examined. If the plants are of the least vigorous type, the curve will mount constantly as vigor increases. If they are moderately vigorous, production will rise with growth up to a certain point and then will fall off with further augmentation of growth. With very vigorous individuals, production will be decreased as growth increases. These responses depend upon the chemical composition of the plant which causes variations in growth and is then altered by these changes in growth. This was shown to be the case with the carbohydrate-nitrogen ratio in tomatoes by Kraus and Kraybill (1918) and was shown for carbohydrates in vinifera grapes by Mueller-Thurgau (1898). The exact shape of the curve and the location of the highest point of productivity will be influenced by seasonal conditions and also by the pruning.

The curves obtained by plotting the data obtained on the relationship between the total yield of these Campbell Early vines and their pruning weights the preceding season, which are given in Table XXIII, in general give graphs of the intermediate type with reductions in productivity for both the least and most vigorous vines. The maximum yields are found in the group of vines whose prunings weighed from 2.0 to 2.9 pounds the preceding winter. The obvious conclusion would be that any further increase in vine growth would be likely to cause the vines to become less productive. However, as the vines have become more vigorous during the course of the experiment, the shape of the curve has altered materially, the vines with the maximum production were more vigorous in 1929 than in previous years and even in 1928 there was some tendency for this swing of productivity to become apparent. In each group of data, the number of vines in the most vigorous groups has been small, but the results have been consistent enough to seem significant. Only three explanations suggest

Table XXIII.—The Relation Between the Vine Growth the Preceding Season and Fruit Yield; Average Pounds of Prunings and Average Pounds of Fruit Per Vine.

Prunings	0.1–0.9	1.0–1.9	2.0–2.9	3.0–3.9	4.0–4.9	5.0–5.9	6.0–6.9	7.0–7.9
Light Pruning								
Crop of								
1926	16.8 (9)	24.8 (16)	25.0 (14)	20.2 (6)	20.7 (3)	....	....	....
1927	9.0 (4)	13.4 (19)	15.8 (16)	10.8 (5)	15.7 (1)	13.1 (2)	19.7 (1)	....
1928	19.4 (2)	23.6 (15)	27.4 (19)	28.8 (8)	32.3 (2)	27.4 (2)	....	....
1929	....	19.8 (10)	23.5 (17)	28.5 (17)	28.1 (2)	30.5 (1)	....	35.6 (1)
Moderate Pruning								
Crop of								
1926	11.3 (5)	16.7 (19)	20.4 (14)	17.4 (8)	5.5 (2)	....	....	....
1927	6.3 (4)	10.7 (12)	11.3 (19)	9.0 (11)	10.2 (1)	8.6 (1)	....	....
1928	11.0 (2)	21.3 (9)	23.0 (20)	20.2 (12)	20.9 (5)	....	....	....
1929	10.2 (1)	16.8 (5)	17.7 (12)	20.5 (24)	19.7 (3)	30.9 (3)	....	....
Severe Pruning								
Crop of								
1926	8.1 (5)	11.5 (17)	11.7 (16)	10.2 (7)	2.4 (2)	....	....	....
1927	5.4 (5)	8.4 (11)	9.3 (21)	8.8 (7)	11.2 (2)	7.8 (1)	....	....
1928	7.9 (1)	15.6 (12)	17.4 (21)	17.4 (11)	14.9 (3)	....	....	....
1929	....	14.3 (7)	17.7 (23)	21.1 (12)	20.0 (5)	17.8 (1)	....	....

Numbers in parentheses indicate number of vines in each group.

themselves. The failure of the very vigorous vines to produce up to their capacity in 1926, 1927, and 1928 may have been due to a hold-over effect from their over-production in 1923, to seasonal conditions, or to a difference in location in the vineyard which permitted unequal spring frost injury, the greatest injury falling on the strongest vines. It is quite possible that all three factors have a part in causing this result.

