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Five Years' Investigations in Apple Thinning

E. C. Auchter

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FIVE YEARS' INVESTIGATIONS IN APPLE THINNING

One of the Nine-year-old Baldwin Trees Used in the Test in 1915. On Young Trees Such as This One Thinning Can be Quickly and Easily Done.

BY

E. C. Auchter

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Five Years' Investigations in Apple Thinning

By E. C. AUCHTER.

INTRODUCTION.

Experiments in thinning apples have been carried on by the West Virginia Agricultural Experiment Station for the past five years. During this time one hundred and seventy-eight trees, including the varieties of Rome, Ben Davis, Baldwin, Delicious, and York Imperial, have been under experiment.

When the work was outlined and started in 1912 it was hoped to include enough trees of each of the principal commercial varieties so that definite recommendations could be made from the results as to the advantages or disadvantages to be derived from thinning apples for commercial purposes.

Not only was it sought to find the best time to thin, the proper distance apart to thin, and the accurate cost of thinning trees of different ages, but also to study especially the effects of annual thinning upon subsequent crops, to find out if trees could be made to bear every year, and thus to determine more accurately the actual profit or loss to be derived from thinning.

During the past five years unforeseen difficulties and circumstances over which no control could be exerted have arisen so that it has been impossible always to thin the same trees year after year and thus to secure as much data regarding the effects of thinning upon subsequent crops as would otherwise have been the case. In the spring of 1913 a severe freeze, which was quite general in the middle and northeastern states, destroyed the chance for a crop on the experimental plots which had been thinned in 1912. As a result no apple thinning whatever was done in 1913 and of course the influence, if any, of the 1912 thinning was destroyed. However, a test on thinning peaches late in the season was carried on during that year. In 1914 apple thinning experiments were again started and some very good results were obtained for that one year. As these trees, thinned or unthinned, bore no fruit in 1915, it was again necessary to carry on the work in a different plot of trees that year. Since the trees thinned in 1915 bore

no apples in 1916, they could not be thinned again. The same trees, however, that had been thinned in 1914 bore another heavy crop and were thinned again in 1916. A new plot of Rome and Delicious was also thinned this year. Thus, although it has been impossible always to thin the same trees each year, still a good deal of data has been secured as to the effect of thinning on subsequent crops and considerable yearly data as to the best time to thin, the proper distance to thin, the cost of thinning, and the profit or loss from thinning under different soil and crop conditions and on different aged trees have been obtained. The present report concerns the yearly data for the 178 trees including the varieties mentioned above, also the effects of thinning on subsequent crops as noticed during the past three years. Thinning work will be continued on the trees that were thinned in 1915 and 1916. More trees, including several varieties, will be added to the test, and more data will be collected on the effects of thinning on subsequent crops.

Since different trees were used in the thinning experiments nearly every year, the results of each year's work will be given separately.

THINNING RESULTS IN 1912.

Thinning experiments were carried on in three different orchards of the state in 1912. One experiment was located in the orchard of Mr. Gray Silver at Inwood, Berkeley County; another was in the orchard of Mr. D. Gold Miller at Gerrardstown, Berkeley County; while a third test was in the orchard of Mr. Virgil Vandervort near Morgantown, Monongalia County. The results in each orchard will be discussed separately.

Thinning Results in the Silver Orchard.

Fifty-four Ben Davis trees, seventeen years old, were selected for the thinning work in the Silver orchard. The orchard was located on a Hagerstown clay loam soil, commonly called a limestone soil. This soil is a very good one not only for orchards but for farm crops as well. This particular orchard was given the usual number of sprayings; was pruned fairly well; was fertilized moderately heavy with a good grade of commercial fertilizer; and the soil management used was generally clean cultivation and cover crops. The crop of fruit set in 1912 was not very heavy, but it was decided to start the

work inasmuch as it would be carried on for several years on the same trees in order to study the effects of annual thinning on subsequent crops.

In order to secure some information on the best time to thin and the proper distance apart to thin, the thinning was done at three different times of the year and three different distances were used at each time of thinning. The first thinning was done just before the June drop; the second just after the June drop; and the third in late summer (August 15). In thinning, all the wormy and diseased apples were removed; clusters were thinned to one apple each; and then the remaining apples on the limbs were thinned, in some cases three to four inches apart, in others six to seven inches apart, and in others nine to ten inches apart. In all cases five thinned trees and one check were used. Thus before the June drop five trees were thinned three to four inches; five were thinned six to seven inches; and five were thinned nine to ten inches with three check trees. This made a total of eighteen trees used before the June drop. A similar number were used in like manner after the June drop and in late summer (August 15), thus making the fifty-four trees (forty-five thinned and nine checks) previously mentioned. Results of the thinning are found in Tables I and II. Only the averages for each group of trees under different treatments are given, as the results for the individual trees in each group were uniform and it seems unnecessary to include several tables of individual tree records which have no particular value.

Note the Size of the Ben Davis Trees Used in the Thinning Tests of 1912, 1914, 1915, and 1916.

TABLE I.—Average Yield and Average Percentage of Yield per Tree of Each Plot (Five Trees) Thinned at Different Times of the Year. (The Average of the Seven Check Trees is Also Given.)

Date of Thinning	Distance Thinned in Inches	Number of Trees per Plot	Average Number Bushels of Apples per Tree			Total Average Yield per Tree (Bu.)	Percentage of Yield		
			0-2¼"	2¼"-3"	3" plus		0-2¼"	2¼"-3"	3" plus
Just before June drop, 6/13-22	3-4	5	.45	7.7	.3	8.45	5.3	91.1	3.5
Just before June drop, 6/13-22	6-7	5	.51	7.1	.7	8.31	6.1	85.4	8.4
Just before June drop, 6/13-22	9-10	5	.45	7.	.63	8.08	5.5	86.6	7.8
Just after June drop, 7/1-5	3-4	5	.56	5.36	.22	6.14	9.2	87.4	3.5
Just after June drop, 7/1-5	6-7	5	.24	3.75	.18	4.17	5.5	90.	4.4
Just after June drop, 7/1-5	9-10	5	.26	4.37	.08	4.71	5.5	92.8	1.7
Late summer, Aug. 15	3-4	5	.40	4.7	.54	5.64	7.1	83.3	9.6
Late summer, Aug. 15	6-7	5	.57	5.8	.93	7.30	7.8	79.4	12.7
Late summer, Aug. 15	9-10	5	*	*	*	*	*	*	*
Check, unthinned		7	.87	9.92	.37	11.16	7.8	88.8	3.3

*No data were obtained from these trees or from two adjacent check trees as they were picked by mistake by Mr. Silver's men.

TABLE II.—Time Required and Cost per Tree of Thinning.

Date of Thinning	Distance Thinned in Inches	Number of Trees Thinned	Average Time per Tree to Thin (Min)	Average Cost per Tree at 20c per Hour
Just before June drop, 6/13-22	3-4	5	72	$0.24
Just before June drop, 6/13-22	6-7	5	54	.18
Just before June drop, 6/13-22	9-10	5	57	.19
Just after June drop, 7/1-5	3-4	5	52	.17½
Just after June drop, 7/1-5	6-7	5	42	.14
Just after June drop, 7/1-5	9-10	5	60	.20
Late summer, Aug. 15	3-4	5	54	.18
Late summer, Aug. 15	6-7	5	60	.20
Late summer, Aug. 15	9-10	5	66	.20⅔

Time to thin per tree—General average, 57 minutes.
Cost to thin per tree—General average, 19 cents.

Conclusions From the Silver Orchard.

By a study of Table I it can be seen that thinning did not materially influence the size and grade of the apples in the Silver orchard in 1912. As stated on page 4, the set of fruit in this orchard was rather light (about 7 bushels per tree) but it was deemed advisable to start the experiment inasmuch as it was to be continued on the same trees for a number of years and it was desired to find the effect of annual thinning on subsequent crops. The results, however, are worth while in that they show that **it does not pay in money returns the first year to thin a healthy, well-cared-for, middle-aged orchard growing on good soil and bearing only a light crop of fruit.** As a result of the light crop, no striking differences indicating the best time or distance apart to thin were brought out. All of the trees seemed able to develop their crop. From general observations, the thinning before the June drop seemed to be too early. At that time the fruits were very small, and many of the fruits thinned off would probably have fallen during the June drop. Many of the fruits remaining at this time did drop off during the June drop, thus leaving some trees thinned more than was desired. The results in Table I show a slight advantage for those trees thinned six to seven inches apart, but this advantage is so small that no particular significance can be given to it. Possibly the thinning would have shown a little more to advantage had another grade been made between two and a fourth and three inches, as the Ben Davis were rather small over the whole orchard this year. The fruit, however, was so uniform in size that this advantage, if any, would have been slight. The average time of thinning per tree for the forty-five trees was fifty-seven minutes for one man. At 20 cents per hour this made a cost of 19 cents per tree for the thinning.

Thinning Results in the Vandervort Orchard.

Sixteen trees, consisting of eight Rome, four York Imperial, and four Baldwin, were used in this experiment. All trees were about eighteen years old, were in a healthy condition, and had a good set of fruit. Since this orchard was growing on rather hilly ground, it was left in sod and barnyard manure was applied annually.

In this experiment, as in the preceding one, three different distances of thinning were used. All thinning was done

on the second day of July, after the June drop. At that time the apples were from one to one and a fourth inches in diameter. With the eight Rome trees, two trees were thinned three to four inches apart, two trees six to seven inches apart, two trees nine to ten inches apart, and two trees were left as checks.

The York Imperial and Baldwin were thinned in the same manner, except that only one tree was used in each case. By mistake Mr. Vandervort picked one of the Rome trees that had been thinned six to seven inches and also one of the Rome checks: thus in these two cases, the results are based on one tree only, while in the other cases the Rome results are based on the average of two trees.

TABLE III.—*Results of Thinning Baldwin Trees. (One Tree Used in Each Case.)

Distance Thinned in Inches	Yield in Bushels Per Tree					Total Marketable Yield in Bushels	Percent Yield			
	0-2½"	2½"-3"	3"-3½"	3½" plus	Total Yield in Bushels		0-2½"	2½"-3"	3"-3½"	3½" plus
Check	2½	11	.13	0	13.63	11.13	18.3	80.7	.9	0
3-4	¾	9¾	3	0	13.5	12.75	5.5	72.2	22.2	0
6-7	.07	5	7	¼	12.32	12.25	.5	40.6	56.8	2
9-10	.07	1½	7	1	9.57	9.5	.7	15.5	73.1	10.4

*Only the picked fruit is considered. Since the fruit all ran large in the orchard this year, no grade between 0 and 2½ inches was made. The fruit was either above 2½ inches or was generally quite small, knotty, aphis-stung, and worthless.

TABLE IV.—Results of Thinning York Imperial Trees. (One Tree Used in Each Case).

Distance Thinned in Inches	Yield in Bushels Per Tree					Total Marketable Yield in Bushels	Percent Yield			
	0-2½"	2½"-3"	3"-3½"	3½" plus	Total Yield in Bushels		0-2½"	2½"-3"	3"-3½"	3½" plus
Check	1½	6¼	3	¼	11	9.5	13.6	56.8	27.2	2.2
3-4	.08	2½	6¼	½	9⅓	9.25	.8	26.8	68.	5.3
†6-7	1	6¾	2	0	9¾	8.75	10.2	69.2	20.5	0
9-10	¼	3	3¾	½	7½	7.25	3.3	40.	50.	6.6

†These results should not be considered too seriously as this tree blew over the latter part of August. It, however, matured a fairly good crop of fruit.

TABLE V.—Results of Thinning Rome Trees.*

Distance Thinned in Inches	Average Yield in Bushels Per Tree					Total Marketable Yield in Bushels	Percent Yield			
	0-2½"	2½"-3"	3"-3½"	3½" plus	Total Yield in Bushels		0-2½"	2½"-3"	3"-3½"	3½" plus
Check	3¼	7	3¾	.13	14.13	10.88	23.	50.	26.5	.9
3-4	1½	6½	5¾	½	14.25	12.75	10.5	45.6	40.3	3.5
6-7	1½	4	3¾	½	9.75	8.25	16.4	41.	38.4	5.1
†9-10	½	3	4¼	¼	8.	7.5	6.25	37.5	53.1	3.1

*The average for two trees is given in the three- to four-inch and nine- to ten-inch groups. The results of the check and the six- to seven-inch group are from one tree.

†The two trees thinned at this distance were smaller than the others and did not have such a heavy set of fruit. As a result they can not fairly be compared to the others.

TABLE VI.—Time Required and Cost per Tree of Thinning the Three Varieties at the Various Distances.

