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PROFIT AND LOSS IN PRUNING MATURE APPLE TREES

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PROFIT AND LOSS IN PRUNING MATURE APPLE TREES

By Roy E. Marshall

The reasons advanced for pruning bearing fruit trees are too well known to necessitate detailed enumeration and discussion. However, in the last analysis, the only one that can be defended is that it is said to make the orchard more profitable. Any pruning practice which does not, directly or indirectly, result in greater returns and more profit per acre or per tree than would be realized were the trees not pruned or were they pruned in a somewhat different manner, has no place in the program of the commercial fruit grower.

In spite of the accumulation of a large amount of information relating to pruning practices, resulting from the observations of both fruit growers and technically trained investigators and from carefully conducted experiments, information based on actual yield and grade records of mature apple trees subjected to different kinds and amounts of pruning is almost completely lacking.

The data presented in the first portion of this bulletin have been obtained incident to what was originally planned as an experiment to determine the return for each dollar expended in (1) fertilizing and in (2) pruning mature apple trees.

Description and History of Farrand Orchard

In the spring of 1920 a fertilizer experiment was started in the 35-year-old Ben Davis orchard of W. F. Farrand, located about one mile east of Eaton Rapids. The land is practically level; the soil is light. The trees were growing in a sparse blue-grass sod and the orchard had not been cultivated or pruned for several years; consequently the trees were in a very low state of vigor, had many dead and weak branches and twigs, were producing very little twig growth and the yields were low.

Each fertilizer plot consisted of three rows of six trees each. The plots, except one to which no fertilizer was applied and one that received acid phosphate only, were fertilized each year with either four pounds of sulphate of ammonia or five pounds of nitrate of soda per tree. One of the five plots received, in addition to the nitrogen-carrying fertilizer, ten pounds of acid phosphate and another plot received ten pounds of acid phosphate and three pounds of muriate of potash per tree. One of the nitrogen-fertilized plots received its application in early September; the others were fertilized two or three weeks before the trees blossomed each spring. The balance of the orchard (not included in the fertilizer tests) received four or five pounds of sulphate of ammonia per tree annually. Yields were recorded for the middle one of the three rows in each plot.

A report on the results of the fertilizer experiment for the five year period, 1921 to 1925 inclusive, was made in 1926.* The results show that neither acid phosphate nor muriate of potash has increased yield

*Marshall, R. E.—Does it pay to prune apple trees for quality production.—56th Ann. Rept. Mich. State Hort. Soc., pp. 5-13, 1926.

and that it makes little, if any, difference, in so far as yields are concerned, whether nitrogen is applied in the form of nitrate of soda or sulphate of ammonia or whether it is applied in early spring or early in September.

The average annual yield for the 29 record trees to which nitrogen was applied was 10.5 bushels per tree. Of this total yield, 6.9 bushels were more than two and one-half inches in diameter, 2.4 bushels were two and one-fourth to two and one-half inches and 1.2 bushels were less than two and one-fourth inches. The average annual yield for the unfertilized trees was 4.1 bushels, 2.0 bushels of which were larger than two and one-half inches, 1.1 bushels being two and one-fourth to two and one-half inches, and 1.0 bushel less than two and one-fourth inches in size. The nitrogen-fertilized trees not only yielded more than two and one-half times as much as the unfertilized trees, but nitrogen applications also resulted in larger fruit, 66 per cent of the yield from the fertilized trees being larger than two and one-half inches compared to 49 per cent from the unfertilized trees. The average annual net returns to the grower were $6.30 and $2.18, respectively, per fertilized and unfertilized tree.

The dead and some of the weaker growing wood was removed from all trees in this orchard during the spring of 1922. This pruning treatment was so light that it probably had little or no effect on either vegetative growth or fruit production. In other words, prior to 1925, the trees were typical unpruned ones of the variety.

The Pruning Treatment

The trees in three of the six rows crossing each fertilizer plot were pruned in the spring of 1925 by systematically thinning out branches one-half to one inch in diameter and a few larger limbs were removed where it seemed desirable. Some of the weaker branches were headed back to laterals. The pruning was largely confined to the outer and uppermost parts of the trees. It was in no sense severe, resembling in both kind and amount that which is commonly afforded many of the best commercial orchards. Nearly all the work was done with lopping shears. The average amount of time spent in pruning each tree was about 50 minutes.

The object was not to compare different methods of pruning but to afford a group of trees what might be termed good commercial pruning and to find out approximately how much may be expected in return for each dollar invested in this way.

Results in 1925

Though the trees set a heavy crop of fruit in the spring of 1925, the dry growing season did not favor its development; consequently, the fruit ran to small sizes, even under the more favorable cultural practices.

Observation before harvest indicated an increase in size due to pruning and it was predicted that the total yields of the pruned would fully equal those of the unpruned trees. Harvesting records, however, showed that the pruned trees of the fertilized plots matured only 68 per cent as many apples as corresponding unpruned trees. Apparently, pruning had

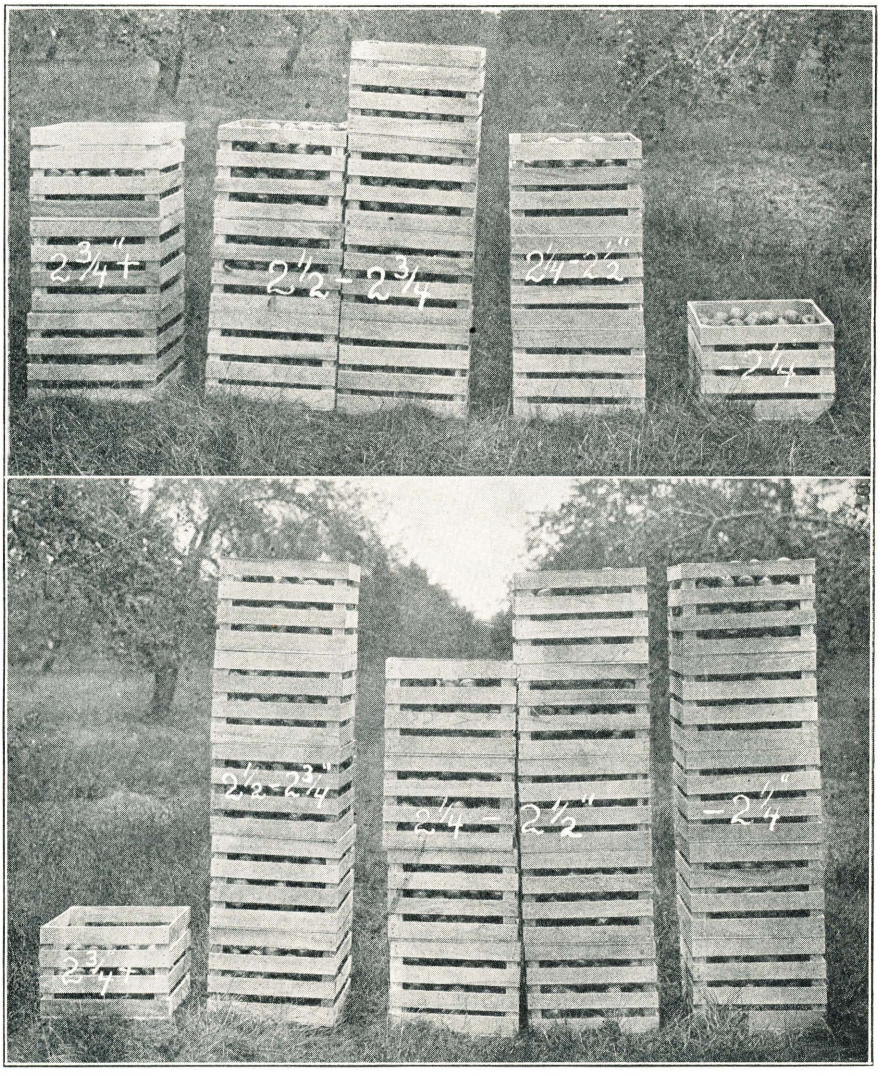

Figure 1.—An average yield of the pruned Ben Davis trees in one of the fertilized plots. October, 1925. (This is an average of three trees while the figures in Table 2 and the chart in Figure 5 represent averages for 15 trees. All figures in the text and tables are packed bushels, while loose bushels are shown in Figures 1, 2, 3 and 4).

Figure 2.—An average yield from the unpruned Ben Davis trees in one of the fertilized plots. Compare with Figure 1. October, 1925.

thinned the crop to the extent of 32 per cent though it resulted in a higher percentage of large apples, 46 per cent of the apples from the pruned trees being over two and one-half inches in diameter compared with 30 per cent for the unpruned trees of the same plot.

The pruned trees of the unfertilized plot produced 17 per cent more apples than the unpruned trees. It is possible that either the initial set was better or the "June drop" was not as heavy. Furthermore, the

TABLE 1—AVERAGE NUMBER OF APPLES PER TREE AND CLASSIFICATION ACCORDING TO SIZE, 1925. (Approximately)*

Treatment	Number apples per tree	Number apples per bushel	Size grade expressed in percentage			
			2¾"+	2½"–2¾"	2¼"–2½"	–2¼"
Fertilized:						
Pruned 1925	2,874	249	8	38	30	24
Not pruned	4,203	268	3	27	36	34
Not Fertilized:						
Pruned 1925	2,005	296	0	13	35	52
Not pruned	1,714	318	0	5	26	69

*A few bushels of each size grade were counted and the number of apples for each tree were then calculated from the yields of corresponding grades.

apples from the pruned portions of the plot were considerably larger than those from the unpruned trees, though the apples from the pruned, unfertilized trees were very much smaller than those from the unpruned trees receiving nitrogen.

Table 2 and Figure 5 show that the pruned trees of the fertilized plots produced only 74 per cent as many bushels of apples as the unpruned trees of those plots during the season following the pruning treatments. In other words, the reduction in number of apples to the extent of 32 per cent that was effected by pruning was not counter-balanced by increased size of the remaining fruits to equal the total yield of the unpruned trees. Furthermore, considering each of the 41 "count" trees of all plots as a unit,—a very marked correlation is found between the number of apples produced by a tree and its total yield in pounds. In other words, though size of apples may be somewhat influenced by pruning, if the number of apples per tree is materially reduced, the yield will likewise be deceased.

The pruned trees of the fertilized plot, however, averaged seven bushels of apples above two and one-half inches in diameter as compared to a yield of 6.2 bushels of corresponding size from the unpruned trees.

TABLE 2.—AVERAGE YIELDS AND GRADES OF PRUNED AND UNPRUNED TREES. 1925.

Treatment	Yield per tree in bushels	Size grades expressed in bushels			
		2¾"+	2½"–2¾"	2¼"–2½"	–2¼"
Fertilized:					
Pruned 1925	11.6	1.7	5.3	3.1	1.5
Not pruned	15.6	.8	5.4	5.7	3.7
Not Fertilized:					
Pruned 1925	6.8	.1	1.2	2.5	3.0
Not pruned	5.4		.4	1.7	3.3

Pruning the unfertilized trees resulted in both larger yields per tree and a much larger proportion of apples of A-grade size.

Practically all the fruits harvested met the requirements for Michigan A- and fancy grades for Ben Davis and color differences between either the pruning or the fertilizer treatments were of no consequence.