About half of the most vigorous vines are at the north end of the vineyard where the site is the lowest and frost injury has been most marked. Unfavorable seasonal conditions, other than frost, particularly early in the season before and during bloom also would be more likely to reduce the yield of the stronger vines to a greater extent than less vegetative vines. Unfortunately, detailed records of weather and growth conditions were not kept in this vineyard so it is impossible to offer data on this point. It is also impossible to determine how much of the increase in productivity in this vineyard is due to its improved fertilization and how much is due to its recovery from over-production. Of the three factors mentioned, the effect of previous over-production is probably the least, although it is reported to be characteristic of the variety for it to suffer ill effects from excessive yields for several years after the over-production.

The data relating to the average number of ounces per bunch on the vines of different growth classes, Table XXIV, follow the trend of total yield fairly closely. If the largest bunches are not found on the vines with the largest production, the point of maximum production is usually in a neighboring growth class. This relationship between bunch size and total yield is similar to the data presented previously on cane performance.

As has been previously mentioned, shoots are often broken from canes during the growing season by accidents of various sorts, and shoots frequently fail to grow for various reasons. In order to avoid these sources of error as much as possible, and to secure a figure that was more indicative of the development of the primordia of the in-

Table XXIV.—The Relation Between the Vine Growth the Preceding Season and Fruit Yield; Average Number of Ounces Per Bunch Produced by Vines of Differing Vigor.

Prunings	0.1–0.9	1.0–1.9	2.0–2.9	3.0–3.9	4.0–4.9	5.0–5.9	6.0–6.9	7.0–7.9
				Light Pruning				
Crop of								
1926	3.8 (9)	5.4 (16)	6.0 (14)	5.6 (6)	5.3 (3)	....	....	....
1927	3.7 (4)	4.9 (19)	4.9 (16)	4.5 (5)	6.8 (1)	4.8 (2)	5.0 (1)	....
1928	4.2 (2)	5.0 (15)	5.6 (19)	5.8 (8)	6.3 (2)	5.5 (2)	....	....
1929	....	4.3 (10)	5.3 (17)	5.7 (17)	5.3 (2)	5.9 (1)	....	6.9 (1)
				Moderate Pruning				
Crop of								
1926	4.3 (5)	5.7 (19)	6.4 (14)	5.6 (8)	4.8 (2)	....	....	....
1927	4.1 (4)	4.9 (12)	5.7 (19)	4.7 (11)	5.0 (1)	4.1 (1)	....	....
1928	5.4 (2)	6.2 (9)	6.6 (20)	6.5 (12)	5.9 (5)	....	....	....
1929	3.9 (1)	5.6 (5)	6.4 (12)	6.7 (24)	7.5 (3)	6.9 (3)	....	....
				Severe Pruning				
Crop of								
1926	3.5 (5)	5.3 (17)	4.9 (16)	5.6 (7)	3.6 (2)	....	....	....
1927	4.1 (5)	4.5 (11)	4.8 (21)	4.3 (7)	4.6 (2)	3.7 (1)	....	....
1928	6.0 (1)	5.8 (12)	6.5 (21)	6.3 (11)	6.6 (3)	....	....	....
1929	....	5.8 (7)	6.7 (23)	7.2 (12)	7.8 (5)	7.5 (1)	....	....

Numbers in parentheses indicate number of vines in each group.

florescences, the average number of bunches produced by fruiting nodes was calculated. The data are tabulated and presented in Table XXV. No calculations were made on the 1926 crop because nodal records were not made for all the vines, as was mentioned previously. There is much less variation in the number of bunches per fruiting node than there is either in total production or in bunch weight. The maximum production of bunches per fruiting node tends to occur on more vigorous vines than does the largest total production or the heaviest bunches.

On the whole, the data presented show a less conspicuous correlation between growth and yield in the Campbell Early than in the Concord (Partridge, 1925). During the entire course of the experiment, the coefficient of correlation between growth and yield has increased from year to year, showing that its regression curve is more nearly approximating a straight line. There is a considerably larger coefficient between the growth and yield of the lightly pruned vines than there is in the case of the severely pruned vines each of the four years. The moderately pruned vines have intermediate values.