Variety, One Tree Each	Distance Thinned in Inches	Time Required per Tree in Minutes	Cost per Tree at 20c per Hour
Baldwin	3-4	125	$0.416
York	3-4	32	.106
Rome	3-4	102	.34
Rome	3-4	82	.273
Average	3-4	85	.284
Baldwin	6-7	110	.366
York	6-7	85	,283
Rome	6-7	75	.25
Rome	6-7	56	.186
Average	6-7	80	.266
Baldwin	9-10	50	.166
York	9-10	86	.286
Rome	9-10	60	.20
Rome	9-10	55	.183
Average	9-10	63	.21

Average time required to thin per tree, 1 hr. and 16 min.
Average cost per tree at $0.20 per hour, 25.3 cents.

Conclusions from the Vandervort Orchard.

The results from thinning in the Vandervort orchard are quite different from those secured in the Silver orchard. By a study of Table III it can be seen that thinning has materially increased the size of Baldwin in every case and has cut down on the percentage of culls when compared to the unthinned tree. Since the fruit ran large in the Vandervort orchard in 1912, no grade between 0 and 2½ inches was made. The fruit that fell below 2½ inches in diameter was generally quite small and of an inferior quality. On the check tree less than 1 percent of the fruit was more than three inches in diameter

with 18.3 percent of it being culls. Thus the bulk of the fruit came in the medium-sized grade. In the case of the thinned trees, the percentage of fruit more than three inches ran from 22.2 percent on the tree thinned three to four inches to 83.5 percent on the tree thinned nine to ten inches. In these cases the percentages of culls range from 5 percent to nothing. It can be noticed that although the unthinned tree had a slightly greater total yield, due to the large amount of culls, there was really more marketable fruit upon the trees thinned three to four inches and six to seven inches apart. Although the tree thinned from nine to ten inches gave the largest percentage of big apples, it will be noticed that the total crop produced was cut down to some extent. For certain fancy trade this plan would no doubt be desirable, as enough additional returns could be secured from the extra large apples to make up for the smaller number; however, in ordinary commercial orcharding, the best results would probably be secured from those trees thinned six to seven inches apart. These trees had more marketable apples on than had the check and the fruit was considerably larger. There is no doubt that any of the three thinned trees, due to larger and better colored fruit, would return a greater profit than would the unthinned tree in most years and in most sections. In this experiment the increased color of the fruit on the thinned trees was very noticeable. This color would be a most decided advantage at selling time.

In the case of the York Imperial (Table IV), an advantage for thinning can again be seen. Although the check trees produced about 15 percent more total fruit than did the first two trees and 32 percent more than the third, still in the case of the tree thinned three to four inches apart, 73.3 percent of the fruit was over three inches in diameter with less than 1 percent culls, while only 29.4 percent of the fruit from the check tree was three inches in diameter and 30.5 percent fell in the cull grade. As a result there was as much marketable fruit on the trees thinned three to four inches apart. In the case of the tree thinned nine to ten inches apart there was 27.2 percent more fruit above three inches compared to that of the check, with 10.3 percent less culls. In this case, however, the total yield was somewhat reduced by this thinning which effect would be detrimental under most circumstances. The data of the tree thinned six inches to seven inches apart can hardly be used since this tree was blown over in August. In this test thinning the fruit three to four inches apart gave good results while nine to ten inches apart seemed to be a little too heavy.

In studying the results of the Rome, the trees thinned from nine to ten inches apart can hardly be compared to the others since they were slightly smaller in the beginning and were not as heavily loaded. Although the check trees and the tree thinned three to four inches apart yielded approximately the same total bulk, the thinned tree having 16.4 percent more fruit above three inches in diameter and 12.5 percent less of culls really produced more marketable fruit. In the case of the tree thinned six to seven inches apart there was 30 percent less fruit, but 16.1 percent more of it was more than three inches in diameter with 6.6 percent less of culls. It is doubtful if the increased size of the fruit would make up for the reduced marketable yield in this case. Thinning three to four inches apart proved very profitable, however, in this test.

Thus in this orchard, although the trees were about the same age as those in the Silver orchard, due to the heavier crop, thinning paid. The size of the apples was increased enormously in some cases. In the case of the Baldwin variety, the tree thinned six to seven inches apart had 58 percent of its fruit more than three inches in diameter; the tree thinned nine to ten inches apart had 85 percent of its fruit this size. The check tree in contrast had less than 1 percent of this grade. While the York Imperial and Rome did not show such decided differences, still there was a marked advantage for thinning. Even though the check trees often produced a greater total yield, still due to such a large percentage of culls there was often a less total marketable yield. This experiment proves that in the case of these three varieties it pays to thin the fruit at least three to four inches apart and that in some cases it is profitable to thin as far as six to seven inches apart. Table VI gives the time required and the cost of thinning each tree. The average time required to thin per tree was 76 minutes at a cost of 25.3 cents.

Thinning Results in the Miller Orchard.

In order to study the effects of thinning on young trees just coming into bearing and to compare these with the middle aged bearing trees of the Silver and Vandervort orchards, an experiment was started in a ten-year-old York Imperial orchard of Mr. D. Gold Miller, near Gerrardstown, Berkeley County. This orchard was a vigorous, well-cared-for one, bearing a good set of fruit. The experiment was planned and started in exactly the same way as was the one in the Silver orchard: that is the thinning was done at three differ-

ent times of the year: before the June drop, after the June drop, and late summer and at each date of thinning five trees were thinned three to four inches, five trees thinned six to seven inches, and five trees nine to ten inches with three checks being left thus making forty-five thinned trees and nine checks. Unfortunately for this experiment, there was this year a very bad outbreak of cedar rust in Berkeley County and, as the York Imperial is especially susceptible, the disease was so bad in our experimental plots that most of the trees became nearly defoliated by the middle of the summer. As a result the trees stopped growing and the fruit ceased to develop. Consequently no results whatever could be secured from this experiment as to the effects of thinning on the size and grade of fruit.

Data as to the cost of thinning were obtained, however, and also some data regarding the June drop. The results follow:

TABLE VII.—Time Required and Cost per Tree of Thinning Ten-Year-Old York Imperial Having a Good Set of Fruit.

No. of Trees Thinned	Date of Thinning	Distance Thinned in Inches	Length of Time Required per Tree in Minutes	Cost per Tree at 20c per Hour
5	Before June drop	3-4	66	$0.22
5	Before June drop	6-7	40	.13⅓
5	Before June drop	9-10	54	.18
5	After June drop	3-4	42	.14
5	After June drop	6-7	44	.14⅔
5	After June drop	9-10	54	.18
5	Late summer	3-4	32	.10⅔
5	Late summer	6-7	30	.10
5	Late summer	9-10	36	.12

Average time required to thin 3-4 inches, 46⅔ minutes per tree at a cost of 15.5 cents.

Average time required to thin 6-7 inches, 38 minutes per tree at a cost of 12.6 cents.

Average time required to thin 9-10 inches, 48 minutes per tree at a cost of 16 cents.

Average time required per tree (all distances), 44 2/9 minutes at a cost of 14.7 cents.

Does it Pay to Thin Before the June Drop?

It has commonly been thought and written that thinning before the June drop is of doubtful value, since many of the fruits thinned off at this time will naturally fall during the June drop. To secure some data on this point, six trees of

equal size and to all appearances with an equal number of apples were selected before the June drop. The apples on three of these trees were thinned so as to leave only one fruit per cluster and the remaining apples from three to four inches apart. This thinning was done before the June drop. The remaining three trees were not thinned. After the June drop had taken place, the apples that had fallen from all the trees were counted. The results are shown in the following table. These results would have been much more valuable had the fruits on all the trees been counted before the June drop so that the percent of drop could have been accurately figured. As stated above, however, all these trees were selected because of their uniform load of fruit: the results should therefore be approximately correct.

TABLE VIII.—Number of Apples That Fell from Thinned and Unthinned Trees During June Drop.

Tree	Distance Thinned in Inches Before June Drop	Apples That Fell at June Drop
1	3-4	406
2	3-4	580
3	3-4	472
Average	3-4	482
4	Unthinned	660
5	Unthinned	1020
6	Unthinned	840
Average	Unthinned	840

The preceding table brings out two different points against thinning before the drop. In the first place it shows that where trees were thinned before the June drop, leaving about the desired number per tree, the June drop then caused 482 additional fruits per tree to drop. This drop resulted in the trees' being thinned more than was desirable. In the second place it shows that approximately twice as many apples fell from the unthinned trees as from the thinned ones, or in other words that 358 apples per tree (the difference between the number that fell in the two different treatments) that had been thinned off before the June drop would naturally have fallen off during the June drop.

Thus from these results it does not seem practical nor profitable to practice thinning before the June drop. In the case of trees thinned this early many of the fruits thinned off will naturally fall during the drop and as a result of the June drop the apples remaining on the thinned trees may then be thinned too much.

THINNING RESULTS IN 1913.

As stated in the introduction to this bulletin, two severe freezes in the early spring of 1913 destroyed all chances for a crop on any of the trees that had been thinned in 1912. As a result thinning could not be continued on these same trees and the annual effects of thinning could not be noted. Due either to the entire lack of a crop or to a very light crop in the other orchards of the state, no apple thinning was done this year.

Results of Thinning Peaches Late in the Season.

Results from different experiment stations* have shown that peach thinning pays. In most cases the best results have been obtained when the thinning was done just after the June drop or before the pits had begun to harden and where the fruit had been thinned to from eight to ten inches apart on the limb.

Thinning is now being carried on systematically by all the commercial peach growers in this state. It is recognized as one of the essentials of good orcharding, the same as is cultivating, spraying, or pruning. One of the hardest things for growers to do is to thin off enough fruit at thinning time. As the fruits are quite small just after the June drop, when the thinning is done, it often appears to a man as if more fruit is being thinned off than is being left on the tree. As a result he keeps reducing the amount of fruit thinned off until only a small percentage is removed. Then in the middle of the summer, when the peaches begin to size up, he realizes that too many have been left on the trees and starts in thinning again, hoping to cut down on the culls and to increase the size of the fruit left.

In order to see if thinning as late as three weeks before picking time would increase the size of the fruit materially and be profitable, two nine-year-old trees of the variety of Edgemont Beauty were selected in the Sleepy Creek Orchard at Sleepy Creek, W. Va. These two trees were of equal size and appeared to be equally loaded. The peaches on one of the trees were thinned so that they were at least four inches apart. The other tree was not thinned. This thinning was done on

*Keffer, C. A., Tenn. Agr. Exp. Sta., Bull. 88.
*Jordan, A. T., N. J. Agr. Exp. Sta., Report of 1900, p. 253.
*Fulton, S. H., Mich. Agr. Exp. Sta., Bull. 187, p. 67.
*Close, C. P., Del. Agr. Exp. Sta., Report of 1902, p. 94.
*Kyle, E. J., Texas Agr. Exp. Sta. Bull. 80, pp. 24-27.

August 6 and on August 29 the fruit was picked and sorted into four grades*: culls, choice, fancy, and extra fancy. Results are shown in the following table.

TABLE IX.—Results of Thinning Peaches Late in the Season (One Tree in Each Case).

Method	Pounds Thinned Off	Pounds of Fruit at Picking Time					Percentages			
		Culls	Choice	Fancy	Extra Fancy	Total Produced	Culls	Choice	Fancy	Extra Fancy
Thinned 4 in. apart ..	20.5	1.8	11.6	74.78	31.6	119.78	1.51	9.68	62.43	26.38
Unthinned	0	6.15	49.49	99.25	0	154.89	3.97	31.95	64.07	0

*The peaches were graded according to size. The average width of the fruit perpendicular to the suture line and its length in inches were recorded. Extra fancy peaches averaged 2.79 inches wide and 2.89 inches in length. Fancy peaches were 2.49 inches wide and 2.52 inches long. Choice peaches were 2.14 inches wide and 2.2 inches long. The culls were smaller than these sizes.