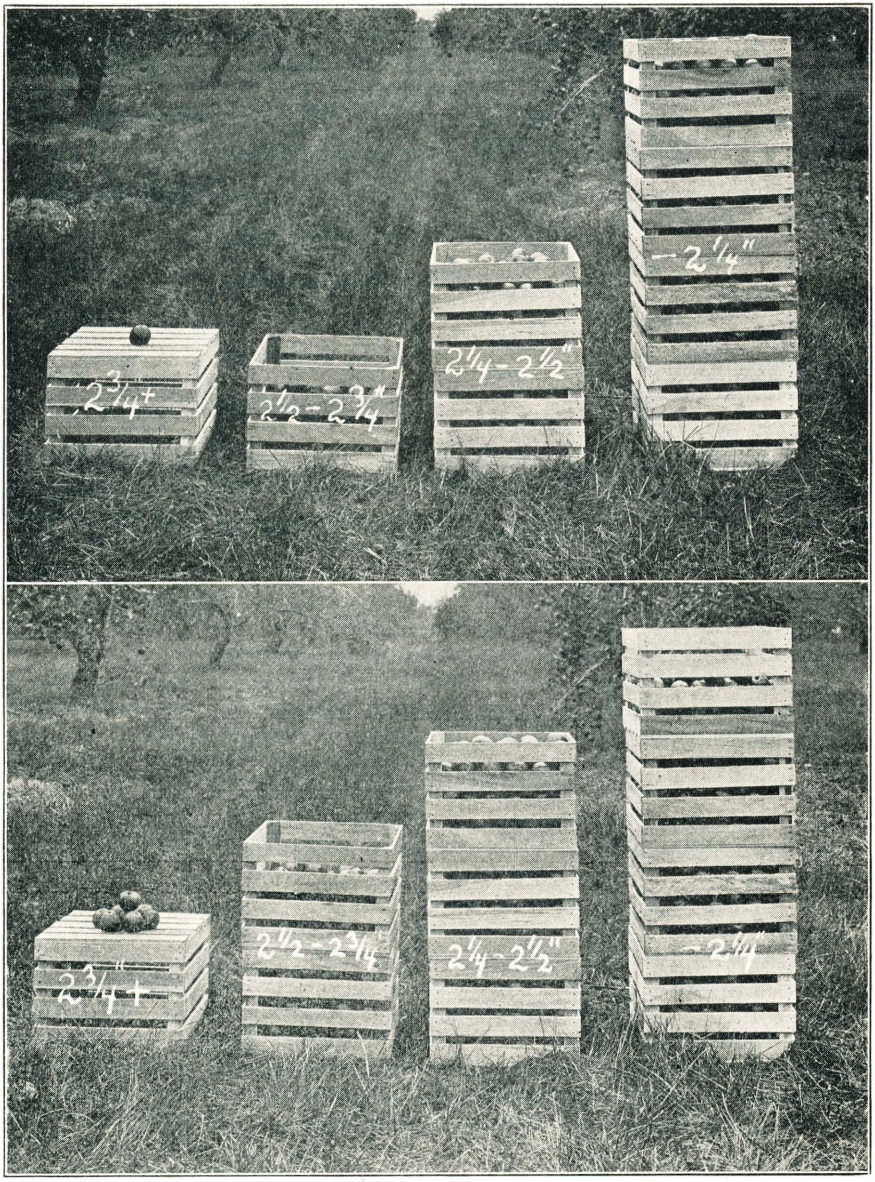

Figure 3.—An average yield from the unpruned Ben Davis trees in the unfertilized plots. October, 1925.

Figure 4.—An average yield from the pruned Ben Davis trees in the unfertilized plots. October, 1925.

The final test of any orchard practice must be based upon the profits or net returns per tree or per acre. The average net returns per tree for the pruned and unpruned trees of both high and low vigor are based upon the 1921 to 1925, inclusive, averages (costs of grading, packing,

etc., are deducted) of the members of several fruit exchanges in Western Michigan. For Ben Davis they were 73 cents per bushel for A-grade, 50 cents per bushel for B-grade and 37 cents per hundred-weight for undergrade. The cost of pruning, which would average from 35 to 40 cents per tree, should be charged against two, three or more succeeding crops and has not been deducted in Table 3.

TABLE 3.—AVERAGE NET RETURNS PER TREE. FARRAND ORCHARD. 1925.

Treatment	A-grade size	B-grade size	Undergrade size	Total
Fertilized:				
Pruned 1925	$5.08	$1.57	$0.26	$6.91
Not pruned	4.51	2.85	.66	8.02
Not Fertilized:				
Pruned 1925	.93	1.27	.53	2.73
Not pruned	.31	.83	.59	1.73

The fertilized or high vigor trees that were not pruned gave an average net income of $1.11 per tree more than those that had been pruned, in spite of the fact that the net value of the A-grade apples of the average pruned tree was 57 cents greater than that of the average unpruned tree. If only the A-grade apples had been packed and the B-grade had been combined with the undergrade at a net price of only 37 cents per hundred-weight, the net returns per tree would have been $5.90 for the pruned and $6.19 for the unpruned trees.

The pruned trees of the unfertilized plot gave an average net return of $1.00 more than those that had not been pruned, the returns for their A-grade apples being three times that of the unpruned trees.

Results in 1926

During the spring of 1926 another group of Ben Davis trees, ten in number, in a row adjacent to the original fertilizer plots, was pruned by five members of the station and extension staffs, each man working alone and according to his own ideas of handling trees of the type of those under consideration. In general, the amount of pruning was uniform and similar to that of the previous year, the differences being in kind of treatment and even these were minor. These trees had received annual spring applications of sulphate of ammonia at the rate of four to five pounds per tree since 1920. They, likewise, had not been pruned, except for the removal of dead and dying branches, for several years.

The apples from these and adjoining unpruned trees were counted as they were fed onto the belt of a mechanical sizer.

TABLE 4.—AVERAGE NUMBER OF APPLES PER TREE AND CLASSIFICATION ACCORDING TO SIZE GRADE. 1926.

Treatment	Number apples per tree	Number apples per bushel	Size grades expressed in percentage		
			2½″+	2¼″–2½″	–2¼″
Pruned (1926)	1,307	163	80	15	5
Not pruned	1,948	181	63	24	13

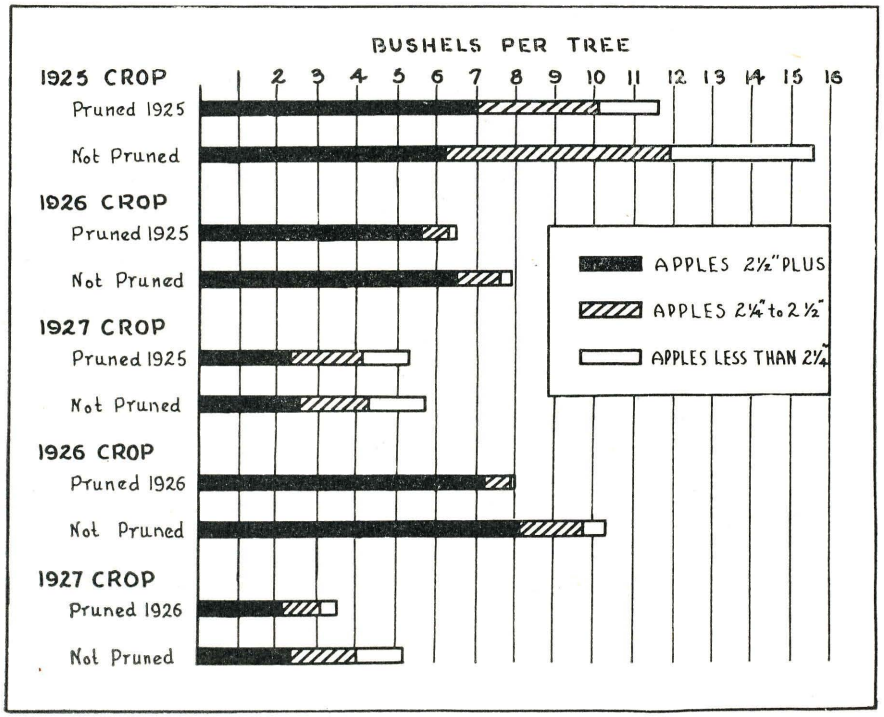

Figure 5.—Average yields and grades for pruned and unpruned Ben Davis trees. The pruned trees produced crops with a higher percentage of first grade product than unpruned ones, but quantity of first grade product was not always increased by pruning. The total yield per tree was materially reduced by pruning.

A comparison of Tables 1 and 4 shows that the average fertilized tree in this orchard produced more than two times as many apples in 1925 as in 1926 and that the apples produced in the latter year were about 50 per cent larger than those produced in the heavier crop year. These years, then, represent one year when the fertilized trees set heavily, even to the point of over-loading, and another year when the set was only fair.

The eight unpruned trees averaged 49 per cent more apples than the ten pruned ones (see Table 4). The average apple produced by the pruned trees, however, was 16 per cent larger than the average one from the unpruned trees. Unfortunately, the kind of records obtained during harvest in 1926 does not permit a calculation of the percentage of apples

TABLE 5.—AVERAGE YIELDS AND GRADES OF PRUNED AND UNPRUNED TREES, SEASON FOLLOWING PRUNING. 1926

Treatment	Yield per tree (bushels)	Size grades expressed in bushels			
		2¾"+	2½"–2¾"	2¼"–2½"	–2¼"
Pruned (1926)	8.0	4.7	2.5	.7	.1
Not pruned	10.3	4.0	4.1	1.6	.6

Figure 6.—A typical unpruned Ben Davis tree that has received annual applications of nitrogenous fertilizers. April, 1927.

Figure 7.—A typical Ben Davis tree that was pruned in 1925 and has received annual applications of nitrogenous fertilizers. April, 1927.

which were larger than two and three-fourths inches, but a comparison of apples larger than two and one-half shows the pruned trees to have grown a much higher percentage of their apples to A-grade size.

Though nearly 90 per cent of the crop of the pruned trees were of A-grade size, as compared to 80 per cent of the unpruned trees, the unpruned trees averaged nearly a bushel more A-grade size apples. Moderate pruning, during a light crop year, evidently thinned the crop too severely to result in a maximum crop of apples above two and one-half inches in diameter. Furthermore, the unpruned trees produced nearly a bushel more apples of B-grade size. The proportion of small apples was low in both cases.

TABLE 6.—AVERAGE RETURNS PER TREE. FARRAND ORCHARD. 1926.

Treatment	A-grade size	B-grade size	Undergrade size	Total
Pruned (1926)	$5.25	$0.34	$0.03	$5.62
Not pruned	5.91	.80	.10	6.81

Assuming the same net values for the three grades that were used in the 1925 computations, average net returns per tree in 1926 were only about $1.25 less than in 1925, in spite of a decrease of more than 50 per cent in the number of apples per tree and a decrease of about one-third

Figure 8.—A typical unpruned and unfertilized Ben Davis tree. April, 1927.

in total yield. This was due to the relatively greater proportion of large sized fruits. As in 1925, the unpruned gave a higher net return than the pruned trees.

Hold-over Effect of Pruning

During 1926 field records were obtained for 17 fertilized trees which were pruned in the spring of 1925 and 18 fertilized trees that were not pruned and likewise from three pruned and three unpruned trees that had not been fertilized (Table 7). These trees were not pruned in 1926. They included those whose 1925 records appear in Tables 1 to 3, with the exception of those in one plot where an application of fertilizer was omitted and in addition included a few trees located on either side of "count rows."

TABLE 7.—AVERAGE NUMBER OF APPLES PER TREE AND CLASSIFICATION ACCORDING TO SIZE GRADE. 1926.

