Some Effects of Severity of Pruning on Growth and Production in the Concord Grape

By A. S. Colby and L. R. Tucker

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CONTENTS

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By A. S. Colby, Chief in Small Fruit Culture, and L. R. Tucker, formerly Scientific Assistant in Pomology

THE GRAPEVINE has been subjected to many methods of pruning and training by growers and investigators, to all of which it has adapted itself readily, giving constant and definite responses. If the grower is to determine the most economical and profitable degree of pruning to use, he must be able to recognize the responses which a grapevine makes to different pruning treatments. He should be able to interpret the condition of a healthy vine by observing its previous season's growth and fruiting activities, if that season was normal. He should be able to tell whether a vine has been pruned correctly, or whether it has been pruned too little or too severely; he should know what results will be obtained by varying the pruning treatments.

The investigations reported in this bulletin deal with the cumulative effects on the growth and fruit production of Concord grapes of consistent winter pruning to varying degrees of severity during the five years 1924-1928.

TYPICAL GROWTH AND FRUITING HABITS

In any pruning experiment the typical growth and fruiting habits of the plant must be taken into consideration. As a grape bud develops into a shoot in normal vine growth, a leaf bud is produced at each node on alternate sides along the shoot. A bud forms in the axil of each leaf, and sometimes a secondary shoot or lateral is later produced near this bud. A tendril or a flower cluster may be found opposite the leaves at some of the basal nodes. After these inflorescences have been produced up to five in number, the shoot may continue to grow for several feet with no more blossoms.

The following year the buds vary in size along the portion of the shoot that was selected as a cane at pruning time. Some do not grow, but remain latent, while some produce weak and others vigorous shoots.

Some time during the late summer of the season previous to fruiting, flowers begin to be differentiated in the fruit bud in the axil of the leaf on the shoot.[6]* The number of these inflorescences in the different buds along the shoot varies, fewer being found near the base than farther out. This habit has been widely studied, usually by measuring the fruit production the following year on the shoots originating from these buds.[2, 7, 8, 9, 11, 14]* These studies, indicating that the basal buds are less fruitful than the buds farther from the base, resulted in the recommendation of the so-called "long-cane" system of pruning (leaving canes with five or more nodes each) rather than the "spur" system (leaving approximately three nodes per cane). Again, buds on some shoots contain more flower clusters than those on other shoots. A study of this variation has shown that the shoot of medium vigor will make the most productive cane the following year.[10, 11]*

When a bud contains more than one flower cluster, the clusters usually vary progressively in size along the fruiting area of the shoot produced from this bud, the tip cluster being the smallest.[4]* This indicates that the clusters nearer the base in the fruit bud increase in size as extra clusters are set, and that the buds carrying the largest number of inflorescences are potential producers of large clusters.

OUTLINE OF EXPERIMENT

In the experiment reported in this bulletin the 4-cane Kniffin system of training was followed. Data were secured from 48 vines in 1927 and from 64 in 1928. The plants used in the experiment are growing in the Station vineyard in Urbana. They were planted in 1917 and are of average size for their age in that locality.

The vineyard is located on the eastern slope of a recessional moraine characteristic of the Early Wisconsin glaciation. The soil is brown silt loam of morainal type merging into a black clay area at the base of the slope. The vines are so distributed over the plot that soil differences are minimized. Clean cultivation is practiced during the early part of the growing season, followed by a cover crop of oats, buckwheat, and soybeans sown in August and disked under the following spring.

The number of nodes to which any vine in this experiment was pruned varied not more than 15 in any two of the six years 1922-1927. In 1922 the vines were classified into seven groups according to degree

*These numbers thruout the text refer to literature citations on page 206.

of severity of pruning, the number of nodes that were left in the respective groups ranging from 20 to 90 in multiples of 10.[a] This treatment was consistently followed for five years and detailed comparisons made of vine growth and production in 1927 at harvest time. The treatment was continued and comparisons again made in 1928.

TABLE 1.—SUMMARY OF GROWTH AND PRODUCTION OF CONCORD VINES, ILLINOIS EXPERIMENTS, 1927 AND 1928

Item		Year	Node-number range to which vines were pruned							Total
			20–29	30–39	40–49	50–59	60–69	70–79	80–89	
1	Number of vines in each range	1927 1928	7 9	3 24	15 17	11 11	9 3	2 0	1 0	48 64
			Vine averages							
2	Average number of shoots produced per vine	1927 1928	17.6 17.1	30.3 25.8	37.7 35.2	47.5 43.1	54.6 50.3	61.5	65 ..	
3	Percentage of nodes dormant	1927 1928	29 28	19 28	26 26	27 24	21 23	29 ..	28 ..	
4	Percentage of nodes producing two shoots	1927 1928	8 8	15 11	12 11	15 8	11 10	16 ..	8 ..	
5	Percentage of shoots broken off	1927 1928	15 16	8 12	5 8	3 5	2 6	1 ..	2 ..	
6	Total growth of main (primary) shoots in feet	1927 1928	130 144	166 183	200 204	226 205	233 233	241 ...	264 ...	
7	Total growth of lateral (secondary) shoots in feet per vine	1927 1928	92 168	56 150	91 140	90 88	78 100	95 ..	64 ..	
8	Total growth of main and lateral shoots in feet per vine	1927 1928	223 312	223 333	291 344	316 293	310 334	336 ...	327 ...	
9	Number of laterals per vine	1927 1928	61 109	83 124	99 138	111 114	122 155	156 ...	146 ...	
10	Total number of clusters per vine	1927 1928	13 18	53 35	60 54	74 63	90 78	96 ..	96 ..	
11	Average weight of fruit per vine in ounces	1927 1928	19.9 48.1	122.8 99.7	173.1 135.2	198.6 167.3	250.6 211.5	247.0	275.0	
12	Average size of cluster in ounces	1927 1928	1.36 2.22	2.35 2.66	2.66 2.48	2.64 2.59	2.70 2.68	2.46	2.86	
13	Number of spur buds left per vine	1927 1928	4.0 4.3	7.7 8.1	12.9 10.7	17.0 18.8	19.8 22.3	24.0	45.0	

(Table is concluded on next page.)

[a]The small buds at the base of the cane were included in making the counts. These buds are dormant or produce a nonfruitful shoot.[5*] In this experiment both fruitful and nonfruitful shoots were considered.

TABLE 1.—*Concluded*

Item		Year	Node-number range to which vines were pruned						
			20–29	30–39	40–49	50–59	60–69	70–79	80–89
			Shoot averages						
14	Average length of main shoot in inches per vine	1927 1928	88 102	67 89	66 70	59 59	51 56	48 ..	49 ..
15	Average length of the laterals in inches from each main shoot	1927 1928	63 123	22 80	33 49	24 26	17 24	20 ..	12 ..
16	Average length per shoot in inches of terminals and laterals combined	1927 1928	151 225	89 169	99 119	82 85	68 79	68 ..	60 ..
17	Average number of laterals from each main shoot	1927 1928	3.4 6.6	2.8 5.2	2.8 4.0	2.4 2.8	2.3 3.1	2.6 ...	2.2 ...
18	Average number of clusters per shoot	1927 1928	.66 1.02	1.73 1.34	1.53 1.54	1.59 1.47	1.65 1.55	1.56	1.48 ....
19	Average weight of fruit in ounces per shoot	1927 1928	1.0 2.7	4.1 3.8	4.4 3.8	4.3 3.9	4.6 4.2	3.9 ...	4.2 ...

Growth and fruit production were studied both separately and collectively in each pruning group, both the shoots and the cane being used as units of comparison. The location and length of each main shoot on the vine, the number and length of its laterals, and the number and weight of clusters produced were noted. From these data the effects of pruning to varying degrees of severity were determined.