From a study of Table IX it can be seen that thinning as late as three weeks before picking time did increase somewhat the size of the remaining fruits. On the thinned tree 88.8 percent of the fruit was fancy or better, while only 64.07 percent of the fruit of the unthinned tree reached this grade. The unthinned tree had more peaches in the choice and cull grades. It can be seen that by thinning 20.5 pounds of fruit from the thinned tree, which fruit otherwise might have sold in the choice grade, the total yield on the thinned tree was somewhat smaller than that on the unthinned one. Whether enough greater financial returns would be secured for the larger sized fruit on the thinned tree to offset the larger quantity of smaller fruit on the unthinned tree would depend of course on the season and the supply and demand for fruit. In years of big crops when fruit was plentiful it might be that thinning would increase the size enough to make salable, fruit that otherwise would be unsalable. In 1913, due to a general light peach crop, prices were good. There was a demand for choice peaches as well as for fancy, so that the peaches from both trees sold well. The fruit from the thinned tree brought $8.03, from the unthinned tree $7.94. It took no longer to thin off the 20.5 pounds of fruit from the thinned tree than it did to pick the additional 35 pounds that the unthinned tree produced; so no charge was made for thinning. Less fruit had to be handled at picking, sorting, and hauling and fewer packages were needed to handle the fruit from the thinned

tree. Thus this experiment showed that it even paid slightly in money returns this year to thin off part of the crop as late as three weeks before picking time. The beneficial effects on the tree caused by removing part of the heavy load is another advantage to be considered.

Although these results show a benefit for late thinning, it would have been much better to have done this thinning earlier in the season. The tree would not then have had to waste its energy in developing so much useless fruit; the remaining fruit would have been of a still much better grade; and the tree would have been healthier and better able to form fruit buds for another season.

C. P. Close on page 99 of the annual report of the Deleware Station for 1902 gives the following table showing the amounts of plant food in 100 fruits (peaches) at different times of the year and the increase in percentages of the same at different stages of growth:

TABLE X.—Amount of Plant Food in 100 Fruits (Peaches) and the Increase in Percentages of the Same at Different Stages of Growth.

Date of Thinning and Gain	NITROGEN		POTASH		PHOS. ACID	
	Pound	Percent	Pound	Percent	Pound	Percent
Fruit thinned off early, June 6	.00368		.00667		.000782	
Fruit thinned off late, June 28	.0108		.0198		.003	
Gain from June 6 to 28		293.		296.8		383.6
Ripe fruit, August 25	.0286		.08294		.009724	
Gain from June 28 to Aug. 25		265.		419.		324.
Gain from June 6 to Aug. 25		777.		1243.6		1243.4

These figures give some idea of the amount of plant food in peaches of different ages and sizes. The percentages of increase in a short time of each of the plant foods taken up are exceedingly large and surprising. It can be seen how large an amount of plant food would be expended uselessly by the tree in developing fruit that was left on until late in the summer and then thinned off. By early thinning, this plant food saved would be available either for developing the fruits left or could be used in making more leaves, bearing wood, or fruit buds.

THINNING RESULTS IN 1914.

Thinning work was carried on in 1914 in one of the same orchards that was used in 1912; namely, in Mr. Gray Silver's orchard near Inwood, Berkeley County. This orchard, then being two years older, was 19 years old. The thinning work was done on the Ben Davis and York Imperial varieties. Since the freeze of 1913 had probably destroyed all influence of the thinning of 1912 and since the experiment was changed somewhat, the same trees of Ben Davis that were thinned in 1912 were not selected but an entirely new lot of trees was used.

Ben Davis Thinning Experiment.

Twelve trees of as nearly equal size and set of fruit as could be found in the orchard were selected for the thinning. All of the trees had a fairly heavy set of fruit. The thinning was all done just after the June drop (June 28). The fruits at that time were from one to one and a fourth inches in diameter. All the small, wormy, diseased, and aphis-stung apples were removed; clusters were thinned to one apple each; and then the remaining apples on the trees were thinned at three different distances as in the previous experiments.

Three trees were thinned three to four inches apart, three were thinned six to seven inches apart, and three trees nine to ten inches apart. The other three trees were unthinned and left as checks. At picking time the fruit from each tree was graded into three different grades based on size; each grade was weighed; and the apples in each grade were counted. The following table gives the individual tree records:

TABLE XI.—Total Number of Apples in Each Grade and the Percentage of Total Number. (Ben Davis Variety.)

Tree	Distance Thinned in Inches	Number of Apples				Percent of Total Number		
		0-2¼"	2¼"-2¾"	2¾" plus	Total	0-2¼"	2¼"-2¾"	2¾" plus
4	3-4	953	2072	17	3042	31.3	68.1	0.55
5	3-4	958	1406	1	2365	40.5	59.4	0.04
6	3-4	1970	730	0	2700	73.96	27.03	0.00
7	Check	3074	1069	2	4145	74.13	25.79	0.04
8	6-7	297	1781	179	2257	13.15	78.91	7.93
10	6-7	361	2263	746	3370	10.71	67.15	22.13
12	6-7	720	1113	16	1849	38.93	60.19	0.86
13	Check	3469	891	0	4360	79.56	20.43	0.00
14	9-10	973	1248	56	2277	42.73	54.37	2.46
15	9-10	998	2284	210	3492	28.58	65.4	6.01
17	9-10	1393	2248	87	3728	37.29	60.3	2.30
18	Check	2741	1180	0	3971	70.28	29.71	0.00

TABLE XII.—Total Number of Bushels of Apples; Bushels of Marketable Apples from Each Tree; and the Percentage of Total Weight. (Ben Davis Variety.)

Tree	Distance Thinned in Inches	Number of Bushels					Percentage of Weight		
		0-2¼"	2¼"-2¾"	2¾" plus	Total Yield in Bushels	Total Market'ble Bushels	0-2¼"	2¼"-2¾"	2¾" plus
4	3-4	3.2	9.37	0.11	12.68	9.48	25.2	73.80	0.87
5	3-4	2.65	5.79	0.01	8.45	5.80	31.4	68.50	0.01
6	3-4	2.99	5.49	0.00	8.48	5.49	35.25	64.74	0.00
7	Check	8.28	4.35	0.017	12.65	4.36	65.43	34.43	0.13
8	6-7	0.82	8.81	1.31	11.00	10.18	7.47	80.60	11.9
10	6-7	0.95	11.61	5.57	18.13	17.18	5.26	64.03	30.7
12	6-7	1.94	4.84	0.09	6.87	4.93	28.27	70.43	1.29
13	Check	8.92	3.74	0.00	12.66	3.74	70.44	29.54	0.00
14	9-10	2.57	5.67	.37	8.61	6.04	29.8	65.80	4.38
15	9-10	2.52	10.91	1.48	14.91	12.39	16.91	73.17	9.91
17	9-10	3.92	10.94	.59	15.45	11.53	25.37	70.81	3.81
18	Check	7.82	4.91	0.00	12.73	4.91	61.43	38.56	0.00

TABLE XIII.—Total Number of Apples on Each Plot; Also Total Yield; the Total Marketable Crop; and the Percentages of the Total Yield in Each Grade (Three Trees of Ben Davis Variety Used in Each Plot).

Distance Thinned in Inches	Total Number Apples When Picked	Numher of Bushels per Plot			Total Yield per Plot	Total Market-able Yield	Percentage of Total Yield		
		0-2¼"	2¼"-2¾"	2¾" plus			0-2¼"	2¼"-2¾"	2¾" plus
3-4	8107	8.84	20.64	0.12	29.60	20.76	30.61	69.01	0.29
6-7	7476	3.72	25.32	6.97	36.	32.28	13.66	71.69	14.62
9-10	9497	9.01	27.52	2.44	38.97	29.96	24.03	69.93	6.03
Check	12476	25.00	13.00	0.017	38.02	13.02	65.76	34.17	0.04

TABLE XIV.—Average Weight per Apple in Each Grade and General Average Weight for All Apples on the Trees.

Distance Thinned in Inches	Weight per Apple in Ounces			Average Weight of Apples in Ounces
	0-2¼"	2¼"-2¾"	2¾" plus	
3-4	1.63	3.52	4.94	2.62
6-7	1.94	3.53	5.32	3.46
9-10	1.92	3.42	4.97	2.95
Check	1.92	2.98	5.92	2.16

TABLE XV.—Time per Tree Required and Cost of Thinning (Figures are for the Average of Three Trees in Each Case of the Ben Davis Variety).

Distance Thinned in Inches	Time per Tree Required to Thin	Cost per Tree at 20c per Hour
3-4	71½ min.	$0.237
6-7	120 min.	.40
9-10	113⅓ min.	.378

Average time to thin, including all trees, 111.7 min. per tree.
Average cost to thin, including all trees, 37 cents per tree.

Results of Thinning Ben Davis.

Thinning was very beneficial in every way on the Ben Davis trees in the Silver orchard this year. Any one walking by the thinned trees could not help but notice the increased size of their fruit and its better color. Tables XI and XII show the number of apples and yield in bushels for each individual tree. In Table XIII the fruit from each plot has been totaled and arranged for comparison. It can be seen that although there were from 3000 to 5000 more apples on the three check trees than on the others that, due to their smaller size, they made only about the same number of total bushels of fruit as did the thinned trees in the six- to seven-inch and nine- to ten-inch plots.

Total and Marketable Yield.—A study of Table XIII shows how necessary it is to thin middle-aged Ben Davis trees that are bearing a good crop. Although the total yield was as great, and in two cases greater, on the unthinned trees, still due to the very poor size of the fruit, there was less than half as much marketable fruit on these trees. Of the marketable fruit on the unthinned trees, practically all of it was in the medium-sized grade, and this grade did not run as good as the same grade from the thinned trees. More of the apples were nearer the lower limits of the grade, as shown in Table XIV. The average weight of the apples in the medium grade from the unthinned trees was 2.98 ounces compared to approximately 3.5 ounces, the average weight of the apples in the same grade from the thinned trees. Although the table shows that the apples in the large grade were larger from the unthinned trees, it can be seen from Table XIII that there were so few apples in this grade that the slight advantage in size would be of no practical value. The culls from the unthinned trees were much less uniform than were those from the thinned trees and there were scarcely any culls on the thinned trees.

Distance Apart to Thin.—The results show that it paid to thin at all of the distances, and that the fruit on those trees which were thinned three to four inches apart would have been much better had the trees been more severely thinned. While the average size of the apples per tree was much better than that from the unthinned trees, still it was considerably less than that for the apples from the trees thinned six to seven and nine to ten inches apart (Table XIV). Had the trees been thinned heavier, less of the fruit would have been culls and there would have been a greater total yield. Those

Appearance of the Ground Beneath a Tree Which Has Just Had Its Fruits Thinned Six to Seven Inches Apart.

trees that were thinned by removing all small, knotty, and diseased fruit, thinning each cluster to one apple and then leaving the remaining apples on the limbs from six to seven inches apart, seemed to give slightly the best results, although the results from trees thinned nine to ten inches apart were very satisfactory. Since the trees thinned nine to ten inches apart had about one bushel more fruit per tree on them than had those thinned six to seven inches apart, this may account to a degree for the larger percent of culls with fewer big apples in this group. However, the variation is well within the realm of chance and either distance seems very satisfactory.

Method of Thinning.—In all of the work thinning was done by hand. It was found that the work could be done just as well this way and in much less time. Two middle-aged

trees of the same size and bearing equal loads of fruit were selected. One was thinned by hand and the other was thinned with clippers. It took forty-five minutes longer and cost 15 cents more to thin the tree with the clippers. If a little care is taken in removing the fruits no spurs will be broken. Generally by raising the fruits and giving them a slight twist, with one finger held at the union of the fruit spur and stem, the stems part easily from the spurs. With some varieties which do not part so readily from the spur, the spur can be held with one hand while the fruit is removed with the other. It may possibly pay with such varieties to use clippers in removing the fruit. It was noticed that a great deal more care had to be taken in thinning York Imperial than Ben Davis as the spurs on the York Imperial broke off much more easily.

Financial Returns from Thinned Versus Unthinned Trees.—Due to the very large crop of apples in the country in 1914, prices were low. Some growers packed their fruit in barrels, making only one grade either two inches and up or two and one-fourth inches and up, while other growers sold by the hundred pounds, using these same grades. There was practically no sale for cull apples. It can be seen that, no matter which way the apples were sold and even if the larger apples from the thinned trees did not bring any better price that year, the trees thinned either six to seven or nine to ten inches apart, having more than twice as many marketable bushels upon them, would return at least twice as much net per tree. Batchelor* of Utah showed that thinned Ben Davis trees eight years old returned net $1.16 more per tree, while Herrick† of Colorado found that thinned bearing Winesap trees returned $1.85 more per tree than did unthinned ones. Ballou‡ of Ohio gives figures for several different experiments in which the fruit from the thinned trees returned a greater net income than did that from the unthinned trees. Blair§ of Nova Scotia also found that apple thinning paid well where trees were bearing a good crop. The cost of the thinning can hardly be charged against the thinned trees, as the following would offset this charge. First, most of the fruit removed at thinning time would have to be picked anyway and this picking would cost about as much at one time as another. This fact was shown by the result that from 1000 to 1666 more apples per tree had to be picked from the unthinned trees and then only

*Batchelor, L. D., Utah Agr. Exp. Sta., Cir. 12.
†Herrick, R. S., Col. Agr. Exp. Sta., Bull. 170.
‡Ballou, F. H., Ohio Agr. Exp. Sta., Bull. 240. pp. 495-498.
§Blair, W. S., Reports Div. of Hort. Dominion Experimental Farms, Ottawa, Canada (Kentville N. S. Reports) 1913, pp. 322-326; 1914, pp. 599-601; 1915, pp. 721-722.

the same bulk of fruit was obtained. Second, it cost considerably more in sorting, to pick out the larger amount of culls on the unthinned trees and after they were picked out, they were practically valueless. Thus, in this particular case no charge could be made for thinning.

