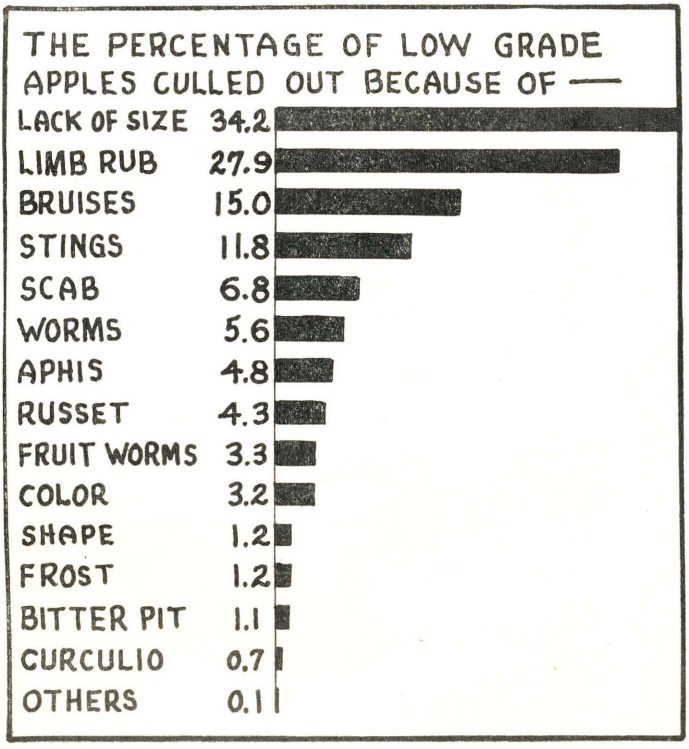
Why A Cull Apple Is A Cull
Michigan State University Agricultural Experiment Station
Special Bulletin
H.P. Gaston, Horticulture
Issued February 1927
43 pages

Special Bulletin No. 160 February, 1927

WHY A CULL APPLE IS A CULL

By H. P. GASTON



AGRICULTURAL EXPERIMENT STATION

MICHIGAN STATE COLLEGE
Of Agriculture and Applied Science

HORTICULTURAL SECTION

East Lansing, Michigan

WHY A CULL APPLE IS A CULL[1]

By H. P. GASTON

The adoption of laws for grading apples gives recognition to the market demand for graded fruit, and the difference in prices brought by the various grades emphasizes the importance to the grower of producing as large a percentage of high grade fruit as is possible. However, the seriousness of the cull problem is not generally realized or appreciated. Few producers know exactly what percentage of their crop is cull fruit and how much money, if any, they lose by its production. As a step in the solution of the low-grade or cull problem, it is necessary to determine the factors which cause culls and to allocate to each one its relative importance.

The study on which this report is based was made for the purpose of answering these questions, which may be stated more specifically as follows:

1. How does the average apple crop grade out; i. e., what percentages are placed in each of the several grades?
2. What do culls cost the grower, or more accurately, how much is he penalized because his low grade fruit is not first class?
3. What are the causes of culls?
   a. Direct causes: what diseases, insects, injuries and defects actually cause low grade apples?
   b. Indirect causes: what are the orchard conditions and practices responsible for these diseases, insects, injuries and defects?

NATURE AND SOURCE OF MATERIAL STUDIED

Data on which reasonably accurate answers to these questions can be based must be taken from a large random sample or cross section of the commercial apple industry of the State. Fortunately, such data could be obtained through the co-operation of a number of fruit selling organizations and certain of their individual members located in some of the more important apple producing sections of Michigan. These organizations handle a considerable portion of the commercial crop produced in their territory, and the product which they handle fairly represents the entire crop. All of the apples passing through any one exchange are graded according to the same standards; hence

1. Adapted from a thesis submitted to the Graduate Committee of Michigan State College in partial fulfillment of the requirements for the degree of Master of Science.

figures for different years, different growers, and different varieties are strictly comparable. Furthermore, prices and grades of former years can be obtained from the detailed records kept by the organization.

The detailed observations, upon which this paper is based, were carried on for most part at the Fennville fruit exchange, Fennville, Michigan, and in the orchards of growers belonging to that organization. In a good year, this exchange handles in the neighborhood of 100,000 bushels of apples. Since a part of this volume comes from small and often rather poorly cared-for orchards which can hardly be classed as commercial, it was thought best to eliminate all but the strictly commercial orchards for this study. It was also deemed advisable to eliminate from consideration a large number of poor or little known varieties upon which complete records could not be obtained, or, if obtained, would be of little practical value. With the help of the exchange manager, 24 representative commercial growers were selected from the 50 or more grower members. There was no attempt to choose good or poor growers, the only requisite being that they class as producers of considerable quantities of apples of standard or commonly grown varieties.

The varieties selected for the detailed study were McIntosh, Jonathan, Canada Red, Northern Spy, Rhode Island Greening, King, Baldwin, Grimes, Wagener, and Hubbardston. Incidentally, it may be stated that the fruit of these varieties constituted over one-half of the total volume handled by this shipping organization, a situation probably characteristic of other exchanges in the state.

Observations were begun in September, 1924. At that time, the harvest of fall apples in the Fennville district had commenced. After the fruit had been graded out and packed, the orchards from which it had come were visited and field records obtained. Later in the year, considerable time was spent at the office of the exchange making a statistical study of the apple crop of that and preceding years.

To supplement the work done at Fennville, eight of the other large exchanges of the state were visited and the grade and price figures of these organizations obtained and compared with corresponding figures for Fennville. Likewise, the figures on specific reasons for grades, though based on a study of the total production of the selected varieties from the 24 representative growers of the Fennville district, were supplemented with observations and notes made on the entire volume of fruit passing through the Fennville exchange and by observations in other exchanges.

The data on orchard practices, age of trees, and the condition of orchards were obtained by talking to the growers and by observing the orchards themselves. Besides the 24 orchards in which a detailed study was made, many others were visited in other parts of the state, and the writer is convinced that the growers selected for intensive study were really representative of those found in the commercial apple producing districts of the state.

METHODS

To answer the question of how the average apple crop grades out, the following information on each of ten varieties was obtained from the books of the exchange: (1) the total number of bushels handled by the organization in the years 1922, 1923, 1924, and 1925; (2) the percentages of the total volume which were A-grade, B-grade, and culls. To supplement these averages, corresponding figures for certain individual growers were recorded. The best grower of each variety and the poorest were noted in particular. These so-called best and poorest growers were selected from among the 24 whose records were averaged.

To determine how much the grower is penalized on prices which he receives for his apples because his B- and C-grade fruit is not A-grade, the writer obtained from the books of the exchange the returns per bushel to the grower from each grade of the ten varieties selected for study for the seasons of 1924 and 1925. ("Net returns", in this case, refers to the per bushel return from exchange to grower, the cost of package, selling, and overhead having first been deducted.)

During 1924 and 1925, the writer was at the exchange at the time that the sales were made, and he was familiar with the methods of marketing and computing returns. It was decided not to take into account the prices obtained in former years, as differences in policy and sales methods, not at once apparent, might have influenced computations. For example, though the crop is generally sold almost as rapidly as it is packed, a portion is occasionally held until late in the season and then sold either at a loss or at a profit greater or less than would have been realized had it been handled in the usual manner. The price figures of these two years were studied from different angles and, as previously mentioned, were also compared with prices received by growers in other parts of the state. In every case they were found to be representative.

A determination of the direct causes of culls was made by carefully inspecting each apple in a large random sample of B-grade and cull apples and by recording the nature of its blemishes or deficiencies as classed by the grading specifications. This study was carried on in the exchange packing house at the time the apples were graded. Only the fruit of the 10 selected varieties produced by the 24 selected growers was thus studied in detail. The grader was so constructed that the fruits of each grade were carried along on separate conveyors to the end of the machine where they were allowed to roll directly into either bushel baskets or barrels, as the case might be. When the apples of one of the 24 selected growers were being graded, the writer took a position where he could easily see and reach the apples of the B- and cull grades. The apples in the A-grade, being practically without injuries or deficiencies, were not examined.

As the fruit passed over the grader, the observer picked up, examined, and made a note (on specially prepared forms) of the reason or reasons for which it had been put into that particular grade. The

observer stood at the grader throughout the entire "run" and examined as many apples as possible. As there were generally from three to four times as many B-grade apples as culls, about every fourth or fifth apple was taken from the conveyor carrying the cull fruit. From five to 15 per cent of the B-grade and cull fruit could be examined in detail, depending upon how the load graded out.

If there were only ten bushels of B-grade and five of culls in a load of 100 bushels, a large percentage of these grades could be observed. If there were 30 bushels of B-grade and 20 of culls in another 100 bushels, a smaller proportion could be observed because both loads ran over the grader in approximately the same length of time. However, even with a load having a high percentage of inferior fruit it was generally possible to examine at least five per cent, and, as the sample was selected at random, it is believed that the data are representative.

Determination of the orchard practices more or less directly responsible for the specific injuries or deficiences which cause the fruit to grade down presented a problem that defied the statistical methods that were applicable in the other studies. There were differences in the age of trees, character of the soil, planting distances, and orchard sites, as well as in cultural and other practices. These variations made it necessary to place considerable reliance on general observations and impressions that did not find expression in terms or figures appearing on the record sheets prepared for this part of the investigation.

HOW THE APPLE CROP GRADES OUT

Table 1 is based on figures obtained from the books of the Fennville Exchange and shows how the apples of the ten varieties selected for study graded out in each of the years 1922, 1923, 1924, and 1925. Figure 1 shows graphically the averages obtained for each variety for

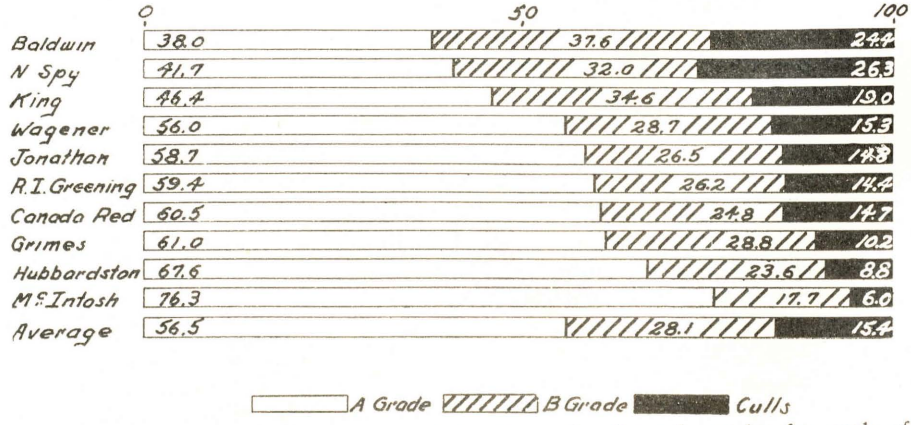


Figure 1.—The average percentages of A-, B-, and cull grade apples for each of the ten varieties for the four-year period, 1922 to 1925.

this period. On the average, only 56.5 per cent of the commercial apple crop has met the requirements of the A-grade. The remaining 43.5 per cent was inferior fruit that must be branded as such and placed on the market at a lower price than that obtained for an A-grade product, resulting in greatly diminished total returns to growers. The records also show that 28.1 per cent of the average crop is placed in the B-grade and 15.4 per cent is of such nature that it must go into the cider barrel.