SHOOT GROWTH AND FRUIT PRODUCTION

Growth.—The 48 vines from which data were secured in 1927, ranging from the 20-to-29-node to the 80-to-89-node group (Table 1, Item 1) produced 2,003 shoots ranging in length from less than 1 foot to more than 50 feet per shoot (Table 2). The 64 vines in the 1928 test ranging up to the 60-to-69 node group (Table 1, Item 1) produced 1,995 shoots. The shoot growth per bud in this group varied in length from less than 1 foot up to 100 feet (Table 2).

The shoots were first grouped according to length of terminals and laterals (Table 2). About half the shoots were less than 5 feet long. The short ones had very few and short laterals. The more vigorous shoots were longer with an increase in both length and number of

TABLE 2.—GROWTH AND FRUIT PRODUCTION OF ALL SHOOTS, CLASSIFIED ACCORDING TO TOTAL TERMINAL AND LATERAL LENGTHS

	Shoots grouped according to their length of growth								
	1-59 inches	60-119 inches	120-179 inches	180-239 inches	240-299 inches	300-359 inches	360-479 inches	480-719 inches	720-1319 inches
1927									
Number of shoots in each class......	1063	475	233	110	56	29	25	12	0
Average number of clusters per shoot	1.37 ± .021	1.78 ± .033	1.83 ± .047	1.74 ± .076	1.41 ± .106	1.03 ± .125	1.32 ± .170	0.75 ± .197	....
Standard deviation................	.98 ± .015	1.07 ± .024	1.07 ± .033	1.19 ± .054	1.18 ± .076	1.00 ± .089	1.26	1.01	....
Average ounces of fruit per shoot....	3.43 ± .084	5.43 ± .163	5.29 ± .227	4.53 ± .315	4.36 ± .477	2.22 ± .418	3.16 ± .562	1.54 ± .573	....
Standard deviation in ounces........	3.98 ± .060	5.26 ± .116	5.16 ± .160	4.92 ± .221	5.30 ± .339	3.34 ± .297	4.16	2.94	....
Average size of clusters in ounces....	2.50	3.05	2.89	2.60	3.09	2.16	2.39	2.05	....
Average length of main shoot in inches	25.8 ± .302	67.4 ± .552	106.2 ± 1.07	131.0 ± 1.69	150.9 ± 2.14	160.0 ± 4.48	165.0 ± 4.70	181.8 ± 8.66	....
Standard deviation in inches........	14.4 ± .216	17.8 ± .392	24.4 ± .756	26.4 ± 1.19	23.8 ± 1.52	35.8 ± 3.19	34.8	44.4	....
Average length of laterals per shoot in inches......................	1.2 ± .101	18.9 ± .567	40.4 ± 1.07	75.1 ± 1.88	116.8 ± 2.40	162.8 ± 4.84	236.2 ± 5.83	379.8 ± 10.47	....
Standard deviation in inches........	4.8 ± .072	18.3 ± .403	24.3 ± .753	29.4 ± 1.32	26.7 ± 1.71	38.7 ± 3.44	43.2	53.7	....
Number of laterals per shoot........	.33	3.19	5.12	6.53	8.43	9.76	11.84	14.58	....
Length per lateral in inches.........	3.6	5.9	7.9	11.5	13.9	16.7	19.9	26.0	....
1928									
Number of shoots in each class......	868	410	258	149	104	65	65	66	10
Average number of clusters per shoot	1.12 ± .023	1.60 ± .034	1.70 ± .042	1.78 ± .052	1.65 ± .071	1.72 ± .092	1.80 ± .087	1.77 ± .085	.90 ± .200
Standard deviation................	.99 ± .016	1.04 ± .025	1.01 ± .030	.94 ± .037	1.07 ± .050	1.10 ± .065	1.03	1.02	.94
Average ounces of fruit per shoot....	2.51 ± .080	4.70 ± .144	4.83 ± .167	5.26 ± .227	4.59 ± .293	4.86 ± .452	4.77 ± .354	4.76 ± .359	2.11 ± .720
Standard deviation in ounces........	3.46 ± .055	4.36 ± .105	3.98 ± .119	4.12 ± .161	4.44 ± .209	5.38 ± .317	4.22	4.32	3.38
Average size of clusters in ounces....	2.24	2.94	2.84	2.96	2.78	2.83	2.65	2.69	2.34
Average length of main shoot in inches	25.3 ± .340	67.3 ± .587	101.5 ± 1.01	126.2 ± 1.65	145.1 ± 2.14	160.6 ± 2.94	167.0 ± 3.07	185.1 ± 2.57	227.0 ± 7.50
Standard deviation in inches........	14.8 ± .237	17.8 ± .427	24.0 ± .720	30.0 ± 1.17	32.4 ± 1.52	35.0 ± 2.06	36.6	31.0	35.2
Average length of laterals per shoot in inches......................	1.5 ± .101	20.5 ± .554	45.3 ± 1.08	80.2 ± 2.16	122.0 ± 2.19	167.8 ± 3.52	242.9 ± 3.96	380.9 ± 5.68	702.4 ± 7.75
Standard deviation in inches........	4.4 ± .070	16.8 ± .403	25.8 ± .774	39.2 ± 1.53	33.2 ± 1.56	42.0 ± 2.48	47.2	68.4	36.4
Average number of laterals per shoot	.39	3.44	5.48	7.87	9.18	11.57	12.42	15.20	18.50
Average length per lateral in inches..	3.8	6.0	8.3	10.2	13.3	14.5	19.6	25.1	38.0

laterals (Fig. 1). Lateral shoot growth occurred, therefore, at a more rapid rate than growth of the central or main shoot. Since the laterals produce many of the leaves, a larger proportion of the leaf surface on the very vigorous shoots must have been formed later in the season than on the less vigorous shoots. Both the very weak and the very

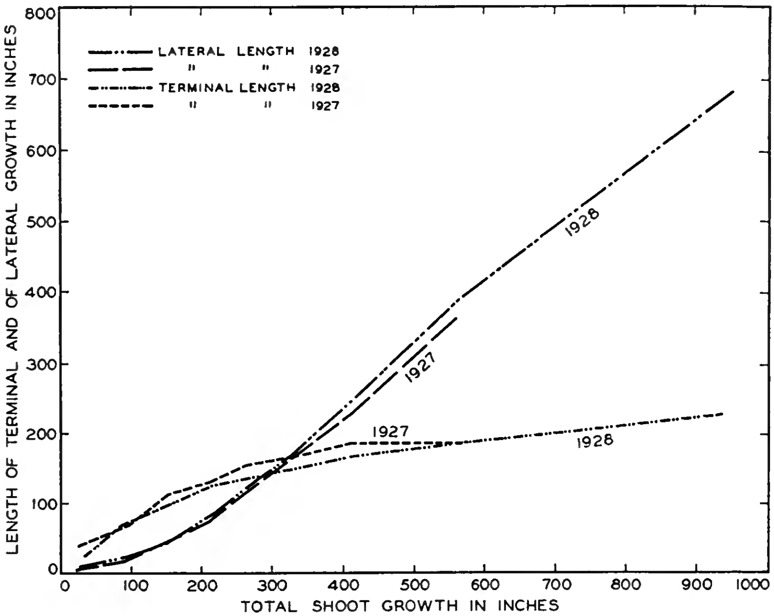

FIG. 1.—RELATIONSHIP BETWEEN LENGTH OF TERMINALS AND OF LATERALS ON SHOOTS OF DIFFERENT DEGREES OF VIGOR, 1927 AND 1928

An increase in shoot vigor resulted in an increase in both length and number of laterals.

vigorous shoots produced slightly fewer clusters and slightly less fruit than did the shoots of medium vigor (Table 2). Similar and less variable results were previously reported by the authors.[4*]

The variation in vigor and fruitfulness between groups was so slight and the variation within each group was so large, as shown by standard deviations in Table 2, that there seemed to be little relationship in these shoots between vigor and fruit-bud formation or fruit production.