These results in 1914 were quite opposite from those of 1912. In that year, due to the rather light crop, it was shown that in this same orchard, and with the same variety, thinning did not pay. **The results emphasize the fact that thinning can not be carried on by any fixed set of rules, but that the practice must be altered according to circumstances.**

York Imperial Thinning Experiment.

Twelve trees were selected in the Silver orchard and divided into four groups of three each, the same as were the Ben Davis. Three trees were thinned three to four inches apart; three trees six to seven inches apart; three trees nine to ten inches apart; and three trees were unthinned and left as checks.

The York Imperial trees did not have a very uniform set of fruit on them this year and it was practically impossible to get twelve trees anywhere near together that were the same size and which had an equal setting of fruit. Inasmuch as the main object of the experiment was to note the effect of annual thinning on subsequent crops, it was thought best to start the work, even though the trees were slightly un-uniform. It happened that the check trees were the largest and turned out to be the most vigorous. As a result they cannot fairly be compared to the other trees. The nine trees thinned at the three different distances, however, were uniform enough so that these can well be compared, and conclusions drawn as to which method of thinning gave the best results. Tables XVI and XVII give the results found.

TABLE XVI.—Total Number of Apples on Each Plot; Also the Total Yield, the Total Marketable Crop, and the Percentages of the Total Yield in Each Grade (Three Trees Used in Each Plot, York Imperial Variety).

Distance Thinned in Inches	Total Number Apples When Picked	Number of Bushels					Percentage of Total Yield		
		0-2¼"	2¼"-2¾"	2¾" plus	Total Yield	Total Marketable Yield	0-2¼"	2¼"-2¾"	2¾" plus
3-4	9983	4.76	33.34	7.17	45.27	40.51	10.98	75.38	13.6
6-7	8795	3.88	25.81	11.57	41.26	37.38	11.00	61.38	27.61
9-10	8095	1.27	25.86	14.47	41.60	40.33	2.91	59.67	37.41
*Check	17688	9.06	53.10	18.23	80.38	71.02	11.4	66.63	21.94

*These trees being much larger and more vigorous not only yielded more fruit but were abie to develop it. They cannot fairly be compared to the other trees.

TABLE XVII.—Time per Tree Required and Cost of Thinning (Figures are for the Average of Three Trees in Each Case, York Imperial Variety).

Distance Thinned in Inches	Time per Tree Required To Thin	Cost per Tree at 20c per Hour
3-4	73 min.	$0.24 1/3
6-7	75 2/3 min.	.25 1/4
9-10	101 min.	.33 2/3

Average time to thin including all trees, 83 1/4 min. per tree.
Average cost to thin including all trees, 27 3/4 cents per tree.

Results of Thinning York Imperial.

As previously stated it was rather difficult to get twelve uniform trees of the York Imperial variety. It happened that the check trees were more vigorous and larger than the others and, although their results are shown, they should not be compared with the thinned trees. The three groups of thinned trees, however, are uniform enough to be justly compared.

Table XVI shows that the best results were obtained with apples thinned to a distance of from nine to ten inches apart. Although there were nearly 2000 more apples at picking time on the trees thinned three to four inches, still the increased size of the apples in the other group resulted in as many total bushels of marketable fruit. Not only was there as much marketable fruit but 24 percent more of it fell in the largest grade. In most years this large proportion of high grade fruit would be a decided advantage for the trees thinned from nine to ten inches apart, as a higher price could be obtained for the larger grade and thus there would be a greater net profit per tree. Since these York Imperial sold for $1.50 a barrel and were packed everything 2 1/4 inches and up this year, the benefits from the larger fruit were not obtained. Less fruit had to be picked and sorted, however, to get the same marketable quantity, as can be seen in Table XVI. As a result, even under these unusual conditions, better results were obtained from the trees that were thinned the greater distance. For the same reasons as stated in the summary of the Ben Davis thinning, the cost of thinning was not charged against the trees. The fruit from those trees thinned six to seven inches apart was much better colored and of better size than that from the trees thinned three to four inches. Although there was a slightly less marketable quantity on the trees thinned six to seven inches apart still, in most years, these trees would return as much if not more profit, since a greater proportion of the marketable quantity fell in the larger grade.

Table XVII shows that nineteen-year-old York Imperial trees bearing from four to five barrels per tree can be thinned by one man in one hour and twenty-three minutes at a cost of twenty-seven cents a tree.

THINNING RESULTS IN 1915.

Since the Ben Davis and York Imperial trees thinned in 1914 were bearing no crop in 1915, new experiments in thinning apples were started in the Knobley Mountain orchard, near Keyser in Mineral County. Thirteen nine-year-old Baldwin trees bearing their first commercial crop were selected for the test.

Since the results of thinning during previous years had shown that thinning the fruit three to four inches apart was not heavy enough, this distance was omitted in 1915. Five trees were thinned six to seven inches apart; five trees nine to ten inches apart; and three trees were unthinned and left as checks. All trees were thinned after the June drop (June 22). The results of the thinning are shown in Tables XVIII and XIX.

TABLE XVIII.—Average Yield per Tree of Thinned and Unthinned Trees with Percentages of Yield in Each Size (Baldwin Variety).

Distance Thinned In Inches	Ave. No. of Apples Per Tree When Picked	Average Weight in Pounds per Tree					Percentage of Weight		
		0-2¼"	2¼"-2¾"	2¾" plus	Total Yield	Total Marketable yield	0-2¼"	2¼"-2¾"	2¾" plus
6-7	437	.486	74.18	55.02	129.69	129.20	.34	57.19	42.42
9-10	301	.172	25.54	78.32	104.03	103.96	.16	24.55	75.29
Unthinned	675	10.20	129.33	20.12	159.66	149.44	6.40	81.00	12.60

TABLE XIX.—Average Weight in Ounces of the Apples in the Different Grades, Thinned and Unthinned Trees (Baldwin Variety).

Distance Thinned in Inches	Weight per Apple in Each Grade in Ounces			
	0-2¼"	2¼"-2¾"	2¾" plus	Average Weight for all Apples per Tree
6-7	1.85	4.20	5.8	4.72
9-10	1.6	4.46	5.87	5.52
Unthinned	2.	3.79	5.77	3.77

TABLE XX.—Average Time Required and Cost per Tree to Thin and to Pick the Crop (Average of 5 Thinned and 3 Unthinned Trees in Each Case of the Baldwin Variety; Figures are for One Man's Time).

Distance Thinned in Inches	Time to Thin	Ave. Cost per Tree to Thin	Total Yield per Tree in Bushels	Time to Pick per Tree	Cost per Tree to Pick
6-7	22.2 min.	7⅔c	2.59	18 min.	6.0c
9-10	28.8 min.	9⅗c	2.08	17 min.	5.4c
Unthinned			3.19	24 min.	8.0c

Results of Thinning Baldwin.

By referring to Table XVIII which shows the average results per tree of thinned and unthinned trees, it can be seen that thinning materially increased the size of the fruit, although the trees did not have a very heavy crop. The trees thinned six to seven inches apart had approximately 30 percent more of their fruit above 2¾ inches than did the unthinned trees and the trees thinned nine to ten inches apart had 62.6 percent more of their fruit in this grade. The thinned trees had practically no culls while 6.4 percent of the fruit on the unthinned trees fell in this grade.

One of the Thinned, Nine-year-old, Baldwin Trees at Picking Time in the Test in 1915. Note the Large, Uniform Fruit.

Although the heaviest thinning gives by far the largest apples, it is rather doubtful if enough higher price could be received for them to make up for the reduced total marketable yield. It can be seen that approximately half the total number of apples set on these trees was removed at thinning, which removal cut down the yield considerably. If the fruit were put up in

packages smaller than the barrel and sold to a fancy trade there is no doubt that even this severe thinning would have paid. In the case of the trees thinned six to seven inches apart, although about one-third of the total fruit set was removed, still the total marketable yield was not very much below that of the unthinned trees. Since so much of the fruit from the thinned trees could be sold for number ones the net returns would be just as large as if not larger than those from the unthinned trees.

Returns per Tree.—The price received for Baldwins in 1915 at the orchard was $2.50 per barrel including all apples above 2½ inches and $1.50 per barrel for all apples from 2¼ to 2½ inches. As can be seen from Table XVIII a distinction between the 2½ and 2¾ inch grade was not made in getting the records on the thinned trees, but if we should take the same prices for our grades, that is, 2¾ inches and up for No. 1, and 2¼ to 2¾ inches for No. 2, which if anything should favor the unthinned trees, the returns per tree would be as follows:

TABLE XXI.—Financial Returns per Tree.

Distance Thinned in Inches	Returns for Each Grade and Total per Tree		
	2¼"-2¾"	2¾" plus	Total
6-7	$0.742	$0.917	$1.66
9-10	0.255	1.300	1.55
Unthinned	1.290	0.335	1.62½

By referring to Table XIX it can be seen why the foregoing grades favor the unthinned trees. The average weight in ounces of the apples in the 2¼-2¾-inch group is much less on the unthinned trees and as a result not as many of them would have fallen in the No. 1 grade had this been 2½ inches as would of the apples from the thinned trees. The above figures, however, show that even in money returns under these conditions it paid slightly to thin.

Table XX shows the length of time and cost per tree of thinning, also the length of time and cost per tree of picking the different trees. It can be seen that with these young trees, bearing a light crop which was easily picked from the ground, it cost 2 cents more per tree to pick the check trees. Deducting this cost from the cost of thinning the trees six to seven inches apart leaves a cost of 5⅔ cents a tree for thinning.

With larger trees and larger yields this difference would be much more noticeable, as shown in the results of Ben Davis for 1914 in which the costs of picking and sorting the larger number of apples on the unthinned trees to get the same bulk easily offset the cost of thinning.

Although as large, if not larger, financial returns were received from thinning these young trees bearing only a medium crop, still probably the greatest benefit from thinning was in relieving some of the limbs from their heavy loads. Many of the limbs on the unthinned trees became bent over to the ground and were under a severe strain during most of the summer. The thinned trees on the other hand were not subjected to such a severe strain. Thinning, then, at this age tended to maintain the shape and preserve the vigor of the trees.

If, by a systematic thinning off of part of the crop each year from the time such varieties as the Baldwin (a biennial bearer) come into bearing it could be possible to influence them to bear good crops annually, the advantage from thinning would be much greater than merely to get larger financial results during any one year. In fact growers could afford to thin such varieties while young even at a loss if this condition could be brought about. The thinning in 1915 has not caused these trees to set fruit in 1916, but thinning will be continued on this as well as on other varieties in the orchard for several years in order to obtain more definite information on this point.

THINNING RESULTS IN 1916.

Since the nine-year-old Baldwin trees thinned in 1915 bore practically no apples in 1916, thinning could not be continued on them. Investigations in thinning were carried on, however, in three other orchards of the state. One test was made in Mr. Gray Silver's orchard near Inwood, Berkeley County, using middle-aged Ben Davis trees; another test was made on middle-aged Rome trees in the college orchard at Morgantown; while a third test, using seven-year-old Delicious trees, was carried on in Mineral County in the Chert Mountain orchards owned by George T. Leatherman.

Ben Davis Thinning Experiment.

It will be remembered that the twelve Ben Davis trees thinned in 1914 bore practically no fruit in 1915 and could not be thinned that year. These same trees, however, bore a good crop of fruit in 1916 and were treated in exactly the same way as they had been in 1914 as described on page 17. The same plot, including three trees that were unthinned in 1914, was again unthinned in 1916, and the other plots were thinned three to four inches, six to seven inches, and nine to ten inches as they were in 1914. In all cases clusters were reduced to one apple each and all knotty, wormy, and diseased fruits were removed. Thinning was done shortly after the June drop (June 29 to 30). At this time the apples were from one and one-eighth to one and one-fourth inches in diameter. The number of apples thinned off, the number that fell during the season, and the number picked were counted. The picked apples were sorted into different grades, based on size, and the number of apples and weights in each grade were obtained Results are shown in the following tables:

TABLE XXII.—Total Number of Apples on Each Plot at Picking Time; Also the Total Number of Bushels Produced, the Total Marketable Crop and the Percentage of the Total Yields in Each Grade (Three Trees of Ben Davis Variety Used in Each Plot).