The Relationship Between the Total Number of Bunches Produced and Their Average Weight

The production of a vine may be resolved into two factors, the number of bunches which it produces and the weight of these bunches. The number of bunches is largely, but not completely, determined at pruning time because most, if not all, of the cluster-primordia which are capable of producing bunches of any size are developed the preceding season and pass the winter in the dormant bud. The number of bunches cannot be increased to any great degree in the spring, although it is frequently reduced by frosts and insect attacks and sometimes by disease. Clusters are sometimes abscised if the nutritional conditions in the young shoot are very unfavorable. Many clusters of blossom buds have been observed to fail to develop following an over-production of fruit on Concord vines. They dried up and were abscised.

The weight that a bunch attains depends largely upon the number of berries that are produced in it (Colby and Tucker, 1929). The size of the berries varies somewhat from cluster to cluster and from vine to

Table XXV.—The Relation Between the Vine Growth the Preceding Season and Fruit Yield; Average Number of Bunches Produced Per Fruiting Node by Vines of Differing Vigor.

Prunings	0.1–0.9	1.0–1.9	2.0–2.9	3.0–3.9	4.0–4.9	5.0–5.9	6.0–6.9	7.0–7.9
Light Pruning								
Crop of								
1927	1.5 (4)	1.6 (19)	1.6 (16)	1.5 (5)	1.8 (1)	1.6 (2)	1.6 (1)	....
1928	2.0 (2)	2.0 (15)	2.2 (19)	2.2 (8)	2.3 (2)	2.0 (2)	....	....
1929	....	1.9 (10)	2.0 (17)	2.0 (17)	2.3 (2)	1.9 (1)	....	2.4 (1)
Moderate Pruning								
Crop of								
1927	1.5 (4)	1.6 (12)	1.6 (19)	1.6 (11)	1.7 (1)	2.0 (1)	....	....
1928	2.2 (2)	2.3 (9)	2.3 (20)	2.2 (12)	2.3 (5)	....	....	....
1929	1.8 (1)	2.0 (5)	1.9 (12)	2.0 (24)	2.0 (3)	2.8 (3)	....	....
Severe Pruning								
Crop of								
1927	1.5 (5)	1.7 (11)	1.7 (21)	1.9 (7)	1.9 (2)	1.7 (1)	....	....
1928	2.3 (1)	2.4 (12)	2.3 (21)	2.3 (11)	2.2 (3)	....	....	....
1929	....	2.1 (7)	2.1 (23)	2.1 (12)	2.3 (5)	2.1 (1)	....	....

Numbers in parentheses indicate number of vines in each group.

vine, but the variations are not very large when expressed on a percentage basis. The number of berries in the cluster fluctuates much more widely, variations of 100 or even 200 per cent being the rule rather than the exception. The factors that influence the number of berries in the cluster are of considerable interest because they not alone affect the total yield but they also influence marketability.

The number of berries in the cluster depends upon the number of blossoms that are differentiated from the cluster primordia and by the number of these blossoms that set fruit. Both of these functions of the vine take place entirely in the spring. However, blossom-bud differentiation is profoundly influenced by the vine conditions the preceding season as well as by events during the current season because the latter are controlled by the former to a considerable extent.

Table XXVI.—Average Number and Weight of Bunches Produced by Vines with Various Yields.