Clusters.—The shoots were also classified according to the number of clusters they produced (Table 3). The number of clusters per shoot during the years 1927 and 1928 ranged from 0 to 5 and 0 to 4 re-

TABLE 3.—GROWTH AND FRUIT PRODUCTION OF ALL SHOOTS, CLASSIFIED ACCORDING TO NUMBER OF CLUSTERS

	Shoots grouped according to number of clusters produced						All shoots
	No clusters	1 cluster	2 clusters	3 clusters	4 clusters	5 clusters	
1927							
Number of shoots in each class	419	531	639	395	18	1	2 003
Average ounces of fruit per shoot	....	1.72 ± .039	5.13 ± .072	9.96 ± .139	12.39 ± .630	19.50	4.18
Standard deviation in ounces	....	1.36 ± .029	2.68 ± .051	4.08 ± .098	3.96 ± .444	......	......
Average weight per cluster in ounces	....	1.7	2.6	3.3	3.1	3.9	2.7
Average terminal length per shoot in inches	58.2 ± 1.71	45.2 ± 1.15	59.9 ± 1.24	75.7 ± 1.47	72.5 ± 5.18	56.00	58.9
Standard deviation in inches	51.8 ± 1.19	39.8 ± .84	45.8 ± 1.04	43.2 ± 1.04	32.6 ± 3.65	......	......
Average lateral length per shoot in inches	36.6 ± 2.41	16.7 ± 1.24	21.3 ± 1.31	29.1 ± 1.50	19.0 ± 4.44	21.0	24.8
Standard deviation in inches	72.9 ± 1.68	42.6 ± .89	48.6 ± .92	44.1 ± 1.06	27.9 ± 3.12	......	......
Average combined terminal and lateral length per shoot in inches	94.8 ± 3.78	62.0 ± 2.15	81.2 ± 2.13	104.8 ± 2.65	91.5 ± 8.73	77.0	83.7
Standard deviation in inches	114.6 ± 2.64	74.1 ± 1.56	78.9 ± 1.50	78.0 ± 1.87	54.9 ± 6.15	......	......
Average number of laterals per shoot	2.60	1.63	2.47	3.57	2.72	5.00	2.50
Average length per lateral in inches	14.1	10.2	8.6	8.2	7.0	4.2	9.9
1928							
Number of shoots in each class	504	470	684	327	10	0	1 995
Average ounces of fruit per shoot	....	1.81 ± .043	5.25 ± .060	9.20 ± .111	12.74 ± .750	......	3.80
Standard deviation in ounces	....	1.38 ± .030	2.32 ± .042	3.00 ± .078	3.52 ± .532	......	......
Average weight per cluster in ounces	....	1.8	2.6	3.1	3.2	......	2.7
Average terminal length per shoot in inches	57.4 ± 1.63	60.2 ± 1.60	83.3 ± 1.44	93.4 ± 2.08	69.8 ± 6.18	......	72.9
Standard deviation in inches	54.4 ± 1.14	51.6 ± 1.14	55.2 ± .99	56.2 ± 1.46	29.0 ± 4.38	......	......
Average lateral length per shoot in inches	38.9 ± 2.87	42.1 ± 2.84	59.2 ± 2.69	75.2 ± 3.72	42.4 ± 13.12	......	52.6
Standard deviation in inches	95.8 ± 2.01	91.6 ± 2.02	103.4 ± 1.86	100.6 ± 2.62	61.6 ± 9.30	......	......
Average combined terminal and lateral length per shoot in inches	96.3 ± 4.10	102.3 ± 4.18	142.5 ± 3.81	168.6 ± 5.33	112.2 ± 19.5	......	125.5
Standard deviation in inches	136.8 ± 2.87	134.7 ± 2.96	146.4 ± 2.96	144.0 ± 3.74	91.8 ± 13.86	......	......
Average number of laterals per shoot	2.77	3.21	4.66	5.86	2.80	......	4.03
Average length per lateral in inches	14.0	13.1	12.7	12.8	15.1	......	13.1

spectively (Table 3), while the amount of fruit on a shoot ranged from none to more than a pound. Since this number had been determined in the flower bud, this grouping was used as an index to the amount of flower formation that took place. The number of clusters was also a very good index of the amount of fruit produced (Tables 2, 3, and 4). Even under the wide range of pruning treatments for the

FIG. 2.—CONCORD VINE SEVERELY PRUNED TO 16-25 NODES, 1924-1929

Severe pruning of the above vine for six years resulted in too vigorous shoots with long internodes. Very little fruit was in prospect from this vine for the 1929 season. (*Photographed June 5, 1929*)

two years, 1927 and 1928, the production of any of the growing buds left on the vines after pruning seemed to be largely determined by the number of embryonic flowers differentiated the previous season.

In accordance with the findings of Partridge,[10*] Schrader,[12*] and the authors,[4*] the average cluster size in a given area became larger as the number of clusters increased (Table 3).

As shown by the standard deviations, a wide range of shoot vigor existed among those shoots having the same number of clusters

(Table 3). There seemed to be little relationship between shoot vigor and the previous year's fruit-bud formation, tho the extent of fruit-bud formation appeared to have considerable effect upon the production of a shoot the following year.

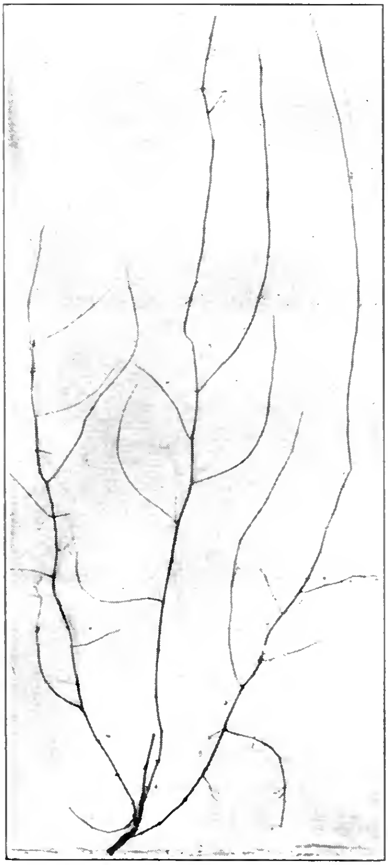

FIG. 3.—CANE FROM CONCORD VINE PRUNED TO 16-25 NODES, 1924-1928

Vigorous shoots with considerable lateral growth, much of which occurred late in the season, developed on this severely pruned cane. One shoot has been broken off near the end of the old cane.

