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PRUNING THE RED RASPBERRY

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East Lansing, Michigan

PRUNING THE RED RASPBERRY

BY STANLEY JOHNSTON AND R. E. LOREE

Although the red raspberry has been grown in this country for many years, there is still some doubt as to the kind and amount of pruning that should be employed to obtain the highest quality of berries without unduly reducing the yield. In general, little or no summer pruning is done except for the removal of old canes after fruiting, a practice about which there seems to be little difference of opinion, though little evidence. There are, however, considerable differences of opinion and practice regarding the number of canes which should be retained for fruiting in the hill or in a given length of row, and the extent to which those canes that are left should be headed back in the spring. Some growers practice very little heading back; the work done is merely the cutting off of the weak or winter-injured ends of the canes or the shortening of those that are very tall and vigorous just enough to prevent breaking or bending over during the fruiting season. Other growers cut the canes back more severely, to within three or even two feet of the ground, regardless of their individual size and vigor. It is possible that neither extreme is the best practice, at least under all conditions. However, very little experimental evidence can be found that will enable the grower to determine how severe the pruning should be.

MacDaniels[1] found that with the Herbert and Marlboro varieties any living bud from the tip to the base of the canes is potentially a fruit bud, although the lower buds on the larger canes usually do not start. When the canes were pruned severely, to about one-fifth their original length, the basal buds produced long vegetative shoots which blossomed later than the others and which terminated in small clusters of large fruit. When the pruning was light many of the basal buds failed to start. Card[2] recommends cutting the canes back to within three or four feet of the ground and states, "that where the canes grow tall and vigorous a heavier yield can doubtless be obtained by leaving more wood at the spring pruning." However he does not refer to any definite data on the subject.

Data on the practice of cane thinning are even more meager, and no one has been able to say whether the same number of canes should be left to the row if the plants are grown in hills as should be left if they are grown in hedgerows. Should the slender canes that are left for fruiting be headed back to the same height as the more stocky ones? Should the branched canes be headed more or less severely than those unbranched? Should the height of heading depend more

[1]MacDaniels, L. H.—Proc. Am. Soc. Hort. Sci. 19:194-200. 1922.
[2]Card, F. W.—Bush Fruits.—The MacMillan Co., New York. 1919.

on the stand of canes in the hill or row or on the diameter of the individual canes? These and many other questions are unanswered; yet yield and grade of berry are influenced by the way in which the grower consciously or unconsciously attempts to answer them at the time he prunes.

Probably answers cannot be obtained definite enough so that exact rules can be given to meet all conditions. There is, however, need of exact data on the bearing habits of the red raspberry as grown under different conditions and pruned in different ways. With such a body of data available it will be possible for the individual grower to work out a pruning system that is suited to his particular conditions. The investigations herein described were undertaken in an effort to obtain such a body of data.

DESCRIPTION OF FIELDS

A part of the experimental work on which this report is based was done on the Station grounds at East Lansing, and a part was done in fields near South Haven.

The East Lansing plot was of the Cuthbert variety, two years old at the time the work was begun. The plants had been set four feet apart in rows eight feet apart and trained according to the linear system. The soil was a well drained, fertile clay loam in which the plants had made a vigorous growth. They were practically free from disease and the stand was uniform.

One of the three South Haven fields was located on a clay loam soil, not entirely uniform in texture; this field was used principally for a study of fruiting habits, and it was possible to select for comparison small areas that presented as uniform conditions as are available in field work. This was evidenced by the general appearance of both soil and plants and the measurements of the cane growth in these areas. The plants in this field had been set four feet apart in rows six feet apart and had been kept in hills. At the beginning of the experimental work with them, they were four years old, vigorous and healthy.

The other two South Haven plots were located on one of the Experiment Station fields. In one of these two plots the soil was a well drained, fertile, sandy loam where growth was vigorous; in the other the soil was a fairly heavy, rather poorly drained clay loam where growth was moderate. Within each of the two plots there was a good stand of plants and the growth was uniform. The rows were seven feet apart and the plants had been set four feet apart in the rows. A part of the field had been trained to the hedge row system and in another part the plants had been kept in hills. They were healthy and three years old at the time this experimental work was begun. Cuthbert was the variety grown in all these plantations.

In no season throughout the period during which this study was in progress (1921-1926) was there any considerable deviation from the mean in the amount of April-August rainfall at either East Lansing

or South Haven. There were, however, differences in the distribution of this rainfall great enough to affect the growth and fruiting of the plants. Thus the May and June precipitation at East Lansing in 1925 was in the form of such light scattered showers that the soil became rather dry and berries in the unirrigated portion of the field did not attain satisfactory size. This made possible some measurement of the relation that the severity of pruning should bear to soil moisture conditions. In general the South Haven plots showed little evidence of injury from drought at any time throughout the period. Table 1 shows the April-August total rainfall at East Lansing and at South Haven for the years 1921-1926.

Table 1.—Total rainfall for the months of April-August, 1921-1926, East Lansing and South Haven. (In inches)

	1921	1922	1923	1924	1925	1926
East Lansing	16.16	13.96	13.94	16.29	10.14	11.89
South Haven	12.79	11.32	11.01	16.33	12.90	16.58

Fruiting Habit of Cuthbert Raspberry

To study the fruiting habit of the Cuthbert raspberry, 80 uniform hill plants were selected. Half of these plants were thinned to three canes and the other half to five canes to the hill. Except for the variations in thinning the pruning in each series was identical. Ten plants of each series were pruned about knee high, these canes averaged 13.8 buds each; ten were pruned about waist high, the canes averaged 20.4 buds each; ten were pruned about breast high, they averaged 33.2 buds each; the remaining ten were left unpruned, except for the removal of their winter injured tips, they averaged 45 buds each. All of these canes were straight and unbranched. Two groups of naturally branched canes were selected for observation and record. In one of these groups the laterals were left full length, averaging 19.8 buds; in the other group they were headed back to a medium length, averaging 14 buds.

Total yield records were obtained for the canes in each of these groups and, in addition, ten average canes in each block were selected for special observation. The buds on these ten canes were numbered from the ground to the tip and records made to determine which buds remained dormant, which had been winter injured, which grew, and whether the resulting shoots were vegetative or fruitful. If any buds became mechanically injured or if any dried up after making a short growth, notations were made accordingly. For convenience in recording these data, strings were tied at every fifth node and the records of each five-bud section assembled accordingly.