Pounds fruit	Light pruning			Moderate pruning			Severe pruning		
	Number vines	Number bunches	Oz. per bunch	Number vines	Number bunches	Oz. per bunch	Number vines	Number bunches	Oz. per bunch
				Crop of 1926					
0.1- 4.9	...	...	...	2	12	1.9	8	14	2.6
5.0- 9.9	2	22	5.8	7	30	5.1	13	27	4.6
10.0-14.9	5	57	3.5	11	36	5.8	16	36	5.4
15.0-19.9	7	55	5.3	11	51	5.6	7	44	6.3
20.0-24.9	15	74	5.0	10	55	6.4	2	50	7.5
25.0-29.9	14	76	5.8	7	65	6.7	1	72	5.8
30.0-34.9	3	86	6.0	...	...	...	...	...	...
35.0-39.9	2	93	6.1	...	...	...	...	...	...
				Crop of 1927					
0.1- 4.9	2	9	2.9	2	11	2.9	6	17	3.5
5.0- 9.9	9	31	4.6	20	29	4.8	28	28	4.5
10.0-14.9	17	46	4.7	23	35	5.4	12	39	5.2
15.0-19.9	18	53	5.2	3	40	6.3	1	58	5.6
20.0-24.9	2	64	5.1	...	...	...	...	...	...
				Crop of 1928					
5.0- 9.9	...	...	...	3	35	4.5	6	28	5.1
10.0-14.9	2	52	4.5	7	35	6.2	13	36	6.0
15.0-19.9	3	66	4.6	10	49	5.9	15	43	6.7
20.0-24.9	15	72	5.1	14	55	6.6	14	53	6.6
25.0-29.9	14	76	5.6	9	63	7.0	...	...	...
30.0-34.9	12	89	5.8	5	75	6.8	...	...	...
35.0-39.9	1	95	6.1	...	...	...	...	...	...
40.0-44.9	1	96	6.8	...	...	...	...	...	...
				Crop of 1929					
5.0- 9.9	...	...	...	1	39	3.9	1	24	6.4
10.0-14.9	1	57	3.9	8	35	5.8	13	36	5.9
15.0-19.9	6	61	4.7	18	45	6.4	13	39	7.1
20.0-24.9	15	75	4.8	14	53	6.8	16	49	7.1
25.0-29.9	18	76	5.7	3	60	7.1	5	56	7.6
30.0-34.9	5	89	5.6	3	64	7.8	...	...	...
35.0-39.9	3	100	5.9	1	78	7.6	...	...	...

The data from these Campbell Early vines have been arranged in Table XXVI to show the relative effect that number of bunches and weight of bunches has upon the total production. As the number of pounds of fruit harvested per vine increases, both the number of the bunches and their average weight increases. In order to achieve maximum yields, it is necessary for the vine to produce a large number of heavy bunches. From the data just presented, it appears that as the number of bunches on the vine increases, their average weight is larger and that there is a close positive association between the factors determining the number of bunches and those controlling the weight of the bunches on each vine.

On rearranging the data, as in Table XXVII, making the divisions depend upon the number of bunches produced per vine, it is seen that there is very little correlation, either positive or negative, between the number of bunches and their average weight. In some years, with certain types of pruning there are slight positive or negative correlations indicated, but their significance is questionable.

It is evident that if a vine is to make a notable yield of fruit, it must produce many as well as heavy bunches. When bunches are few and

Table XXVII.—Average Weight of Bunch Produced by Vines Carrying Different Numbers of Bunches.

Number bunches	Ounces per bunch		
	Light pruning	Moderate pruning	Severe pruning
Crop of 1926			
1-19	7.1 (1)	3.4 (3)	3.0 (7)
20-39	5.5 (2)	5.7 (16)	5.1 (27)
40-59	5.5 (11)	6.1 (19)	5.6 (12)
60-79	5.2 (18)	5.9 (10)	5.8 (1)
80-99	5.0 (16)	....	....
Crop of 1927			
1-19	2.9 (2)	4.4 (4)	3.8 (6)
20-39	4.9 (12)	5.2 (37)	4.6 (33)
40-59	4.9 (28)	5.2 (7)	4.9 (8)
60-79	4.8 (6)	....	....
Crop of 1928			
20-39	....	5.8 (11)	5.9 (20)
40-59	5.0 (3)	6.6 (20)	6.6 (26)
60-79	5.5 (25)	6.5 (16)	5.7 (2)
80-99	5.4 (18)	6.4 (1)	....
100-119	5.2 (2)	....	....
Crop of 1929			
20-39	....	6.4 (10)	6.8 (20)
40-59	5.0 (4)	6.5 (29)	6.9 (27)
60-79	5.4 (28)	6.6 (9)	6.7 (1)
80-99	5.1 (14)	....	....
100-119	5.4 (2)	....	....

small, the yield is very small. Vines having moderate yields may have a large number of small bunches, a small number of large bunches or a moderate number of medium sized bunches. In this vineyard there is little or no correlation between the size and number of bunches produced per vine.