Distance Thinned in Inches	Total Number Apples per Plot When Picked	Number of Bushels for Each 3 Trees				Total Yield in Bushels	Total Marketable yield in Bush'ls above 2¼	Percent of Total Yield			
		0-2"	2"-2¼"	2¼"-2½"	2½" plus			0-2"	2"-2¼"	2¼-2½"	2½" plus
3-4	7,524	3.65	16.41	14.33	2.11	36.5	16.44	10.00	44.95	39.26	5.78
6-7	8,669	2.22	13.10	23.64	7.42	46.38	31.06	4.78	28.24	50.97	16.00
9-10	8,711	1.73	13.75	19.94	12.13	47.55	32.07	3.63	28.91	41.93	25.50
Check	11,724	8.00	25.08	16.44	2.39	51.91	18.83	15.41	48.31	31.67	4.60

TABLE XXIII.—Percentage of the Total Yield from Each Three Trees or Plot That was Marketable, and the Percentage That was Unmarketable (Ben Davis Variety).

Distance Thinned in Inches	Percentage of Crop Unmarketable (Below 2¼ Inches)	Percentage of Crop Marketable (Above 2¼ Inches)
3-4	54.95	45.04
6-7	33.02	66.97
9-10	32.54	67.43
Check	63.71	36.27

TABLE XXIV.—Average Weight of Apples in Each Grade and General Average Weight for All Apples on the Trees.

Distance Thinned In Inches	Weight per Apple in Each Grade in Ounces				Average Weight in Ounces per Apple for all Apples per Tree
	0-2"	2"-2¼"	2¼"-2½"	2½" plus	
3-4	2.50	3.295	4.00	4.77	3.49
6-7	2.16	3.36	4.16	5.10	3.85
9-10	2.32	3.36	4.08	5.05	3.93
Check	2.28	3.16	3.84	4.32	3.18

TABLE XXV.—Original Number of Apples per Tree; Number Thinned Off; Number Dropped During Season; Number Picked; and Yields in Bushels (Figures are for the Average of Three Trees of the Ben Davis Variety in Each Case).

Distance Thinned in Inches	Original Number per Tree After June Drop	Number Thinned Off	Number Dropped During Season Exclusive of June Drop	Number at Picking Time per Tree	Marketable Yield in Bushels per Tree, Above 2¼ in.
3-4	3869	576	785	2508	5.48
6-7	5111	1196	1025	2890	10.35
9-10	5037	1996	937	2904	10.69
Check	5163	000	1255	3908	6.28

TABLE XXVI.—Time and Cost of Thinning per Tree (Figures Based on Average of Three Trees of the Ben Davis Variety per Plot and for One Man's Time).

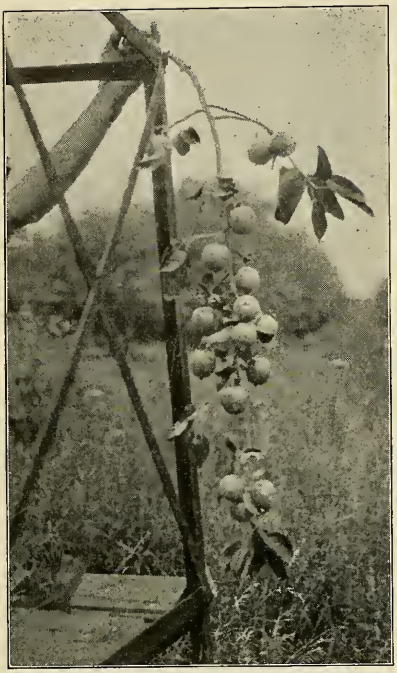
Distance Thinned in Inches	Average Number Apples Thinned Off per Tree	Average Time Required to Thin per Tree	Average Cost per Tree at 20c per Hour
3-4	576	35.5 min.	11.8 cents
6-7	1196	55.5 min.	18.5 cents
9-10	1996	105.0 min.	35.0 cents

Average time to thin per tree including all trees, 65.3 minutes.
Average cost to thin per tree including all trees, 21.8 cents.

Results of Thinning Ben Davis.

Thinning was a profitable practice in the orchard under discussion in 1916. Even before careful records were taken it could be seen that the fruit on the trees thinned six to seven and nine to ten inches apart was larger, more uniform in size, and of a much better color than that on the unthinned trees. An uninterested person could easily pick out the trees which had been thinned.

Total and Total Marketable Yields.—A study of Table XXII shows that thinning materially increased the size of the fruit. Although the unthinned trees had approximately 1000



A Branch of Ben Davis Apples Before Thinning.

The Same Branch as Shown on the Left with Fruits Thinned Three to Four Inches Apart.

more apples per tree at picking time and produced a slightly larger total yield, still the amount of small unmarketable fruit was so large on these trees that only a little more than one-half as much marketable fruit was obtained as from the trees thinned six to seven and nine to ten inches apart. The trees thinned three to four inches apart having a lighter crop can hardly be included in this comparison. Very rarely is fruit under 2¼ inches in diameter (transverse) packed in boxes or barrels, so that all fruit under this size has been thrown in the unmarketable grade. A grade between 2 and 2¼ inches has, however, been made in the table so that if some persons sell by the hundred weight down to 2 inches in diameter they can still see how much marketable fruit would be produced under these conditions. Under such conditions it can be seen by referring to the table that the total marketable yield would still be larger from the trees thinned six to seven and nine to ten inches apart than from the unthinned trees.

The Same Branch as Shown on Opposite Page with Fruits Thinned Six to Seven Inches Apart.

The Same Branch as Shown on the Left with Fruits Thinned Nine to Ten Inches Apart.

In Table XXIII the percentages of the total yield of each plot that are marketable and those that are unmarketable have been added up and are shown in more concise form, so that the difference can be more easily seen by the reader. It will be noticed that in the case of the trees thinned six to seven and nine to ten inches apart two-thirds of the fruit was marketable and one-third was unmarketable. These percentages are practically reversed in the case of the unthinned trees. Those trees thinned three to four inches apart, while better than the check, are not as good as those on which more severe thinning was practiced.

Distance Apart to Thin and Percentage of Total Crop to Remove.—Table XXII giving the total yields produced by each plot shows that the trees thinned three to four inches apart were bearing a lighter crop in 1916 and as a result can hardly be compared to the other plots as far as yields go.

However, data as regards the effects of the thinning on the size of the fruits can correctly be compared. It will be noticed that, while lighter thinning increased the size of the fruit over the check trees, it was not as beneficial in this respect as was the heavier thinning. Probably, if the trees thinned three to four inches apart had been bearing as heavy a crop as the check trees, the advantages due to light thinning would hardly have been noticed. It will be noticed that, although the trees thinned six to seven and nine to ten inches apart had a less total yield than the unthinned trees, due to the larger fruit with fewer culls there was approximately a 75 percent greater yield of marketable fruit on these trees. In this orchard this year thinning the fruits to from nine to ten inches apart gave the best results; also thinning to from six to seven inches apart gave very satisfactory results.

Table XXIV shows the average size for all apples per tree. It will be noticed that the average size of the apples is largest on those trees that were thinned nine to ten inches apart, followed closely by those from the trees thinned six to seven inches apart. The smallest apples, on the average, came from the unthinned trees.

Table XXV gives the original number of apples per tree after the June drop and before thinning, the number thinned off, the number that fell during the season exclusive of the June drop, and the number picked together with the total marketable yields.

Since the trees thinned three to four inches apart had a lighter crop, they cannot well be compared to the remaining three groups. In the last three groups it will be seen that the original number of apples per tree was very uniform. In one case 1196 apples, or approximately 24 percent of the apples, were removed, while in the other case in which the trees were thinned nine to ten inches apart, 1996 apples, or approximately 40 percent of the crop, were removed. Of course, no apples were removed from the check trees. More apples, however, fell from the check trees during the summer. At picking time there were approximately 1000 more apples per tree on the unthinned trees, but only six and one-fourth bushels of marketable fruit, compared to approximately ten and one-half bushels on those trees thinned six to seven and nine to ten inches apart. Table XXII shows that of this ten and one-half bushels of marketable fruit per tree, more of it fell in the largest grade from the trees thinned nine to ten inches apart than from those trees thinned six to seven inches apart. Table XXV shows that as high as 40 percent of the original set of fruit can profitably be removed at thinning time on

middle-aged bearing trees producing a heavy crop. It is even possible that a larger percentage could be profitably removed, but 40 percent of the total set was the largest amount removed in any of the experiments.

Financial Returns from Thinned and Unthinned Trees.—Table XXIII shows that from the trees thinned six to seven and nine to ten inches apart two-thirds of the fruit was marketable, while from the unthinned trees one-third was marketable. In all cases the total yields per tree were approximately the same.

Table XXV shows what this means in bushels per tree. The thinned trees produced approximately ten and one-half bushels of marketable fruit per tree as compared to six and one-fourth bushels per tree from the unthinned trees. Sixteen to twenty-five and one-half percent of the marketable fruit on the thinned trees was more than 2½ inches in diameter while only four and six-tenths percent of the fruit from the unthinned trees fell in this grade. The thinned fruit was also much more highly and more uniformly colored. From these facts it can readily be seen that no matter which way the fruit was sold, the returns from the thinned trees would at least net seventy-five percent more per tree than would those from the unthinned ones.

Time Required and Cost per Tree to Thin.—Table XXVI shows the average time required to thin a tree and the cost of this thinning. Results show that one man thinned fruit at the rate of 1140 apples per hour, or 11,400 apples per day. The average time required to thin per tree, including all trees, was 65.3 minutes with a cost of 21.8 cents per tree. According to these figures, one man should be able to thin nine middle-aged trees per day. This average is a rather high one, however, as the ordinary help will probably not average more than six or seven trees per day.

As explained on page 21 the cost of thinning can hardly be charged against the thinned trees as the apples must be removed at picking time anyway and it will cost practically no more to remove them at thinning time than it would at picking time. Table XXII shows that approximately 1000 more apples per tree had to be removed at picking time from the unthinned trees. The table also shows that a large percentage of this fruit was too small for packing and had to be sorted out, thus increasing the sorting cost of the unthinned trees. It is believed that these two extra costs at picking and packing time easily offset the cost of thinning.

Rome Thinning Experiment.

A small thinning test was carried on this year in the college orchard at Morgantown. Four middle-aged Rome trees bearing a medium-sized crop were included in the test. One tree was thinned three to four inches apart, another six to seven inches apart, another nine to ten inches apart, while the fourth tree was unthinned and left as a check. On the thinned trees, all clusters were reduced to one apple each and all knotty, wormy, and diseased fruit was removed. The remaining apples on each tree were then thinned as previously described. The thinning was done on July 10 and 11, a little too late for best results that year. Had the thinning been done about three weeks earlier, just after the June drop, greater benefits would probably have resulted. The following tables show the results of the thinning:

TABLE XXVII.—Number of Apples Picked per Tree; the Total Yield per Tree; the Total Marketable Yields; and the Yields in Each Grade With the Percentages of the Total Yields in Each Grade (Rome Variety).

Distance Thinned in Inches	Number Apples Picked per Tree	Bushels of Apples				Total Yield in Bushels per Tree	Total Marketable Yield in Bushels	Percentages of Total Yield			
		0-2¼"	2¼-2½"	2½"-3"	3" plus			0-2¼"	2¼-2½"	2½"-3"	3" plus
3-4	1,533	.27	.30	5.12	4.24	9.93	9.66	2.72	3.02	51.56	42.7
6-7	1,776	.15	.70	5.12	5.04	11.01	10.86	1.36	6.35	46.50	45.78
9-10	1,410	.00	.00	4.20	5.96	10.16	10.16	0.00	0.00	41.34	58.66
Check	2,313	1.17	.72	7.25	2.00	11.14	9.97	10.50	6.46	65.08	17.95

TABLE XXVIII.—Average Weight per Apple in Each Grade and General Average Weight for All Apples per Tree.

Distance Thinned in Inches	Average Weight in Ounces of Each Grade				Average Weight in Ounces for all Apples
	0-2¼"	2¼"-2½"	2½"-3"	3" plus	
3-4	2.12	2.80	4.80	6.9	5.18
6-7	2.10	3.10	4.80	5.9	5.00
9-10	0.00	0.00	4.80	6.7	5.76
Check	1.72	2.74	4.42	6.1	3.85

TABLE XXIX.—Number of Apples Thinned Off; Time Required; and Cost per Tree (Figures are for one Man's Time).