Influence of Pruning on Breaking of Buds

When growth starts in the spring, some buds remain dormant, some open to produce fruiting or vegetative laterals, and still others open to produce short weak vegetative shoots that soon wither and drop

off. Data relating to the influence of pruning on the opening of the buds and on the character of shoots that they produce are shown in Table 2. The average for all the canes under the several pruning treatments shows that 61.9 per cent of the buds produced shoots which matured fruit; 8.1 per cent remained dormant; 11.8 per cent produced

Table 2.—Growth record of ten average red raspberry canes under each of several pruning treatments.

Block	Total buds	Remaining dormant		Living vegetative shoots percent	Fruitful shoots		Winter injured percent	Mechanically injured shoots percent	Producing shoots which dried up percent
		No.	Percent		No.	Percent			
Five cane series:									
Canes waist high (20.4 buds)	204	29	14.4	8.9	113	55.9	4.0	8.9	7.9
Canes breast high (33.2 buds)	332	22	6.0	15.0	212	63.9	5.7	3.6	5.1
Canes full length (45 buds)	450	20	4.4	12.2	276	60.2	12.7	8.0	1.3
Three cane series:									
Canes waist high	191	32	16.8	5.8	122	63.9	0.5	5.0	7.5
Canes breast high	294	29	9.9	11.9	200	68.0	2.4	4.4	3.4
Canes full length	415	22	5.3	13.3	244	58.8	16.9	4.8	1.0
Percent of total	.....	.....	8.1	11.8	.....	61.9	8.6	5.7	3.6

vegetative shoots that yielded no fruit; 8.6 per cent of the buds were winter killed; a condition in evidence principally at the tips of the long canes; 5.7 per cent produced shoots that were mechanically injured by wind, cultivators, pruning shears, and other means; and 3.6 per cent of the buds produced weak shoots that soon dried up.

As would be expected, the lighter the heading, the greater was the proportion of winter injured buds, since winter killing is usually more severe on the younger and more slender growth than on the older portion of the cane. That there should be an equal number or even more buds that remained dormant on the heavily headed than on the lightly headed and unheaded canes was hardly anticipated. The differences are probably not great enough to be significant but, as a whole, the figures indicate that such variations in severity as are likely to be afforded in ordinary pruning are not likely to affect materially the total number of buds that fail to open. It is likewise evident that the amount of heading back, within the range commonly afforded red raspberries, is not likely to greatly influence the number of shoots that start to grow and then stop and wither; such influence as there is on this feature of the plant's growth is in the opposite direction from that which might be expected. The numbers both of fruitful and of non-bearing shoots are roughly proportional to the height to which the canes are pruned, although, with winter-injured buds omitted from consideration, the percentage of buds that produce fruitful shoots is smaller in the case of the canes pruned waist high than it is in the case of those pruned breast high or left unpruned. This indicates that if fruit bud formation takes place in the spring after growth starts, as recent investigations seem to show, the pruning that is ordinarily done neither promotes nor interferes with bud formation. The fact that

about the same percentages of buds open on the canes of the three-cane hills as on those of the five-cane hills and that they give rise to about the same proportion of fruitful and of non-fruitful shoots is important in indicating that each cane apparently is to a large degree independent of others in the same hill. It suggests that it may be easy to carry the practice of cane thinning too far, thereby reducing yields.

Fruit Production on Various Parts of Unbranched Fruiting Canes

Fruiting records of different sections of unbranched non-headed canes are shown graphically in Figure 1. The basal five buds of the cane are always relatively unproductive, due to a comparatively high percentage remaining dormant and to others that produce non-fruitful shoots. The second five-bud section is almost invariably the most productive portion of the cane, most of its buds opening and giving rise to fruitful laterals. Beyond the tenth bud each five-bud section is progressively less productive. Only the second, third, and fourth five-bud sections yielded more heavily than the basal section. Smaller sizes of berry were associated with the progressively lower yields of the median and upper sections of the cane. The largest berries were produced on those shoots originating near the base of the cane.

Fruit Production of Different Sections of Branches on Branched Canes

The records of yield and size of fruit on different five-bud sections of the branches of naturally branched canes are shown in Table 3. The branches were grouped according to their bud length. Those 15 buds in length yielded more than the basal 15-bud sections of longer laterals and more than the entire laterals on longer branches. Beyond the fifteenth bud there was a decided falling off in total yield and size of berry, though the difference in average size of berry was slight. Invariably the first five buds on lateral branches proved relatively

Table 3.—Yield records of 5-bud sections on branches of five selected canes.

Section	Branches (average length)					
	10 buds long	15 buds long	17.5 buds long	20.5 buds long	24 buds long	Average
1. Yield in oz.	1.43	3.0	.18	1.12	87	1.32
No. berries	32	86	4	30	26	35.6
No. berries per oz.	23	29	22	27	30	26
2. Yield in oz.	3.12	9.62	1.56	2.56	1.56	3.68
No. berries	79	273	60	75	42	106
No. berries per oz.	32	29	38	29	28	31
3. Yield in oz.	.....	10.37	1.93	4.0	1.87	4.54
No. berries	.....	294	54	135	59	135
No. berries per oz.	.....	29	29	34	32	31
4. Yield in oz.	.....	.....	2.50	1.43	1.75	1.89
No. berries	.....	.....	67	50	61	59
No. berries per oz.	.....	.....	27	42	36	34
5. Yield in oz.	.....	.....	.....	.....	.62	.62
No. berries	.....	.....	.....	.....	20	20
No. berries per oz.	.....	.....	.....	.....	32	32