Yield.—The shoots were again classified and studied according to the number of ounces of fruit they produced (Table 4). Under this method of grouping, average growth was similar to that shown in Table 3, where the number of clusters was taken as the unit. Under

TABLE 4.—GROWTH AND FRUIT PRODUCTION OF ALL SHOOTS, CLASSIFIED ACCORDING TO WEIGHT OF FRUIT

	Shoots grouped according to ounces of fruit produced					
	No fruit	.1–3.9 ounces	4.0–7.9 ounces	8.0–11.9 ounces	12.0–15.9 ounces	16.0–27.9 ounces (aver., 18.2 oz.)
1927						
Number of shoots in each class	419	721	451	265	108	39
Average number of clusters per shoot	....	1.35 ± .013	2.12 ± .017	2.63 ± .022	2.94 ± .023	3.21 ± .050
Standard deviation	....	.53 ± .010	.54 ± .012	.54 ± .016	.35 ± .016	.46 ± .033
Average terminal length per shoot in inches	58.2 ± 1.71	50.9 ± 1.13	59.0 ± 1.40	72.7 ± 1.75	71.4 ± 2.38	82.7 ± 3.87
Standard deviation in inches	51.8 ± 1.19	45.2 ± .81	43.6 ± .96	42.8 ± 1.24	36.6 ± 1.68	35.8 ± 2.58
Average lateral length per shoot in inches	36.6 ± 2.41	21.0 ± 1.22	18.5 ± 1.03	25.5 ± 1.82	33.2 ± 2.71	33.1 ± 4.31
Standard deviation in inches	72.9 ± 1.68	48.9 ± .88	32.1 ± .71	44.4 ± 1.29	41.7 ± 1.92	39.9 ± 2.87
Average combined terminal and lateral length per shoot in inches	94.8 ± 3.78	71.9 ± 2.12	77.5 ± 2.21	98.2 ± 3.20	97.5 ± 3.98	115.9 ± 7.52
Standard deviation in inches	114.6 ± 2.64	84.9 ± 1.53	69.0 ± 1.52	78.0 ± 2.26	61.2 ± 2.82	69.6
Average number of laterals per shoot	2.60	1.90	2.25	3.38	3.90	5.21
Average length per lateral in inches	14.1	11.1	8.2	7.5	6.7	6.4
1928						
Number of shoots in each class	504	632	530	263	55	11
Average number of clusters per shoot	....	1.34 ± .014	2.10 ± .014	2.68 ± .021	2.96 ± .035	3.18 ± .079
Standard deviation	....	.51 ± .010	.49 ± .010	.49 ± .014	.38 ± .024	.39 ± .056
Average terminal length per shoot in inches	57.4 ± 1.63	64.4 ± 1.48	83.4 ± 1.54	95.8 ± 2.32	97.7 ± 4.99	92.2 ± 10.43
Standard deviation in inches	54.4 ± 1.14	55.0 ± 1.04	53.0 ± 1.11	55.2 ± 1.60	54.8 ± 3.51	51.4 ± 7.40
Average lateral length per shoot in inches	38.9 ± 2.87	46.1 ± 2.61	59.8 ± 2.89	75.0 ± 4.44	77.8 ± 9.08	44.4 ± 2.30
Standard deviation in inches	95.8 ± 2.01	96.8 ± 1.84	99.6 ± 2.09	105.6 ± 3.06	99.8 ± 6.39	45.8 ± 6.60
Average combined terminal and lateral length per shoot in inches	96.3 ± 4.10	110.5 ± 3.79	143.2 ± 4.05	170.8 ± 6.16	175.4 ± 13.02	136.5 ± 19.36
Standard deviation in inches	136.8 ± 2.87	140.4 ± 2.67	139.8 ± 2.94	146.7 ± 4.25	143.1 ± 9.16	90.9 ± 13.09
Average number of laterals per shoot	2.77	3.35	4.88	5.98	6.02	3.55
Average length per lateral in inches	14.0	13.8	12.3	12.5	12.9	12.5

this range of consistent annual pruning, individual shoot vigor had very little apparent effect on the same year's fruit production.

PRUNING AND GENERAL VINE GROWTH

The growth and fruiting activities of the different groups of vines varied with the treatments they received (Table 1 and Figs. 2, 4, and 6). The number of shoots was limited in proportion to the number

FIG. 4.—CONCORD VINE PRUNED TO APPROXIMATELY 60 NODES DURING 1924-1929

Moderate pruning of the vine as shown above resulted in shoots of medium vigor and with sufficient bloom to yield a good crop. (*Photographed June 5, 1929*)

of buds left at pruning time (Table 1, Item 2). This limitation, however, did not seem to affect markedly either the percentage of nodes producing two shoots (Item 4) or the percentage of nodes remaining dormant (Item 3).

At harvest time a survey of the activity of these vines showed that the amount of their new wood or shoot growth was not limited by the severity of the pruning treatment (Item 9). Even where the more severe pruning reduced the number of buds and thus limited the possible number of potential shoots, each shoot was usually longer than the shoots on vines less severely pruned (Item 7) and produced more laterals of greater vigor (Item 15). As a result the total vegetative growth of the vine remained about constant even tho the type of growth varied.

Two other conditions resulting from the pruning need to be taken into account in this connection. First, more severe pruning resulted in an increase in the percentage of shoots broken by various causes, such as storms and tools used in cultivation (Item 5). This may be explained by the fact that the smaller number of shoots afforded less

FIG. 5.—CANE FROM CONCORD VINE PRUNED TO 56-65 NODES, 1924-1928

Shoots of medium vigor with few laterals resulted on this moderately pruned cane. Compare with the too vigorous shoots resulting from severe pruning as shown in Fig. 2. Polarity along the cane is illustrated by the shoot growth.

protection to one another while the resulting vigorous and tender growth offered a greater exposure. Next, the 4-cane Kniffin system of training, as previously mentioned, theoretically involves leaving four spurs at pruning time for renewal purposes. With the vines in the very severely pruned group, spurs were often unattainable in the desired location (close in to the trunk). The severely pruned canes were short and in some cases behaved similarly to spurs in that they furnished some of the shoots for canes the following year. On the other hand, where the very light pruning (Item 13) was followed consistently, it was often impossible, at pruning time, to find four canes long enough to furnish the required number of buds, and a few extra spurs were necessarily left on the vine.

PRUNING AND VINE YIELD

The average yield per vine in the different groups declined as the severity of pruning was increased (Table 1, Item 11). Since pruning has long been practiced as a method of thinning the fruit of the grape, this result was expected.

The average production per shoot was also slightly smaller with this decreased total yield (Item 19). Shoot production was determined by size and number of clusters (Items 12, 18), both of which varied in a more or less similar manner.

GROWTH AND PRODUCTION RESPONSES

Effects of Cane Length on Shoot Growth and Fruit Production of Vines Similarly Pruned.—Grape production is related to the fruiting pattern of individual canes, as previously discussed. In this experiment the cane length of the vines, which were trained to the 4-cane Kniffin system, necessarily varied under the different pruning treat-

TABLE 5.—AVERAGE GROWTH AND FRUIT PRODUCTION PER SHOOT FROM CANES PRUNED TO DIFFERENT NUMBERS OF NODES AND ORIGINATING FROM VINES PRUNED TO A SIMILAR NUMBER OF NODES

Number of nodes per cane left after pruning	Terminal length	Lateral length	Total length	Number of clusters	Weight of fruit	Size of clusters	Nodes forming shoots
	inches	*inches*	*inches*		*oz.*	*oz.*	*perct.*
Vines with 40 to 49 nodes (1927)							
Canes with 1 to 8 nodes......	68	29	98	1.81	5.18	2.86	69
Canes with 9 to 16 nodes.....	66	30	97	1.88	5.96	3.17	79
Increase due to extra cane length	−2	+1	−1	+.07	+.78	+.31	+10
Vines with 40 to 49 nodes (1928)							
Canes with 1 to 8 nodes......	78	63	141	1.68	4.20	2.50	72
Canes with 9 to 16 nodes.....	68	41	108	1.87	4.80	2.56	78
Increase due to extra cane length	−10	−22	−33	+.19	+.60	+.06	+6
Vines with 50 to 59 nodes (1928)							
Canes with 1 to 8 nodes......	53	26	79	1.57	4.13	2.63	70
Canes with 9 to 16 nodes.....	65	30	95	1.92	5.45	2.84	81
Increase due to extra cane length	+12	+4	+16	+.35	+.32	+.21	+11

ments. The effects of pruning on yield may be studied thru the activities of the canes as well as thru those of the vine.