Distance Thinned in Inches	Number of Apples Removed per Tree	Time Required to Thin per Tree	Cost to Thin at 20c per Hour
3-4	1850	120 min.	40 cents
6-7	1866	130 min.	43⅓ cents
9-10	2263	148 min.	49⅓ cents
Check	0000	000 min.	00 cents

Average time required to thin per tree (one man), 133 min.
Average cost to thin per tree, 43⅓ cents.

Results of Thinning Rome.

Although the benefits from thinning Rome were not as striking as were those in the case of the Ben Davis, still the results show that it paid to thin Rome. In the case of the Ben Davis variety in 1914 and 1915, thinning was especially profitable in that it increased the size of all of the apples so that a much larger percentage of them was marketable. While this same advantage was also secured with Rome, still the most noticeable advantage was in the production of a large quantity of fruit more than three inches in diameter on the thinned trees. Table XXVII gives the results of the Rome thinning.

It will be noticed that although the unthinned tree had from 500 to 900 more apples at picking time than did the thinned trees, the total marketable yield was slightly larger in the case of the trees thinned six to seven and nine to ten inches apart. In the case of the tree thinned nine to ten inches apart, 58.6 percent of its crop was more than three inches in size with no fruit less than 2½ inches in diameter. Contrasted with this, the check tree had only 18 percent of its crop more than 3 inches in diameter, while 17 percent of it was less than 2½ inches.

The tree thinned six to seven inches apart, although it did not produce quite as much fruit of the large grade, still produced a greater total marketable yield than did the tree thinned nine to ten inches apart. Thinning even to a distance of three to four inches apart considerably increased the size of the apples.

The color of the fruit was noticeably better on the thinned trees. In all cases, but especially on those trees thinned six to seven and nine to ten inches apart, the apples from the thinned trees not only had more color and a deeper color but were also more uniformly colored. In those cases where color as well as size are considered in packing and selling fruit, the crop from the thinned trees would command a much better price per box or barrel.

Table XXVIII shows the weight of the apples in each grade, also the average weight in ounces per apple for all apples per tree. It can be seen that the fruit from the thinned trees is much larger on the average.

Table XXIX gives the time required to thin per tree and the cost. On the average it took one man one hundred and

thirty-three minutes to thin a tree at a cost of forty-three and one-third cents. In this particular experiment, the total marketable yields were about the same on thinned and unthinned trees. If a better price could be received for the larger and much better colored fruit from the thinned trees (which is nearly always the case), thinning would be very profitable; otherwise the returns in favor of thinning would not be so striking.

Delicious Thinning Experiment.

One of the arguments commonly given by writers and speakers on the subject of thinning is that, by annual thinning of fruit, trees can be made to bear a crop every year, instead of in alternate years as is the case with some varieties, noticeably Baldwin and York Imperial. The assumption is that spurs which bear fruit one year will not bear the next, and that if the fruit is entirely removed from some of the spurs on a tree bearing a heavy crop one year these spurs, from which the fruit was removed, will then bear the following year.

Yearly Records of Fruit Spurs.—Our results described on pages 37 and 38 indicate that annual bearing is not influenced by thinning. To obtain further information on this subject and to get some accurate experimental data on it, all of the spurs on a young seven-year-old Delicious tree, bearing a good crop were carefully labeled. The spurs bearing apples to maturity this year were labeled differently from the ones which did not set any fruit, while the spurs from which fruit was removed at thinning time were labeled in a still different way. A record of all spurs on the tree has thus been obtained. In 1917 the performance of these spurs will be carefully studied and records will be made.

Although lack of time and a light crop on the other varieties reduced this kind of work to only one Delicious tree this year, it is hoped to continue the work next year with several different varieties of apples, such as the Baldwin and York Imperial which are noticeably biennial in bearing habits. Annual performance records of the spurs will be kept for several years with the hope of securing some accurate experimental evidence on this important point.

In the future practically all of the time spent on this project will be along the above-mentioned lines, as it is felt that enough data have been secured to prove the profitableness of apple thinning during any one year of heavy crops.

EFFECTS OF THINNING ON SUBSEQUENT CROPS.

As stated in the introduction to this bulletin, one of the most important reasons for starting thinning experiments with apples was to see what effect annual thinning of part of the apples had on the future bearing of the tree. One of the arguments commonly quoted in favor of thinning by writers and speakers on this subject is that by systematic thinning off of part of the crop each year the trees will tend to become annual bearers. Many varieties such as the York Imperial and Baldwin are biennial bearers, that is they produce a crop every other year. It is at once evident that if such varieties could by thinning be made to bear a fair crop yearly, orchards of these varieties would be worth double their present value. A tree loaded down with a heavy crop of fruit seldom makes much wood growth that same year, the food taken in by the tree going to develop the crop of apples and as a result in many varieties few fruit buds are formed.

In most varieties the bulk of the apples are borne on small spurs which are scattered over the tree on wood two years old or older. These fruit spurs are supposed to bear every other year; that is, when a spur is bearing an apple one year it is supposed to be forming a leaf bud at the same time. The next year the leaf bud grows out a short distance lengthening the spur, and then forms a fruit bud for the following year. The plan of thinning to produce annual bearing is to thin off the fruit entirely from part of these spurs. The thinned spurs, it has been said, will then develop fruit buds at once for the next year rather than leaf buds and should bear a crop of fruit while the other spurs are growing. In this way part of the spurs will bear one year and part the next. As a result there should be no off years but fair crops should be borne yearly.

West Virginia Results Regarding Annual Bearing as Affected by Yearly Thinning.—Although we have not secured a great deal of information on this subject, that which we have secured does not bear out the supposition that thinned trees will bear any better or produce more fruit the following year than unthinned ones. As previously stated, a severe freeze in the spring of 1913 destroyed the chance for a crop on the trees thinned in 1912. As a result no effects of thinning on the next crop could be obtained. As no apple thinning could be done in 1913, due to the general light crop, another year's time was lost. Nothing happened, however, to affect

the nineteen-year-old Ben Davis and York Imperial trees thinned in 1914, which thinning has been previously described on pages 17 to 23 inclusive. As these trees, thinned or unthinned, bore hardly any apples in 1915, it would appear that in this case, and under these conditions, thinning had not influenced the next crop. All of these trees bore a good crop of fruit again in 1916 and have again been thinned. In this case thinning did not affect the next crop on the annual (Ben Davis) or biennial (York Imperial) bearer, although other conditions were favorable for a crop of fruit. In 1915 ten nine-year-old Baldwin trees, bearing their first commercial crop, were thinned, while three trees were left as checks. Although conditions were favorable for a crop in 1916, there was no bloom on any of these trees and of course no fruit set. A commercial orchardist in the eastern part of the state thinned five middle-aged York Imperial trees bearing a good crop in 1915 and left several check trees. He states that although the results of thinning were profitable in 1915, still the thinning did not seem to influence the next year's crop as neither thinned nor unthinned trees bore many apples the next year (1916). In this case as in the previous ones, thinning has not succeeded in causing the spurs on the thinned trees to bear the following year and thus to change the bearing habits in the case of these biennial bearers. It would be unwise, however, to draw a final conclusion from these three years of observations and further work along this line will be pursued.

Results of Other States—Beach* found that in New York thinning did not cause any material change in either the amount or regularity of fruit production when working with bearing trees of the Baldwin, Rhode Island (Greening) and Hubbardston varieties of from twenty-five to forty years of age, respectively. M. G. Kains†, recently Professor of Horticulture at Pennsylvania State College, reported a case before the West Virginia Horticultural Society in 1913, in which a fruit grower had succeeded in getting fifteen crops of Baldwin apples from his orchard in seventeen years. He stated that the grower had laid special stress upon thinning as the principal factor in getting good crops. The orchards had failed to give a crop only two out of the seventeen years and at each of those times there was a frost that had killed off the crops. Batchelor‡ at Utah, said, "By reducing the tree's crop this year there is much likelihood of a good crop the following year. Much of the so-called habit of 'alternate

*Beach, S. A., New York Geneva Agr. Exp. Sta., Bull. 239, p. 221.
†Kains, M. G., Proceedings of the 20th Annual Meeting of the West Virginia State Horticultural Society, 1913, p. 87.
‡Batchelor, L. D., Utah. Agr. Exp. Sta., Cir. 12, p. 4.

bearing' in apple trees is directly traceable to the fact that they overbear one year and recover from this overtax by bearing a very light crop the following year." Herrick* working with the mature Winesap in Colorado stated that systematic annual uniform thinning done from the time the trees come into bearing should have much to do in securing an annual crop, thereby doing away with the so-called "off year" bearing of some of the apple varieties. Gourley† states that in some apple thinning investigations in which he assisted at the Ohio Agricultural Experiment Station, trees which had their fruits thinned to twelve inches apart produced no more blossoms the following spring than did the unthinned trees which had borne an excessive crop.

Present and Future Plans and Investigations.—It can be seen that the above results are somewhat contradictory. Thinning will be continued at the West Virginia Agricultural Experiment Station, on the same trees as previously described, for several years and more trees, including several varieties, will be added to the test with the hope of getting more definite information on this important subject. The fruit spur records started in 1916 will be continued. In several cases with young trees of different varieties just coming into bearing, all spurs on the trees will be labeled and it is intended to keep a yearly performance record of all these spurs. In this way it is hoped to prove the truth or fallacy of the claim that fruit spurs bear only in alternate years, and that spurs from which fruit has been thinned off one year will produce fruit the next. Studies of food storage and bud formation among other things will be made in the case of several different spurs. If spurs do vary considerably in their bearing habits and are affected by certain treatments the reasons for these variances will be sought. Wiggans‡ of Missouri in studying some spurs of the Gano, Jonathan, and Rome varieties found that only a very few of the spurs, which bore in 1913 produced fruit again in 1914. Similarly Yeager¶ of Oregon noticed that of 1435 spurs of the Grimes variety that fruited in 1915, only 125 bore fruit in 1914. Several years ago Goff§ of Wisconsin on the other hand, stated that the same spurs had formed flowers two years in succession in the case of several varieties of apples in their college orchard. There is no doubt that varieties differ in their regularity of fruit bud formation upon fruit spurs and that we still have considerable

*Herrick, R. S., Col. Agr. Exp. Sta., Bull. 170, p. 12.
†Gourley, J. H., N. H. Agr. Exp. Sta., Tech. Bull. No. 9, p. 75.
‡Wiggans, C. C., Mo. Agr. Exp. Sta., Bull. 141, p. 35.
¶Yeager, A. F., Ore. Agr. Exp. Sta., Bull. 139, p. 84.
§Goff, E. S., Wis. Agr. Exp. Sta., Rept. of 1900, p. 275.

to learn concerning this subject. Goff, in the Seventh Annual Report of the Wisconsin Agricultural Experiment Station, stated as follows: "It seems probable that varieties of apples that bear annually are able to do so because they form flowers in buds of the current season, as is true of the cherry and plum. Indeed this is almost the only explanation of continuous annual fruitage. One important secret of securing an apple crop every year is probably to select varieties that possess the property of forming annual flower buds." If certain varieties, commonly called biennial bearers, do not bear flower buds annually, this careful study of fruit spurs should conclusively prove whether it would be possible to obtain annual crops with these varieties by causing part of the spurs to bear one year and part the next, or whether annual crops could be secured by causing the trees to form annual flower buds, due to thinning. It will also throw more light on the bearing of fruit spurs over a period of years and will bring out any variety differences in this respect.

GENERAL CONCLUSIONS AND DISCUSSION OF RESULTS.

Since not only different varieties but also different aged trees of the same variety under different environmental conditions have been worked with during these thinning experiments, it will probably be well to bring all the data together to see what conclusions and recommendations can be made from the results.

Does Thinning Pay?

The results of these five years' experiments including five winter varieties of different ages show that, where apple trees are bearing from a medium to a heavy crop of fruit, thinning pays, but that under certain conditions, as discussed later, such as light crops with fertile soils and vigorous trees, thinning may not pay.

Effects of Thinning on Size of Apples.

By thinning off a part of the apples from a tree, those which remain are increased in size. The amount of this increase depends upon how heavy the tree has been thinned, the variety of apples, the vigor of the tree, the age of the tree, and several other factors. In some cases this increase is enough that apples are made salable, where otherwise they would be practically a total loss. In thinning bearing Ben Davis trees in 1914 it was found that the apples on the un-

thinned trees were so small that 65.7 percent of the crop was less than 2¼ inches in diameter, 34.1 percent of the crop was between 2¼ and 2¾ inches, and practically none was above 2¾ inches. In contrast to this, the crop from those trees thinned six to seven inches apart had only 13.6 percent of the fruit less than 2¼ inches while 71.6 percent was between 2¼ and 2¾ inches and 14.6 percent was more than 2¾ inches. Although there were nearly 2000 more apples per tree on the unthinned trees at picking time, still due to their small size, they produced less than one-half as great a total marketable quantity.