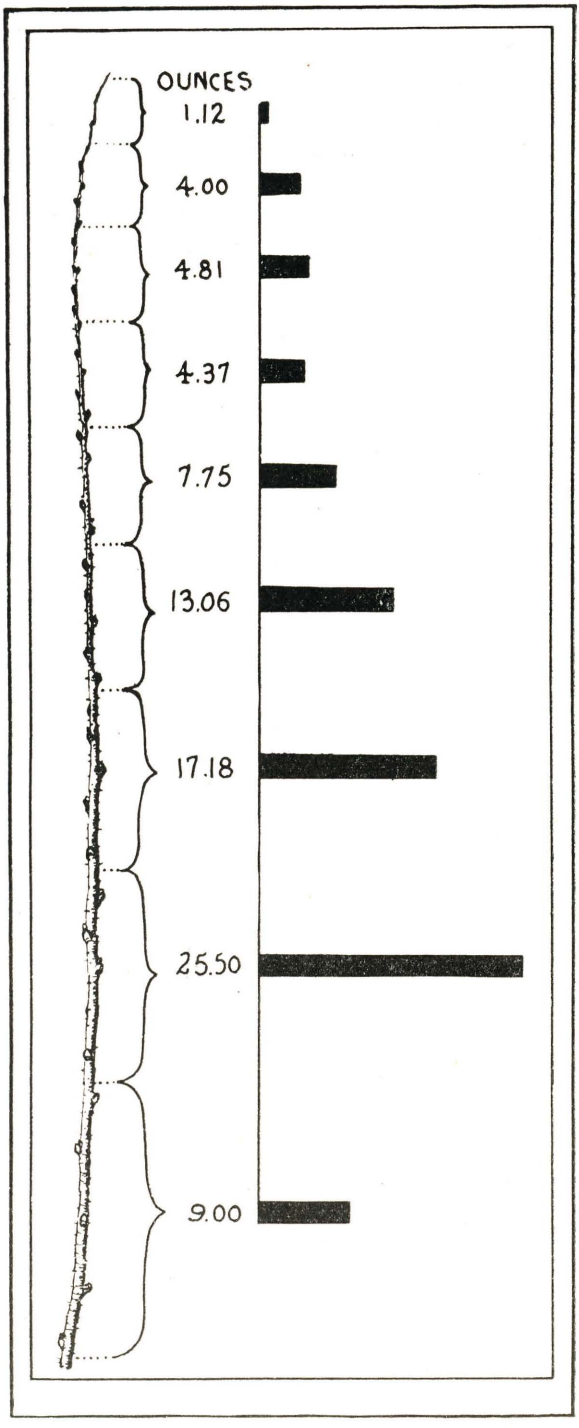

Fig. 1.—Yield records of different five-bud sections of ten average full length canes, in ounces.

unproductive, although the berries were large. Many of the buds on the basal section of the branches remained dormant or, if they opened, they gave rise to vegetative shoots. This is in contrast to the behavior of buds on corresponding portions of lateral branches in the

Fig. 2.—A vigorous Cuthbert raspberry cane, five-eighths inch in diameter at the base and possessing four lateral branches. Canes of this size averaged over 12 ounces of berries apiece. This is an extremely heavy yield (requiring only 12 feet of hedgerow with a stand of two and one-half canes to the foot to produce a crate) and is 50 per cent greater than the average yield of unbranched canes of the same diameter.

black raspberry and should be given due consideration when pruning back the laterals of branched canes.

Comparison of Unbranched and Branched Canes

Data on the average yield and size of berry for a group of unbranched and branched canes that were similarly pruned are brought together in Table 4. Branched canes outyielded the unbranched canes by a third, though their berries were somewhat smaller. Probably a little heavier heading back of the main canes of these branched canes would have resulted in some increase in the size of their fruit without materially affecting their yield. Even if such pruning did not affect the size, the difference in yield is great enough to make the branched canes more profitable than those without branches.

Table 4.—A comparison of the average yield and size of berry on unbranched and branched canes.

	No. canes averaged	Yield in oz.	No. berries	No. berries per ounce
Average for unbranched canes, 45 bud length	10	8.6	199.8	23
Average for naturally branched canes 45 bud length, laterals 14 bud length	10	12.6	359	29

This raises the question as to the advisability of pinching the tips out of the new red raspberry shoots, as is the practice with black raspberries, to force their branching. Observation leads to the belief that pinching in the red raspberry may be followed by such severe winter injury to the resulting branches that it is not good practice. On the other hand, though naturally branched canes are subject to a certain amount of killing back at the tips; usually it is not so severe as in the branches forced out by pinching. Naturally branched canes should be saved at the time of pruning and undoubtedly yields can be materially increased by those soil conditions and cultural practices that promote natural branching.

Relation of Cane Diameter to Yield and Size of Fruit

Cane diameters of those canes left for fruiting in this particular test varied from 0.312 to 0.437 inches. The records of these canes are assembled in groups according to their size in Table 5. The

Table 5.—Relation of cane diameter to total yield and size of berry. (Canes pruned breast high)

No. canes averaged	Av. cane diameter six inches above ground (inches)	Yield in ounces	No. berries per ounce
4	.312	4.0	31
7	.375	5.8	28
5	.406	5.7	26
4	.437	7.5	26

heaviest yields were obtained from the largest canes, though all of them were pruned to about the same height and carried about the same number of buds. Furthermore there was a similar, though not