Treatment	Number apples per tree	Number apples per bushel	Size grades expressed in percentage		
			2 ½"+	2 ¼"–2 ½"	–2 ¼"
Fertilized:					
Pruned (1925)	1,091	169	77	17	6
Not pruned	1,404	179	69	21	10
Not Fertilized:					
Pruned (1925)	114	168	82	12	6
Not pruned	21	238	76	10	14

Figure 9.—A typical pruned but unfertilized Ben Davis tree. April, 1927.

The records show that even in the second season after pruning and during a light crop year, the unpruned trees of the more vigorous group (fertilized) produced nearly 30 per cent more apples per tree. In other words, the moderate thinning of the fruiting wood in 1925 resulted in a thinning of the fruit for the 1926 as well as the 1925 crop. The pruned trees produced ten per cent more apples of A-grade size and it is conceivable, had counts been made of the fruits of above two and three-fourths inches in diameter, that the pruned trees would have made an even better showing. That there was not a great difference, however, in the average size of the apples from the pruned and unpruned trees is indicated by the figures in the column giving the number of apples per bushel.

The unfertilized trees produced very few apples. Those that were pruned not only produced more per tree but the fruits averaged more than 40 per cent larger than those from corresponding unpruned trees. Just how much significance can be placed upon results from three trees of each treatment where the yields were as low as those records in Tables 7 and 8 is questionable. However, they indicate that pruning trees of low vigor may result both in more and larger fruit.

TABLE 8.—AVERAGE YIELDS AND GRADES OF PRUNED AND UNPRUNED TREES, SECOND SEASON AFTER PRUNING. 1926.

Treatment	Yield per tree (bushels)	Size grades expressed in bushels			
		2¾"+	2½"–2¾"	2¼"–2½"	–2¼"
Fertilized:					
Pruned (1925)	6.5	3.2	2.5	.7	.1
Not pruned	7.9	3.5	3.0	1.1	.3
Not Fertilized:					
Pruned (1925)	.7	.3	.3	.1	
Not pruned	.1				

The average yield of the 18 unpruned fertilized trees exceeded that of the 17 pruned trees in the second season following the 1925 pruning by more than five pecks per tree (Table 8 and Figure 5). Furthermore, the average unpruned tree outyielded the pruned trees in each of the four size grades, including a size with a minimum diameter of two and three-fourths inches. This indicates that these trees were capable of producing at least eight bushels of apples per tree without material reduction of the yield of large sized fruits and that thinning the crop by means of pruning simply reduced the number of apples without substantially increasing the size of those that were left.

TABLE 9.—AVERAGE NET RETURNS PER TREE, SECOND SEASON AFTER PRUNING. 1926.

Treatment	A-grade size	B-grade size	Undergrade size	Total
Fertilized:				
Pruned (1925)	$4.12	$0.34	$0.03	$4.49
Not pruned	4.75	.53	.05	5.33
Not Fertilized:				
Pruned (1925)	.44	.03		.47
Not pruned	.05			.05

The production of the unfertilized trees was very low but the data show the pruned to have outyielded the unpruned trees, as in 1925.

The average net returns for the unpruned trees of the fertilized plots was 84 cents more than that for the pruned trees; 63 cents of this difference in returns is accounted for in the A-grade size. It is interesting to note that in this year of comparatively low yields 92 and 89 per cent of the average net returns from the pruned and unpruned trees, respectively, came from the apples of A-grade size.

Actual Results of Pruned Trees Compared to Probable Results Without Pruning. 1925 and 1926

Ben Davis is generally regarded as an annual bearing variety. Nevertheless, the orchard under consideration has been bearing in a two-year cycle during the six-year period that it has been under study. It is unnecessary to make a detailed study of the actual average yields, grades and returns for the two-year period (1925 and 1926), but since the records of certain trees are available for two two-year cycles previous to the time the pruning was done in 1925 it is possible to determine the probable yields of the pruned trees for 1925 and 1926 had they not been pruned. The calculations are based upon the following proportion: the average yield per unpruned tree for the four-year period, 1921 to 1924: the average yield per pruned (1925) tree for the years 1921 to 1924:: the average yield per unpruned tree for the years 1925 and 1926: the average probable yield for the pruned trees for the years 1925 and 1926 had they not been pruned. A comparison of the latter figure with that actually recorded shows the probable gain or loss due to pruning.

TABLE 10.—A COMPARISON OF THE PROBABLE YIELDS AND NET RETURNS OF UNPRUNED TREES FOR THE YEARS 1925 AND 1926 WITH THE ACTUAL YIELDS OF THE SAME TREES FOLLOWING PRUNING OF 1925.

Treatment	Yield per tree per year (bushels)	Size grades expressed in bushels			Net returns per tree per year
		2½"+	2¼"–2½"	—2¼"	
Fertilized:					
Pruned (actual).....	8.2	5.7	1.8	.7	$5.19
Not pruned (probable)...	10.7	4.6	3.2	2.9	5.44
Not Fertilized:					
Pruned (actual).....	3.7	.93	1.30	1.48	1.56
Not pruned (probable)...	4.5	.35	1.50	2.61	1.28

The performance records of eight pruned and eight unpruned trees of the fertilized plots and the three pruned and three unpruned trees of the unfertilized plot (the trees used in making calculations for Table 10) indicate that there were local environmental conditions or inherent differences in the trees which slightly favored the unpruned trees of the fertilized plots and the pruned trees of the unfertilized group, and these have undoubtedly resulted in slightly exaggerated differences in the several comparisons that have been made between pruned and unpruned trees.

Though the unfertilized trees would have produced larger yields without pruning, such a large proportion of their apples would have gone to the cider mill that the computed estimated net returns per tree would

have been 28 cents greater for the pruned trees. This, more or less, substantiates the actual results recorded in earlier tables, namely, that pruning of the low vigor trees in this particular orchard has been profitable. It is, however, very evident that more could have been accomplished in increasing the yields and net returns per tree in this orchard by the use of nitrogenous fertilizers than by moderate pruning.

Actual Grade Records of Pruned and Unpruned Trees, 1926

The apples from three representative trees pruned in the spring of 1926 and from three unpruned trees were carefully hand graded and the reasons for the grading down of each apple recorded. Columns 2, 3, 6 and 7 of Table 11 show that the proportion of the apples from unpruned trees showing a typical spray injury to which Ben Davis is particularly susceptible was slightly more than 50 per cent greater than that for the pruned trees, but columns 4 and 5 show spray injury to be responsible for a greater percentage of the low grade apples of the pruned trees than for the unpruned ones. The only logical conclusion, however, appears to be that pruning has aided in preventing spray injury. With more careful application of spray materials and with varieties less susceptible to this type of injury this factor would probably be of little significance with either pruned or unpruned trees.

TABLE 11.—PERCENTAGES OF APPLES AND YIELDS OF PRUNED AND UNPRUNED TREES PLACED IN THE LOWER GRADES AND THE REASONS FOR GRADING DOWN. 1926.

Reasons for placing in low grades	Per cent of total apples graded down for each reason		Per cent low grade apples so placed for each reason		Per cent of total yield graded down for each reason	
	Pruned	Unpruned	Pruned	Unpruned	Pruned	Unpruned
Size deficiency	10.8	38.3	28.5	53.7	5.5	22.9
Color deficiency	3.6	5.5	9.0	7.7	3.6	5.5
Spray injury	24.8	37.5	61.4	52.6	24.8	37.7
Lime rub	4.0	3.7	9.6	5.2	3.8	3.7
Misshapen	1.9	6.3	5.1	8.9	2.0	6.3
Sting	.8	1.0	2.2	1.4	.9	1.0
Scab	.2	1.0	.7	1.4	.3	1.0
Worm	.2	.2	.3	.3	.1	.2
Total*	46.3	93.5	116.8	131.2	41.0	78.3
Actual total	40.4	71.2	100.0	100.0	34.8	61.3

*The totals shown in this and other similar tables include a number of duplications and a few triplications and do not show the actual percentage of apples or yields placed in the lower grades. An apple, for instance, may be smaller than two and one-fourth inches, colorless and slightly spray injured. It would then be classified as undergrade for lack of size and as B-grade for lack of color and also because of spray injury.

The apples of this variety apparently colored as well in one case as in the other, in so far as comparison can be based upon standard grading practices. Other factors were of minor importance and, with the possible exception of misshapen and ill-formed fruits, were practically as serious for one treatment as for the other.

If all the factors listed in Table 11 are taken into consideration with no allowance for duplication of reasons for grading down, the returns per pruned tree are $4.43 and those of the unpruned trees $4.79 based on the average yields per tree shown in Table 5.

Returns Are Determined by Yields

The data for 1925 and 1926 for 87 individual trees which had received nitrogenous fertilizers for five to seven years show a very close relationship between the number of apples produced by a tree and its yield in pounds or bushels and also its net returns to the grower. The relationship between any of these three items and the yield of A-grade apples or the returns for A-grade apples is very much less pronounced. Coefficients of correlation are as follows: number of apples and yield per tree, .821 ± .023; yield and net returns per tree, .918 ± .006; total yield and yield of fruit of A-grade size per tree, .527 ± .034, and total returns and returns of the A-grade size per tree, .581 ± .030. The figures show that, for the orchard under consideration, high returns per tree depend primarily on high yields and high yields in turn depend on a relatively large number of apples per tree. The coefficients of correlation between yields of and net returns for A-grade apples per tree and total yields and grades are high and show the necessity of having a reasonable percentage of A-grade fruit from the standpoint of the net returns. In other words, yield is of primary importance and grade is a secondary consideration in this orchard. Any orchard practice, therefore, which will improve both total yield and percentage of A-grade fruit is the best; any practice that will increase either without materially reducing the other is second best, but any practice which will materially reduce yield in order to secure a material gain in yield of A-grade apples is of questionable expediency and may be unprofitable unless there is a wide margin in price between the first and the second grades. Fertilization has increased the total yield, A-grade yield and net returns per tree. Pruning has increased the A-grade yield in most cases but this was accompanied by decreased total yield and decreased net returns.

Figure 10 shows the total yields, yields of A-grade apples and the net returns for each of the 87 trees upon which the coefficients of correlation are based and substantiates the foregoing discussion. The close correlation between the total length of each bar in the graph and the point at which the net return line crosses the path of that bar is the outstanding point of interest and indicates the correlation between total yield per tree and net returns per tree. It is also noticed that the heavily shaded portions of the bars, indicating the yields of A-grade size apples, tend to shorten as the yields and net returns decrease, although the relationship is much less marked than that between yields and returns.