The weight which the bunches will attain upon any vine is profoundly influenced by events in the spring. However, the nutritional conditions in the early spring are largely predetermined by the behavior of the vine the preceding season. If a vine over-produces, there will be a smaller supply of carbohydrates stored in its tissues. If it is weak there is little chance that the fruiting canes will have the characteristics that are associated with the production of the heaviest bunches. The potential fruiting capacity of the vine may be lost to a great degree by the selection of poor fruiting canes, by unfavorable weather during the bloom, or by the removal of too many of the fruiting nodes. Productivity can be built up to a certain degree but not to anything like the extent that it may be reduced.

By grouping those vines which were pruned to 60 nodes each and whose production in 1929 was characterized by heavy and light bunches, it is possible to contrast the two groups of vines. These data, Table XXVIII, indicate that under the uniform pruning treatment given these vines, the average weights of the bunches produced are rather closely related to the total amount of growth, as measured by the pruning weights the preceding winter of 1928-1929. It is evident that those vines producing large bunches in 1929 had not produced excessive crops in 1928 because not a single vine in the group produced as much as five pounds more than the plot average. In view of the vigorous growth these vines were making, these yields cannot be considered to be more than moderate. Those vines which produced light bunches

Table XXVIII.—The Production of Vines Yielding Heavy and Light Bunches in 1929; Vines Pruned to 60 Nodes.

Vine	Ounces per bunch	Number of bunches	Pounds fruit 1929	Pounds prunings 1928-1929	Pounds fruit 1928	Pounds prunings 1927-1928
8- 4	7.2	61	27.4	3.6	27.8	5.5
8- 7	6.4	74	29.4	2.7	23.8	4.4
8-15	6.7	72	29.9	2.6	24.3	2.1
8-20	6.9	83	35.6	7.3	27.0	5.0
8-28	6.1	43	16.3	2.3	25.1	1.4
8-33	6.1	66	25.1	3.4	31.8	3.1
8-38	6.6	66	27.1	2.9	24.0	2.6
8-39	6.2	72	27.8	3.7	25.3	3.2
8-41	6.4	77	30.7	3.7	26.8	2.9
8-50	6.4	74	29.4	3.7	30.1	2.9
8-13	4.3	76	20.5	1.7	25.3	1.8
8-14	4.4	57	15.5	1.7	23.7	1.4
8-16	4.5	88	24.7	1.7	14.7	1.3
8-17	4.3	73	19.5	1.8	22.0	1.6
8-19	3.9	57	13.7	1.2	21.7	0.8
8-21	3.2	77	15.4	1.1	14.8	1.0
8-29	3.8	92	22.0	1.2	17.2	0.9
8-32	4.3	75	20.4	2.8	20.6	1.7
Plot average	5.3	76	25.1	2.9	26.3	2.5

in 1929 made much less growth in 1928 than did those producing heavy bunches. While the production of these vines was less than the production of those that yielded large bunches in 1929, their growth was much less. Considering the difference in their vigor, these vines more nearly over-produced in 1928 than did the others. Similar results are obtained when like data are compiled for the other pruning treatments, and the conclusions are confirmed.

By grouping those vines together that produced a large number of bunches in 1929 and those that produced a small number of bunches in another group, as in Table XXIX, it is seen that there is less correlation with the behavior of the vine the preceding season. There is a certain tendency for vines making strong growth to produce a large number of bunches rather than a small number, and for vines making a weak growth to produce a small number. However, there are many more exceptions than appeared in the preceding table. The most marked contrast found between the vines producing large and small numbers of bunches is in the percentage of nodes not producing a shoot. Those vines which yielded many bunches had relatively few nodes which did not grow while those that produced few bunches showed a much larger percentage of dormant or injured buds. The difference in the number of bunches produced is not entirely dependent upon the percentage of nodes producing shoots, some of the difference is undoubtedly due to a chance selection of varying proportions of productive and non-productive canes which also affects the production of bunches.