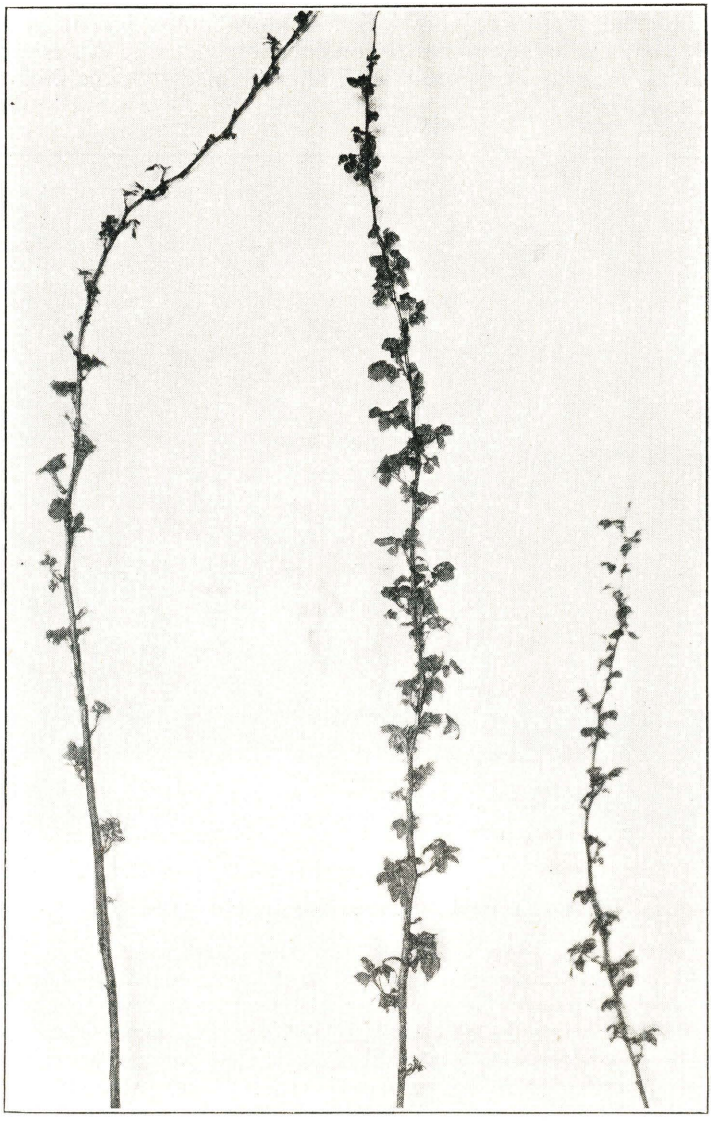

Fig. 3.—Unbranched canes of the Cuthbert variety, ½, ⅜ and 9/32 of an inch in diameter, respectively. The average yields of the ½ inch canes was over ½ pound, requiring less than 18 feet of row to produce a crate. The average yields of the ⅜ inch canes was about 5.8 ounces, requiring about 24 feet of row standing two and a half canes to the foot to produce a crate. The average yield of 9/32 inch canes was less than ¼ pound, requiring more than 36 feet of row to produce a crate.

so close correlation between cane diameter and size of berry. Additional evidence on the influence of cane diameter on yield and size of berry is afforded by a comparison of the figures in Tables 6 and 7.

Probably the heavier yields of branched as compared with unbranched canes, that were referred to in a previous paragraph, are due primarily to the fact that they carried more buds, but it is likewise significant that the canes were of considerably greater diameter (averaging half an inch as compared with three-eighths of an inch for unbranched canes).

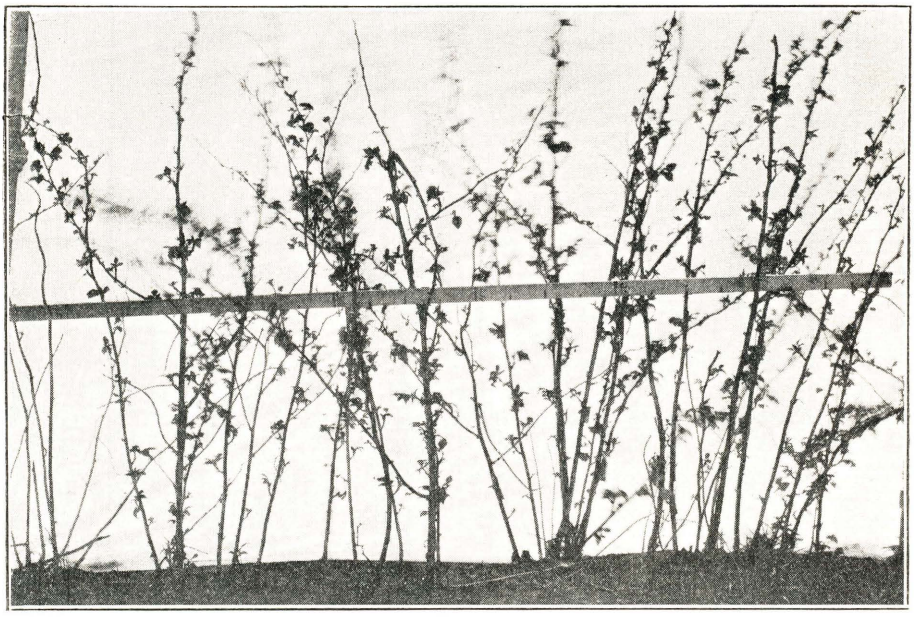

Fig. 4.—Seven feet of hedgerow in a Cuthbert raspberry plantation before pruning. It contains 24 reasonably large vigorous canes and a number of weak slender ones. Compare with Fig. 5.

Pruning Red Raspberries in Hedgerows

It has just been shown that when red raspberries are grown in hills, yield is materially reduced without compensating improvement in size of berries when the canes are thinned from five to three in the hill (a reduction from 9,000 canes to 5,400 to the acre when set 6 x 4 feet apart) and when they are headed rather severely. Presumably a similar reduction is to be expected when canes growing in hedgerows are similarly thinned and headed. The large percentage of red raspberry fields that are trained in this way, together with the great variation in pruning treatments that growers give their plants, seemed to warrant the securing of exact data on this question.

Suitable portions of a red raspberry plantation on the South Haven Experiment Station grounds were selected for this work. In one part, the soil was a well drained, fertile, sandy loam; in the other

it was a rather heavy clay loam, none too well drained. The canes on the well drained land were vigorous; those on the poorly drained area were only medium to below medium in size. Apparently the soil within each of the two areas was uniform, for the plants presented little variation in appearance. The rows were seven feet apart and the plants had originally been set four feet apart in the row but, as is usual with red raspberries when trained in the hedge form, the canes were fairly evenly distributed along the rows.

Eight blocks, each 16 feet long, were marked off in the rows. Six of these were thinned to 40 canes to the block, 2.5 to the foot; one to 32 canes, 2 to the foot; and one to 24 canes, 1.5 to the foot. The canes

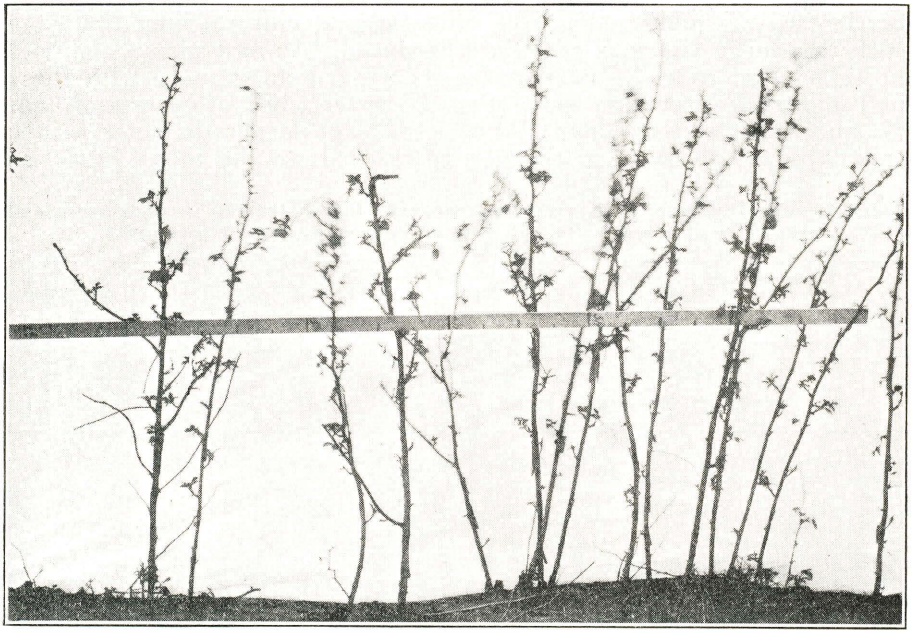

Fig. 5.—The same seven feet of hedgerow in a Cuthbert raspberry plantation as shown in Fig. 4 after pruning. It still contains 15 of the largest, most vigorous canes, over two to the foot, and all of these canes and their laterals have been headed back. This illustrates about the amount of pruning that can be done without appreciably reducing yield.