In the average year, the percentage of the low grade Baldwins is greater than that of any other important variety. The production of Baldwins in Michigan probably exceeds that of any other variety, and it is very unfortunate that this apple should grade out so unsatisfactorily. From the standpoint of poor grading qualities Baldwin is followed by Northern Spy, another of Michigan's leading varieties. This is a thin skinned apple which, to be grown successfully, must have

Table 1.—Grade records of the varieties of apples for the years 1922, 1923, 1924 and 1925. (Percentages)

Variety	Grade	1922	1923	1924	1925	Average[1] '22-'25
Baldwin	A	48.3	34.5	26.0	55.4	38.0
	B	31.8	42.4	42.0	25.0	37.6
	C	19.9	23.1	32.0	19.6	24.4
Canada Red	A	47.5	62.6	35.1	62.3	60.5
	B	25.6	26.7	32.3	27.2	24.8
	C	26.9	10.7	32.6	10.5	14.7
R. I. Greening	A	60.4	48.1	39.2	60.0	59.4
	B	22.2	35.4	39.2	29.0	26.2
	C	17.4	16.5	21.6	11.0	14.4
Grimes	A	69.3	59.4	44.3	57.2	61.0
	B	19.8	31.7	40.0	30.9	28.8
	C	10.9	8.9	15.7	11.9	10.2
Hubbardston	A	70.6	65.7	54.1	70.9	67.6
	B	19.1	25.3	31.4	22.3	23.6
	C	10.3	9.0	14.5	6.8	8.8
Jonathan	A	64.4	54.2	39.6	78.2	58.7
	B	21.1	33.2	31.5	14.8	26.5
	C	14.5	12.6	28.9	7.0	14.8
King	A	27.9	51.3	39.5	65.0	46.4
	B	45.1	34.5	37.6	19.0	34.6
	C	27.0	14.2	22.9	16.0	19.0
McIntosh	A	67.5	64.5	66.2	84.5	76.3
	B	10.7	26.7	20.4	12.1	17.7
	C	21.8	8.8	13.4	3.4	6.0
Northern Spy	A	27.9	39.1	27.4	53.4	41.7
	B	32.3	37.2	36.3	27.0	32.0
	C	39.8	23.7	36.3	19.6	26.3
Wagener	A	48.9	54.7	41.2	63.4	56.0
	B	32.3	34.6	32.5	24.8	28.7
	C	18.8	10.7	26.3	11.8	15.3
Averages[2]	A	51.2	51.6	35.3	62.0	56.5
	B	28.9	33.5	37.9	24.2	28.1
	C	19.9	14.9	26.8	13.8	15.4

1. In obtaining these averages, the figures for different years were "weighted" in proportion to the volume of the crops in the different years.

2. In obtaining these averages, each variety was "weighted" in proportion to the amount of fruit of that variety handled by the exchange.

not only good culture but also careful handling. It is not produced in many apple sections and, when well grown and carefully packed, commands a good price. Here, again, it is unfortunate that the percentage of sound fruit is so small.

The two varieties that grade out best are McIntosh and Hubbardston. Hubbardston is a tough-skinned apple which will stand considerable rough handling; it is comparatively easy to grow, and its high rank is no cause for surprise. McIntosh, however, does not have these characteristics and its being at the top of the list, perhaps can be explained by the fact that in this section it has been planted on a commercial scale only in comparatively recent years. None of the commercial plantings in this district were more than 20 years old.

At least a part of the crop of the other nine varieties came from trees that were from 40 to 50 years of age. It is easier to grow A-grade apples on young than on old trees and hence this variety has had an advantage over the others. As the trees increase in age, it is probable that the apples coming from them will not grade out as well.

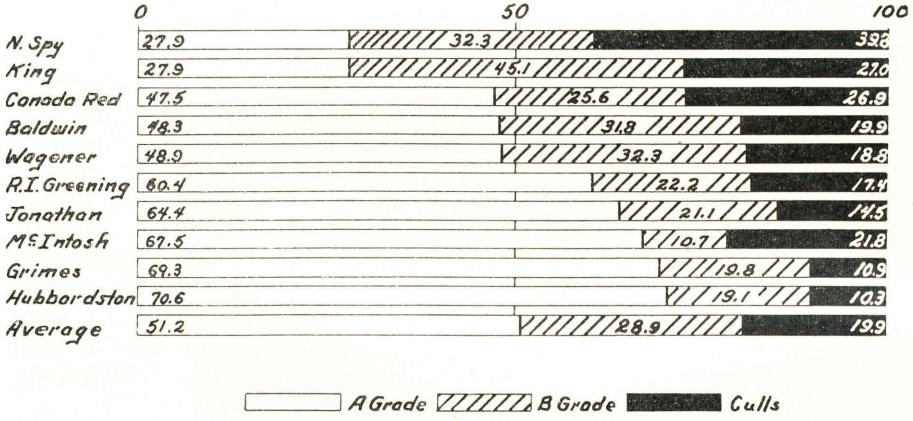


Figure 2.—How ten varieties graded out in 1922. Figures are percentages.

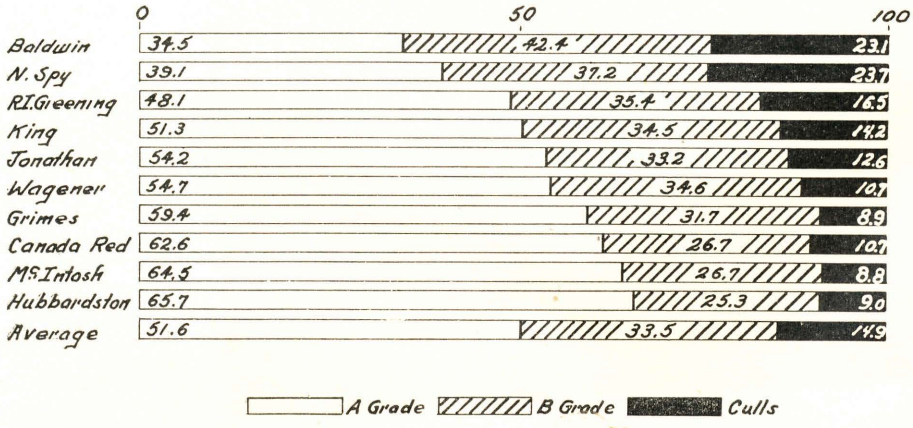


Figure 3.—How ten varieties graded out in 1923. Figures are percentages.

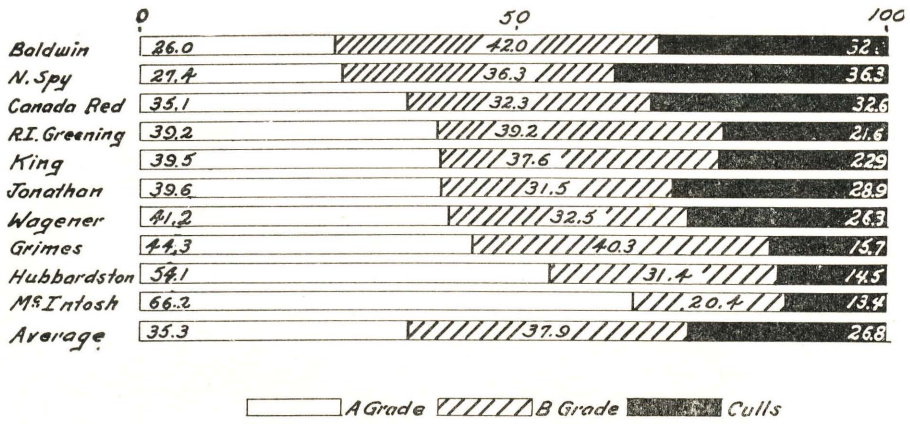


Figure 4.—How ten varieties graded out in 1924, a year when an unusually large proportion of the crop graded out poorly. Figures are percentages.

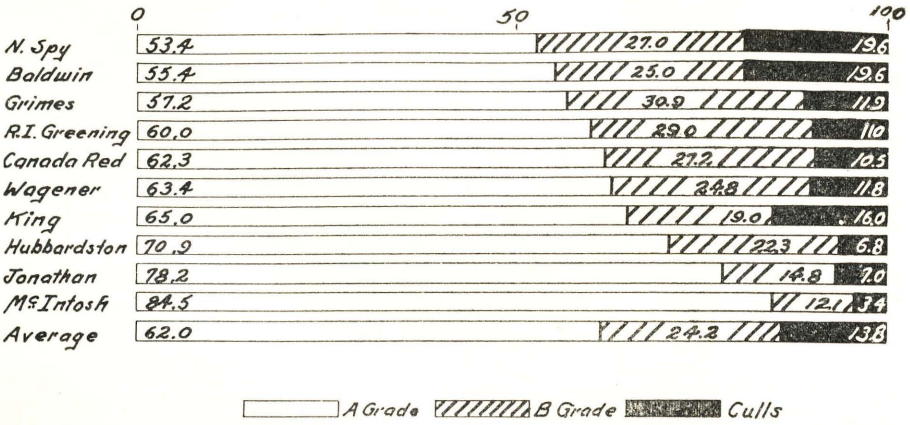


Figure 5.—How ten varieties graded out in 1925, a year with a comparatively high percentage of good quality apples. Figures are percentages.

Figures 2, 3, 4 and 5 show how the apples graded out in 1922, 1923, 1924, and 1925 respectively. On the whole, 1922 and 1923 were years in which the fruit was of about average grade. On the other hand, 1924 was a season in which apples graded out very poorly, and in 1925 the percentages of high grade fruit were much greater than usual.

Attention is directed to the fact that McIntosh and Hubbardston were among the three varieties producing the highest percentage of A-grade apples in each of the four years. In other words, they graded out better than the other varieties under consideration in a good year, an average year, or in a poor one. On the other hand, Northern Spy and Baldwin graded out the poorest of the ten varieties in every year, except in 1922 when Baldwin was in seventh place.

Of the other six varieties, Grimes graded out the best even though it made a showing only a little better than Northern Spy and Bald-

win in 1925 which was the good year from the standpoint of grade. It is interesting to note that Jonathan made only a medium showing during the average and poor years but ranked second only to McIntosh in 1925, the year of high grades, with 78.2 per cent of A-grade apples. Less than 28 per cent of the King crop was A-grade in 1922, but in 1925 it packed out 65 per cent A-grade.

Table 2 includes figures for the best, average, and the poorest grading records of each variety for each of the four years, 1922 to 1925 inclusive. These so-called best and poorest grading records of each variety were those of individuals among the 24 commercial producers previously mentioned. Averages for the four years for each variety have been included. The several varieties graded out differently in different years and figures for individual varieties in particular years are of little value in giving a general idea of the situation.