The average of the ten best trees (ten top bars in Figure 10) from the standpoint of net returns shows that only 52 per cent of the yield was of A-grade size, compared to 85 per cent for the average of the ten poorest trees (ten bottom bars). Furthermore, the range in percentage of A-grade size apples for the first lot is from 31 to 79 while that for the second lot is 76 to 94. This shows clearly that percentage of A-grade means nothing in terms of net returns per tree, unless this percentage is associated with reasonably high yields. Absolute quantity of A-grade is a much more reliable index of an orchard's profitableness or unprofit-

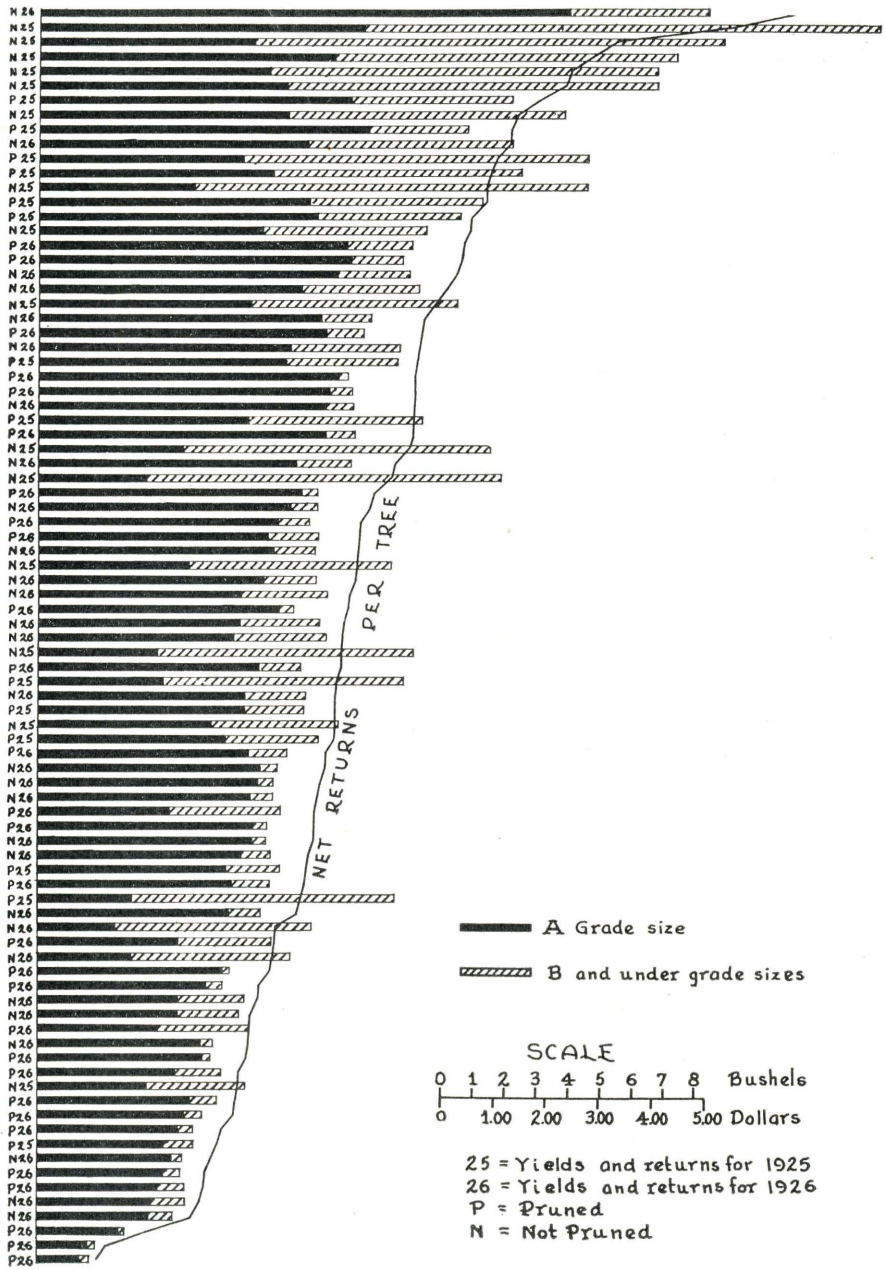

Figure 10.—A comparison of the yields, grades and returns of each of 87 fertilized trees. The tree performance representations are arranged in the order of net returns per tree as indicated by the diagonal line at the right end of the horizontal bars.

ableness but even the yield of A-grade apples does not indicate profitableness as accurately as does yield per tree. Only two pruned trees were among the ten most profitable ones and only three unpruned ones among the ten least profitable trees. Of the 25 best trees, 15 were not pruned and of the 25 poorest trees, 15 were pruned. These comparisons substantiate earlier tabular presentations of relative net returns per tree for pruned and unpruned lots of fertilized trees.

Figure 10 also shows that the trees of the orchard were on the whole more profitable in 1925 than in 1926. The trees produced heavier yields in 1925, though the percentage of A-grade size apples was much lower than in 1926. Indeed very few two and three-fourths inch apples were produced in 1925.

Results in Farrand Orchard, 1927

Trees on one side of this Ben Davis orchard failed to set a crop in 1927. Those on the other side set a reasonable number of fruits but the season was very dry (the rainfall for June, July and August was only 41 per cent of the normal at East Lansing) and this moisture deficiency combined with lack of scab control in an epidemic year resulted in heavy losses of foliage and small apples. Records were obtained from comparable trees located in the fruiting portion of the orchard. Some of the records for 1927 are from trees included in the results for 1925 and 1926 and some are from additional trees. The pruned and unpruned lots of trees, however, had been fertilized alike for the preceding six years and the lots stand adjacent to each other.

Two lots of unpruned trees are presented in Table 12, one of five trees for comparison with the same number of adjacent trees pruned in 1926 and another of 12 adjacent to an equal number pruned in 1925. The figures for the number of apples per tree are based upon actual counts of fruits from 31 per cent of the orchard crates. The trees pruned in 1925 produced nearly as many apples per tree as the unpruned ones while those pruned in 1926 produced 44 per cent fewer apples than adjoining non-pruned ones. This indicates that pruning as a fruit thinning practice, has little effect on total yield the third season after pruning.

TABLE 12.—AVERAGE NUMBER OF APPLES AND AVERAGE YIELDS AND GRADES PER TREE. FARRAND ORCHARD. 1927.

Treatment	Number apples per tree	Number apples per bushel	Yield per tree (bushels)	Size grades in bushels			
				2¾"+	2½"-2¾"	2¼"-2½"	-2¼"
Pruned (1926)	807	230	3.5	.7	1.4	1.0	.4
Not pruned....	1,436	276	5.2	.4	1.9	1.7	1.2
Pruned (1925)	1,415	276	5.3	.4	1.9	1.8	1.2
Not pruned....	1,529	268	5.7	.5	2.0	1.8	1.4

There was little difference in size of apples from the unpruned trees and those pruned in 1925, though the fruits from trees pruned a year later were considerably larger than apples from unpruned trees.

The differences in yields per tree and in yields for each size grade are remarkably similar for the two lots of unpruned trees and those pruned

in 1925, indicating that pruning has little, if any, holdover influence the third season after pruning. Trees pruned in 1926 yielded only two-thirds as much as their unpruned neighbors. The average pruned tree grew 60 per cent of its crop to A-grade size as compared to 44 per cent for the average unpruned one, but the latter produced a slightly larger yield of A-grade apples. On the whole, the data for the trees pruned in 1926 and for the adjoining unpruned trees are similar to that presented in Table 7 for pruned and unpruned trees the second season after the treatment.

The net returns per tree for those pruned in 1926 was $2.10; those pruned in 1925 returned $2.79 per tree and the unpruned lots averaged $2.71 and $2.97 net per tree. The trees pruned in 1926 returned 61 cents less than comparable unpruned trees while those pruned a year earlier returned 18 cents less than unpruned trees in the same portion of the orchard. The latter difference represents a loss of about six per cent for the pruned trees—too small to support any conclusion other than that the effects of pruning did not hold over for the third crop after the treatment.

Results in Nichols Orchard

Some 43-year-old Baldwin trees in the Trevor Nichols orchard, located about three miles west of Fennville, were pruned under the direction of extension specialists in the early spring of 1925, a few more were pruned in the spring of 1926 and a few were left unpruned.

These trees are 37 feet apart. The orchard is located on strong clay soil and had been given clean cultivation for at least ten years. The catch cover crop was heavy. Two to four pounds of nitrate of soda per tree had been applied in 1923 and in 1924. The heavy crop of 1924, an average of 30 bushels per tree with many trees producing 40 to 48 loose crates, consisted of many very small, undercolored and aphis-injured fruits. Thorough spraying was difficult and the harvesting was costly.

The trees were very dense before pruning, had produced little growth and practically all the fruits were produced from terminal buds on short shoot growths. The object of the pruning was to facilitate orchard management operations such as cultivation, thinning and harvesting, reduce the spray dosage and time required for spraying, and increase the size and color of the fruits. The pruning treatment given in February of 1925 consisted of a heavy thinning out of branches one-half to one inch in diameter at the point of cutting and a light heading back. Where the limbs were not dense a spur pruning was practiced.

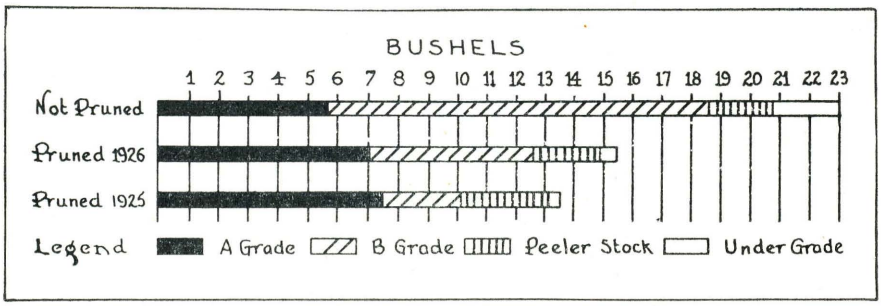

Figure 11.—Average yields and grades of Baldwin apples per tree. Nichols Orchard, 1926.

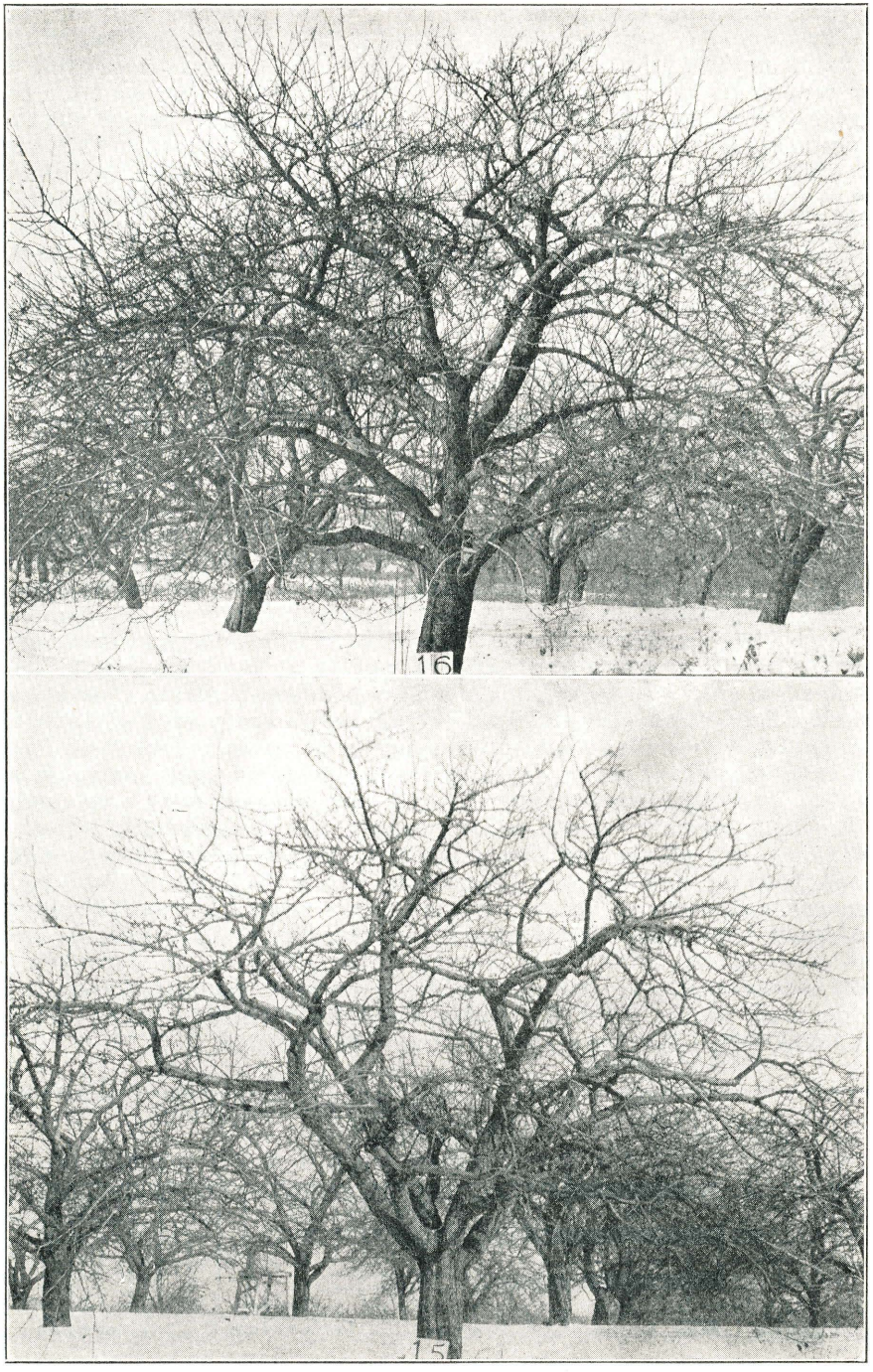

Figure 12.—An unpruned Baldwin tree in the Nichols orchard. February, 1927.
Figure 13.—A typical Baldwin tree in the Nichols orchard pruned in the spring of 1926. February, 1927.