of one of the blocks thinned to 40 were left unheaded, those of another were headed back to 35 buds, those of a third to 30 buds, those of a fourth to 25 buds, those of a fifth to 20 buds, and those of the sixth block were headed back varying amounts, according to the size and vigor of the individual cane. The canes of the two blocks thinned to two and to one and one-half canes to the foot of row were headed back to 30 buds each. Some of the canes left in these rows for fruiting met with accident, the numbers actually fruiting are given in Tables 6 and 7. Duplicate series were laid out in the vigorous and non-vigorous parts of the plantation. The test thus affords some measure

of the influence of thinning out and of heading back of strong and of medium canes when trained in hedgerows. Yield and other data are summarized in Tables 6 and 7.

The data presented in Table 6 show that in the field with large vigorous canes yields are more or less directly proportional to the total number of canes, even up to 15,000, to the acre and that thinning out any of these vigorous canes reduces yield corresponding to the amount of thinning that is done. Moreover, thinning of the canes apparently does not result in any material increase in size of berry. These records lend support to the statement previously made that when the hill system of culture is practiced, at least under the soil and climatic conditions of this experiment, each cane seems to be largely independent of others in the row. Apparently, large crops of good sized berries may be expected if soil, climatic, and cultural conditions are such that large vigorous canes are produced. At first glance the data in Table 7 for canes of smaller size seem to be at variance with those in Table 6 but inspection shows that the several lots of canes were not as uniform in size as might be desired. The larger diameter of the canes thinned to two and to one and one-half to the foot of row, as

Table 6.—Fruiting records of vigorous raspberry plants trained in hedgerows and pruned in different ways. (16 feet of hedgerow, rows 7 feet apart)

Pruning treatment	No. canes actually fruiting	Theoretical no. canes per acre	Av. cane diameter (inches)	Av. no. buds per cane	Total no. berries harvested	Total wt. fruit harvested (ounces)	Av. wt. fruit per cane (ounces)	No. berries per ounce	Calculated av. yield per acre (16 qt. crates)
40 canes no pruning	40	15,450	.381	41.5	5,189	201.4	5.04	26	221
40 canes headed back according to vigor	39	15,450	.394	26.8	4,851	201.1	5.15	24	226
40 canes headed back to 35 buds	37	15,450	.397	34.7	5,776	212.6	5.75	27	252
40 canes headed back to 30 buds	40	15,450	.381	29.1	5,347	200.8	5.02	27	220
40 canes headed back to 25 buds	40	15,450	.353	23.9	3,903	142.1	3.55	27	156
40 canes headed back to 20 buds	39	15,450	.371	20.0	4,177	147.3	3.77	28	165
32 canes headed back to 30 buds	31	12,360	.410	29.4	3,782	169.7	4.84	22	170
24 canes headed back to 30 buds	24	9,270	.389	29.2	3,736	142.1	5.92	26	156

Table 7.—Fruiting records of non-vigorous raspberry plants trained in hedgerows and pruned in different ways.

Pruning treatment	No. canes actually fruiting	Theoretical no. canes per acre	Av. cane diameter (inches)	Av. no. buds per cane	Total no. berries harvested	Total wt. fruit harvested (ounces)	Av. wt. fruit per cane (ounces)	No. berries per ounce	Calculated av. yield per acre (16 qt. crates)
40 canes no pruning	34	15,450	.288	34.2	2,580	94.2	2.77	25	121
40 canes headed back according to vigor	36	15,450	.295	22.5	2,151	83.1	2.30	26	101
40 canes headed back to 35 buds	37	15,450	.300	29.4	2,365	79.3	2.14	33	93
40 canes headed back to 30 buds	36	15,450	.284	23.0	2,368	82.5	2.29	29	100
40 canes headed back to 25 buds	37	15,450	.304	24.3	2,405	102.6	2.77	24	121
40 canes headed back to 20 buds	37	15,450	.306	19.1	1,890	77.7	2.10	24	92
32 canes headed back to 30 buds	31	12,360	.360	30.0	2,545	93.7	3.02	27	105
24 canes headed back to 30 buds	24	9,270	.316	28.0	2,629	88.4	3.68	33	97

compared with that of those standing two and one-half to the foot, accounts for their relatively heavier yields. These statements regarding the undesirability of cane thinning should not be interpreted as evidence against the removal of the short, very slender growths that generally kill back rather severely during the winter and that most growers regard as suckers, nor should the data be interpreted as evidence against the practice of thinning when the number of canes per foot greatly exceeds the maximum number retained in this test, two and one-half to the foot or 15,000 to the acre.

Fig. 6.—A hill of Cuthbert raspberries, before pruning. Compare with Figs. 7 and 8.

The figures on the influence of heading back on yield and on size of berry are equally clear. Slight heading back of canes results in no decrease in yield and even a moderate heading back effects little or no reduction. On the other hand, heavy heading materially decreases yield per cane and per acre and is attended by very little if any increase in size of berry. A comparison of the figures presented in Tables 6 and 7 indicate that the smaller canes can be cut back to a lower height than the stronger canes without reducing their yields. The main advantage to be derived from heading back lies in the greater stockiness and compactness of plant and in the consequent greater ease of picking and less danger from being blown over by wind.