The real question is how, on the average, do the best and poorest grading records compare with the average and with each other in any

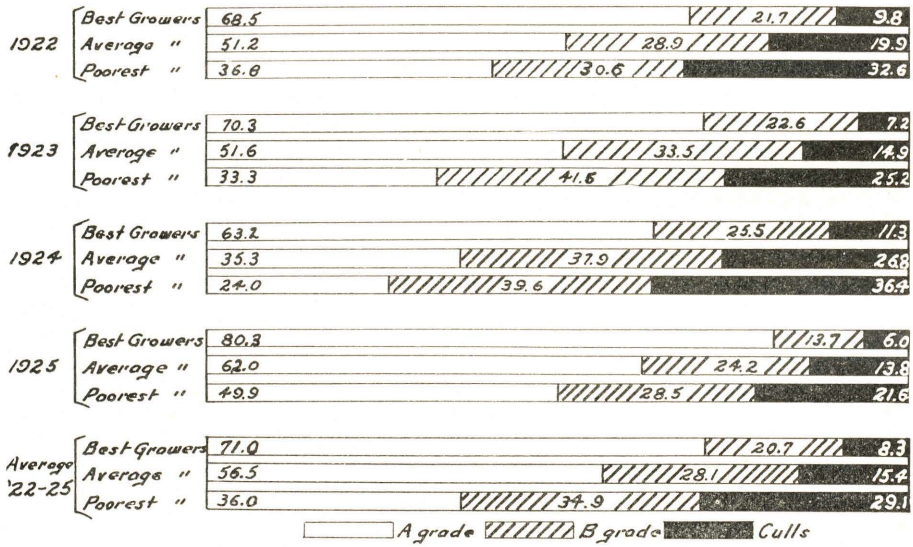


Figure 6.—How different growers vary in the percentage of A-grade, B-grade, and culls produced in different years. The figures represent an average of the ten varieties included in the investigation.

given year or as a rule? Figure 6 throws considerable light on this question. It shows that, on the average, the best grower will produce a crop of apples which will have 35 per cent more A-grade fruit than the crop produced by the poorest grower will have. In other words, every time one bushel of the poorer grower's crop goes into the A-grade nearly two bushels of the better grower's crop goes into that grade.

There are marked differences between orchards in the character and fertility of their soil, the age of their trees, elevation, and exposure which, in a measure, accounts for the differences in percentages of A's that are produced. However, it is believed that this difference in

Table 2.—Variation in percentages of A-grade, B-grade, and culls produced by different growers.

Variety	Grade	1922			1923			1924			1925			Average, 4 years		
		Best grower	Average grower	Poorest grower	Best grower	Average grower	Poorest grower	Best grower	Average grower	Poorest grower	Best grower	Average grower	Poorest grower	Best growers	Average growers	Poorest growers
Baldwin	A	72.3	48.3	31.0	64.3	34.5	10.6	41.7	26.0	11.1	71.6	55.4	36.1	62.4	38.0	22.0
	B	20.3	31.8	39.4	27.9	42.4	48.1	35.8	42.0	45.5	19.1	25.0	28.4	25.2	37.6	40.4
	C	7.4	19.9	29.6	7.8	23.1	41.3	22.5	32.0	43.4	9.3	19.6	35.5	12.4	24.4	37.6
Canada Red	A	67.7	47.5	24.9	76.4	62.6	44.2	62.0	35.1	24.6	81.2	62.3	49.1	73.0	60.5	35.8
	B	18.1	25.6	36.7	18.7	26.7	25.9	28.7	32.3	31.9	15.4	27.2	33.9	20.0	24.8	32.1
	C	14.2	26.9	38.4	4.9	10.7	29.9	9.3	32.6	43.5	3.4	10.5	17.0	7.0	14.7	32.1
R. I. Greening	A	69.0	60.4	52.2	65.0	48.1	39.4	62.9	39.2	30.3	78.8	60.0	50.8	68.6	59.4	43.0
	B	20.9	22.2	23.4	25.9	35.4	35.9	26.5	39.2	43.0	14.7	29.0	33.3	24.2	26.2	33.4
	C	10.1	17.4	24.4	9.1	16.5	24.7	10.6	21.6	27.7	6.5	11.0	15.9	7.2	14.4	23.6
Grimes	A	77.6	69.3	56.3	72.1	59.4	48.1	64.3	44.3	34.2	81.4	57.2	43.2	74.5	61.0	45.2
	B	14.9	19.8	27.3	21.2	31.7	38.1	26.9	40.3	43.0	15.1	30.9	38.2	19.0	28.8	36.9
	C	7.5	10.9	16.4	6.7	8.9	13.8	8.8	15.7	22.8	3.5	11.9	18.6	6.5	10.2	17.9
Hubbardston	A	84.4	70.6	49.9	78.7	65.7	34.7	74.5	54.1	39.9	84.3	70.9	64.5	81.3	67.6	47.6
	B	10.9	19.1	26.3	18.7	25.3	44.7	19.6	31.4	38.8	12.8	22.3	20.6	13.9	23.6	31.7
	C	4.7	10.3	23.8	2.6	9.0	20.6	5.9	14.5	21.3	2.9	6.8	14.9	4.8	8.8	20.7
Jonathan	A	72.9	64.4	54.7	65.1	54.2	37.2	58.4	39.6	19.0	82.7	78.2	65.5	70.0	58.7	44.3
	B	17.5	21.1	22.5	27.6	33.2	40.6	26.2	31.5	27.9	13.7	14.8	23.1	21.1	26.5	28.6
	C	9.6	14.5	22.8	7.3	12.6	22.2	15.4	28.9	53.1	3.6	7.0	11.4	8.9	14.8	27.1
King	A	54.3	27.9	21.6	64.2	51.3	31.9	59.6	39.5	19.7	78.6	65.0	38.2	64.0	46.4	27.8
	B	31.8	45.1	43.3	26.8	34.5	47.0	26.5	37.6	47.7	12.4	19.0	27.5	24.6	34.6	41.4
	C	13.9	27.0	35.1	9.0	14.2	21.1	13.9	22.9	32.6	9.0	16.0	34.3	11.4	19.0	30.8
McIntosh	A	72.0	67.5	49.0	79.4	64.5	45.7	81.5	66.2	24.4	88.1	84.5	74.7	80.8	76.3	48.4
	B	20.3	10.7	18.1	16.2	26.7	40.0	12.7	20.4	42.4	8.0	12.1	16.4	13.4	17.7	29.1
	C	7.7	21.8	32.9	4.4	8.8	14.3	5.8	13.4	33.2	3.9	3.4	8.9	5.8	6.0	22.5
Northern Spy	A	49.1	27.9	10.1	67.9	39.1	18.8	59.4	27.4	11.7	70.3	53.4	33.0	62.0	41.7	18.8
	B	36.8	32.3	25.7	16.7	37.2	47.8	29.9	36.3	45.0	15.2	27.0	27.2	24.8	32.0	36.0
	C	14.1	39.8	64.2	15.4	23.7	33.4	10.7	36.3	43.3	14.5	19.6	39.8	13.2	26.3	45.2
Wagener	A	65.7	48.9	18.7	69.6	54.7	22.2	67.9	41.2	24.9	86.2	63.4	43.7	73.0	56.0	27.3
	B	25.5	32.3	43.0	25.1	34.6	46.6	22.5	32.5	31.0	10.7	24.8	36.5	21.0	28.7	39.7
	C	8.8	18.8	38.3	5.3	10.7	31.2	9.6	26.3	44.1	3.1	11.8	19.8	6.0	15.3	33.0
*Averages	A	68.5	51.2	36.8	70.3	51.6	33.3	63.2	35.3	24.0	80.3	62.0	49.9	71.0	56.5	36.0
	B	21.7	28.9	30.6	22.5	33.5	41.5	25.5	37.9	39.6	13.7	24.2	28.5	20.7	28.1	34.9
	C	9.8	19.9	32.6	7.2	14.9	25.2	11.3	26.8	36.4	6.0	13.8	21.6	8.3	15.4	29.1

*In obtaining averages for "Average Growers" the figures were weighted as explained in Table 1 (see page 7).

orchards is often greatly overestimated. It was found, for example, that one so-called good grower produced apples which graded out well on both young and old trees, while another so-called poor grower was unable to produce a crop which graded out well even under the most favorable conditions of age and environment. Several instances were found where a change in the management of an orchard resulted in a noticeable difference in grading records.

WHAT CULLS COST THE GROWER

Table 3 gives the return per bushel to the grower from each of the three grades of apples for 1924 and 1925. The average prices for the two years have been included and also the averages of each grade for

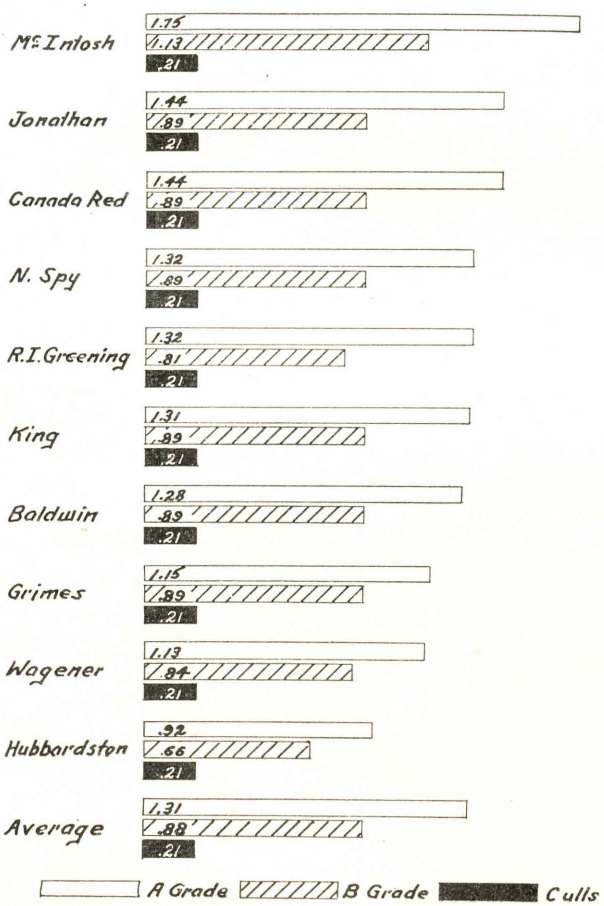


Figure 7.—This graph shows the return per bushel to the grower for each grade of the varieties in 1924.

each variety for the two years. Figure 7 shows graphically the returns per bushel to the grower for each grade of each of the varieties for 1924 and figure 8 gives similar data for 1925. In these graphs, the

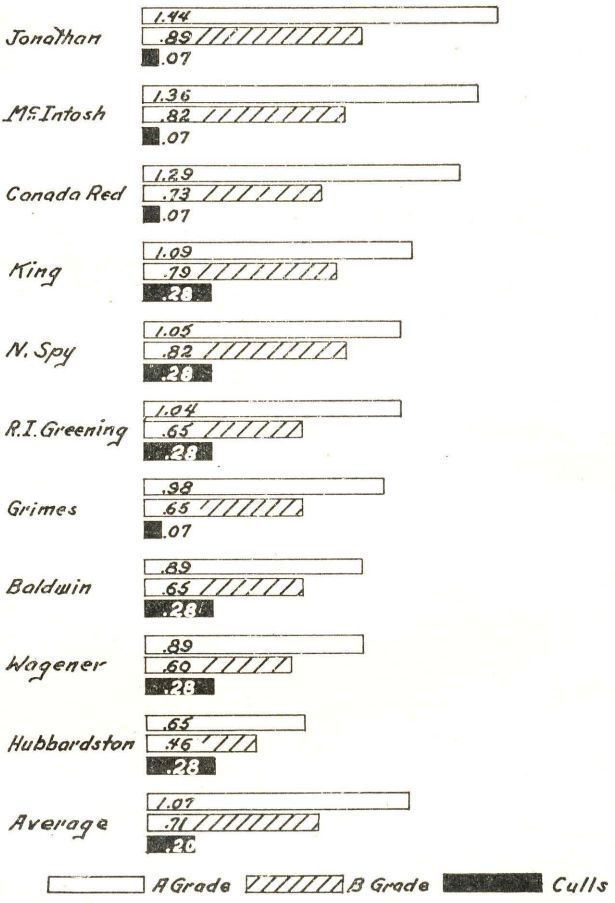


Figure 8.—A graphical representation of the return per bushel to the grower for each of the ten varieties in 1925.

ten varieties have been arranged in order, starting with the variety the A-grade of which brought the greatest return, and proceeding in order to the one whose A-grade brought the smallest return. Though prices were a little higher in 1924 than in 1925, the varieties which sold well in 1924 again brought high prices in 1925. Similarly, the varieties which brought low prices in 1924 were near the bottom of the list in 1925. With the returns of only two years as evidence, the positive statement that this relationship of price will continue can not be made. However, it is evident that this factor should be taken into account when orchards are set.