To determine the effect of cane length upon growth and production, all of the canes in one group of vines were divided according to their length, as shown in Table 5. This treatment was repeated with three groups in order to obtain three measures of the average variations. The canes with nine or more nodes formed a noticeably larger number of shoots per node than did those with fewer nodes.

TABLE 6.—EFFECT OF DEGREE OF SEVERITY OF PRUNING ON GROWTH AND FRUIT PRODUCTION PER SHOOT FROM CANES WITH SIMILAR NUMBERS OF NODES

Number of nodes per cane left after pruning	Terminal length	Lateral length	Total length	Number of clusters	Weight of fruit	Size of clusters	Nodes forming shoots
	inches	*inches*	*inches*		*oz.*	*oz.*	*perct.*
Canes with 5 to 8 nodes on vines pruned to—							
(*1927*)							
44 nodes or less	80	48	128	1.33	3.26	2.45	71
45 nodes or more	60	26	86	1.80	4.74	2.63	71
(*1928*)							
39 nodes or less	91	88	180	1.60	5.18	3.24	71
40 nodes or more	70	52	122	1.66	4.15	2.50	72
Canes with 9 to 12 nodes on vines pruned to—							
(*1927*)							
49 nodes or less	68	30	99	1.86	5.94	3.20	77
50 to 59 nodes	60	23	82	1.83	5.20	2.85	75
60 nodes or more	55	17	72	1.83	5.24	2.85	84
(*1928*)							
39 nodes or less	95	74	170	1.63	4.42	2.71	79
40 to 49 nodes	70	44	114	1.85	4.84	2.61	72
50 nodes or more	68	34	102	1.85	5.27	2.85	77

The average productivity of these shoots was also greater in both number and size of clusters. The shoots consisted of about the same length terminals and laterals in each cane class. The variations in yield in the 9-to-16-node section were actually larger than they appear at first glance, since the average is taken on all shoots of the cane and not on the shoots of this area alone.

It is concluded, therefore, that increased length of cane increased the average yield per shoot, but did not affect shoot vigor.

Effects of Severity of Vine Pruning on Shoot Growth and Fruit Production of Canes With Similar Node Numbers.—The effects of severity of vine pruning upon growth and production of buds on canes with similar bud numbers were next determined (Table 6). The number of buds forming shoots did not vary consistently with the different pruning treatments, nor was there a consistent variation in the average yield per shoot. As the severity of pruning was increased, growth and production of the remaining buds were affected in the following manner: Shoot growth consistently increased with a proportionately wider variation in length of laterals than of terminals. Production was not markedly affected within the divisions made.

Growth and Production Relationships.—Results of the experiment having indicated that shoot vigor is determined by the severity of winter pruning and production by the number of nodes left and by the number of flowers formed in the buds the previous season, an effort was next made to determine if any correlation exists between production, number of clusters, and growth on like portions of canes similarly pruned. Shoots grown in 1927 from the fifth to the eighth node on canes 9 to 12 nodes long on vines pruned to 49 to 63 nodes were studied. This was the closest selection possible if a dependable number of shoots was to be retained.

A study of these selected shoots is summarized in Table 7. A correlation of + .319 ± .043 was found to exist between terminal shoot

TABLE 7.—RELATIONSHIP BETWEEN GROWTH AND FRUITING OF SHOOTS FROM 5TH TO 8TH NODES ON CANES 9 TO 12 NODES LONG ON VINES PRUNED TO 49 TO 63 NODES, 1927

Correlation between number of clusters and—	
Ounces of fruit per shoot	+ .778 ± .019
Terminal length per shoot	+ .351 ± .042
Lateral length per shoot	+ .142 ± .047
Combined terminal and lateral length per shoot	+ .275 ± .044
Correlation between ounces of fruit and—	
Terminal length per shoot	+ .319 ± .043
Lateral length per shoot	+ .142 ± .047
Combined terminal and lateral length per shoot	+ .211 ± .046

length and ounces of fruit. Since the correlation between length of laterals and production was still lower, altho positive (+ .142 ± .047), it seems unlikely that the same year's growth and production have much in common. A correlation of + .351 ± .042, which is fully as high as the one just mentioned, between number of clusters and terminal shoot length indicates that the relationship that does exist may continue from the earlier existing relationship between fruit-bud formation and bud vigor. This is further substantiated by the much higher correlation of + .778 ± .019 between number of clusters and yield. The relationship resulting between shoot vigor and fruit-bud formation as measured by number of clusters is related to parallel patterns of activity along the cane. These patterns appear in the section on growth and production along the cane, page 194 to 201.

To check still further the relationship between fruiting and growth the same summer (1928), the factor of vigor as it affects fruit-bud formation was eliminated as much as possible by selecting shoots with two clusters. The effect of vigor as induced by pruning was also largely nullified by choosing shoots with the same range in primary length (80 to 99 inches). The weight of fruit on these shoots with similar fruit-bud formation and similar vigor at pruning time was correlated with lateral length in inches. The variation in lateral growth as measured by the standard deviation was 45.4 inches, and in production was 2.4 ounces. These variations were larger than the limitations placed on terminal growth and number of clusters. After thus limiting the factors of fruit-bud formation and early vigor, a correlation of no significance ($+ .096 \pm .076$) was found between fruit development and lateral growth during the summer. This correlation indicates that under the conditions existing in this experiment the amount of fruit normally produced by a shoot seems to have little or no effect on growth. Since this is a shoot study, it does not take into account the effect of production by one shoot on the growth of another, which may partially explain why these data appear to disagree with those of Chandler and Heinicke,[1*] who found that fruit production decreased top growth on the vine as a whole.

In order to measure the relationship between fruit-bud formation and the vigor of the buds the following spring, one vine (Fig. 6) was left unpruned in 1929 and at blooming time, June 5, the number of flower clusters present and the vigor in terms of shoot length were determined. Since the vine was left unpruned in 1929, the individual buds were expected to show the same relative vigor as they had the previous season. The correlation between fruit-bud formation and growth at blooming time was $+ .444 \pm .026$. This is similar to the correlation found by Schrader[13*] between shoot length on May 22 and size of bunch on shoots that were thinned to one cluster before setting. The correlation was, however, slightly higher than that of terminal growth and fruiting, as previously presented, and shows that the relationship between growth and fruiting is one of bud vigor and fruit-bud formation continuing on to fruit development.

GROWTH AND PRODUCTION ALONG THE CANE

Vines trained to the 4-cane Kniffin system and pruned to different degrees of severity would, judging from the above data, be expected to vary in cane length somewhat proportionately to the severity of pruning. The distribution of the 199 canes left on the 48 vines in 1927 and the 225 canes of 1928, according to length in number of nodes and pruning treatment of the vine supporting them, is shown in Table 8. The average activity of the different length canes proved to be directly

FIG. 6.—CONCORD VINE MODERATELY PRUNED TO 50 NODES IN 1928, WITH NO PRUNING IN 1929

A large number of weak shoots beginning growth with too many fruit clusters resulted from moderate pruning in 1928 and no pruning in 1929. (*Photographed June 5, 1929*)

related to the pruning range followed the preceding winter and also, altho to a less extent, of the winter before that.

Shoot Growth Along the Cane.—The number of shoots produced per node along the cane was larger as more nodes were left on the cane and vine at pruning time (Table 9). Examination of the canes from base to tip indicated that this growth pattern was due primarily to greater activity of buds on more distal nodes in starting shoots.