The differences in yield between the very vigorous and the moderately vigorous canes was far greater than the differences in yield between the most and the least severely thinned or the most and the least severely headed canes. For instance, canes averaging .317 inches in diameter and headed back to 20 buds yielded almost twice as much as canes averaging only .28 to .30 inches in diameter and carrying over a third more buds. The crop borne by the individual fruiting lateral depends more on the size of the cane from which it springs

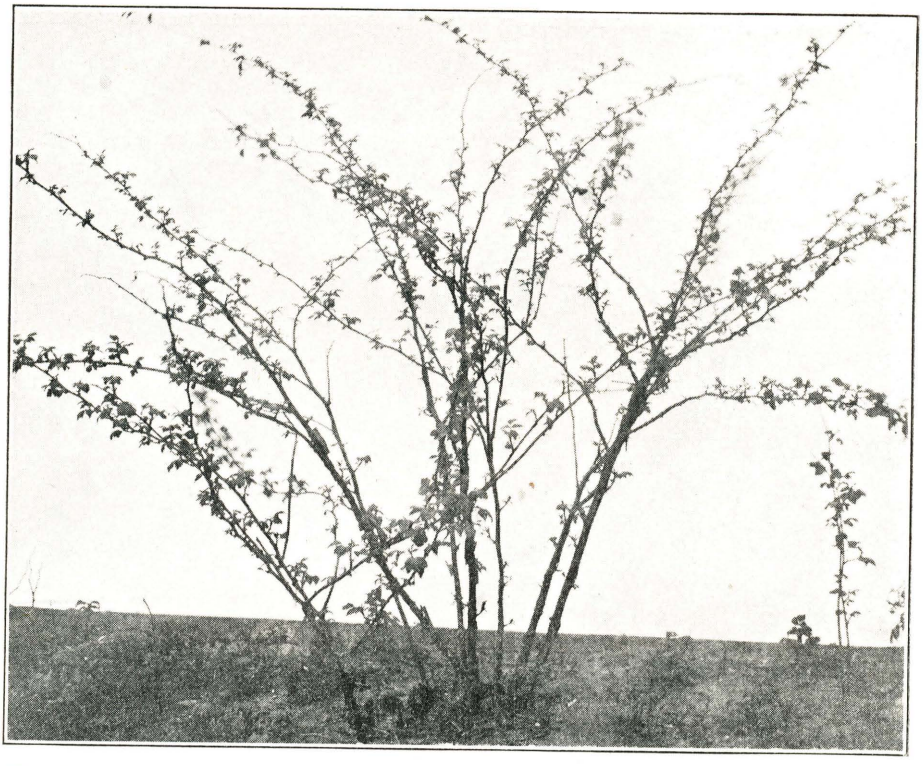

Fig. 7.—The hill of Cuthbert raspberries shown in Fig. 6 after thinning out the weaker canes. It still possesses nine canes, enough for a full crop.

than on the number of buds that the cane originally carried or on the extent to which it is headed back. The importance of the selection of such sites and soils and the employment of such cultural methods as will promote vigorous growth can hardly be overemphasized.

The first berries to ripen on the red raspberry cane are those near the tips and this condition is more pronounced on unpruned or lightly pruned than on heavily pruned canes. This at once suggests the possibility of leaving canes long for the purpose of obtaining as many early berries as possible, because early berries usually bring the highest prices. However, the first few berries are so scattering that the

extra expense of gathering them would nearly offset the higher value of the fruit.

Berries are harvested most easily from canes that are headed back lightly to moderately. These canes usually stand erect and carry the bulk of their crop far enough away from the new shoots to make picking comparatively easy. In the severely headed canes the dense foliage on the new non-fruiting shoots combined with the rather heavy foliage of the short, severely headed canes made the harvesting of the fruit rather difficult. Many of the full length canes of the unpruned plants

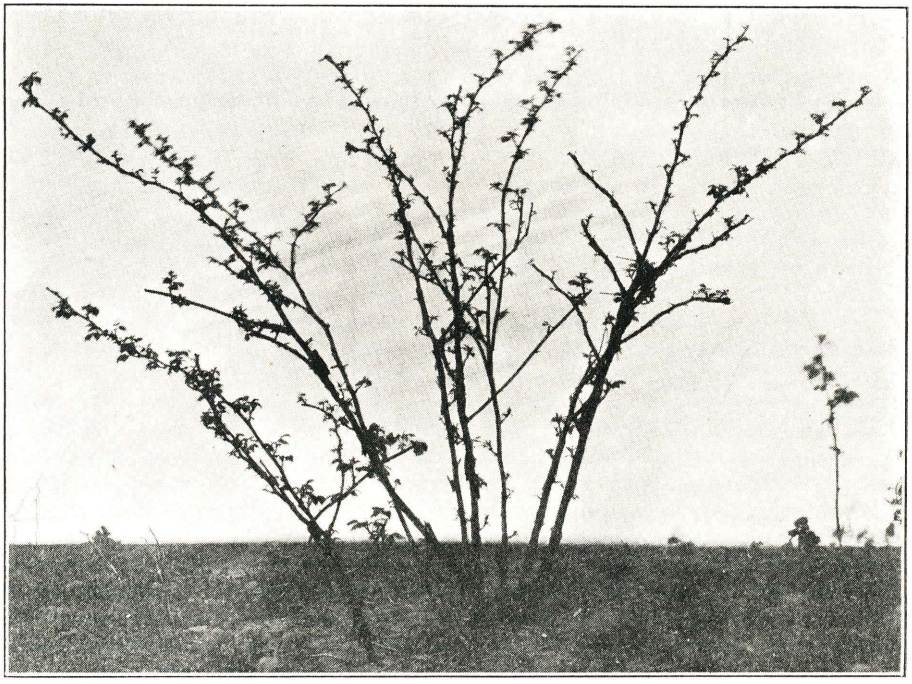

Fig. 8.—The hill of Cuthbert raspberries shown in Fig. 6 after thinning out the weaker canes and heading back those that remain. Pruning of this type does not appreciably reduce yield and it results in a distinct improvement in size of berry.

were so long and top-heavy that they bent down into the rows where they were difficult to pick and much of the fruit was knocked off by the pickers or by the cultivator.

Comparison of Hill and Hedgerow Systems of Culture

Both systems of training have their advocates and their advantages and disadvantages. Plants grown in hills may be cultivated both ways for a longer period than those trained to a hedge, and, even after cross cultivation becomes impracticable, they are easier to keep free from weeds and grass. Diseased plants are rogued out with greater

facility and harvesting operations are carried out more readily. On the other hand, experience indicates that heavier yields are possible with the hedgerow than with the hill system of culture. This is easily understood in the light of what has been brought out regarding the degree of independence of different fruiting canes and of the further fact that usually the hedgerow system carries a greater number of fruiting canes to the row or acre. In the course of this experiment, no specific planting was made or test carried out for the purpose of directly comparing hill and hedgerow culture. However, some records were obtained on the influence on yield of the number of canes in the hill and of cane thinning that, combined with the data presented in Tables 6 and 7, throw some light on this question. These are summarized in Table 8.