Though there is considerable variation in the returns from the A-grades of the different varieties, there is very little variation in

what is received for their B-grades. In 1924, (see figure 7) the B-grade of six different varieties, Jonathan, Canada Red, Northern Spy, King, Baldwin, and Grimes, brought exactly the same price, though there was a spread of 29 cents per bushel in the returns for their A-grades. The same tendency is noticed in 1925 (Figure 8).

In general, it is desirable to so grow apples that as many of them as possible will go into the A-grade. It is a nice question in orchard management to decide in cases of labor or other shortage whether or not it would be well to concentrate efforts upon those varieties whose A-grade commands high prices. For example: in 1924 A-grade McIntosh brought 62 cents per bushel more than B-grade, while A-grade Hubbardston brought only 26 cents more than a bushel of B-grade fruit of the same variety. In this particular case, extra care of the McIntosh would have yielded twice the gross returns and perhaps quadruple the net profits that would be derived from the same extra care of the Hubbardston.

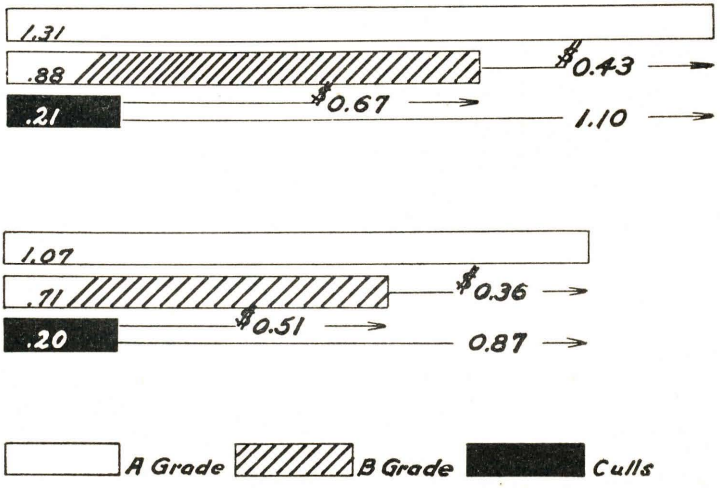


Figure 9.—The differences in returns from different grades of fruit are shown for 1924 (above) and 1925 (below). The returns for the ten varieties are averaged.

Figure 9 shows the average return per bushel to the grower in 1924 and 1925 for the ten varieties studied. The differences in returns for the different grades are also shown. One of the most striking things about these figures is the great differences in returns for the different grades. In 1924, the average bushel of B-grade fruit brought 67 cents more than the average bushel of culls, and the average bushel of A-grade brought $1.10 more than the average bushel of culls. These differences help to emphasize the importance of reducing the percentage of culls to the minimum.

Figure 6 shows that the better grower produced only about one-half the percentage of culls that the average grower did and less than one-third the percentage of the poor grower. Some additional labor and capital might be required for the poor grower materially to improve his grade, but the fact that the more prosperous growers are in

Table 3.—The per bushel net return to the grower.

Variety	1924			1925			Average 1924–1925		
	A	B	C	A	B	C	A	B	C
McIntosh	$1 75	$1 13	$0 21	$1 36	$0 82	$0 07	$1 56	$0 98	$0 14
Jonathan	1 44	89	21	1 44	89	07	1 44	89	14
Canada Red	1 44	89	21	1 29	73	07	1 36	81	14
King	1 31	89	21	1 09	79	28	1 20	84	24
Northern Spy	1 32	89	21	1.05	82	28	1 18	86	24
R. I. Greening	1 32	81	21	1 04	65	28	1 18	73	24
Baldwin	1 28	89	21	89	65	28	1 08	77	24
Grimes	1 15	89	21	98	65	07	1 07	77	14
Wagener	1 13	84	21	89	60	28	1 01	72	24
Hubbardston	92	66	21	65	46	28	79	56	24
Average	$1 31	$0 88	$0 21	$1 07	$0 71	$0 20	$1 19	$0 79	$0 20

nearly every case using the necessary labor and capital indicates that it pays. Not only would additional labor and capital pay, but there is considerable evidence that in many cases the grade could be materially improved without additional cost, by simply shifting the growers' efforts from certain comparatively unimportant problems to those of greater moment.

DIRECT CAUSES OF CULLS

Of the many factors responsible for placing apples in the low grades, there are at least a dozen of importance. These factors affect different varieties somewhat differently; they are not of the same relative importance, even with different grades of the same variety. Their evaluation is made still more complicated by the fact that they influence the same variety somewhat differently from year to year and in the same year they may operate differently in the orchards of different growers.

Study of the blemishes or deficiencies directly responsible for culls was confined to the seasons of 1924 and 1925. Two better years could hardly have been selected. In 1924, the fruit was of very poor quality, only 35.5 per cent of the crop being classified as A-grade. The remaining 64.5 per cent afforded an unusual opportunity for a study of the factors responsible for culling. In 1925, conditions were entirely different; the apple crop graded out better than it had for a number of years. Though these two years were more or less extreme, probably the figures obtained afford a fairly good indication of what can be expected.

The data on the reasons for low grading are assembled and considered from three different angles: (1) A study of the causal factors and the effect which they have on the entire crop of the ten important varieties; this study gives a general view of the subject and an idea of their relative importance; (2) A study of the effect of each in-

sect, injury, defect, or disease upon each variety shown; (3) A comparison of the way different varieties are affected by these different factors.

THE REASONS FOR B-GRADE AND CULLS, AND THE EFFECT WHICH EACH HAS UPON THE APPLE CROP

Table 4 lists in the order of their importance 14 major causes of low grade apples, as found at Fennville. Graphic representations of these same data are presented in Figures 10 and 11. Figure 10 shows the different injuries and the effect which each had on the crop in 1924. Lack of size, limb rub, handling bruises, scab and "stings" were, in this year, the factors of greatest importance. Figure 11 illustrates the situation in 1925, a favorable growing season. Lack of size, limb rub, handling bruises and "stings" were again the important factors in determining grade.

Attention is directed to the fact that in 1924 (Figure 10) more than one-half, and in 1925 (Figure 11) nearly one-third of the B-grade apples were placed in that grade because of lack of size. Limb rub, a factor regarded rather lightly by most growers, accounted for 20 per cent of the B-grade apples in 1924 and 27 per cent in 1925. These two factors explain why in an average season more than 60 per cent of the B-grade apples are in that grade. Furthermore, they account for the presence of more than half of the apples that must be culled out to find a place in the cider barrel.

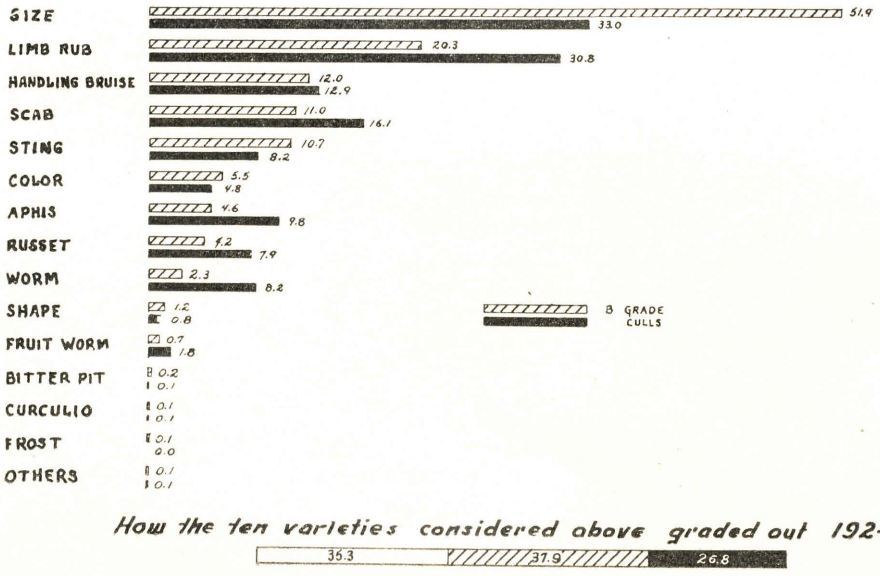


Figure 10.—The reasons for the B-grade and culls of the ten varieties for 1924 are shown in this graph. The figures represent the percentages of B-grade or cull apples placed in those grades because of a specific injury.

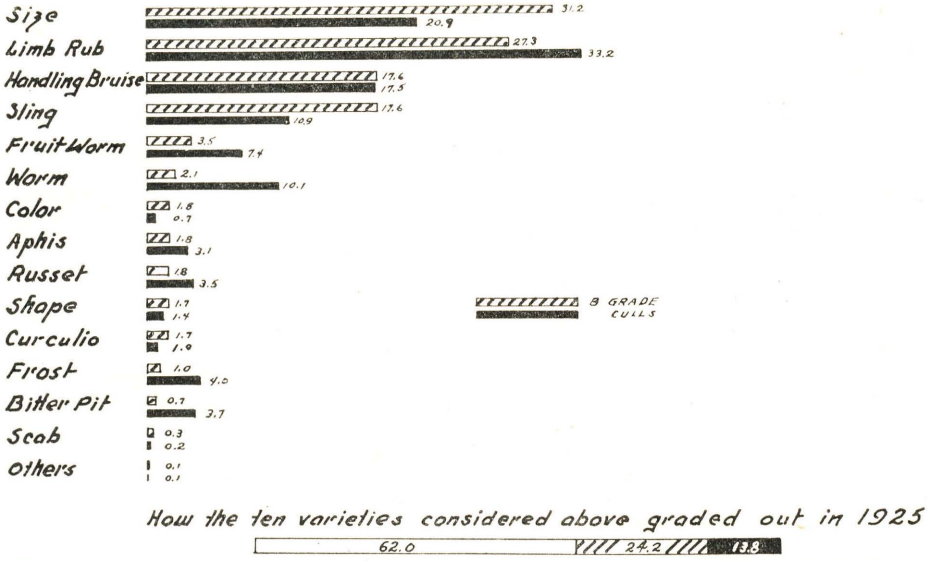


Figure 11.—The reasons for the B-grade and culls of the ten varieties in 1925 are shown in this graph. The figures represent the percentages of B-grade or cull apples placed in those grades because of a specific injury.