XXIX.—The Production of Vines Yielding Many and Few Bunches in 1929; Vines Pruned to 60 Nodes.

Vine	Number of bunches	Ounces per bunch	Per cent of nodes producing shoots	Pounds fruit 1929	Pounds prunings 1928-1929	Pounds fruit 1928	Pounds prunings 1927-1928
8-16	88	4.5	68	24.7	1.7	14.7	1.3
8-18	98	5.0	68	30.8	4.3	21.4	3.5
8-27	89	5.1	70	28.6	2.8	31.6	1.9
8-29	92	3.8	72	22.0	1.2	17.2	0.9
8-31	108	5.6	80	37.9	3.9	19.6	2.1
8-34	98	5.0	80	30.7	3.6	32.0	2.6
8-36	89	4.8	73	26.7	3.0	19.6	1.8
8-37	90	5.6	71	31.5	3.8	31.7	2.3
8-46	108	5.2	72	35.3	3.2	25.0	2.6
8- 4	61	7.2	60	27.4	3.6	27.8	5.5
8- 5	55	5.5	65	19.1	2.2	24.3	2.5
8- 8	62	4.9	70	18.8	1.6	21.7	2.3
8-14	57	4.4	60	15.5	1.7	23.7	1.4
8-19	57	3.9	62	13.7	1.2	21.7	0.8
8-25	65	5.2	72	21.3	2.4	22.7	1.5
8-28	43	6.1	42	16.3	2.3	25.1	1.4
Plot average	76	5.3	68	25.1	2.9	26.3	2.5

It is rather surprising to observe that there is a closer relation between the average weight of the bunches and the past performance of the vine than there is between its past behavior and the number of bunches that is produced on vines pruned to equal numbers of nodes. However, the Campbell Early tends to produce about the same number of bunches per shoot in any particular season, as has been shown in the data presented in Table XXV. This number is not influenced to any great degree by the vigor of the vine's growth.

The Influence of Pruning on the Specific Gravity of the Extracted Juice

The quality of grapes depends upon their flavor and the sugar content of the juice as well as upon the appearance and size of the bunches and berries. During the harvest of 1927, representative samples of grapes were taken from each vine and Brix hydrometer readings were made of the juice. The grapes were first crushed and then sufficient juice was squeezed through a double thickness of muslin to float the hydrometer. Enough grapes were used to obtain the juice with slight pressure, which, of course gives a sample higher in sugar than would a complete extraction. This method is not as accurate as an analysis, but it has the advantage of speed. This test does serve to disclose large variations in sugar content, as is easily confirmed by a comparison of the flavor of samples with high and low readings. The fruit was harvested each day from approximately equal numbers of vines receiving each pruning treatment to avoid variations due to increasing maturity during the picking season.

The significance of hydrometer readings of grape juice, which measure the total solids dissolved in the juice has been questioned by Caldwell (1925). His analyses were made on a large number of varieties of grapes which have a varying proportion of their total solids in the form of sugar. A large commercial company manufacturing Concord grape juice has determined to their satisfaction that the hydrometer reading is sufficiently accurate to permit the use of this instrument in their plants to secure a reasonably uniform product. They have made many check analyses and the percentage of sugar in the total solids is reasonably uniform. Consequently, this test has been considered accurate enough to bring out any material variations in maturity and sugar content that may occur.

As will be noted in the data presented elsewhere, Table XX, the crop of 1927 was the smallest of the four harvested during this experiment. The quality of the fruit was exceptionally good, and the averages are probably higher than in ordinary years. The Brix readings were correlated to the severity of the pruning. The average readings were: lightly pruned vines, $16.6° \pm .08$; moderately pruned vines, $16.9° \pm .08$; and severely pruned vines $17.1° \pm .07$. The greater the number of buds left per vine, the smaller the percentage of total solids in the juice.