The average vigor of shoots or growth per bud as measured by length of terminals (Table 10) and of laterals (Table 11) decreased with length of cane. The growth of laterals diminished more rapidly than that of terminals, as would be expected from the conclusions drawn from the data in Table 6 (page 192).

TABLE 8.—DISTRIBUTION OF CANES ACCORDING TO NUMBER OF NODES TO WHICH VINES WERE PRUNED AND ACCORDING TO NODES PER CANE

Nodes per vine	Nodes per cane				All canes
	1–4	5–8	9–12	13–16	
Number of canes in each group, 1927					
20–29	3	23	0	0	26
30–39	3	6	3	0	12
40–49	3	31	25	3	62
50–59	2	13	24	6	45
60–69	2	9	20	7	38
70–79	5	1	4	2	12
80–89	0	1	2	1	4
Total number of canes	18	84	78	19	199
Average nodes per vine	51.2	42.8	54.9	60.3	
Number of canes in each group, 1928					
20–29	10	22	2	0	34
30–39	4	77	15	0	96
40–49	1	35	31	2	69
50–59	2	17	21	4	44
60–69	0	4	6	2	12
Total number of canes	17	155	75	8	255
Average nodes per vine	31.6	38.3	46.4	54.5	

TABLE 9.—AVERAGE NUMBER OF SHOOTS PER NODE IN CANE SECTIONS PRUNED TO DIFFERENT NODE NUMBERS

(Data for same canes as in Table 8)

Number of nodes per cane left after pruning	Section of cane from base to tip				Average for all sections
	1st–4th nodes	5th–8th nodes	9th–12th nodes	13th–16th nodes	
Number of shoots per node, 1927					
1–4	.71	....	....	....	.71
5–8	.56	1.03	....	....	.74
9–12	.60	1.08	1.14	....	.91
13–16	.54	1.00	1.19	1.36	.97
Average for all canes	.58	1.04	1.15	1.36	.86
Number of shoots per node, 1928					
1–4	.66	...	....	....	.66
5–8	.54	.96	....	....	.71
9–12	.51	.97	1.19	....	.82
13–16	.62	.91	1.00	1.00	.87
Average for all canes	.54	.96	1.15	1.00	.76

TABLE 10.—AVERAGE TERMINAL GROWTH PER SHOOT IN CANE SECTIONS PRUNED TO DIFFERENT NODE NUMBERS
(Data for same canes as in Table 8)

Number of nodes per cane left after pruning	Section of cane from base to tip				Average for all sections
	1st–4th nodes	5th–8th nodes	9th–12th nodes	13th–16th nodes	
	Terminal growth per shoot, 1927				
	inches	*inches*	*inches*	*inches*	*inches*
1–4	65	..	..	..	65
5–8	65	74	..	..	70
9–12	51	60	70	..	61
13–16	42	52	59	71	56
Average for all canes	57	64	67	71	63
	Terminal growth per shoot, 1928				
1–4	86	..	..	..	86
5–8	82	84	..	..	83
9–12	65	72	88	..	75
13–16	36	36	50	59	45
Average for all canes	76	77	82	59	77

TABLE 11.—AVERAGE LATERAL GROWTH PER SHOOT IN CANE SECTIONS PRUNED TO DIFFERENT NODE NUMBERS
(Data for same canes as in Table 8)

Number of nodes per cane left after pruning	Section of cane from base to tip				Average for all sections
	1st–4th nodes	5th–8th nodes	9th–12th nodes	13th–16th nodes	
	Lateral growth per shoot, 1927				
	inches	*inches*	*inches*	*inches*	*inches*
1–4	37	..	..	..	37
5–8	30	42	..	..	36
9–12	18	19	34	..	23
13–16	15	20	21	43	24
Average for all canes	14	27	34	43	28
	Lateral growth per shoot, 1928				
1–4	106	..	..	..	106
5–8	69	77	..	..	73
9–12	39	44	58	..	46
13–16	6	6	7	14	8
Average for all canes	61	60	50	14	59

Both terminal and lateral shoots from each group of canes were shortest at the base of the cane and increased in length as they originated nearer the tip. Apparently the shoot-vigor pattern of a vigorous cane, like its productiveness, tends to increase with the buds farther out from the base to at least the sixteenth node. This probably explains most of the correlation found between shoot growth and produc-

FIG. 7.—FLOWERING SHOOTS FROM A HEAVILY PRUNED, A MODERATELY PRUNED, AND AN UNPRUNED CONCORD VINE

The vine pruned severely to 16-25 nodes (1) shows a more vigorous growth than the vine pruned moderately to 56-65 nodes (2). The vines that received no pruning (3) was much less vigorous than either of the pruned vines.

tion (Table 7). As pruning treatments become more severe and shorten the cane accordingly, they also increase the vigor of the remaining buds nearer the base (Figs. 3 and 5).

Production Along the Cane.—In some of the earlier studies on cane production the node was used as a unit instead of the shoot, which is usually considered as the unit in this study. The node is used as a unit in Tables 12 and 13, in which production results are shown.

In general, the findings in this experiment confirm duplicate studies in other states. That is, they show that the production per shoot tended to be low at the base of the cane and increased to about the ninth to sixteenth nodes (Table 15), and that the production per node varied in the same direction, altho more widely, owing to the differences in number of shoots produced at the various nodes (Table 16). This variation in the production of the different areas of the cane in the

TABLE 12.—AVERAGE NUMBER OF CLUSTERS PER SHOOT IN CANE SECTIONS PRUNED TO DIFFERENT NODE NUMBERS
(Data for same canes as in Table 8)

Number of nodes per cane left after pruning	Section of cane from base to tip				Average for all sections
	1st–4th nodes	5th–8th nodes	9th–12th nodes	13th–16th nodes	
Number of clusters per shoot, 1927					
1–4	1.31	....	....	....	1.31
5–8	1.59	1.55	....	....	1.57
9–12	1.75	1.98	1.70	....	1.84
13–16	2.03	1.96	2.09	2.07	2.04
Average for all canes	1.67	1.83	1.81	2.07	1.74
Number of clusters per shoot, 1928					
1–4	.63	....	....	....	.63
5–8	1.50	1.73	....	....	1.62
9–12	1.66	1.91	1.74	....	1.80
13–16	2.00	2.17	2.25	2.35	2.19
Average for all canes	1.50	1.82	1.82	2.35	1.71

TABLE 13.—AVERAGE NUMBER OF CLUSTERS PER NODE IN CANE SECTIONS PRUNED TO DIFFERENT NODE NUMBERS
(Data for same canes as in Table 8)

Number of nodes per cane left after pruning	Section of cane from base to tip				Average for all sections
	1st–4th nodes	5th–8th nodes	9th–12th nodes	13th–16th nodes	
Number of clusters per node, 1927					
1–4	.93	....	....	....	.93
5–8	.89	1.60	....	....	1.17
9–12	1.05	2.14	1.94	....	1.68
13–16	1.10	1.96	2.50	2.82	1.98
Average for all canes	.98	1.90	2.90	2.82	1.53
Number of clusters per node, 1928					
1–4	.42	....	....	....	.42
5–8	.82	1.66	....	....	1.15
9–12	.84	1.85	2.06	....	1.48
13–16	1.25	1.97	2.25	2.35	1.90
Average for all canes	.81	1.75	2.10	2.35	1.30

TABLE 14.—AVERAGE WEIGHT OF FRUIT PER CLUSTER IN CANE SECTIONS PRUNED TO DIFFERENT NODE NUMBERS
(Data for same canes as in Table 8)