The 1925 growth from points near the cuts, averaged about 14 inches on the non-fruiting trees and about eight to ten inches on the partial crop trees. None of them produced a full crop. The leaves of the pruned trees were about three times as large in area as those on the unpruned trees.

During the spring of 1926, about half of the remaining unpruned trees were given a pruning treatment similar to that of 1925 except that it was a little less severe. A few trees produced a light crop and many trees were practically barren in 1926. The pruning of 1925 did not result in a greater percentage of fruitful trees in 1926 even though leaves of the pruned trees were larger in 1925.

Table 13 and Figure 11 show the average yields and grades for five of the more fruitful Baldwin trees that were pruned in the spring of 1925, five pruned in the spring of 1926 and five that had not been pruned for several years. These apples were graded and packed in separate lots at the Fennville Fruit Exchange by the regular packing house crew. Apples of A-grade size showing superficial blemishes of sufficient importance to disqualify them for B-grade were sent to the canning factory and are classified as "canner stock." It is reasonable to assume that some of the B-grade apples and many of the undergrade ones were of A-grade size and that pruning or lack of pruning is in no measure responsible for the grading down of these apples.

TABLE 13.—AVERAGE YIELDS AND GRADES OF PRUNED AND UNPRUNED BALDWIN APPLE TREES, NICHOLS ORCHARD. 1926. (BUSHELS)

Treatment	Yield per tree	A-grade	B-grade	Canner stock	Undergrade
Pruned (1925)	13.5	7.5	2.6	3.1	.3
Pruned (1926)	15.5	7.1	5.6	2.2	.6
Not pruned	23.0	5.7	12.9	1.6	2.8

The 1926 pruning resulted in a reduction in yield of 7.5 bushels per tree or more than 32 per cent. The 1925 pruning, which was somewhat more severe, resulted in a 9.5 bushels reduction. More than 55 per cent of the 1926 crop of the trees pruned in 1925 was A-grade, about 46 per cent of that from trees pruned the spring preceding harvest were A-grade, while less than 25 per cent of the apples from unpruned trees were placed in that grade.

TABLE 14.—AVERAGE NET RETURNS PER PRUNED AND UNPRUNED BALDWIN APPLE TREE, NICHOLS ORCHARD. 1926.

Treatment	A-grade	B-grade	Canner stock	Undergrade	Total
Pruned (1925)	$8.17	$1.82	$1.22	$0.06	$11.27
Pruned (1926)	7.74	3.92	.86	.12	12.64
Not pruned	6.21	9.02	.62	.56	16.41

During the 1921-1925 period members of Michigan fruit exchanges have received a net price of $1.09 per bushel for A-grade Baldwins; 70 cents per bushel for B-grade, 81 cents per hundredweight for canner

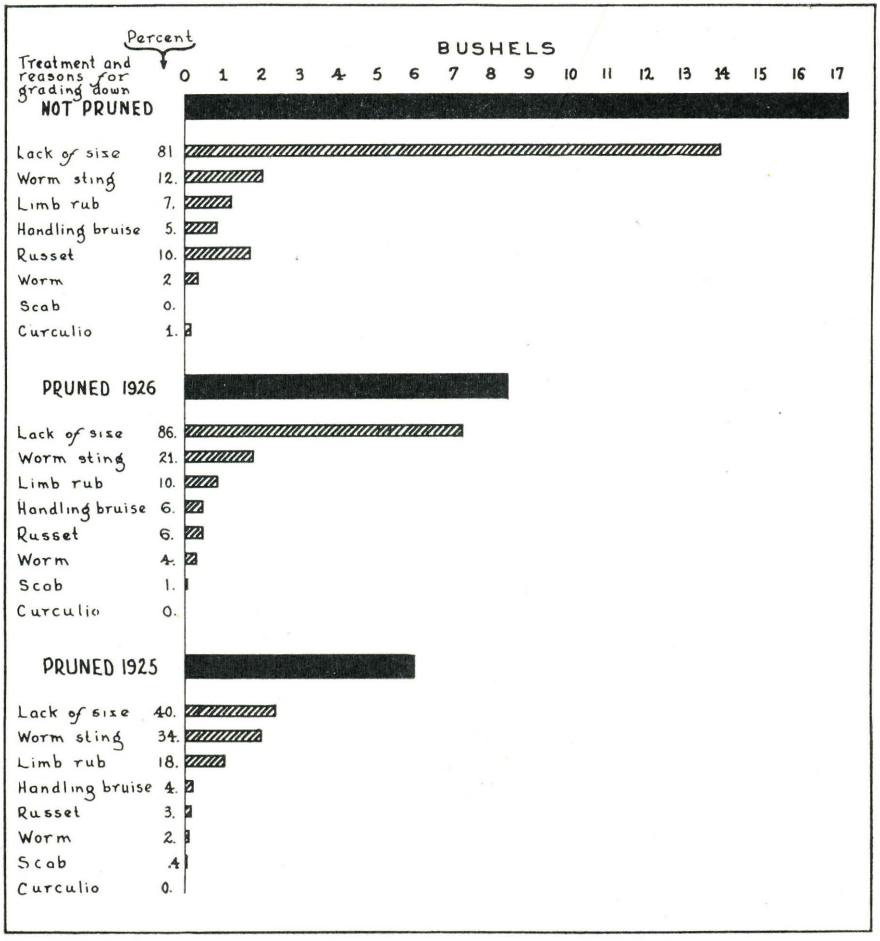

Figure 14.—The wide solid bars show the relative yields of low grade Baldwin apples in bushels per tree. The shaded bars show the relative numbers of low grade apples (not yields) that were placed in the lower grades for each reason. The aggregate of the shaded bars for each treatment is more than 100 per cent, or the length of the corresponding solid bar, because some of the apples show more than one defect or deficiency. All apples met A-grade color requirements in 1926. Nichols orchards, 1926.

stock and 42 cents per hundredweight for undergrade apples. These prices have been used in computing net returns for this variety.

The returns for A-grade apples were increased $1.53 and $1.96 by pruning but the B-grade apples of the unpruned trees sold for $5.10 and $7.20 more than those for the corresponding pruned trees. The total net returns per tree were reduced 23 and 31 per cent respectively, because of the pruning of 1926 and 1925.

The data presented graphically in Figure 14 were obtained in the manner described in detail by Gaston.* The apples were run over a standard make mechanical sizer and graded by the regular packing house crew of the Fennville Fruit Exchange. Approximately one off-

*Gaston, H. P.—Why a cull apple is a cull.—Michigan Exp. Sta. Special Bul. 160, 1927.

grade apple of every ten was examined as they were carried over the conveying belts of the machine and the one or more reasons for grading down were recorded. The percentage of B, peeler or undergrade apples which were placed in these grades for each of the listed reasons were then calculated.

Figure 14 shows the proportions of low grade apples of each treatment that were placed in the lower grades because of the listed reasons for grading down. The length of bars showing relative *yields* of apples that graded down for each reason would be very similar to those shown except that for lack of size. The latter would be materially shorter because more apples of B-grade or undergrade sizes are required to fill a bushel container than of blemished apples which are of A-grade size.

Except for lack of size, there were a few more apples graded down because of blemishes or deficiencies in the case of the pruned trees than for the unpruned ones. Pruning has therefore been of little consequence in gaining control of insects and diseases and in preventing mechanical injuries.

Results with Old Trees in Richards Orchard

Most of the 50-year-old trees in the cultivated orchard of Ed. Richards, Fennville, were pruned during the spring of 1926 by Mr. Richards and his son. They had not been pruned for several years. The pruning consisted of a moderate thinning out of the outer and upper parts of the trees, such as had been recommended by extension specialists for old trees. It was not strictly a "detail" type of pruning, although it more closely approached that type than so-called "bulk" pruning. Records for five average unpruned and three average pruned Baldwin trees are shown in Tables 15 and 16.

TABLE 15.—AVERAGE YIELDS AND GRADES OF PRUNED AND UNPRUNED BALDWIN APPLE TREES, RICHARDS ORCHARD. 1926. (BUSHELS)

Treatment	Yield per tree	A-grade	B-grade	Canner stock	Undergrade
Pruned	14.0	6.0	6.0	1.6	.4
Unpruned	19.0	4.9	9.9	1.7	2.5

Table 15 shows that the average pruned tree produced 22 per cent more A-grade apples than the average unpruned tree, but the latter produced 65 per cent more B-grade apples. The average total yield of the unpruned trees exceeded that of the pruned trees by five bushels or about 36 per cent. The trees produced about the same amounts of canner stock or blemished apples of A-grade size. The net income from the A-grade apples was $1.20 more per tree from the pruned than from the unpruned trees but the B-grade apples from the unpruned trees returned $2.73 more per tree. Even if the canner stock had been of A-grade quality and the undergrade or culls were discarded the unpruned trees would have returned $1.64 more per tree. Actually, the unpruned trees returned $1.99 more per tree to the grower than the pruned trees.

TABLE 16.—AVERAGE NET RETURNS OF PRUNED AND UNPRUNED BALDWIN APPLE TREES, RICHARDS ORCHARD. 1926.

Treatment	A-grade	B-grade	Canner stock	Undergrade	Total
Pruned	$6.54	$4.20	$0.62	$0.08	$11.44
Unpruned	5.34	6.93	.66	.50	13.43

Of particular importance for this orchard was lack of under colored apples, russeting, scab and worms on both the pruned and unpruned trees. The relative proportions of small apples for the pruned and unpruned trees were strictly similar to those of the Nichols Baldwins. The fact that there were more than four times as many apples showing stings from the unpruned trees as from the pruned ones makes it appear that spraying was not done as effectively in the unpruned trees, although an absence of scab and worms does not support the possibility of less effective spraying. Limb rub was not decreased by pruning. On the whole, it appears that the only effects of pruning have been to increase the size of the apples and decrease yields and net returns.

Ten 50-year-old Rhode Island Greening trees that were pruned in the spring of 1926 yielded 15.5 bushels per tree and ten unpruned ones gave exactly the same average per tree. Grade records for these trees are not available, but it is reasonable to assume that the pruned trees produced a greater proportion of A-grade apples and net income of approximately $1.00 (not deducting the cost of pruning) more per tree than the unpruned ones.