The average production of fruit per vine also varies with the severity of the pruning. In 1927, the average yield per vine was 13.7 pounds with light pruning, 10.1 pounds with moderate pruning and 8.7 pounds with severe pruning. Table XXX was prepared to show what effect varying yields might have upon the Brix reading under the same pruning treatments. The results are not consistent, however, and it is impossible to determine whether fruit production has had any definite effect upon the reading. In general, however, with equal fruit yields, the same superiority in the quality of the juice noted on the part of the severely pruned vines is again observed, so the result is not due entirely to the smaller yields of fruit.

Table XXX.—The Relation Between Fruit Production and Brix Reading.

Pounds fruit	Light pruning	Moderate pruning	Severe pruning
1– 5	16.9 (2)	16.5 (2)	17.1 (9)
6–10	16.9 (9)	16.9 (24)	17.2 (27)
11–15	16.5 (20)	16.9 (21)	17.3 (10)
16–20	16.5 (17)	17.5 (1)	15.6 (1)

Numbers in parentheses indicate the number of vines in each group.

Table XXXI was prepared to exhibit any decided relationship that might exist between the amount of vine growth, as measured by pruning weights and the Brix readings. The data are inconclusive. With light pruning, there is a tendency for the reading to rise as the amount of growth increased but with the severe pruning this slight trend is reversed. The lowest figure in the severely pruned group is larger than the corresponding largest figure for the lightly pruned vines.

Table XXXI.—The Relation Between Vine Growth and Brix Reading.

Pounds prunings	Light pruning	Moderate pruning	Severe pruning
Less than 2	16.4 (17)	16.8 (11)	17.2 (12)
2–3.9	16.7 (27)	16.9 (32)	17.1 (32)
4–5.9	16.8 (4)	16.8 (5)	17.0 (3)

Numbers in parentheses indicate the number of vines in each group.

These tendencies may or may not be significant. However, it is possible that in a year of larger production, differences in the composition of the juice might occur which would be of commercial significance and which could be related to the vigor of the vine growth.

There were considerable differences in the degree of the maturity of the fruit between different grapevines at harvest, but the differences cannot be correlated with either total fruit production or the amount of vine growth. There is a tendency for the Brix reading to rise as the pruning is more severe. This is believed to be a regular condition in this pruning block, for it is usually necessary to leave the lightly pruned row until the last to avoid picking immature fruit. Some vines on the other rows show this same delayed maturity, but there are fewer of them.

Discussion

There are rather marked differences in the growth and fruiting habits of the varieties of American bunch grapes. These call for corresponding differences in the culture and pruning of the vines. Many growers have not altered their practices to conform to these variations, with the result that they have not secured the best results with some kinds of grapes. The Concord is the variety most widely grown and most familiar to Michigan vineyardists and may be used as a basis of comparison.

The larger the diameter of the shoots grown on Campbell Early, as measured in the fall after the harvest, the greater their production. This is not the case with Concord or Moore Early, which produce their best bunches on shoots of a moderate size. The culture of the Campbell Early must be adapted to secure more vigorous shoot growth than is necessary for Concord vines.

The most productive canes on the Concord measure about a quarter of an inch in diameter. The best canes on the Campbell Early are at least three-eighths of an inch in diameter. In order to secure the potential production of the Campbell Early, it is necessary that the vine grow these large canes and that the grower select them for fruiting when he prunes his vines. These vigorous canes produce more shoots per node, more vigorous shoots and yield larger numbers of larger bunches than do the smaller canes. With all cane lengths, the largest canes are the most productive.

The most productive quarter-inch canes on the Concord are those whose sixth internode measures from five to eight inches in length. There is very little correlation between the length of this internode and productivity in the Campbell Early. Growers are justified in neglecting the length of the internodes in selecting their fruiting wood.