Table 4.—Reasons for B-grade and cull apples arranged in the order of their importance. (Ten varieties have been taken into account.)

Percent of B-grade			Reasons for placing in low grade	Percent of culls		
1924	1925	Average 1924-1925		1924	1925	Average 1924-1925
51.9	31.2	41.6	Under size	33.0	20.9	26.9
20.3	27.3	23.8	Limb rub	30.8	33.2	32.0
12.0	17.6	14.8	Handling bruises	12.9	17.5	15.2
10.7	17.6	14.2	Sting	8.2	10.9	9.5
11.0	0.3	5.6	Scab	16.1	0.2	8.1
5.5	1.8	3.6	Under color	4.8	0.7	2.7
4.6	1.8	3.2	Aphis	9.8	3.1	6.4
4.2	1.8	3.0	Russett	7.9	3.5	5.7
2.3	2.1	2.2	Worm	8.2	10.1	9.1
0.7	3.5	2.1	Fruit worm	1.8	7.4	4.6
1.2	1.7	1.4	Poor shape	0.8	1.4	1.1
0.1	1.7	0.9	Curculio	0.1	1.0	0.5
0.1	1.0	0.5	Frost	0.0	4.0	2.0
0.2	0.7	0.4	Bitter pit	0.1	3.7	1.9
0.1	0.1	0.1	Others	0.1	0.1	0.1

NOTE: If the percentages of a particular grade which has been graded down for stated reasons are added, the total will be greater than 100. This does not mean that the figures are in error, but that some of the apples examined had two or more injuries, any one of which would have been sufficient to place that particular fruit in the low grade.

In Table 4 and Figure 10 the term "size" refers to lack of size; "sting" refers to the injury which results when the skin of the apple is punctured by a codling moth larva which dies either before gaining entrance to the apple or soon afterwards; "color" refers to lack of color; "worm" refers to that injury caused by codling moth larvae which live and "work" in an apple; "fruit worm" refers to the injury caused by the common species of caterpillars that hatch in the spring and feed on the leaves and young fruit; "curculio" refers to the work of the plum curculio; "bitter pit" refers to those fruit spots sometimes called Baldwin spot, brown spot, fruit pit, or stippen; "handling bruises" includes skin cuts and breaks as well as all bruises occuring during the harvesting and highway transportation operations. The other terms used are self-explanatory.

sect, injury, defect, or disease upon each variety shown; (3) A comparison of the way different varieties are affected by these different factors.

THE REASONS FOR B-GRADE AND CULLS, AND THE EFFECT WHICH EACH HAS UPON THE APPLE CROP

Table 4 lists in the order of their importance 14 major causes of low grade apples, as found at Fennville. Graphic representations of these same data are presented in Figures 10 and 11. Figure 10 shows the different injuries and the effect which each had on the crop in 1924. Lack of size, limb rub, handling bruises, scab and "stings" were, in this year, the factors of greatest importance. Figure 11 illustrates the situation in 1925, a favorable growing season. Lack of size, limb rub, handling bruises and "stings" were again the important factors in determining grade.

Attention is directed to the fact that in 1924 (Figure 10) more than one-half, and in 1925 (Figure 11) nearly one-third of the B-grade apples were placed in that grade because of lack of size. Limb rub, a factor regarded rather lightly by most growers, accounted for 20 per cent of the B-grade apples in 1924 and 27 per cent in 1925. These two factors explain why in an average season more than 60 per cent of the B-grade apples are in that grade. Furthermore, they account for the presence of more than half of the apples that must be culled out to find a place in the cider barrel.

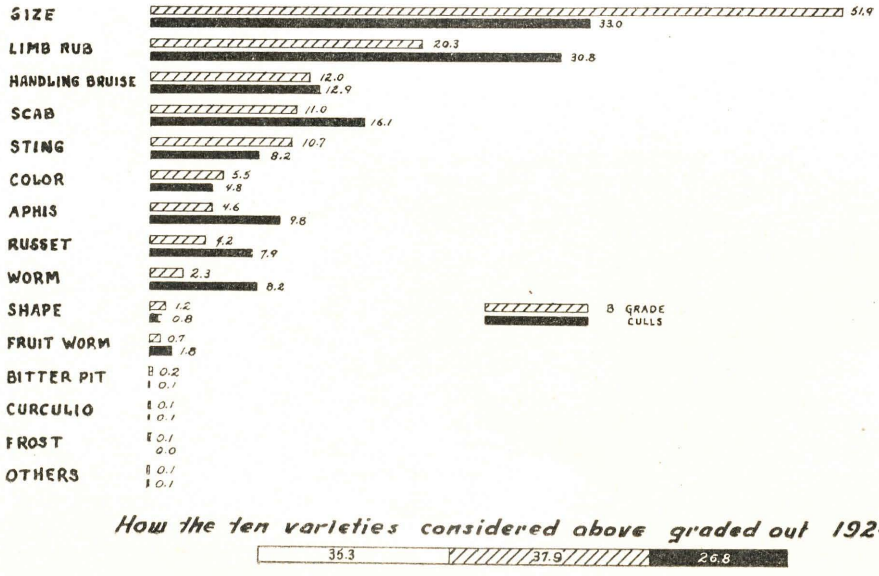


Figure 10.—The reasons for the B-grade and culls of the ten varieties for 1924 are shown in this graph. The figures represent the percentages of B-grade or cull apples placed in those grades because of a specific injury.

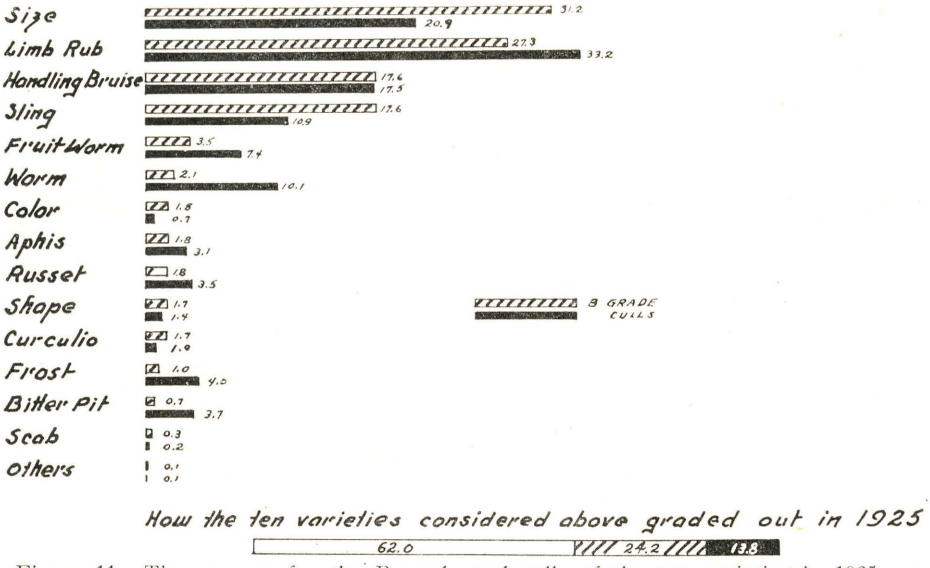


Figure 11.—The reasons for the B-grade and culls of the ten varieties in 1925 are shown in this graph. The figures represent the percentages of B-grade or cull apples placed in those grades because of a specific injury.

Table 4.—Reasons for B-grade and cull apples arranged in the order of their importance. (Ten varieties have been taken into account.)

Percent of B-grade			Reasons for placing in low grade	Percent of culls		
1924	1925	Average 1924-1925		1924	1925	Average 1924-1925
51.9	31.2	41.6	Under size	33.0	20.9	26.9
20.3	27.3	23.8	Limb rub	30.8	33.2	32.0
12.0	17.6	14.8	Handling bruises	12.9	17.5	15.2
10.7	17.6	14.2	Sting	8.2	10.9	9.5
11.0	0.3	5.6	Scab	16.1	0.2	8.1
5.5	1.8	3.6	Under color	4.8	0.7	2.7
4.6	1.8	3.2	Aphis	9.8	3.1	6.4
4.2	1.8	3.0	Russett	7.9	3.5	5.7
2.3	2.1	2.2	Worm	8.2	10.1	9.1
0.7	3.5	2.1	Fruit worm	1.8	7.4	4.6
1.2	1.7	1.4	Poor shape	0.8	1.4	1.1
0.1	1.7	0.9	Curculio	0.1	1.0	0.5
0.1	1.0	0.5	Frost	0.0	4.0	2.0
0.2	0.7	0.4	Bitter pit	0.1	3.7	1.9
0.1	0.1	0.1	Others	0.1	0.1	0.1

NOTE: If the percentages of a particular grade which has been graded down for stated reasons are added, the total will be greater than 100. This does not mean that the figures are in error, but that some of the apples examined had two or more injuries, any one of which would have been sufficient to place that particular fruit in the low grade.

In Table 4 and Figure 10 the term "size" refers to lack of size; "sting" refers to the injury which results when the skin of the apple is punctured by a codling moth larva which dies either before gaining entrance to the apple or soon afterwards; "color" refers to lack of color; "worm" refers to that injury caused by codling moth larvae which live and "work" in an apple; "fruit worm" refers to the injury caused by the common species of caterpillars that hatch in the spring and feed on the leaves and young fruit; "curculio" refers to the work of the plum curculio; "bitter pit" refers to those fruit spots sometimes called Baldwin spot, brown spot, fruit pit, or stippen; "handling bruises" includes skin cuts and breaks as well as all bruises occuring during the harvesting and highway transportation operations. The other terms used are self-explanatory.

Handling bruises, due to negligence in picking or highway transportation operations, account for more than 12 per cent of the low grade fruit in 1924 and for upwards of 17 per cent in 1925.

Scab was an important factor in 1924, but in 1925 it was found on very few apples. Codling moth stings were quite prevalent in both seasons, although the number of "wormy" apples made this type of injury of secondary importance. It will undoubtedly be a surprise to many growers to learn that lack of color is only of secondary importance when compared to several of the other causes of low grade fruit, even in a section where some growers have complained that environmental factors are not as favorable for high color as they are farther inland.