Results with Young Jonathan Trees

A group of 14-year-old Jonathan trees in the Trevor Nichols orchard were thinned out rather severely (although no more severely than is common commercial practice with trees of that variety and age) in the spring of 1925 and another group were moderately thinned in the spring of 1926. A third lot had not been pruned for some years previous to the 1926 harvest. This orchard adjoins the Nichols orchard of old trees containing the Baldwins, hence the character of the soil and the cultural treatments are similar to that previously described. The trees are of average size for the variety and have been making a moderate growth. The time spent in pruning in 1925 was one man-hour per tree and in 1926, 45 minutes per tree. The apples were put through the local fruit exchange and records similar to those of the Baldwin from the Nichols and Richards orchards were obtained. The records are averages for five trees pruned in 1925, 26 pruned in 1926 and six unpruned ones.

TABLE 17.—AVERAGE YIELDS AND GRADES OF PRUNED AND UNPRUNED 15-YEAR-OLD JONATHAN TREES, NICHOLS ORCHARD. 1926. (BUSHELS)

Treatment	Yield per tree	A-grade	B-grade	Canner stock	Under-grade	Number apples per crate
Pruned (1925)	4.1	3.3	.6	.2	negligible	186
Pruned (1926)	5.8	4.6	.9	.2	.1	191
Not pruned	5.5	3.2	2.1	.2	negligible	219

Figure 15.—A Jonathan tree in Nichols orchard typical of those pruned in the spring of 1926. February, 1927.

Nineteen per cent of the crop from each of the pruned lots and 42 per cent of the crop from the unpruned trees were below A-grade size requirements (Table 17). The rather heavy pruning of 1925 resulted in a decrease in total yield of 25 per cent and a slight increase in yield of A-grade apples, although the percentages of A-grade apples were 80 and 58 respectively for the heavily pruned and unpruned trees. The moderately pruned trees outyielded the unpruned ones and produced 14 per cent more bushels than the heavily pruned trees. The differences in size of tree-run apples from the two lots of pruned trees are negligible while 18 per cent more apples from unpruned trees were required to fill a crate.

The net prices to the grower for Jonathan for the five-year period ending with 1925 were: A-grade $1.22 and B- grade 85 cents per bushel, canner stock 86 cents and undergrade 34 cents per hundredweight.

TABLE 18.—AVERAGE NET RETURNS PER PRUNED AND UNPRUNED 15-YEAR-OLD JONATHAN TREE, NICHOLS ORCHARD. 1926.

Treatment	A-grade	B-grade	Canner stock	Undergrade	Total
Pruned (1925)	$4.03	$0.51	$0.08	.....	$4.62
Pruned (1926)	5.61	.76	.08	$0.02	6.47
Not pruned	3.90	1.78	.08	.....	5.76

The trees pruned moderately in 1926 gave the best net returns because of the gains of $1.58 and $1.71 in the amounts received for A-grade stock. The trees pruned rather heavily in 1925 returned only 13 cents more to the grower for the A-grade apples produced by each tree than was received from the apples of this grade produced by the average unpruned tree and the total net income was $1.14 per tree in favor of the unpruned ones.

Lack of size was not of great consequence in the crop from these young trees. (The minimum sizes of A-grade and B-grade Jonathan are two and one-fourth and two inches in Michigan). Even in the case of the unpruned trees only one apple of every six that went into the lower grades was placed there because of small size.

Limb rub, the item of greatest importance in lowering the grade of the Jonathan, was more prevalent in the unpruned trees but there were negligible differences in number of apples placed in the lower grades because of lack of control of insects and diseases by spraying.

Pruning resulted in increased size of the Jonathan apples and in less limb rub injury. Rather heavy pruning resulted in decreased yields and net incomes, while moderate pruning resulted in a slight increase in yield and net income, although the difference cannot be regarded as significant.

Additional Results with Young Jonathan Trees

So many of the Jonathan apples from the orchard of A. A. Lackey, near Galesburg, were small in 1926 that the owner decided to prune the trees rather heavily the following spring to improve the size and grade of the fruit. These 15-year-old trees were of good size for the variety. They had not been pruned for nine years and were comparatively dense. The orchard is located on rather rolling land; the soil is light and not fertile; the orchard is in sod, and the trees have had several applications of nitrogenous fertilizers, although no fertilizer was applied in 1927.

The owner was induced to leave two trees of his own selection without pruning. One of the trees was more or less typical of the largest ones in the orchard and the other typical of trees of the other extreme in size. Because of the biennial bearing habit of the Jonathan trees in this orchard it was necessary to select pruned trees for comparison which had apparently blossomed and set rather heavily as did both the unpruned trees. Four pruned trees, two large and two small, were selected as comparable in every respect to the unpruned ones.

The fruit produced in this orchard during 1927, a year very favorable for scab development, was practically free from insect and disease injury, rosy aphis excepted. Furthermore, this orchard has a reputation of

TABLE 19.—AVERAGE NUMBER OF APPLES PER TREE AND CLASSIFICATION ACCORDING TO SIZE, LACKEY ORCHARD. 1927.

Treatment	Number apples per tree	Number apples per bushel	Size grades expressed in percentage		
			2 ¼″ +	2″–2 ¼″	–2″
Pruned (1927)	1,003	190	87	10	3
Not pruned	2,552	309	31	39	30

producing apples of exceptionally high color and finish. Consequently, lack of size was the only important reason for placing fruits in the lower grades.

Data based upon such small numbers of trees can be regarded as merely indicative. The removal of more than 60 per cent of the potential apples through commercial pruning suggests the severity of the pruning treatment. The differences in the sizes of fruits from pruned and unpruned trees are greatly in favor of the pruned group.

TABLE 20.—AVERAGE YIELDS AND GRADES OF PRUNED AND UNPRUNED 15-YEAR-OLD JONATHAN TREES, LACKEY ORCHARD. 1927. (BUSHELS)

Treatment	Yield per tree	A-grade	B-grade	Undergrade
Pruned (1927)	5.6	5.2	.4	negligible
Not pruned	8.2	3.3	3.4	1.5

Nearly 93 per cent of the apples from the pruned trees were A-grade as compared to 40 per cent from the unpruned trees (Table 19). Furthermore, the pruned trees produced nearly 60 per cent more bushels of A-grade product than the unpruned ones (Table 20). Although pruning resulted in a 32 per cent decrease in yield in this orchard, it has evidently been responsible for a material improvement in grade, even more than data of the kind presented can indicate because the A-grade apples from the pruned trees were a better A-grade than those from the unpruned trees.

TABLE 21.—AVERAGE NET RETURNS PER PRUNED AND UNPRUNED 15-YEAR-OLD JONATHAN TREE, LACKEY ORCHARD. 1927.

Treatment	A-grade	B-grade	Undergrade	Total
Pruned	$6.34	$0.34	$0.01	$6.69
Not pruned	4.03	2.89	.25	7.17

In most of the other orchards considered in this publication, the difference in the cost of picking the greater number of fruits from the unpruned trees could undoubtedly be balanced against the cost of pruning but it is doubtful if the cost of pruning in this orchard will equal the added expense of picking two and one-half times as many apples. Even then, the A-grade apples from the pruned trees must command a better price than those from the unpruned trees before one would be justified in pruning the trees for profit. Had a greater number of trees been involved, the complexion of the data might have been somewhat changed in either direction.

Results with Northern Spy

During the spring of 1927 one-half of each of two 35 to 40-year-old Northern Spy trees in the College orchards were pruned. These trees are located on medium heavy loam. The orchard has been in sod for

seven years and has been used as a poultry range. The trees had not been pruned for four years and were rather dense. They had not produced a full crop since 1923.

The pruning consisted of a thinning out of branches having diameters of one-half inch to one and one-half inches and nearly all the work was done in the upper and outer parts of the trees. The trees blossomed and set heavily and since the summer rainfall was only 41 per cent of the normal the apples were very small for the variety.

TABLE 22.—AVERAGE NUMBER OF APPLES PER TREE AND CLASSIFICATION ACCORDING TO GRADE, COLLEGE ORCHARD. 1927.

Treatment	Number apples per tree	Number apples per bushel	Grades expressed in percentages		
			A-grade	B-grade	Undergrade
Pruned	2,964	212	27	44	29
Not pruned	5,560	242	12	40	48

The fruit was graded and the A-grade divided into lots with not more than one-fourth inch size variation and all the fruits for each size and grade were counted. The pruning treatment evidently removed about 47 per cent of the potential fruits from the trees but increased the size of the fruits somewhat as indicated by the number of fruits to the bushel. Forty-eight per cent of the apples from the pruned portions of the trees were smaller than two and one-half inches as compared to 68 per cent for unpruned portions. Scab, stings and limb rub accounted for the placing of 25 per cent of the apples from the pruned portions in the lower grades as compared to 20 per cent for the unpruned parts of the trees. The percentages expressed in Table 22 are based upon both size and injuries of the fruits. The data, however, show that spraying was fully as effective on the unpruned sides of the trees as on the pruned sides. Size was chiefly responsible for the differences that exist in the grade records, as indicated by the fact that 80 per cent of the apples from the pruned and 92 per cent of those from the unpruned parts of the trees were placed in the lower grades because of size deficiency. This seems unlikely for apples of this variety but may be explained in part by the moisture deficiency during the summer months.

TABLE 23.—AVERAGE YIELDS AND GRADES OF PRUNED AND UNPRUNED NORTHERN SPY TREES, COLLEGE ORCHARD. 1927.

Treatment	Yield per tree (bushels)	Grades expressed in bushels		
		A-grade	B-grade	Undergrade
Pruned	14.0	4.8	6.4	2.8
Not pruned	23.0	3.7	11.5	7.8

The yield of A-grade apples was increased 30 per cent or at the rate of 1.1 bushels per tree by pruning but the pruned trees yielded 39 per cent or nine bushels per tree less than the unpruned ones. The average

pruned tree produced 8.6 bushels of apples larger than two and one-half inches as compared to 8.5 for the unpruned. These yields represent 62 and 37 per cent respectively of the totals. Thus, the proportions of fruit of A-grade size were materially increased by pruning but the total yields of the pruned portions of the trees were reduced to such an extent that the actual yields of apples of A-grade size were essentially the same. The differences in yields of fruit larger than two and three-fourths inches was one bushel per tree in favor of the pruned trees.

TABLE 24.—AVERAGE NET RETURNS PER TREE. NORTHERN SPY. 1927.

Treatment	A-grade	B-grade	Undergrade	Total
Pruned	$5.33	$4.54	$0.56	$10.43
Not pruned	4.11	8.16	1.56	13.83

The average net returns to growers for Northern Spy for the seasons 1921 to 1925 were $1.11 per bushel for A-grade, 71 cents per bushel for B-grade and 42 cents per hundredweight for undergrade. Although the average pruned tree made a net return of $1.22 more for A-grade apples than the average unpruned one, the latter netted $3.40 more for the total crop. If a fancy grade* had been packed and the spread between the net prices for fancy and A-grade equaled that for A-grade and B-grade, the average unpruned tree would have made a net return of $3.12 greater than that for the average pruned one. Furthermore, had the fruits been free from blemishes, the average unpruned tree would have netted the grower $5.88 more than the average pruned one.

Yields, Grades, and Returns of Eighteen Old Baldwin Orchards

During the early spring of 1927, the 40 to 60-year-old Baldwin orchards of 18 growers in Allegan and Berrien Counties were visited and descriptions made of the pruning practices, soils, locations and cultural treatments which might influence the yields and grades.