The basal nodes of both Concord and Campbell Early are relatively unproductive. Both the varieties tend to have the point of maximum productivity farther out on the cane when the vine growth is vigorous than is the case when it is weak. In general, the point of highest productivity is farther from the base of Campbell Early canes than of Concord. The heaviest bunches, the greatest number of bunches per node, the smallest percentage of unproductive nodes, the largest percentage of nodes with multiple shoots, the most productive shoots, and the largest yield of fruit are found in the same general region of the cane. The canes should be left long enough to retain this productive region on the vines rather than to be discarded in the prunings.

In pruning the vines, it is better to have the production on a small number of nodes rather than to distribute the crop over many nodes. It is cheaper to prune the vines severely, spraying may be done more thoroughly and more rapidly, and the fruit is picked more easily. In addition to these factors which simplify the vineyard operations, the bunches on the most productive nodes whose shoots are vigorous, are larger and more compact, as has been illustrated in Figures 3 to 5.

Canes of the Campbell Early that had 15 nodes were more productive than those of any other length. The shorter the canes were pruned, the greater the percentage of nodes that were unproductive. Shoot growth of the same vigor on comparable canes was less productive on shorter than on longer canes. The advantage in productivity of the longer canes over the shorter ones was not as pronounced when canes of small diameter were compared as it was when the canes were more vigorous. If the vines are not strong enough to support four 15-bud canes, it is better to reduce the number of canes rather than to reduce the number of buds on the individual canes very much. The last five nodes on 20-bud canes were less productive than the median portion; and, under the same pruning treatment, the 20-bud canes were less productive than the 15-bud canes. The recommended cane length for Concord is eight to 10 nodes, which is in marked contrast to the longer canes recommended for Campbell Early.

Considerably more data are available on the pruning of the Concord than on the Campbell Early. The vines in this vineyard are vigorous, and, if they were Concords, would require the use of from 40 to 60 nodes per vine depending upon the vigor of the individual plant. The best results with Campbell Early have been secured from a 40-bud pruning which is more severe than that mentioned, and leaves about two-thirds the number of nodes usually given similar Concords by growers. As the number of nodes is increased, more scraggly bunches are produced. These reduce the grade of the crop. The increased number of scraggly bunches is probably due to the fact that the more nodes there are left on the vine, the weaker the shoot growth. Underpruning the Campbell Early reduces the quality of the crop the following year as well as the quality of the current crop because the weak shoots make weak and unproductive fruiting canes the following season. Underpruning is likely to result in over-production which appears to be much more injurious to Campbell Early than to Concord.

Weak vines are less productive than strong vines in both Concord and Campbell Early. Concord becomes over-vegetative when fertilized too heavily, especially when grown on strong soils. This condition is not so apparent in Campbell Early. This variety does well on soils too fertile to produce good Concord grapes, but is very unproductive on the poorer soils on which Concord vines are able to make fair yields. Campbell Early does best on a soil too rich for Concord and should not be grown on sandy soils low in fertility, because the vines are then unable to grow the vigorous shoots and canes necessary to produce fruit of high grade.

There is little correlation, either positive or negative, between the weight of bunches and the number of bunches produced by these vines. The number of bunches is influenced more by the percentage of nodes that do or do not have productive shoots than by any other factor. The average weight of the bunches is influenced more by the amount of growth made the previous season and by the amount of fruit produced then. In discussing the data secured from canes of various types, the most productive nodes and canes also had the largest number of bunches. Production is closely associated with vigor of shoot growth. Where vigorous shoot growth occurs, there is a decreased percentage of unproductive nodes and an increased percentage of nodes producing more than one shoot. The average nodal production of bunches is thus increased by the presence of more shoots on the nodes, and this accounts for a large part of the increase in the number of bunches noted.

The juice extracted from the grapes grown under the different pruning treatments is of higher quality the more severe the pruning. Underpruning the Campbell Early results not only in a greater proportion of low grade scraggly bunches, but also in later maturity and poorer quality of juice.

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