Table 8.—Fruiting records of red raspberries thinned to different numbers of canes to the hill.

Pruning treatment	No. canes recorded	Calculated no. canes per acre	Av. no. berries per cane	Av. no berries per plant	Av. wt. fruit per cane (oz.)	Av. diameter of cane (inches)	Av. no. berries per ounce	Calculated yield per acre (16 qt crates)
12 canes per hill headed to 30 buds	33	18,540	85	1,020	3.35	.406	26	176
10 canes per hill headed to 30 buds	28	15,450	93	930	3.60	.423	26	158
8 canes per hill headed to 30 buds	24	12,360	114	912	4.90	.418	25	172
6 canes per hill headed to 30 buds	17	9,270	138	828	5.95	.454	23	148
5 canes per hill headed to 33 buds	15	7,725	156	780	6.10	.....	26	134
3 canes per hill headed to 33 buds	9	4,635	163	489	6.40	.....	26	84

In the discussion accompanying Tables 6 and 7, it was pointed out that there was no evidence of crowding or injury to one cane by another when they are left to stand in the hedgerow at the rate of two and one-half to the foot, making 15,450 to the acre, when the rows are seven feet apart. Individual canes that grew at this distance from one another were practically as productive as other individual canes nearly twice that far apart. However, for hill plants to total 15,450 canes to the acre when set four feet apart in rows seven feet apart, the hills would have to average 10 canes apiece. The data in Table 8 show clearly that, at least under the soil and climatic conditions of this experiment, there is a reduction in average cane yield when there are more than six or seven canes to the hill. When there are 10 to 12 canes to the hill, individual cane yields fall to a little over half those of canes of equal size that stand only three to five to the hill. Yields per acre are not correspondingly reduced because the extra number of canes partly compensates for their less satisfactory performance individually. The figures in the tables probably minimize rather than accentuate these differences because the records of the hill-trained plants are of canes distinctly larger in diameter than those of the hedgerow plant. Indeed it would seem that there is little to be gained by having more than 10,000 to 11,000 canes to the acre if the plants are to be kept in hills, unless the hills are so close together in the row that there is eventually a close approach to the hedgerow

system of culture. In view of the planting distances ordinarily employed in training to hills and to hedgerows, the statement seems warranted that a fourth to a third heavier yields are probable with the latter system, a difference that compensates many times for the slight advantages offered by the hill system of culture.

Response to Pruning as Influenced by Moisture

It is a matter of common observation that seasonal conditions influence to a considerable extent the development of the fruit of the raspberry. High temperature, associated with soil and atmospheric drought, invariably results in small size, if not in the actual drying up of some of the berries before reaching picking maturity. The results from two years' experimental work in pruning the black raspberry indicate that in sections characterized by low growing season temperatures and by an abundance of available soil moisture a little longer pruning may be practiced than in sections where the temperatures are higher and moisture conditions less favorable. Similar results presumably are to be expected with the red raspberry, but no data have been available which would enable one to determine how much, if any, the usual pruning practices should be modified to adjust the plant to varying moisture conditions. An experiment outlined to furnish information on this question was conducted in a small block of Cuthbert at East Lansing during the seasons of 1924 and 1925. The plot consisted of seven rows approximately 250 feet long. Three rows on one side of the plot were watered by means of an overhead irrigation system. Those on the opposite side received only the normal rainfall during the season. The center row was left as a barrier between the irrigated and non-irrigated sections.

In 1924, the canes of selected plants were pruned to different bud lengths depending on the average size and vigor of the plant but all canes in each hill were headed back to the same number of buds. Records were taken of the diameter of the canes and of the number and weight of berries harvested from each hill. As shown in Table 1, there was an abundance of rain during the season and there were practically no differences in the production of the plants in the irrigated and non-irrigated sections which could be attributed to moisture conditions. Consequently the yield records for the irrigated and non-irrigated blocks for that year are not presented separately.

In 1925, somewhat different conditions prevailed. The rainfall during May and June was light and, although there were frequent showers during the harvesting season in July, there was seldom more than enough to moisten the surface soil. As a result the soil became rather dry and there were considerable differences in the fruiting of the plants in the irrigated and non-irrigated plots. The percentages of moisture in the soil at various depths and at various times during the season is given in Table 9. Although there are some irregularities in the percentages given in the table, due perhaps to variation in soil texture or to an uneven distribution of the irrigation water, the figures as a whole show that there was more moisture in the irrigated than in the non-irrigated plot, particularly in the upper two feet of soil where a large portion of the feeding roots of the plants were located.

No attempt was made to collect data from individual plants or to

Table 9.—Moisture content of soil in irrigated and non-irrigated plots (1925).

Date	Percent moisture									
	6 inches		1 foot		2 feet		3 feet		4 feet	
	Irr.	Unirr.	Irr.	Unirr.	Irr.	Unirr.	Irr.	Unirr.	Irr.	Unirr.
May 23	.....	.....	14.17	9.77	12.94	12.65	15.63	12.0	11.16	10.8
June 1	15.5	11.4	11.78	11.0	13.32	14.0	11.9	10.6	12.4	10.09
June 9	14.3	10.3	10.2	8.3	9.1	9.7	9.6	12.6	10.6	10.4
June 15	14.1	9.0	10.3	8.4	12.2	11.5	11.0	9.8	10.2	10.0
June 22	15.3	9.4	15.0	10.4	11.13	6.0	12.36	13.1	13.85	13.5
July 1	17.8	9.1	14.0	10.2	14.3	6.2	14.3	9.3	14.7	.....
July 7	16.0	11.8	16.0	11.2	14.2	11.75	13.0	11.5	.....	.....

shorten the canes to a definite number of buds as in 1924. Each row was divided into four sections. In one section the canes were left full length (unpruned); in the other three sections they were headed back to heights of three, four, and five feet respectively. Only straight unbranched canes were saved for fruiting. They were thinned uniformly, leaving six of the most vigorous canes in each hill. A comparison of the total yields and the numbers and size of the berries in the irrigated and non-irrigated plots is presented in Table 10. The average total yield of berries per cane was larger in all sections of the irrigated plot. However, the difference was less marked in the sections where the canes were pruned to three feet, the slightly greater yield in the irrigated plot being due almost entirely to larger sized berries. In the four-foot, five-foot, and unpruned sections, irrigation resulted in some increase in the number of berries as well as a very noticeable increase in their size.