Likewise in 1915 thinning on young nine-year-old Baldwin trees increased the size of the fruit materially. On the unthinned trees only 12.6 percent of the fruit was more than 2¾ inches in diameter, 81 percent between 2¼ and 2¾ inches, and 6.4 percent was less than 2¼ inches. In contrast to this the fruit from the trees thinned nine to ten inches apart sorted out as follows: 75.29 percent was more than 2¾ inches in diameter; 24.5 percent was between 2¼ and 2¾ inches; and practically none was less than 2¼ inches. The average weight in ounces for all apples on the trees thinned six to seven inches apart was 4.72; for the trees thinned nine to ten inches apart the weight was 5.52 ounces; while the fruit on the unthinned trees averaged 3.77 ounces (Table XIX).

In 1916 two-thirds of the apples on twenty-one-year-old thinned Ben Davis trees were more than two and one-fourth inches in transverse diameter with one-third of them less than this size. These results were practically reversed in the case of the unthinned trees bearing the same sized crops. Nearly two-thirds of the total apples borne in this case were less than two and one-fourth inches in diameter and about one-third were larger than this size (Table XXIII). In the case of the Rome thinning in 1916, the trees thinned nine to ten inches apart had 58.66 percent of the fruit more than 3 inches in diameter and 41.34 percent between 2½ to 3 inches in diameter with no fruit less than this size. The unthinned trees on the other hand had approximately only 18 percent of their fruit more than 3 inches in diameter with 65.08 percent of their fruit between 2½ to 3 inches and 17 percent less than 2½ inches. In 1912 thinning also increased the size of the fruit on Baldwin, Rome, and York Imperial as can be seen by referring to that year's record. Due to a light crop of fruit on the Ben Davis thinning plots in this year, the size of the apples was not materially increased.

In all cases where the trees needed thinning the size of the fruit was noticeably increased. Similar results have been

found by other investigators, reference to whom can be found in the appended bibliography. That thinning often increased the size of the fruit considerably is shown by the fact that in some cases with only one-half as many apples per tree, the thinned trees produced as much if not more total marketable fruit. Ballou* of Ohio states a case in which one unthinned tree had a greater weight of apples under 2 inches in diameter at picking time than the total weight of this size from 62 thinned trees of the same age and variety, growing under the same conditions.

Effects of Thinning on Color of Apples.

The results of each year's thinning proved that whenever trees were bearing a heavy crop the color of the fruit was considerably improved by thinning. In 1912 this change was especially noticed in the Baldwin variety. The fruit from the thinned trees was not only higher colored but also more uniformly colored. A solid red blush covered the entire apple. The Rome and York Imperial were likewise improved in color but not so noticeably as were the Baldwin.

In 1914, the fruit from the thinned Ben Davis and York Imperial trees was much better and more uniformly colored that that from the unthinned trees. The color of the Ben Davis was uniformly much improved and plainly noticeable when the two piles of fruit from the thinned and unthinned trees were lying side by side. These same results were noticed with the Ben Davis in 1916 and were very striking in the case of the Rome in 1916.

Where the trees were bearing a light crop as were the Ben Davis in 1912, thinning did not materially influence the color of the fruit. These results as to color improvement are in accord with those found by Beach†.

Effects of Thinning on Market Value and Net Returns.

There is no doubt that thinning increased the market value of the fruit. The thinned fruit, as previously shown, was much larger and in most cases much better colored. In those orchards where box packing is practiced a large proportion of the thinned fruit being of uniform good size and color could be packed either in the Fancy or Extra Fancy grades and much greater returns would be received than from a larger quantity of fruit from the unthinned trees which could not be packed in these grades. Even in barrels the larger and

*Ballou, F. H., Ohio Agr. Exp. Sta., Bull. 240, p. 499.
†Beach, S. A., N. Y. Geneva Agr. Exp. Sta., Bull. 239.

better colored fruit would often bring more money than the prevailing prices. In large crop years when apples are plentiful thinning might be the cause of one's making a satisfactory sale when otherwise it would be hard to get a fair offer for the fruit.

As regards the net returns per tree from the thinned and unthinned trees these results show that, when trees are bearing from a medium to a heavy crop of fruit, greater money returns can be expected from the thinned trees than from the unthinned ones. In the case of the eighteen-year-old Baldwin trees thinned in 1912 (page 8), the results show that, although there was a greater total yield on the unthinned trees, due to the smaller size of the apples the total marketable yield was not as great as from those trees thinned three to four inches apart or six to seven inches apart. In the case of the trees thinned six to seven inches apart, which produced 12.32 total bushels of fruit, 7¼ bushels were larger than three inches in diameter and 5 bushels were from 2½ to 3 inches in diameter with practically no culls. In the case of the unthinned tree, producing 13.62 total bushels of fruit, only thirteen hundreths of one bushel was larger than 3 inches in diameter, 11 bushels were from 2½ to 3 inches in diameter, and 2½ bushels were culls. From these results it can be seen how much greater would be the net returns per tree from the thinned trees. By referring to Tables IV and V it can be seen that approximately the same results were obtained with the York Imperial and Rome that year.

Thinning results in 1914 on bearing Ben Davis trees showed approximately twice as large money returns from the thinned trees as from the unthinned ones. In this case, although the thinning did not make such exceptionally large apples, it did make a considerable number of them salable which would not otherwise have been so. Although the check trees had from 1000 to 1666 more apples per tree upon them at picking time, still they produced fewer than one-half as many total marketable bushels as did the thinned trees and this fruit was practically all in the medium-sized grade (page 18). No matter how the apples were sold, the thinned trees would have netted twice as much as the unthinned ones. The York Imperial trees thinned in this orchard showed that those thinned nine to ten inches apart would return a greater net profit than those in which the trees were thinned only three to four inches apart. Since the check trees were so much larger and more vigorous they were not comparable to the thinned trees.

In 1915 it was shown (page 26) that it paid to thin nine-year-old Baldwin trees bearing their first crop. Where the

fruits were thinned six to seven inches apart, although about one-third of the apples were removed, the remaining apples increased in size to such an extent that they brought slightly greater money returns than did the fruit from the unthinned trees. There is another probably greater benefit in thinning trees of this age, however, than merely the getting of greater financial returns and that is the effect of thinning on the vigor of the tree.

Notice How the Limbs on This Unthinned Tree are Bent and Twisted. Although the Tree is Propped it is Still Under a Severe Strain. The Removal of a Part of the Fruit Earlier in the Season Would no Doubt Have Been Profitable to Both Tree and Owner.

In 1916 the Ben Davis trees thinned six to seven and nine to ten inches apart, having produced 75 percent more marketable fruit on them than did the unthinned trees, would return at least 75 percent greater net returns. As a matter of fact, since the extra fruit was also of a better grade than that of the unthinned tree, greater net returns than this were received. The thinned Rome trees brought slightly more returns in 1916, but the differences in favor of the thinned trees were not so striking.

Effect of Thinning on Vigor of Tree.

In order to keep an orchard in a healthy and vigorous condition, care should be taken to avoid those things which tend to retard seriously the natural growth of the tree. Several of the varieties in West Virginia that come into bearing early are very liable to overbear when young. In many cases where some of the fruits are not thinned off, several of the limbs either become so badly bent and twisted that the tree never fully regains its former shape, or else some of the limbs are broken completely down. It can be seen that the vigor of a young tree would be greatly impaired when such a condition existed. The chances are that young trees loaded down with heavy crops during the first three or four years of their bearing gradually become weakened and are not so able to withstand their natural enemies as are those trees that have not been subjected to such a severe strain. It is generally known that young trees, which bear such heavy crops, do not make much wood growth during the same time. The trees gradually become stunted and probably never become as large or long lived as similar trees under the same conditions which have not been weakened by overbearing when young. These points can well be kept in mind when thinning young trees, even if financial returns from thinning are not large during the first two or three crops.

In the case of the middle-aged Ben Davis trees thinned in 1914, it will be remembered that the unthinned trees had to carry from 1000 to 1666 more apples to produce the same total yield and then half of this yield was not marketable. Similar results were also found in the Ben Davis and Rome thinning of 1916. The tree's purpose is to develop seed in order to reproduce itself. Man desires the flesh of the apple. Since a great deal of the tree's energy goes to develop seeds it can be seen that much of the energy of the unthinned trees was spent for naught in developing the seeds of the small apples. This energy might better have been spent in strengthening the trees and developing fruit buds for the next year.

As a rule, the fruit from thinned trees is generally less wormy, and fungous diseases are somewhat held in check by thinning. This condition is especially true in the case of peaches or other stone fruits in which brown rot quickly spreads from peach to peach where they are touching one another.

Effect of Annual Thinning on Subsequent Crops.

One of the arguments given by writers and speakers on this subject in favor of thinning fruits is that by annual thinning off of part of the fruits from a tree, it can be made to bear annual crops instead of alternate ones, as is the case in some varieties such as the York Imperial and Baldwin. If this argument is true, then all of the above-mentioned advantages of thinning are of not so much importance as this one factor. If all apple trees could be made to bear yearly, it would not be of so much importance if thinning did not pay such large returns in any one year; and young trees just coming into bearing could even be thinned at a loss financially if the tendency to annual bearing could be instilled in them.

When thinning work was started at the West Virginia Experiment Station the main object was to secure definite information on this subject, but as stated in the introduction difficulties over which no control could be exerted were encountered, and it was impossible to secure as much data on this subject as otherwise would have been the case. What data have been secured, however, do not bear out the supposition that thinning off of part of the fruit one year will cause the trees, biennial in bearing habit, to bear the next year. Nineteen-year-old Ben Davis and York Imperial trees thinned in 1914 produced practically no fruit in 1915, although the season was favorable. All of these trees, thinned and unthinned, bore a good crop again in 1916 and were again thinned. Likewise young Baldwin trees bearing their first heavy crop and thinned in 1915 did not produce any fruit in 1916 on either the thinned or unthinned trees. A practical orchardist in the eastern part of the state, who thinned five middle-aged trees bearing good crops in 1915, states that the thinning did not cause these trees to bear in 1916. It would be unwise to draw final conclusions from the work of these three years, however, and several more trees, including different varieties, will be added to the first test with the main purpose of securing further information on this important subject. In some cases all of the fruit spurs on the trees are being labeled and yearly performance records will be kept of all spurs. By this manner it is hoped to prove the truth or fallacy of the claim that spurs bear only every other year and that spurs from which the fruits have been thinned one year will produce fruit the next. For a more detailed discussion of this point see pages 37 to 39 inclusive.

The Time to Thin.

The best time to thin fruit seemed to be just after the June drop. This drop varies in different years in this state but usually comes from June 20 to July 5. Apples at this time are from an inch to an inch and one-fourth in transverse diameter. When thinning was done at an earlier date, or before the June drop, it was found (page 13) that many fruits thinned off would naturally have fallen during the June drop. In those trees that were thinned the proper distance apart before the June drop, many more apple fell during the June drop, thus leaving the fruit thinned too far apart. While it will probably pay somewhat to thin fruit late in the season (our results showed that it paid to thin peaches even as late as three weeks before picking time in 1913, page 15) still as good results will not be obtained as if the thinning is done just after the June drop. It can readily be seen that if the fruits are thinned early so that the food from the trees can be used to develop the fruits that are left, that these fruits will attain much better size than if the thinning were delayed until it was seen that the trees could not develop their load. While it might pay to thin even this late still the results would not be as satisfactory and it is useless to have a tree waste its energies in developing seeds and flesh for several apples which are later to be picked off and destroyed. In the case of early varieties such as the Yellow Transparent, Red Astrachan, Early Harvest, Gravenstein, Oldenburg, etc., it might be well to delay thinning until the fruits are large enough to use. Then by several thinnings, not only could some use be made of the fruit thinned off but the fruit left until harvest time would be of excellent quality.

Distance Apart to Thin and Method.