HOW DIFFERENT VARIETIES ARE AFFECTED BY FACTORS CAUSING CULLS

Table 5 and Figures 12-21 give the reasons for B-grade and culls, expressed as percentages of the grade, for each variety studied in 1924 and in 1925. On the whole, the graphs show clearly that though the less important reasons for low grade vary considerably in their effects on different varieties and even on the same variety from year to year,

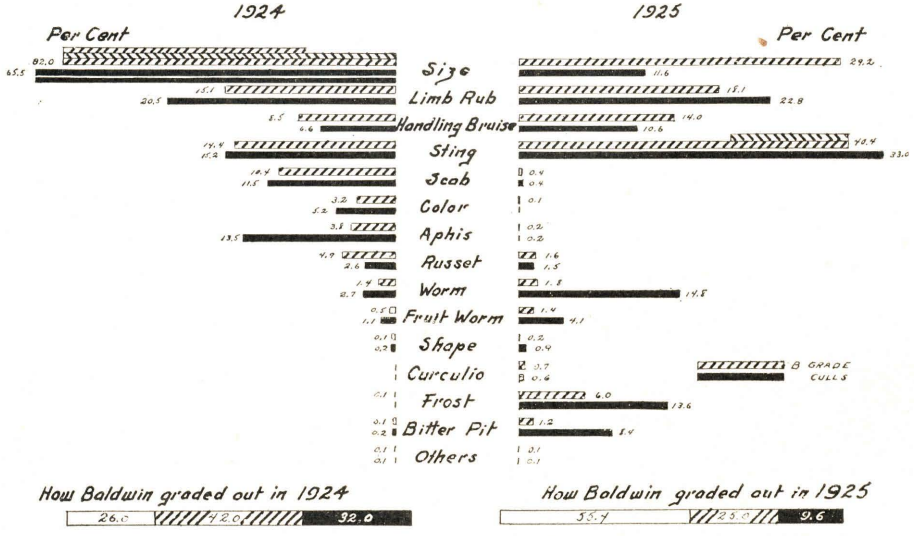


Figure 12.—The reasons for B-grade and cull Baldwin, 1924 and 1925.

the important reasons, such as lack of size, limb rub, handling bruises, and stings are relatively uniform in their influence on grade. In other words, though certain varieties are reasonably free from some of the injuries of lesser importance, all are subject to the more important factors causing culls.

In studying these figures, it will be well to bear in mind that, though

in many cases the percentages of the grade affected by a given injury are just as great in 1925 as in 1924, the B- and cull grades in 1925 represent a smaller percentage of the total production. For instance, in 1924, 10.5 per cent of the Jonathan was placed in the B-grade because of handling bruises; in 1925 the percentage was approximately the same as for the previous year. However, the percentage of B-grade Jonathan in 1924 was more than twice that in 1925, indicating that handling bruises of such character as to warrant placing the apples in B-grade were more than two times as serious that season.

Baldwin:—A study of Figure 12 shows that in 1924, 82 per cent of the B-grade and 65.5 per cent of the cull grade Baldwins were placed in these grades because of small size. That year this factor was of more importance than all others combined. When the figures for grades and those for factors responsible for low grades are considered together, it would appear that about 55 per cent of the fruits produced in 1924 were too small to meet the A-grade requirements.

Table 5.—The reasons for B-grade and culls expressed in percentages of the grade.

	Baldwin	Northern Spy	King	Wagener	Jonathan	R. I. Greening	Canada Red	Grimes	Hubbardston	McIntosh	Average
B-grade 1924:											
Size	82.0	30.4	11.5	67.3	55.5	45.5	52.0	69.0	58.6	47.2	51.9
Limb rub	15.1	35.1	23.5	18.2	17.5	36.5	22.2	12.6	12.5	9.9	20.3
H. bruises	8.5	30.3	3.2	10.6	10.5	4.5	7.9	14.3	9.8	20.4	12.0
Sting	14.4	7.7	31.4	9.7	5.8	13.2	4.1	5.9	10.7	3.8	10.7
Scab	10.4	9.3	19.8	2.4	1.6	10.1	22.7	2.7	2.9	27.8	11.0
Color	3.2	3.6	2.9	7.1	0.7	0.0	0.9	0.0	19.5	5.0	4.3
Aphis	3.8	0.5	1.7	0.1	40.0	0.0	0.0	0.1	0.1	0.0	4.6
Russet	4.9	0.1	4.7	2.9	13.7	2.1	0.0	5.5	7.4	3.2	4.4
Worm	1.4	0.4	5.4	0.7	0.5	4.9	0.8	0.6	3.3	5.4	2.3
Fruit worm	0.5	2.1	1.6	0.4	0.2	0.4	1.0	0.4	0.1	0.0	0.7
Shape	0.1	1.7	0.0	6.5	0.0	0.0	2.1	0.5	0.0	0.8	1.2
Curculio	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Frost	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Bitter pit	0.1	0.1	0.0	0.0	0.0	0.0	1.5	0.0	0.0	0.0	0.2
Others	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Culls 1924:											
Size	65.5	21.2	2.5	56.4	27.0	29.6	15.7	38.0	41.0	33.2	33.0
Limb rub	20.5	53.3	42.6	25.1	27.0	46.9	31.1	26.1	20.5	14.8	30.8
H. bruises	6.6	20.2	4.2	20.5	3.7	1.7	8.5	26.8	10.4	26.7	12.9
Sting	15.2	3.8	19.3	9.9	2.4	10.6	3.9	4.8	9.2	3.1	8.2
Scab	11.5	16.6	20.4	2.1	5.2	11.0	43.7	5.4	4.3	40.6	16.1
Color	5.2	0.7	0.0	17.8	0.0	0.0	0.0	0.0	12.7	4.3	4.1
Aphis	13.5	2.8	0.5	1.0	77.8	0.0	1.8	1.3	0.2	0.0	9.9
Russet	2.6	0.0	2.0	14.5	34.4	1.0	0.0	6.7	9.5	8.1	7.9
Worm	2.7	4.3	30.6	2.9	2.4	8.1	1.9	5.5	12.6	10.8	8.2
Fruit worm	1.1	4.3	2.7	1.1	2.4	0.0	1.4	4.1	1.4	0.0	1.8
Shape	0.2	1.5	0.0	5.7	0.0	0.0	0.0	0.7	0.2	0.0	0.8
Curculio	0.0	1.1	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Frost	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bitter pit	0.2	0.1	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.1
Others	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1

Stings account for the presence of 40 per cent of the B-grade Baldwins in 1925 and were of considerable importance in 1924. Limb rub and handling bruises were also items of major importance in each of the two years. Scab and aphis were responsible for many low grade Baldwin apples in 1924 but were of minor importance in 1925, a year when worms, frost injury and Baldwin fruit spot were more prevalent. It is interesting to note that practically all Baldwins met the A-grade

Table 5.—Continued

	Baldwin	Northern Spy	King	Wagener	Jonathan	R. I. Greening	Canada Red	Grimes	Hubbardston	McIntosh	Average	Aver. 1924-1925
B-grade 1925:												
Size	29.2	15.2	5.0	18.9	22.0	24.6	54.0	79.4	35.2	29.0	31.2	41.6
Limb rub	18.1	34.2	24.3	26.9	32.2	60.5	30.6	10.4	14.4	22.2	27.3	23.8
H. bruise	14.0	44.3	5.7	15.3	10.8	10.4	9.5	30.8	11.0	24.7	17.6	14.8
Stings	40.4	15.6	37.5	19.4	16.7	6.1	6.7	5.2	19.8	8.3	17.6	14.2
Scab	0.4	0.5	0.5	0.0	0.0	0.3	0.9	0.0	0.1	1.0	0.3	5.6
Color	0.1	0.9	0.2	3.3	0.2	0.0	0.4	0.0	13.1	0.3	1.8	3.6
Aphis	0.2	0.0	0.0	0.3	16.6	0.4	0.0	0.0	0.2	0.0	1.8	3.2
Russet	1.6	0.5	2.4	0.1	6.6	0.1	0.9	0.1	4.8	1.4	1.8	3.0
Worm	1.8	1.5	2.5	3.2	3.1	1.7	0.0	0.9	5.1	1.3	2.1	2.2
Fruit worm	1.4	1.8	6.6	11.4	1.1	3.9	0.0	0.2	2.8	6.1	3.5	2.1
Shape	0.2	3.7	0.1	3.0	0.4	0.6	1.3	0.1	0.4	7.4	1.7	1.4
Curculio	0.7	2.5	1.4	3.5	1.2	1.1	2.2	0.7	2.5	1.2	1.7	0.9
Frost	6.0	0.2	0.1	2.4	0.1	0.9	0.0	0.0	0.1	0.5	1.0	0.5
Bitter pit	1.2	2.9	0.4	2.4	0.2	0.0	0.0	0.0	0.1	0.0	0.7	0.4
Others	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Culls 1925:												
Size	11.6	11.0	4.5	18.6	18.8	9.8	34.0	43.7	26.2	21.4	20.9	26.9
Limb rub	22.8	36.4	43.5	27.6	25.5	72.4	34.0	18.6	26.4	24.4	33.2	32.0
H. bruise	10.6	33.9	3.0	13.7	17.1	5.9	19.0	26.0	12.4	33.4	17.5	15.2
Sting	33.0	10.4	12.7	10.9	9.9	5.9	1.4	6.6	15.5	2.8	10.9	9.5
Scab	0.4	0.1	0.0	0.2	0.4	0.0	0.0	0.1	0.0	0.5	0.2	8.1
Color	0.0	1.2	1.0	0.4	0.0	0.0	2.7	0.0	1.4	0.0	0.7	2.7
Aphis	0.2	0.1	0.0	0.0	26.9	1.3	0.0	2.7	0.0	0.0	3.1	6.4
Russet	1.5	0.1	19.5	0.0	2.3	1.3	2.7	1.0	3.4	3.1	3.5	5.7
Worm	14.8	5.4	15.0	7.9	12.3	6.4	8.1	7.0	17.6	6.7	10.1	9.1
Fruit worm	4.1	5.8	10.5	15.6	7.0	11.4	1.4	4.8	3.2	10.3	7.4	4.6
Shape	0.9	4.2	0.1	1.4	0.2	0.2	2.7	1.5	0.1	2.8	1.4	1.1
Curculio	0.6	2.1	0.1	2.1	0.6	1.0	0.0	0.9	0.4	1.6	1.0	0.5
Frost	13.6	0.3	1.0	7.0	11.7	1.1	0.0	0.0	0.4	4.8	4.0	2.0
Bitter pit	8.4	21.7	0.0	5.5	0.2	0.2	0.0	0.9	0.3	0.0	3.7	1.9
Others	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1

NOTE. If the percentages of a particular grade which has been graded down for stated reasons are added, the total will be greater than 100. This does not mean that the figures are in error, but that some of the apples examined had two or more injuries any one of which would have been sufficient to place that particular fruit in the low grade.

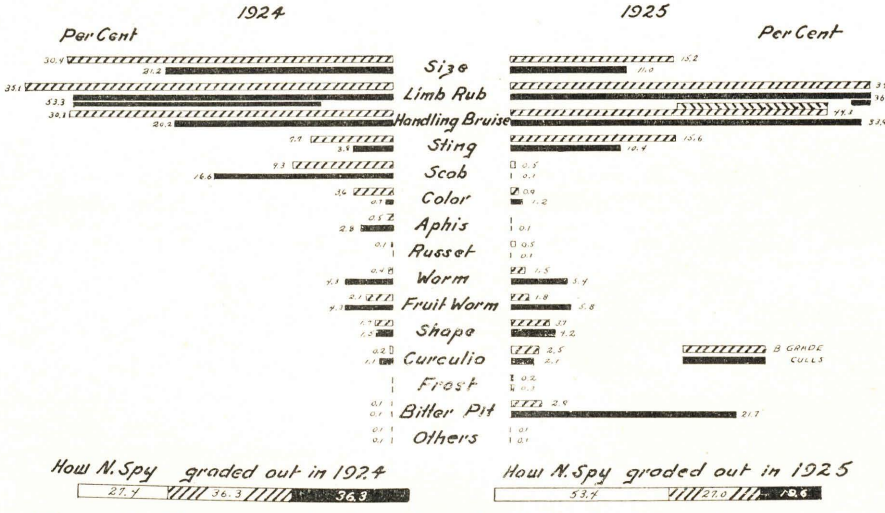


Figure 13.—The reasons for B-grade and cull Northern Spy, 1924 and 1925.

color requirements in 1925 and that few apples of this variety were under color in 1924.