Each grower's fruit was graded and packed in community packing houses and it was possible to obtain yield and grade records from the packing house books for each orchard. The number of trees involved was obtained and average yields, grades and net returns per tree calculated for each orchard. The data for the 1925 and 1926 crops are presented in Table 25 and are shown graphically in Figure 16.

It is not possible accurately to list these orchards in the order of severity of pruning treatment because the trees differ considerably in vigor and amount of new growth and because they were not all pruned the same season. A few of the growers have pruned annually and others at two, three or even four or five year intervals. An effort was made, however, to divide the 18 orchards into three classes according to length of time lapsed since last pruned, the severity of the treatment and the density of the trees as they appeared in the late winter of 1927. For convenience these classes may be designated as heavily pruned, moderately pruned and lightly pruned.

*The specifications for Michigan Fancy and Michigan A-grade are the same except that 50 per cent characteristic color is required for Fancy and 15 per cent for A-grade Northern Spy.

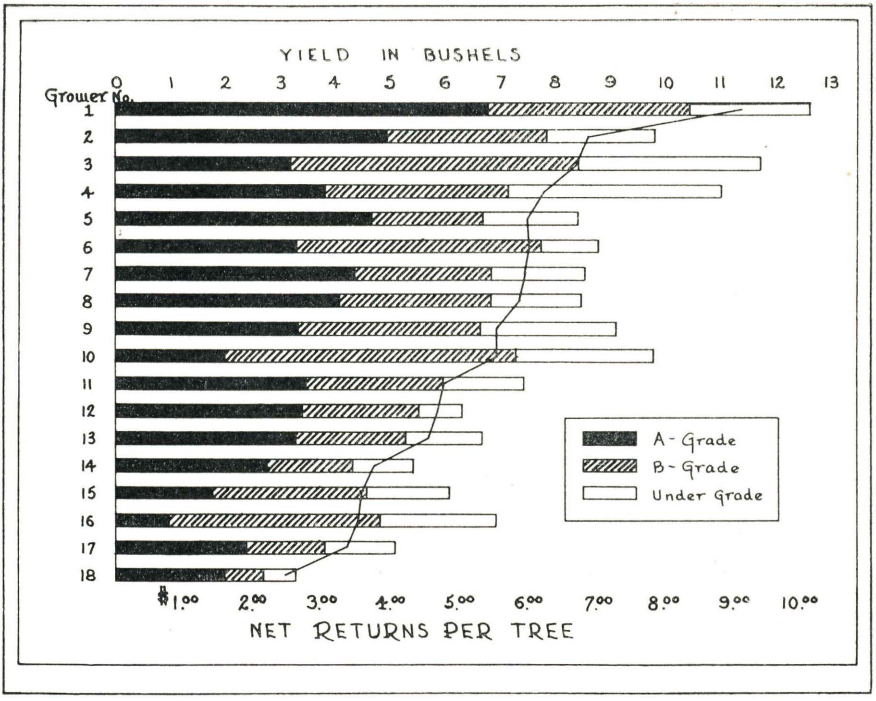

Figure 16.—Average yields, grades and net returns per tree per year for 18 old Baldwin orchards located in Allegan and Berrien Counties, seasons of 1925 and 1926. The length of the bars represents total annual yields per tree as indicated by the scale at the top of the figure. The annual net income per tree is shown at the place the diagonal line crosses each bar and the scale for returns per tree appears at the bottom of the figure. The orchards are arranged in the order of net returns per tree.

In the first class are listed those orchards that received rather severe pruning during the past two or three years and those pruned rather moderately each year. The moderately pruned orchards have had a light treatment or in some cases the pruning may have been severe but several years have elapsed since then so that the trees as a whole are moderately thick. In some cases this moderate treatment has consisted largely in the removal of dead and weak wood, crossing and closely parallel branches, perhaps a lowering of the tops of some of the higher trees and a light to moderate thinning. The third group consists of orchards which have not been pruned for five or more years or, if pruned recently, the treatment has been light in character.

Orchards 1, 7, 8, 12, 14 and 18 make up the group that has had the most severe treatment; the moderately pruned ones are 2, 3, 5, 10, 11 and 16, and those with no pruning or a very light treatment are 4, 6, 9, 13, 15 and 17. In Table 25 and in Figure 16 the orchards are arranged and numbered in the order of annual net returns per tree for the two-year period. It is evident that there is no correlation between the net returns per tree and the kind or degree of pruning which these several orchards have received. Among the nine better orchards, from the standpoint of net returns during this two-year period, are three heavily pruned, three moderately pruned and three lightly pruned ones and the same ratios exist among the nine poorer orchards. The five best orchards include

TABLE 25.—AVERAGE YIELDS, GRADES AND NET RETURNS PER TREE PER YEAR FOR 18 OLD BALDWIN ORCHARDS. 1925 AND 1926.

Orchard Number	Number trees	Yields per tree in bushels				Per cent A-grade	Net returns per tree
		A-grade	B-grade	Undergrade	Total		
1	40	6.7	3.7	2.2	12.6	54	$9.10
2	140	4.9	2.9	2.0	9.8	50	6.83
3	20	3.2	5.2	3.3	11.7	27	6.70
4	20	3.9	3.3	3.9	11.1	35	6.24
5	100	4.7	2.0	1.7	8.4	55	6.00
6	180	3.3	4.3	1.1	8.7	38	6.00
7	125	4.3	2.5	1.7	8.5	51	5.96
8	115	4.1	2.7	1.7	8.5	48	5.87
9	36	3.3	3.3	2.5	9.1	36	5.55
10	60	2.0	5.3	2.5	9.8	20	5.54
11	75	3.5	2.5	1.4	7.4	47	4.77
12	100	3.4	2.1	.8	6.3	54	4.68
13	50	3.3	2.0	1.4	6.7	49	4.57
14	135	2.8	1.5	1.1	5.4	51	3.77
15	35	1.8	2.8	1.5	6.1	29	3.60
16	29	1.0	3.8	2.1	6.9	14	3.52
17	100	2.4	1.4	1.3	5.1	48	3.36
18	150	2.0	.7	.6	3.3	61	2.45

Figure 17.—A 45-year-old Baldwin tree in orchard No. 2. These trees have received a light to moderate annual thinning out. The average annual yield for the years 1925 and 1926 was nearly ten bushels, half of which were A-grade. Fertilization, cultivation and a clay subsoil account for the good results. February, 1927.

Figure 18.—A 30-year-old Baldwin tree in orchard No. 5. These trees have been thinned lightly on alternate years. The average annual yield was 8.4 bushels, 55 per cent of which were A-grade. The soil is a deep, rich, clay loam. It is thoroughly cultivated and fertilized annually. February, 1927.

one that was heavily pruned, three that were moderately pruned and one that was lightly pruned, while the five poorest orchards include two that were heavily pruned, one pruned moderately and two pruned lightly. Certainly, it cannot be said that pruning or a lack of pruning has been responsible for the manner in which these orchards group themselves.

Orchards 1, 2, 5, 7, 12, 14 and 18 have produced crops which have graded out 50 or more per cent A-grade. Four of these orchards were heavily pruned and three were moderately pruned. Two orchards produced fruit containing less than 25 per cent A-grade apples and both were moderately pruned. One of the two orchards, however, received a spray treatment in 1926 that injured the foliage and was responsible for much fruit of small size. The data warrant the statement that the percentage of A-grade apples was somewhat increased by pruning.

Gardner* found that there was "no close relation between grade of fruit and pruning" and that "there is evident no relation between yield and kind and amount of pruning." He shows that yields are determined by location or site, the fertility, depth, drainage and water holding

*Gardner, V. R.—Varieties and locations as factors in apple production. Mich. Exp. Sta. Special Bul. 161. 1927.

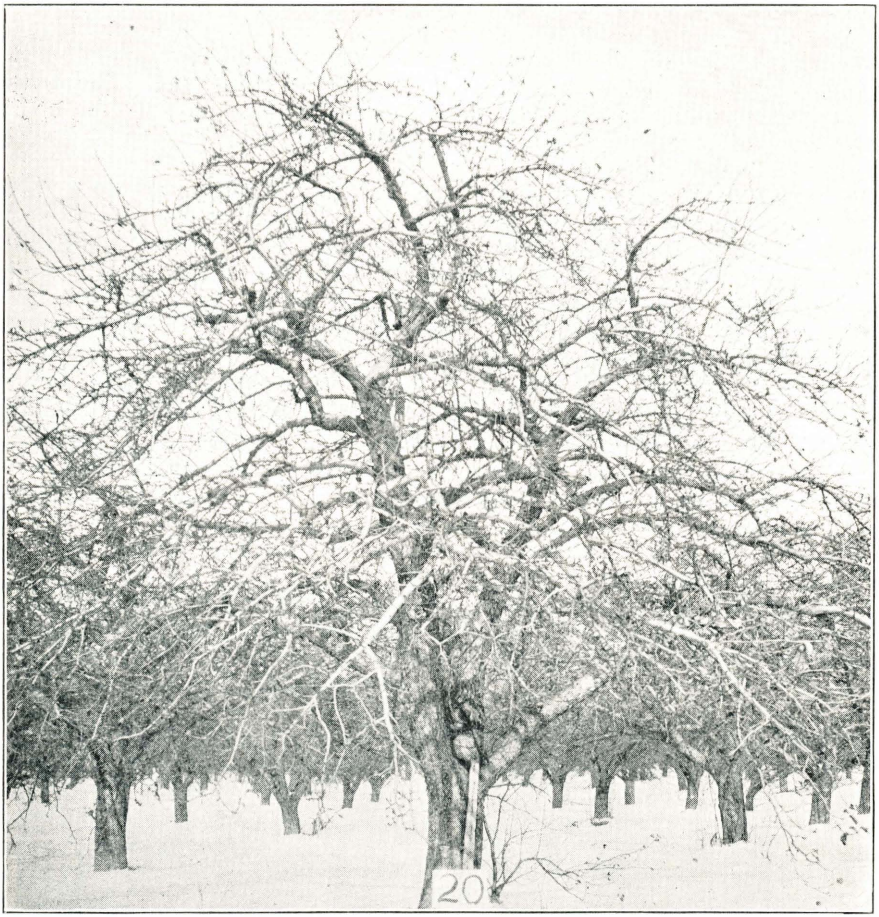

Figure 19.—Above 60 per cent of the 50 to 70-year-old Baldwin trees in orchard No. 6 have not been pruned since 1922. The ends of the branches are rather thick and there is some dead and weak wood. The clay soil has had only fair management and the trees are not vigorous. An average of two man-hours were spent pruning trees that were like this one. February, 1927.

capacity of the soil and by soil management methods. These, together with spraying, also determine grades. Brief descriptions of the five best Baldwin orchards included in this study show that factors other than pruning are responsible for the better returns per tree.

The 42-year-old trees in Orchard 1 stand 36 feet apart on a rich loamy, lowland soil. The orchard is thoroughly cultivated and each tree receives seven to eight pounds of quickly available nitrogenous fertilizer each spring. The trees receive a "detail" pruning each spring. The cuts are all small and well distributed throughout the trees. This pruning treatment was more nearly like that recommended by most experiment stations than was found in any of the other orchards.

The trees in Orchard 2 (Figure 17) are 45 years old and stand 42 feet apart on a sandy soil that is underlain by clay subsoil. It is cultivated and manured each year and the trees are vigorous. They are given a

light to moderate pruning every year. Their tops were lowered a few years ago. The ends of most of the branches are still rather thick.