In thinning, the object should be to remove all diseased, injured, or insect-eaten fruit and the small green and knotty apples hanging on the lower limbs of the trees which seldom become marketable. Clusters of fruit should be reduced to one apple each, and then the remaining apples on the limbs should be thinned to a certain distance apart, depending on different conditions. This distance apart to thin the remaining apples on the limbs will depend on the age of the trees, the set of fruit, the vigor of the trees as affected by soil type and orchard management, the variety, and several other factors. No definite rule can be stated which will suit all conditions. Common sense must be used and the method of thinning altered to suit the different cases. With young Baldwin

trees just coming into bearing (page 25) it was found that although thinning the fruits nine to ten inches apart gave the best-sized apples, that this thinning cut down on the total number of fruits to such an extent that it was not profitable to thin the fruits so far apart. In this case, thinning the fruits to from six to seven inches apart gave the best results as the trees then developed the remaining apples to such an extent that more returns were received from these trees than from the unthinned ones. On the contrary, it was found that when thinning middle-aged York Imperial trees bearing a good crop, the best results were obtained when the fruit was thinned nine to ten inches apart (page 23). In this case although fewer apples were left per tree than on the other trees, still they increased in size to such an extent that a greater marketable yield was produced. Bearing Ben Davis in 1914 gave about as good, if not better, results thinned six to seven inches apart as they did where thinned nine to ten inches. In 1916, Ben Davis thinned nine to ten inches apart, removing 40 percent of the apples set, gave a little the best results. There was not much difference between six- to seven- and nine- to ten-inch thinning in the results of thinning middle-aged Rome trees bearing a good crop in 1916. It was found that while it paid best in some cases to thin as lightly as three to four inches apart, in most cases much better results were obtained where this distance was increased to at least six to seven inches (pages 8, 20, 23, 32, and 35).

The best results of any one distance under all conditions were obtained when the fruits were thinned six to seven inches apart. If any one distance were to be recommended for all cases regardless of conditions this would be the one. This distance proved to be the best under New York and Utah conditions, while a minimum distance of eight inches apart gave good results in Ohio and from nine to ten inches seemed best in Colorado when thinning the mature Winesap*. Blair† in Nova Scotia found that as a rule the heavier thinnings gave the largest apples.

In our work in West Virginia, better results were obtained when the thinning was done by hand rather than when clippers were used. The work could be done by hand much quicker and cheaper (page 21) and with as good results. It might be that with some varieties, in which the fruit spurs break very easily, it would pay to use clippers. It was noticed in our

*Beach, S. A., N. Y. Geneva Agr. Exp. Sta., Bull. 239.
*Ballou, F. H., Ohio Agr. Exp. Sta., Bull. 240.
*Batchelor, L. D., Utah Agr. Exp. Sta., Cir. 12.
*Herrick, R. S., Col. Agr. Exp. Sta., Bull. 170.
†Blair, W. Saxby, Rept. Div. of Hort., Dominion Experimental Farms, Ottawa, Canada (Kentville N. S.) Rept. of 1913, p. 324.

work that the spurs of the York Imperial broke off much more easily than did those of the Ben Davis. With a little care, however, no trouble was experienced from this source with any of the varieties under test.

A tree should never be shaken as a means of thinning fruit since the wrong fruit is very liable to fall. It has been said that pruning could be a method of thinning, but while pruning would take out certain limbs, fruit spurs, (and shorten the terminal growths in the case of peaches), and thus lighten the load on a tree somewhat, still the fruit remaining on the other limbs of the tree would be too close and would need thinning.

Kinds of Trees and Different Conditions Influencing Thinning.

The question is often asked whether it will pay to thin all kinds and ages of trees under all conditions. The results secured show that it will not. It is a fact that some varieties are very prolific, come into bearing late, and are known as shy bearers. There is no doubt that such early bearing sorts as Jonathan, Grimes, and Gano will need thinning long before the Northern Spy comes into commercial bearing. Certain soils are much more fertile and stronger than are others. The same tree in one soil might be able to develop a certain load satisfactorily without thinning and, in another and poorer soil, thinning would be necessary in order that the fruit might size up enough to be marketable.

The same trees on the same soil might need thinning very badly one year, while bearing a big crop, and would not need thinning another year when bearing from a light to a medium crop. Our results show that in a seventeen-year-old Ben Davis orchard bearing a light crop thinning did not pay (page 7) but that two years later, when the same orchard was bearing a heavy crop, the thinned trees produced twice the bulk of marketable apples as did the unthinned trees in spite of the fact that there was a much smaller number of apples upon them at picking time.

It paid slightly in money returns the first year to thin young Baldwin trees bearing their first commercial crop although it would have paid to thin these trees even at a loss financially inasmuch as many of the limbs would otherwise have been overloaded and the trees would have been subjected to a severe strain. It is difficult also to maintain the vigor and health of young trees that are allowed to overbear from year to year.

Time Required and Cost per Tree to Thin.

Results show that time and cost of thinning are influenced by several factors such as age of trees, price of labor, character of labor, set of fruit, pruning of the trees, height of trees, ease with which apples leave the spurs, distance that the fruit is thinned, and many others. The figures presented here are for man labor figured at 20 cents an hour.

In 1912 the average time per tree for one man in thinning forty-five seventeen-year-old Ben Davis trees bearing a light crop (7 bushels per tree) was 57 minutes. The cost was 19 cents per tree. The same year the average time for thinning sixteen trees of Baldwin, York Imperial, and Rome about eighteen years old and bearing a fair crop (3 to 5 barrels per tree) was 1 hour and 16 minutes and cost 25.3 cents per tree. The average time in thinning ten-year-old York Imperial this same year, including forty-five trees which were bearing a good set of fruit, was 44¼ minutes at a cost of 14.7 cents per tree.

In 1914 the average time of thinning per tree, including twelve Ben Davis nineteen years old and bearing four barrels of apples per tree, was 1 hour and 51 minutes per tree at a cost of 37 cents each. To thin the same number of York Imperial trees of the same age bearing from four to five barrels per tree took 1 hour and 23 minutes per tree for one man at a cost of 27¾ cents per tree.

In 1915 the average time per tree, including five trees in each case, in thinning nine-year-old Baldwins bearing nearly one barrel per tree was 22.2 minutes and 28.8 minutes at a cost of 7⅔ cents and 9⅗ cents per tree respectively when the trees were thinned so that the fruits in the first case were six to seven inches apart and in the second case were nine to ten inches apart.

In 1916 the average time required for one man to thin twenty-one-year-old Ben Davis trees bearing from four to five barrels each was 65.3 minutes per tree at an average cost of 21.8 cents. In thinning twenty-year-old Rome bearing from three to four barrels per tree it took one man an average of 133 minutes and cost 43⅓ cents per tree.

It had been found in this thinning work, however, that if trees were heavily loaded, the cost of thinning could not fairly be charged against the thinned trees. Different factors such as the following offset this charge in such cases. In the first place, the fruit thinned off at thinning time would have to be picked at picking time anyway and it would cost as much to remove it then as it would at thinning time. This was

the case with the Ben Davis in 1914 (page 21) when the unthinned trees had from 1000 to 1666 more apples per tree to be picked. It will be remembered also that even with this additional fruit there was then less than one-half as great a total marketable yield as there was from the thinned trees bearing the smaller number of apples. Results similar to these were also found in the Ben Davis thinning of 1916. Second, it cost considerably more in sorting to remove the large number of culls from the unthinned trees and after the sorting these culls were then not salable. Thus in this case no charge could be made for thinning. Even in the case of thinning young nine-year-old Baldwin it cost 35 percent more to pick the unthinned trees. Here again the sorting cost was increased with more unsalable apples from the unthinned trees.

Thus, although the first case of the middle-aged Ben Davis trees may be exceptional, still, in most cases where thinning is necessary, only a small part, if any, of the cost of thinning can be charged against the thinned trees.

SUMMARY.

Investigations in thinning apples have been carried on by the West Virginia Agricultural Experiment Station for the past five years. During this time one hundred and eighty-seven trees of different ages, growing under different environmental conditions and consisting of the varieties of Rome, Baldwin, York Imperial, Delicious, and Ben Davis have been under test.

Does Apple Thinning Pay?—Results show that where apple trees are bearing from a medium to a heavy crop of fruit, the removal of part of this fruit by thinning is a very profitable practice. Under certain conditions, however, such as light crops with fertile soils and vigorous trees, thinning may not pay.

Size.—In all cases where the trees had a good crop, thinning increased the size of the fruit. In some plots an extra large grade was secured, while in others considerable fruit was made salable which otherwise would not have been so.

Color.—The color of the fruit on heavily-loaded trees was much superior when thinning was practiced. The apples not only took on a deeper red color but were also colored more evenly and all apples were more uniform in color.

Market Value.—The thinned fruit being larger and better colored would ordinarily command a better price per barrel. For boxing purposes and fancy trade, the thinned fruit would command a much better price.

Net Returns per Tree.—From trees bearing good crops, greater net returns were always received by thinning. One year in one plot of twelve trees the thinned trees returned twice as much net per tree as did the unthinned ones. Another year the thinned trees gave at least a 75 percent greater net return per tree. In some cases, however, the differences were not so striking. In one case in 1912, as mentioned later, thinning did not pay.

Vigor and Shape of Young Trees.—Especially in the case of young trees, thinning tends to maintain the vigor and shape of the trees by preventing overloading. Limbs on the thinned trees are not subjected to such a severe strain and consequently seldom break down.

Vigor of Bearing Trees.—In the case of the older bearing trees, much of the energy and vigor of the tree can be saved with just as large financial returns if part of the apples are removed early in the season. In 1914 the unthinned trees in the thinning plots had to carry 1000 to 1666 more apples per tree up to picking time in order to have the same total yield of fruit as the thinned trees, and after developing the seeds and flesh of these extra apples there was only one half as much total marketable fruit per tree. Similar results were found in 1916.

Effect of Thinning on Annual Bearing.—Due to a freeze in 1913 which destroyed the effect of the previous year's thinning and made thinning impossible that year, data on the effect of annual thinning on subsequent crops have been obtained only for the past three years. While final conclusions are not attempted, results indicate that thinning does not influence subsequent crops nor cause trees, naturally biennial in bearing habit, to bear a crop each year. Nineteen-year-old York Imperial and Ben Davis trees thinned in 1914 produced no fruit in 1915, but all trees thinned and unthinned bore a good crop in 1916. Nine-year-old Baldwin thinned in 1915 bore no fruit in 1916. Several middle-aged York Imperial trees thinned by a commercial orchardist in 1915, produced practically no crop in 1916. In this respect they did not differ from similar unthinned trees.

Time to Thin.—The best time to thin winter varieties is just after the June drop, in West Virginia from June 20 to

July 5. In the case of summer or early autumn varieties it will probably pay to delay thinning until the fruit is large enough to use, and then several thinnings should be made as the fruit sizes up.

Method and Distance to Thin.—In thinning, it should be the aim to remove all injured or insect-eaten fruit and the small green and knotty apples on the lower inside limbs which seldom ever become marketable. Clusters should be reduced to one apple each and the remaining apples on the limb should be thinned to a certain distance, depending on different conditions such as age of tree, set of fruit, vigor of tree, etc. No definite rule can be made to suit all conditions. In most of our experiments the best results were obtained when the fruits were thinned six to seven inches apart. In the case of old trees bearing good crops, however, nine to ten inches apart gave slightly better results.

Clippers versus Thinning by Hand.—Although it may pay under some conditions to use clippers for thinning purposes, it was found in our experiments that the work could be done quicker, cheaper, and as well by hand. It might be that with some varieties in which the fruit spurs break very easily it would pay to use clippers, but we did not experience this difficulty with the varieties under test.

Kinds of Trees and Different Conditions as Influencing Thinning.—It will not pay to thin all kinds of trees the same under all conditions. Certain early-bearing trees need thinning sooner than do others. Some soils are more fertile than others and can develop the same load of fruit much easier. Some trees are naturally shy bearers and do not need as much thinning as do others. Healthy, vigorous trees on fertile soil can develop a light to medium crop without thinning. Our results in 1912 with middle-aged Ben Davis located on good soil and bearing a light crop showed practically no advantages for thinning.

Time Required and Cost of Thinning.—The length of time required to thin a tree and the cost will vary with several factors, such as cost of labor, set of fruit, height of tree head, etc. In our experiments, for one man, a range of from 25 minutes per tree at a cost of 8⅓ cents on nine-year-old Baldwins, bearing one barrel per tree, to 2 hours and 13 minutes per tree at a cost of 43⅓ cents on middle-aged trees of different varieties bearing from 4 to 6 barrels per tree was found. Low-headed, middle-aged trees bearing about 5 barrels can ordinarily be thinned by one man in about one and one-half hours at a cost of 30 cents per tree.

Charges Which Offset Cost of Thinning.—Our investigations show that only a small part, if any, of the cost of thinning should be charged against the thinned trees. In the first place, the fruit thinned off would have to be removed at picking time anyway, and the cost of removal would not be much different in either case. In the second place, it takes much longer and costs more in sorting to pick out the larger amount of culls on the unthinned trees, and these culls are then not salable.

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