Northern Spy:—Limb rubs were the most serious kind of injury found on Northern Spy (Figure 13). Thirty-five per cent of the B-grade and 53 per cent of the culls in 1924 were so graded because of these blemishes and in 1925 the corresponding figures were 34 and 36. Handling bruises made it necessary to place much of the fruit of this tender-skinned variety into the low grades—in fact handling bruises were the most serious kind of injury in 1925. Lack of size was a factor of considerable importance even with this large-sized variety. Stings were nearly as important as lack of size in 1925. Apple scab was rather serious in 1924 but of minor importance the following year. More than one-fifth of the cull Spies in 1925 were graded out because of bitter pit.

King:—King (Figure 14) sized up reasonably well both years and withstood the handling practices better than any of the other ten varieties. Howèver, it proved to be very susceptible to limb rubs, stings, scab (in 1925) coding moth, and russet.

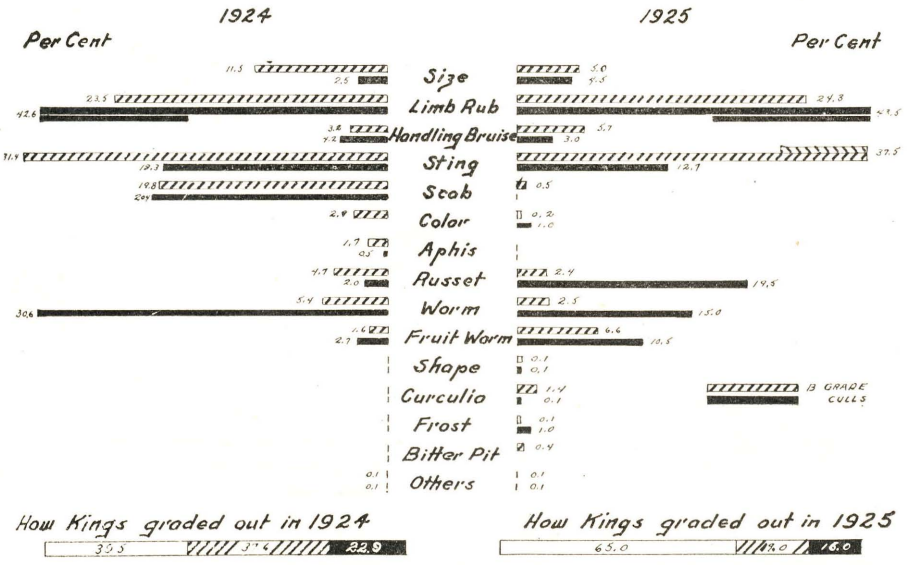


Figure 14.—The reasons for B-grade and cull King, 1924 and 1925.

Wagener:—Lack of size was the most important reason for the grading down of Wagener (Figure 15) in 1924 and ranked second among the causes of low grades in 1925. Limb rub, handling bruises, and stings were also serious factors in both years. Lack of color and russet were responsible for considerable grading down in 1924 but neither were important the succeeding season. Fruit worm and codling moth injuries together were responsible for the grading down of about one fruit of every 16 or 17 in 1925. Frost injury and bitter pit were of secondary importance during the second season of investigation.

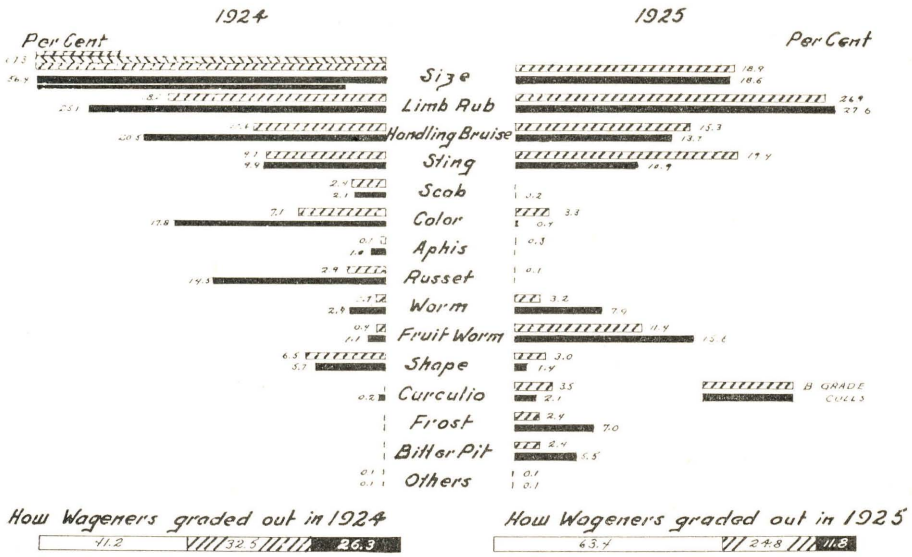


Figure 15.—The reasons for B-grade and cull Wagener, 1924 and 1925.

Jonathan:—Less than 40 per cent of the Jonathans were placed in the A-grade in 1924. Lack of size and limb rub (Figure 16) were among the leading causes of grading down with this variety, although aphis injury was the most serious factor, and russeting was of major importance. Forty per cent of the B-grade Jonathans and 77.8 per cent of the culls were placed in these grades because of aphis injury. This type of injury was of minor importance with the other varieties under consideration with the exception of Baldwin, a variety closely

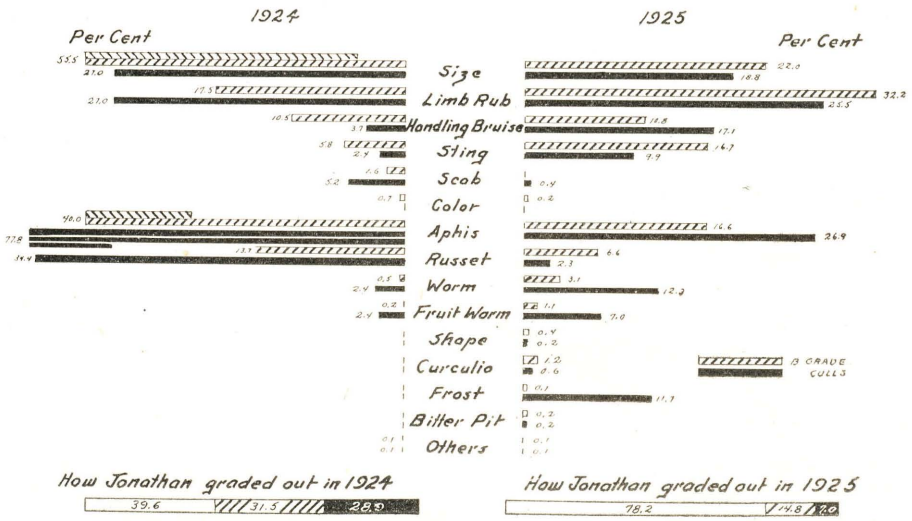


Figure 16.—The reasons for B-grade and cull Jonathan, 1924 and 1925.

related to Jonathan. Stings were not serious in 1924. The variety withstood handling better than the average of those studied. In 1925, 78 per cent of the crop went into A-grade. Again aphis injury was one of the main reasons for grading down and worms and frost affected this variety about as badly as they did others for that season.

Rhode Island Greening:—Limb rubs were the principle causes of low grades with Rhode Island Greening in both 1924 and 1925 (Figure 17). In 1924, they were nearly as prevalent in this variety as on Northern Spy, and in 1925, a year favorable for high grade fruit with most varieties, about one out of every four Rhode Island Greening apples were graded down because of limb rubs. Lack of size, stings, scab (1924) and worms also accounted for considerable quantities of low grade apples. The variety ranks comparatively well in withstanding handling bruises.

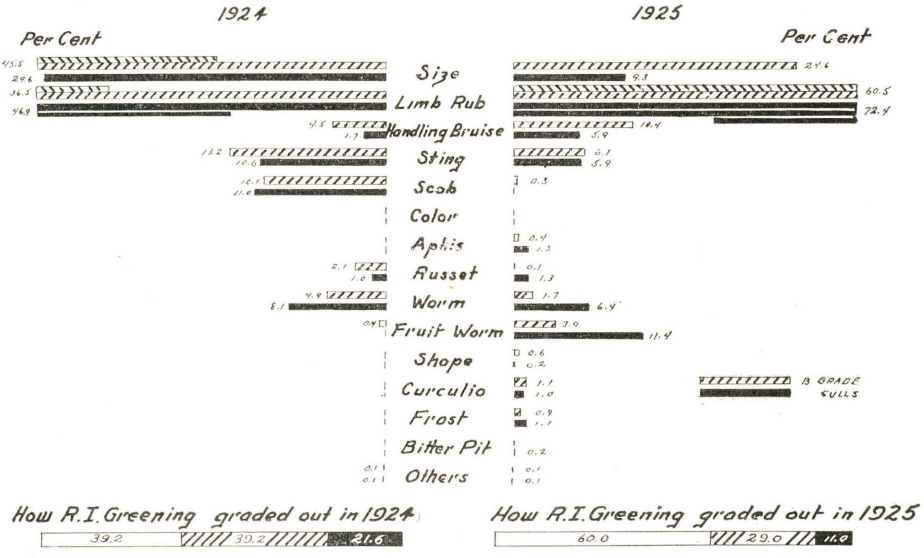


Figure 17.—The reasons for B-grade and cull Rhode Island Greening, 1924 and 1925.

Canada Red:—Approximately 14 per cent of the Canada Reds of 1924 (Figure 18) were placed in the lower grades because of scab, although this disease was of negligible importance the following year. Lack of size accounted for more than one-half of the B-grade apples each of the two years. Limb rub was fully as serious with this variety as it was with the average of the others studied, but handling bruises were not so much in evidence.

Grimes:—More than one-third of the Grimes apples failed to meet the A-grade size requirement for this variety (Figure 19). It was also very susceptible to handling bruises and limb rubs, these injuries being conspicuous enough to force more apples with these kinds of blemishes into the cull grade than into B-grade. Stings, scab, russet and worms were of secondary importance. It is interesting to note that no frost injury was noticed on Grimes or Canada Red in 1925.