Orchard 3 consists of 60-year-old trees standing 40 feet apart on a gravelly clay loam. It is manured and cultivated each year. The trees are pruned annually but no "detail" thinning is done so that the ends of the branches are rather dense. The orchard is more or less of a side line on the farm.

Orchard 4 consists of 50-year-old trees planted 40 feet apart on a clay loam. The orchard is in sod but there is evidently a good supply of moisture and the trees receive both manure and quickly available nitrogenous fertilizers. The trees have not been pruned for three or four years and even then the work was carelessly done. This orchard evidently receives rather indifferent management, yet it produces good crops because of favorable soil and location.

Orchard 5 (Figure 18) consists of Baldwins, as well as other varieties, of two ages, 30 and 60 years. The trees are 28 feet apart and badly crowding one another. The soil is a deep, rich, clay loam. It receives thorough cultivation and nitrogenous fertilizers. The trees receive a moderate thinning out every year. The work is done from the inside of the trees and the ends of most of the branches are thick.

Figure 20.—This 40-year-old Baldwin tree has just received its annual moderate to heavy pruning treatment. The average time required to prune each tree was 45 minutes. The orchard is located on a light sandy soil but cultivation is intensive and both nitrogenous fertilizers and barnyard manure are applied annually. The trees are strong and vigorous. Orchard No. 7. February, 1927.

Enough has been written to show that the orchards with the better incomes are all located on good orchard soils and receive stable manure or some nitrogenous fertilizer such as sulphate of ammonia or nitrate of soda. Orchard 1, for instance, would produce relatively high yields regardless of any pruning treatment. No two of them have received similar pruning treatments. The data do not indicate whether the yields, grades and returns would have been better or poorer with different pruning treatments, but it is evident that the effects of pruning are secondary to those of location or site, soil and soil management practices.

In Figure 10 it was shown that high yields are correlated with high net returns, and that they could not be sacrificed for sake of better grading out properties. Figure 16 substantiates these statements, that is, in general, high yields are associated with high net returns and low yields result in low net returns. Decreasing the yields in these orchards has not resulted in high percentages of A-grade apples; in fact the higher yielding half of the orchards are also the better in percentage of A-grade apples.

Discussion

The results obtained in this investigation raise a question as to whether or not much of the pruning that is commonly afforded fully mature apple trees that are in a reasonably vigorous condition is profitable. Profits resulted from pruning trees in a low state of vigor but other orchard management practices produce the same results more effectively and at a lower cost.

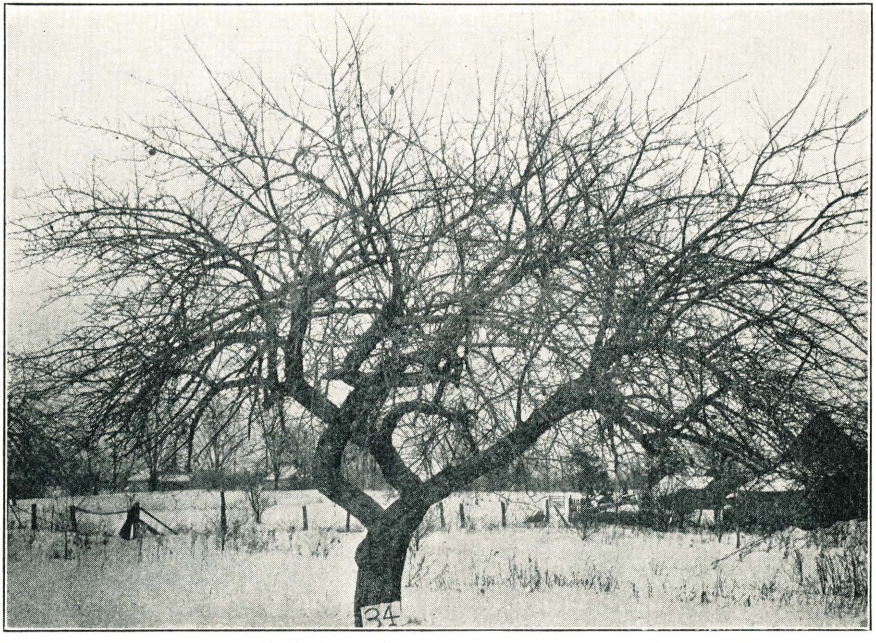

Figure 21.—These 50-year-old Baldwin trees have not been pruned for eight years; then the treatment consisted of a removal of the tree tops. The sandy soil is given clean cultivation and annual applications of nitrogen. The trees are vigorous. Orchard No. 9. February, 1927.

Calculations show that the grower received approximately $2.40 for each dollar expended in pruning Ben Davis trees of low vigor (Tables 3 and 9) and approximately $26.00 for each dollar expended in sulphate of ammonia or nitrate of soda for these same trees (page 4). For each dollar expended in pruning moderately vigorous (fertilized) trees his returns were reduced approximately $1.85 (Tables 3, 6, 9 and 12).

Pruning resulted in more or less increase in average size of fruit, a higher percentage of A-grade product and, where not too severe, it afforded an actual increase in quantity of A-grade product. On the other hand, it reduced the total number of apples produced by normal or vigorous trees, reduced the yield and reduced the net income for two or more years and these reductions more than offset the gain in size and grade under present marketing conditions. Furthermore, pruning has had no appreciable effect in bettering the control of the common diseases and insects of the average Michigan orchard which are held in check by spraying. There is some evidence that with Jonathan it resulted in a smaller percentage of limb rub.

Yield is of first importance in determining income and profits in the average Michigan orchard and grade, though important, is nevertheless of secondary importance. Both heavy yields and high grade are necessary for the largest profits, but yield cannot be sacrificed materially for

Figure 22.—The 65-year-old trees in orchard No. 14 have just been severely pruned (February, 1927). They received a similar treatment in 1925. The orchard is located on one of the best orchard sites. The soil is a clay loam and has received good cultivation and applications of barnyard manure. The annual yield was only 5.4 bushels per tree, of which 51 per cent were A-grade, while an adjoining orchard with much less severe pruning graded out 48 per cent A-grade.

sake of a little improvement in average grade. Furthermore, the quantity of A-grade apples produced per tree or per acre is of vastly more importance than the percentage.

Pruning has often been likened to thinning and recommended as a substitute for it. In reality it is followed by distinctly different results. When a tree is pruned, potentially good and poor fruits are removed; when it is thinned the poorer fruits principally are removed and the larger, more perfect specimens left for maturity. It is not possible, even in "detail" pruning, to pre-thin fruit as satisfactorily as when the half grown fruit is on the tree. Fruit thinning may result in both a higher percentage and more bushels of A-grade apples. Pruning effects its improvement in grade largely through a reduction in yield. Pruning cannot be considered a satisfactory substitute for fruit thinning.

The ideal of the average grower has been to produce crops that will grade out well. He has been encouraged in his ideal by the buyer, the packer and other agencies. The objective is worthy, provided the grower can attain it without sacrificing yield. This may be done by employing suitable methods but not by pruning.

In the orchards from which these records were taken applications of nitrate of soda or sulphate of ammonia materially increased the yields of A-grade apples as well as total yield and these results are in line with

Figure 23.—Orchard No. 18 is located on a gravelly to sandy loam soil. All but the steeper slopes are cultivated. Sulphate of ammonia and barnyard manure are applied. The trees are vigorous. Thinning out and heading back, similar to that shown in the photograph, is practiced every third year. Sixty-one per cent of the apples produced in 1925 and 1926 were A-grade, but the average annual yield was only 3.3 bushels per tree. February, 1927.

the experience of many growers. Cultural practices that will increase the moisture holding capacity of the soil will produce similar results. Fruit thinning may be expected to increase both the proportions and amounts of fruits of larger size without material reductions in total yields. Furthermore, the defective fruits may be removed at thinning time and the handling costs at harvest time correspondingly reduced. Thorough and timely spraying is of prime importance.

The results presented in the preceding pages are based upon grading specifications and prices in effect during the years 1921 to 1925, inclusive, in Michigan and as long as the present spread in prices for A-grade and B-grade apples exists, similar results may be expected. Even if prices for Delicious are substituted for those of Ben Davis, the net returns per unpruned tree would be $1.50 greater than those from pruned trees, based upon the data presented in Table 2. Wherever and whenever the spread between prices for these two grades increases, or should certain changes be made in the grading rules, the economic aspect of this work might undergo some change. However, large apples would have to command a much better price than they do today and B-grade apples would have to go to the cider press before the spread in prices would be sufficient to justify pruning as an aid in producing apples of larger size.

Recommendations

It might be inferred from the data and the discussion that have been presented that the writer recommends no pruning for fully mature apple trees. Such, however, is not the case. Pruning has its place in mature as well as young apple orchards. The data show, however, that it is relatively ineffective in accomplishing what is generally regarded as its primary object and furthermore that this object is usually attained at the expense of reduced yields and reduced profits. Little pruning from this standpoint is therefore warranted.

On the other hand, there are a number of other objectives in pruning, commonly recognized, but generally classed as of secondary importance. It facilitates such orchard management operations as spraying, thinning, harvesting and cultivation, and rids the trees of dead and weak or fruited-out growth. The tops of bearing trees may become too high to permit thorough spraying and economical thinning and harvesting. The trees may be crowding to such an extent that sprayers, trucks and tractors cannot be driven between the rows without damage to the trees and fruits and inconvenience to the operators. The lower limbs may be so close to the ground that they lie on it when loaded with mature fruits or they may not permit satisfactory cultural practices. Watersprout growth may become too dense and perhaps long and willowy in the interior of the trees. Pruning for form is usually associated with young trees, but even in bearing trees some pruning to prevent the development of weak crotches and closely parallel branches may be desirable. Dense trees may require some pruning to permit better coloring of fruits of certain varieties. It may also be advisable to prune certain varieties to reduce limb rub injury.

It is evident that pruning of the bearing apple orchard cannot be altogether ignored. There are probably very few mature orchards that should be allowed to go for more than five or six years without a light pruning. Annual, biennial or even triannual pruning, however, is un-

necessary for most bearing apple orchards and if practiced may lead to decreased returns. Any pruning of old trees must be very light and must be done with the idea of removing dead and weak wood and possibly to facilitate or cheapen some orchard management operation. In other words, the pruning should be done with some one or more of the so-called secondary objects in view. A grower should not prune just because his neighbors are pruning. In general, don't prune the old apple tree unless there is dead or weak wood to remove or it is becoming expensive and difficult to manage.

Summary

The pruning of bearing apple trees invariably resulted in fruits of larger size and consequently a higher percentage of A-grade. The increase in percentage of A-grade apples was principally due to the difference in size. The increase in size of fruits, however, was not as great as that effected by less expensive fertilizer treatments.

Pruned trees of mature age that were in a moderately vigorous to vigorous condition produced fewer apples, smaller yields and lower net returns per tree or per acre than unpruned ones, and the differences were proportional to the severity of the pruning treatment. Low vigor trees produced more apples of larger size when pruned than when not pruned.

The control of insects and diseases was not appreciably affected by pruning. There was a little more limb rub on apples from non-pruned Jonathan trees in one orchard than from pruned ones.

High net returns per tree depend primarily on high yields and, in turn, high yields depend on a relatively large number of apples per tree.

No direct profits were derived from pruning old, but fairly vigorous, apple trees. Profits did result from pruning trees in a very low state of vigor. The data for young bearing trees is not extensive enough to warrant conclusions.

Factors other than pruning have been responsible for the higher yield and grade records of the better Baldwin orchards.

Any orchard practice that materially reduces yield in order to effect an improvement in grade may be unprofitable unless there is a wide difference in the prices offered for A- and B-grades.

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