Number of nodes per cane left after pruning	Section of cane from base to tip				Average for all sections
	1st–4th nodes	5th–8th nodes	9th–12th nodes	13th–16th nodes	
	Weight of fruit per cluster, 1927				
	oz.	oz.	oz.	oz.	oz.
1–4	2.64	....	....	....	2.64
5–8	2.36	2.73	....	....	2.56
9–12	2.65	3.18	2.88	....	2.97
13–16	2.92	3.31	2.89	2.68	2.97
Average for all canes	2.57	3.06	2.88	2.68	2.86
	Weight of fruit per cluster, 1928				
1–4	2.62	....	....	....	2.62
5–8	2.54	2.91	....	....	2.75
9–12	2.23	2.91	2.80	....	2.72
13–16	2.08	2.87	3.14	2.46	2.74
Average for all canes	2.50	2.91	2.87	2.46	2.70

TABLE 15.—AVERAGE WEIGHT OF FRUIT PER SHOOT IN CANE SECTIONS PRUNED TO DIFFERENT NODE NUMBERS
(Data for same canes as in Table 8)

Number of nodes per cane left after pruning	Section of cane from base to tip				Average for all sections
	1st–4th nodes	5th–8th nodes	9th–12th nodes	13th–16th nodes	
	Weight of fruit per shoot, 1927				
	oz.	oz.	oz.	oz.	oz.
1–4	3.45	....	....	....	3.45
5–8	3.76	4.23	....	....	4.02
9–12	4.65	6.31	4.91	....	5.48
13–16	5.91	6.48	6.05	5.53	6.06
Average for all canes	4.51	5.60	5.22	5.53	5.18
	Weight of fruit per shoot, 1928				
1–4	1.66	....	....	....	1.66
5–8	3.80	5.04	....	....	4.46
9–12	3.72	5.57	4.87	....	4.91
13–16	4.15	6.23	7.07	5.79	6.00
Average for all canes	3.74	5.30	5.23	5.79	4.71

TABLE 16.—AVERAGE WEIGHT OF FRUIT PER NODE IN CANE SECTIONS PRUNED TO DIFFERENT NODE NUMBERS
(Data for same canes as in Table 8)

Number of nodes per cane left after pruning	Section of cane from base to tip				Average for all sections
	1st–4th nodes	5th–8th nodes	9th–12th nodes	13th–16th nodes	
	Weight of fruit per node, 1927				
	oz.	oz.	oz.	oz.	oz.
1–4	2.46	....	....	....	2.46
5–8	2.09	4.35	....	....	2.99
9–12	3.79	6.81	5.58	....	4.99
13–16	3.20	6.48	7.22	7.54	5.89
Average for all canes	2.64	5.90	6.02	7.54	4.45
	Weight of fruit per node, 1928				
1–4	1.10	....	....	....	1.10
5–8	2.07	4.82	....	....	3.16
9–12	1.88	5.38	5.78	....	4.04
13–16	2.59	5.64	7.07	5.79	5.20
Average for all canes	2.03	5.09	6.02	5.79	3.58

Illinois studies, as in those in other states, was determined largely by the number of clusters produced but was also somewhat affected by the size of the clusters.

EFFECTS OF PRUNING ON FRUIT-BUD FORMATION

The data in Tables 12 and 14 show that the shoots on each section of the short canes consistently produced both fewer and smaller clusters than did the shoots on the same regions of the longer canes. These data include a larger range of variables in vine pruning than do the data in Tables 5 and 6, where this variation does not show consistently.

Keeping in mind that the severity of pruning within the limits of this experiment did not affect the current year's cluster production of the buds left, and that the ability of a bud to produce was determined largely at the time of fruit-bud formation, the authors began studies to determine the effects of the severity of pruning on fruit-bud formation.

The number of clusters produced by a shoot during the growing season was considered an index of the ability of the bud to form inflorescences, since practically no aborted flowers were noted. Any discrepancy caused by the polarity of cane activity was overcome by

TABLE 17.—EFFECTS ON FRUIT-BUD FORMATION[1] OF DIFFERENT DEGREES OF SEVERITY IN PRUNING, 1925–1927

Nodes per vine	Year fruit-buds were formed	Nodes from which the shoots grew, numbering from base of cane: 1 and 2		3 and 4		5 and 6		7 and 8			9 and 10		11 and 12		13 and 14		15 and 16		17 and 18		19 and 20	
		Number of shoots	Number of clusters	Number of shoots	Number of clusters	Number of shoots	Number of clusters	Number of shoots	Number of clusters	Average of nodes 1 to 8	Number of shoots	Number of clusters	Number of shoots	Number of clusters	Number of shoots	Number of clusters	Number of shoots	Number of clusters	Number of shoots	Number of clusters	Number of shoots	Number of clusters
20-29	1925	25	1.40	54	1.80	38	2.08	19	2.26	1.88	6	2.33	0	0	0	0	0	0	0	0	0	0
	1926	59	1.02	109	1.39	84	1.38	42	1.48	1.32	16	1.06	9	1.11	2	2.50	0	0	0	0	0	0
	1927	42	.71	56	.84	30	1.40	11	1.45	1.10	1	0	0	0	0	0	0	0	0	0	0	0
	Average	...	1.04	...	1.34	...	1.62	...	1.73	1.43	...	1.13	...	.37	..	.83	..	....	..	....	..	....
30-39	1925	86	1.77	174	2.07	159	2.12	86	2.15	2.03	22	2.09	9	2.22	2	2.00	0	0	0	0	0	0
	1926	131	1.21	282	1.56	269	1.86	207	1.66	1.57	84	1.77	18	1.56	2	2.50	0	0	0	0	0	0
	1927	72	1.15	151	1.49	143	1.46	68	1.62	1.43	8	2.00	0	0	0	0	0	0	0	0	0	0
	Average	...	1.38	...	1.71	...	1.81	...	1.81	1.68	...	1.95	...	1.26	..	1.50	..	....	..	....	..	....
40-49	1925	125	1.91	308	2.14	338	2.26	278	2.29	2.15	142	2.26	40	2.18	9	2.44	3	2.67	0	0	0	0
	1926	155	1.48	358	1.84	359	2.01	308	1.98	1.83	216	1.88	80	1.89	22	2.14	1	1.00	0	0	0	0
	1927	111	1.31	232	1.71	233	1.82	143	1.92	1.69	57	1.96	9	1.89	3	2.00	0	0	0	0	0	0
	Average	...	1.57	...	1.90	...	2.03	...	2.06	1.89	...	2.03	...	1.99	..	2.19	..	1.22	..	....	..	....
50-59	1925	73	2.10	199	2.24	215	2.29	207	2.37	2.25	177	2.51	111	2.48	47	2.53	14	2.79	3	3.00	1	3.00
	1926	120	1.67	277	1.89	286	2.08	268	2.15	1.95	238	1.97	146	2.03	60	2.08	26	2.04	5	2.20	1	3.00
	1927	87	1.53	221	1.80	233	1.87	161	1.94	1.78	97	1.88	31	2.03	7	1.71	3	1.67	2	2.00	0	0
	Average	...	1.77	...	1.98	...	2.08	...	2.15	1.99	...	2.12	...	2.18	..	2.11	..	2.17	..	2.40	..	2.00
60-69	1925	21	2.10	62	2.31	69	2.26	64	2.31	2.24	55	2.42	33	2.27	20	2.45	6	3.00	0	0	0	0
	1926	63	1.56	144	1.93	151	1.98	138	1.98	1.86	116	2.04	83	1.89	54	1.98	23	2.39	5	2.40	0	0
	1927	52	1.44	135	1.97	132	1.87	91	2.01	1.82	55	2.04	36	1.78	16	2.00	1	3.00	0	0	0	0
	Average	...	1.70	...	2.07	...	2.04	...	2.10	2.01	...	2.17	...	1.98	..	2.14	..	2.79	..	.80	..	....
70-79	1925	0	0	0	0	0	0	0	0	....	0	0	0	0	0	0	0	0	0	0	0	0
	1926	0	0	0	0	0	0	0	0	....	0	0	0	0	0	0	0	0	0	0	0	0
	1927	21	1.00	36	1.81	39	1.87	33	2.27	1.74	15	1.53	7	2.00	0	0	0	0	0	0	0	0