It is of interest that the average size of berry was nearly the same (21 per ounce) in all the irrigated sections, regardless of the pruning treatment, while in the non-irrigated plot sizes ranged from 25.1 per ounce in the three-foot section to 31.7 per ounce in the unpruned section. It is also of interest that the yield in the three-foot non-irrigated section was actually larger than in the unpruned section and nearly as large as in the four-foot and five-foot sections. Furthermore the berries were considerably larger. More fruit was harvested from the four-foot or the five-foot sections than from either the three-foot or

Table 10.—A comparison of the yields of differently pruned red raspberry canes in irrigated and non-irrigated plots.

Pruning treatment	Total number of canes		Av. no. buds per cane		Av. no. berries per cane		Av. wt. berries per cane (ounces)		Av. no. berries per ounce		Calculated yield per acre (crates)	
	Irr.	Unirr.	Irr.	Unirr.	Irr.	Unirr.	Irr.	Unirr.	Irr.	Unirr.	Irr.	Unirr.
3 ft.	124	146	15	16	136	138	6.5	5.5	21	25.1	138	117
4 ft.	157	138	23	22	178	150	8.5	5.7	21	26.3	180	121
5 ft.	76	141	30	30	186	168	8.7	5.8	21	28.6	184	122
Not pruned	96	151	44	45	180	162	8.3	5.1	21.7	31.7	177	110

the unpruned sections of the irrigated plot. Apparently some heading back of canes is desirable, even under favorable soil moisture conditions. In seasons of drought, in characteristically droughty soils, or in sections where the rainfall is likely to be light during the harvesting season somewhat shorter pruning should be practiced.

DISCUSSION

The results of these investigations indicate that the pruning of the red raspberry should not be so severe as that required for some of the other bramble fruits. Relatively, fewer fruit buds are differentiated by the red raspberry, and, in many cases, the total number of buds that eventually produce fruitful shoots is not many more than is required for a full crop. Where such conditions obtain, very little spring pruning is required, provided the old canes have been removed after harvest the previous season. On the other hand, in more vigorous plantations some reduction in the number of buds by judicious thinning and heading of the canes may be necessary if a maximum yield of high grade fruit is to be secured.

The matter of thinning is often more important than that of heading the canes, although the latter is usually given the most consideration. The data show clearly that, at a given cane-height, any surplus above a certain number of canes per hill or unit length of hedgerow results in an inferior grade of fruit. Total yield is proportional to the size and vigor of the individual canes. In practice, therefore, the thinning should consist of removing the least vigorous canes and, if necessary of reducing the number of strong canes sufficiently to insure the highest quality of fruit without sacrificing yield. In determining the severity of heading those that are left, the grower should be guided by their vigor, the method of training or support, the moisture holding capacity of the soil, and the possibility of rainfall during the ripening period. On light soils which tend to dry out quickly or in localities where the rainfall is normally light during the summer months, the canes should be shortened considerably. However, with an ample moisture supply much larger yields of marketable fruit will be secured if the canes are left longer. From the evidence submitted, it would seem that in most plantations a moderate heading is advisable, although in some cases a more severe pruning or in others a very light pruning may give better results.

The data that have been presented deal only with the effects of cane pruning on the yields of those same canes and do not furnish evidence on its possible influence on the new shoot growth. Observation, however, indicates that any such influence that it may have is negligible. Furthermore, the experimental work on which this is a report was done with the Cuthbert variety, and it is not expected that the statements made or the recommendations given will apply equally well to other varieties or even to the Cuthbert when grown under entirely different conditions. However, it is thought that the data presented together with the discussions should be of value to the grower in developing a system of pruning red raspberries which will be more satisfactory under his particular conditions.

SUMMARY AND CONCLUSIONS

1. The investigations discussed in this report were conducted at East Lansing and South Haven. The average total rainfall for East Lansing for the months of April to August inclusive in the period of 1921 to 1926 inclusive was 13.73 inches; for South Haven the average total rainfall for the same period was 13.48 inches. Though the average total rainfall for the two places was almost identical there were considerable differences in its distribution.

2. The study was made on plants of the Cuthbert variety, from three to five years old, apparently free from diseases. The soils ranged from a sandy loam to a clay loam.

3. Average canes receiving different pruning treatments were selected for detailed study with reference to bud development. It was found that about 62 per cent of the buds on a red raspberry cane produced shoots which mature their fruit; about 10 per cent remained dormant; 12 per cent grew into vegetative shoots which produced no fruit; another 10 per cent of the buds were winter killed, this condition being more prevalent at the tips of the canes; a few buds developed into shoots that were mechanically injured by wind and in cultivation; and a few buds produced weak shoots that later dried up.

4. Numbering from the base of the cane, the first five buds were moderately productive, the fifth to tenth buds the most productive, and the tenth to fifteenth buds were second in production. From the fifteenth bud to the tip of the cane, the average yield of the laterals progressively decreased. The size of the berries decreased gradually from the base to the tip of the cane.

5. Markedly higher yields were obtained from large canes as compared with those of small diameter. Therefore, such cultural methods should be used as will promote the growth of large canes.

6. Naturally branched red raspberry canes were larger, more vigorous, and more productive than unbranched canes. The branches produced satisfactory yields of large berries. The first five buds on the branches gave rise to a number of vegetative or barren shoots; the tenth to fifteenth buds produced the best yielding laterals. Beyond the fifteenth bud, the yield and size of fruit decreased rapidly.

7. Pinching the tips of the new red raspberry canes resulted in branches being formed that were very susceptible to winter injury. This injury was so severe as to result in a marked reduction in yield.

8. In general, thinning of canes greatly reduced the yield without any material increase in size of berry. However, data are presented to show that probably not more than 10 canes to four feet of hedgerow should be left for fruiting. Where the plants were grown in hills, eight canes per plant gave the best results.

Materially higher yields may be expected when the plants are grown in hedgerows than when they are grown in hills.

9. Light heading back of the canes resulted in an increased total yield over no pruning, while severe heading back greatly reduced the total yield. There was no marked increase in size of fruit due to heading

back the canes, except during a very dry season at East Lansing in 1925.

10. Canes receiving a light heading back were the easiest to harvest. The dense foliage of the new shoots and the fruiting canes made it more difficult to harvest the fruit from the severely pruned canes. Unpruned canes are likely to be top heavy and bend over into the rows where much of the fruit is knocked off by the pickers or by the cultivators. The main portion of the cane should receive a light heading back, while the branches should be pruned to approximately 15 buds or about 10 inches. Somewhat heavier heading is warranted where the moisture supply is a limiting factor.

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