[1]Fruit-bud formation was observed by noting the number of clusters produced per shoot in definite locations along the cane the following season.

numbering all nodes progressively outward, starting with the basal node at the trunk. The clusters on the shoots from each two nodes of all canes of the vines in each group were averaged separately, as shown in Table 17. The averages of the shoots in the first four groups, including those from the first eight nodes, were then averaged as an

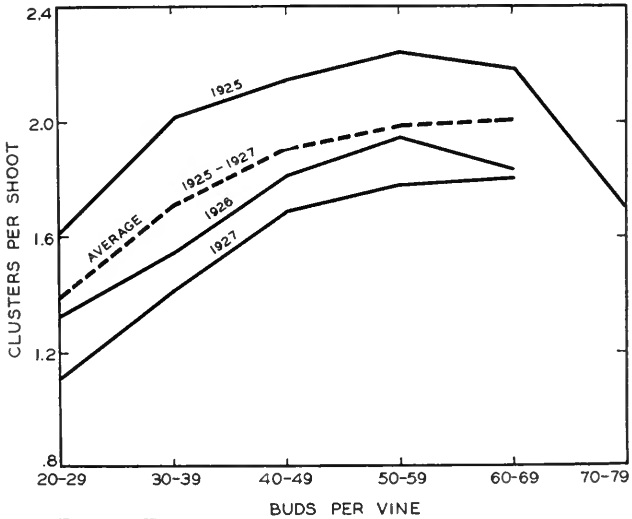

FIG. 8.—EFFECTS OF PRUNING ON FRUIT-BUD FORMATION

The rate of fruit-bud formation per node was low when severe pruning was practiced and increased with the decrease in severity of pruning up to 56-65 nodes.

index of fruit-bud formation. Data for the other nodes were listed but not averaged owing to the small number of shoots in some classes.

Since this study covers a period of three years and includes thousands of shoots, the indexes may be considered as representative. They result in a very smooth, even graph (Fig. 8). The rate of fruit-bud formation per node was low when severe pruning was practiced and increased at a constantly diminishing rate with the decrease in severity of pruning until the peak was reached at 56 to 65 nodes per vine. At this point the rate apparently started to decline. Since these curves are so consistent in direction for each of the three years, it may be concluded that under conditions similar to those of this experiment 56 to 65 nodes is the optimum number to leave in pruning Concord grapevines for maximum flower-bud production.

SUMMARY

1. The total amount of shoot length produced by a Concord vine was little affected in these experiments by the severity of the previous winter's pruning. The vigor of individual shoots was, however, increased proportionately as the severity of pruning increased. The increasing vigor of weak shoots was evidenced mainly by their greater length and of very vigorous shoots by the growth of laterals. The average length of the growth per shoot varied inversely with the number of buds left on the vine at pruning time.

2. The total yield produced by a vine was greatly influenced by the severity of the previous winter's pruning, the possible number of fruit clusters being limited by such pruning. Where fewer buds were left at pruning time and where the number of potential shoots was reduced, the number of clusters resulting was automatically lessened. The yield of individual shoots from the buds left to grow was not noticeably changed.

3. The patterns of shoot growth and of fruit production along the cane varied similarly from base to tip within the groups having a similar number of nodes per cane. The degree of severity of winter pruning treatment given a vine changed proportionately the vigor of all the shoots on a cane, the more severe pruning increasing the vigor of the shoots but having little effect on their production.

4. The degree of severity practiced in dormant pruning had a marked effect upon the formation of inflorescences in the buds along the shoots growing the following summer. With the more severe pruning, fewer inflorescences were formed.

5. Except under very unusual conditions during the fruiting season, the yielding ability of a shoot was largely determined in the bud the previous year, while its vigor was increased or decreased by the number of nodes left on the vine at pruning time, the smaller numbers resulting in an increase in vigor.

6. In this experiment vines pruned to about 56 to 65 nodes produced a profitable yield and also produced the largest number of flower primordia in the buds of the young shoots for the following year's crop.

PRACTICAL APPLICATION

The grower's problem is to secure high annual yields of marketable fruit and at the same time to cause the vine to form the largest inflorescences possible in the buds along the growing shoot for the future crop. Usually conditions that favor the formation of large flower clusters also favor a large number of flower clusters.[4*] Winter pruning modifies the immediate crop, mainly by limiting the number of clusters that can be produced. It influences the following year's crop by affecting the condition of the new shoots and their ability to form flower buds.

The grower should look upon his vines as individuals and, allowing for gradations in vigor resulting from the presence of insects or diseases, soil differences, and weather conditions, should handle them in such a way that vine growth and yield of well-matured clusters are balanced yearly.

The plants should have sufficient vigor and enough shoots, properly located, that will ripen into desirable canes, to produce a good crop. Since the condition of the crop cannot readily be determined while in the bud, the best available index that can be used at pruning time during the dormant season is the growth of the last season's shoots.

If most of the shoots were short and were too weak to produce laterals, the vine was pruned too lightly; that is, too many nodes were left the previous season. More severe pruning should be practiced, depending on the degree of weakness found.

If the shoots were so vigorous that they produced more than a third of their combined terminal and lateral length in laterals, the previous winter's pruning treatment was too severe and more nodes should be left in order to obtain higher yields the coming season and maximum fruit-bud formation for the next crop.

Concord vines grown under conditions similar to those occurring in the University vineyard and pruned to about 56 to 65 nodes will bear shoots that are vigorous but not sufficiently vigorous to produce much, if any, lateral growth. Vines with such a type of growth can carry large-sized bunches to full maturity and at the same time they have enough vigor to differentiate large flower clusters in the nodes along the growing shoots for the following year's crop.

After the severity of pruning treatment for the individual vine has been determined in terms of number of nodes to be left, the canes should be selected which will bear the following year's crop. Colby and Vogele[5*] found that shoots with a diameter of about ⅜ inch measured between the third and fourth nodes and well matured out to the tip will make the most productive canes the following year. Canes of this type, with few laterals, should be selected as arms to form the framework of the vine since the buds on these canes carry many and large inflorescences.

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DEFINITION OF TERMS

Shoot. The young growing branch originating from a bud. All fruits are borne on shoots, but not all shoots bear fruit.

Terminal or main shoot. The one central or principal shoot starting at the bud.

Lateral. A secondary growth arising from the main shoot the same year that the shoot grows.

Cane. A shoot of the previous season which may be left as an arm at pruning time.

Node. The enlarged portion or joint of the shoot at which the tendril, leaf, bud, and cluster are or may be borne, or the joint of the cane where the bud or shoot may be attached.

Internode. The part of the cane or shoot between two nodes.

Spur. A short piece of the base of a cane, having one to four nodes with one or more buds each, where renewal wood may be obtained at pruning time. Sometimes known as a renewal spur.

Bud. An undeveloped shoot.

Fruit bud or mixed bud. A bud in which a shoot bearing flowers originates; a bud containing rudiments of both shoot and flowers.