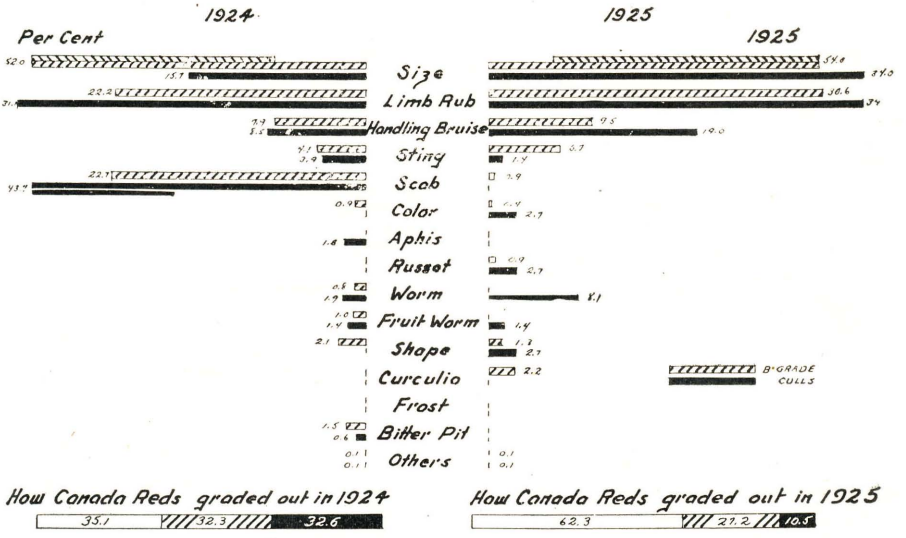


Figure 18.—The reasons for B-grade and cull Canada Red, 1924 and 1925.

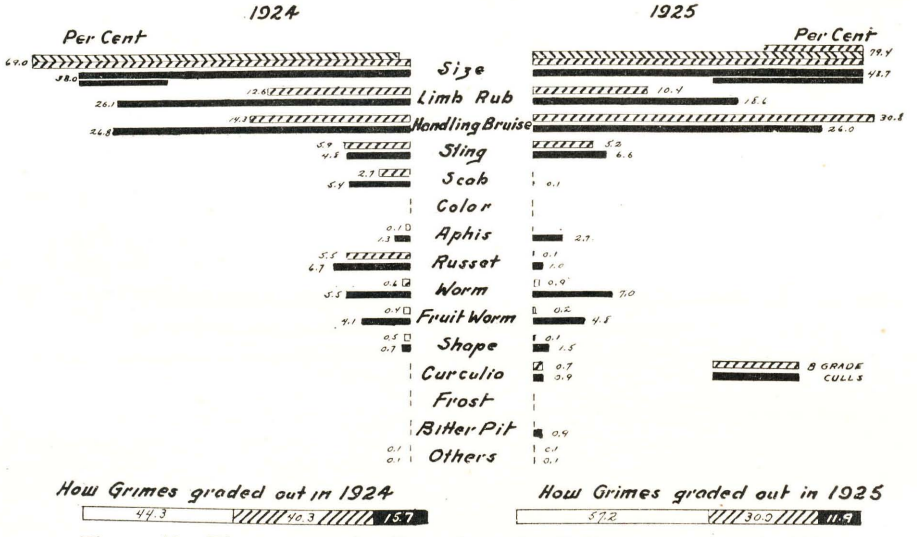


Figure 19.—The reasons for B-grade and cull Grimes, 1924 and 1925.

Hubbardston:—Figure 20 shows the causes for grading down with Hubbardston, a variety which graded out somewhat better than the average. The chart may therefore be misleading. For instance, the solid bar for limb rub in 1925 stands out quite prominently, but it must be borne in mind that less than nine per cent of the Hubbardston of that year were culls. Lack of size was the most important reason for grading down. Lack of color ranked along with limb rubs, handling

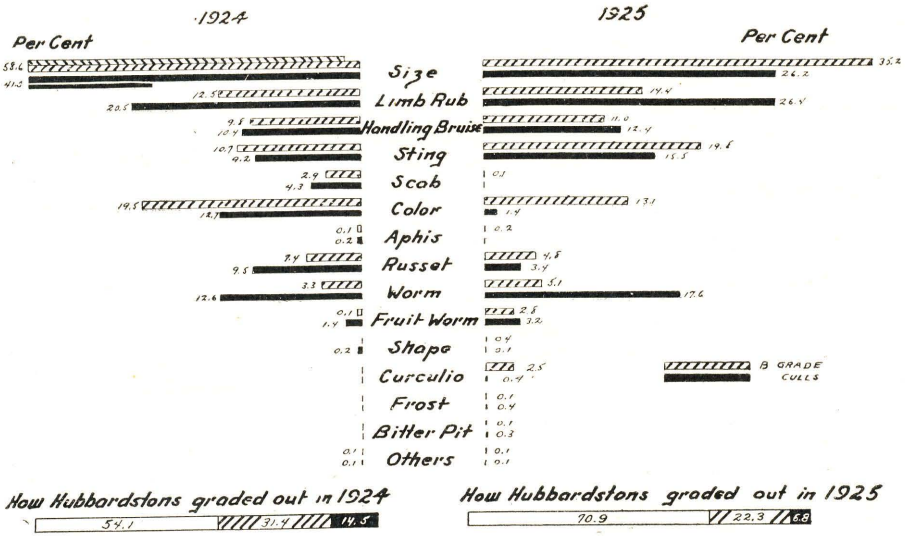


Figure 20.—The reasons for B-grade and cull Hubbardston, 1924 and 1925.

bruises, stings, worms, and russet as important causes of low grade Hubbardston.

McIntosh:—McIntosh (Figure 21) was the outstanding variety of the ten studied from the standpoint of grading, 66 per cent of the 1924 crop and 84 per cent of the 1925 crop being A-grade. In spite of its relatively good showing, there is nevertheless plenty of opportunity to increase the percentage of high grade fruit. Lack of size, scab, handling bruises, and limb rubs may be regarded as the primary reasons for grading down, although the variety showed more or less suscep-

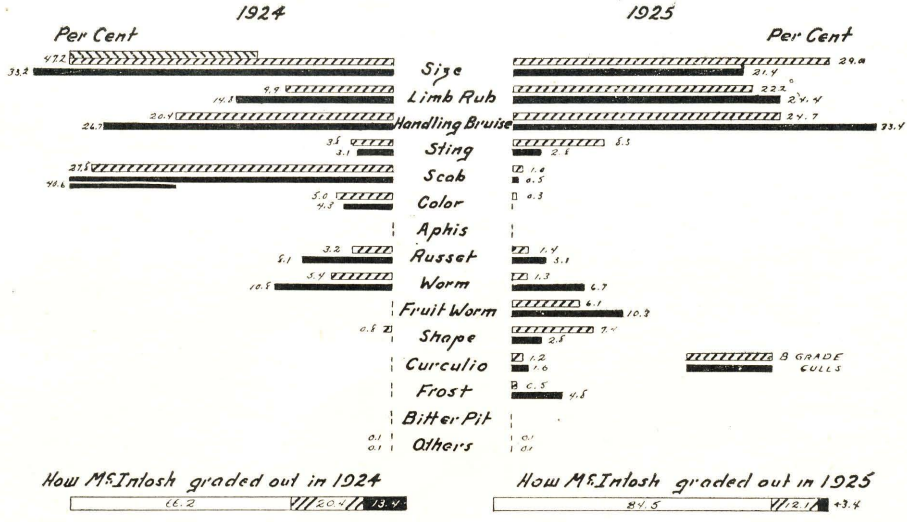


Figure 21.—The reason for B-grade and cull McIntosh, 1924 and 1925.

tibility to worms, stings, russet, frost injury, and lack of color under the average methods of management. Perhaps the outstanding item in this chart is handling bruises. McIntosh is usually considered as an apple that must be handled with care. Whether the McIntosh included in this study were handled more carefully than Northern Spy is not known. It is conceivable that the young McIntosh trees would offer less occasion for the picking bag to bump against ladders, but on the other hand the fruit was handled over the same roads and in the same trucks which were driven by the same drivers. At any rate, it is evident that only one out of about 13 McIntosh apples in 1924 and one out of 25 in 1925 were graded down because of this defect while in the case of Northern Spy the ratios were one to five or six and one to six or seven for the two years.

HOW THE DIFFERENT VARIETIES ARE AFFECTED BY INDIVIDUAL FACTORS RESPONSIBLE FOR LOW GRADES

Table 6 shows how the several injuries and deficiencies affect each of the ten varieties studied and also how they affect the fruit of the best and poorest growers of each variety. The figures are for 1924, a year when there was a high percentage of low grade fruit. Figures number 22 to 27 inclusive were prepared from the data included in Table 6 and show the effects of the six more important factors upon B- and cull grades of each of the ten varieties for the season of 1924. The wide bars represent the average percentages of fruit of the B- and cull grades that were graded down because of the injury, the broken line shows how this factor affected the fruits of the best grower of each variety and the solid line shows the percentage of the poorest grower's fruit that was placed in the lower grades because of the injury. It should be emphasized that the data in Table 6 and their graphic representation in Figures 22 to 27 do not show the percentages of the total crop of each variety graded down because of any one of the injuries; they simply show the relative importance of these several factors in causing the B- or cull grades.

Size:—Figure 22 shows that more than three-fourth of the B-grade Baldwins were placed in that grade because of size deficiency and that more than one-half of the Wagener, Jonathan, Canada Red, Grimes, and Hubbardston of this grade were graded down for the same reason. Even the best grower of Baldwin had 63 per cent of his second grade fruit so placed because of lack of size. It will also be noted that size deficiency was one of the main reasons for placing fruits of most of the varieties in the cull grade. Lack of size was not an important factor in the grading down of King. Northern Spy ranks second although size was an important reason for the large amount of low grade fruit of this variety.

Limb Rub:—None of the varieties studied seem relatively free from injury caused by limb rub (Figure 23). Perhaps this is to be expected from the very nature of the injury. McIntosh made the best showing but even with that variety nearly ten percent of the B-grade and about

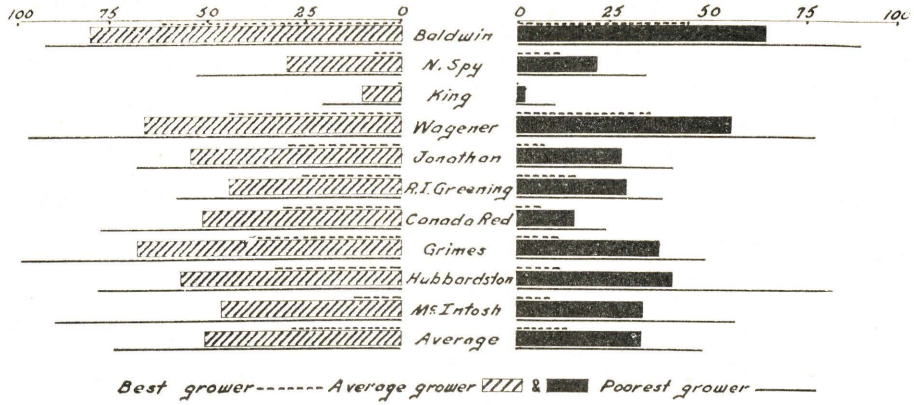


Figure 22.—The average percentage of the grade which was graded down because of size deficiency is shown for the B- and cull grades for each variety for 1924. The range between the best and the poorest growers of each variety is also indicated.

15 per cent of the culls were placed in those grades because of this type of blemish. Northern Spy and Rhode Island Greening were the most susceptible varieties. It will be noted that there is a rather wide spread between the percentages of fruits of the best grower and the poorest grower of each variety which were graded down because of limb rub. This difference may conceivably be correlated with differences in their pruning and thinning practices.

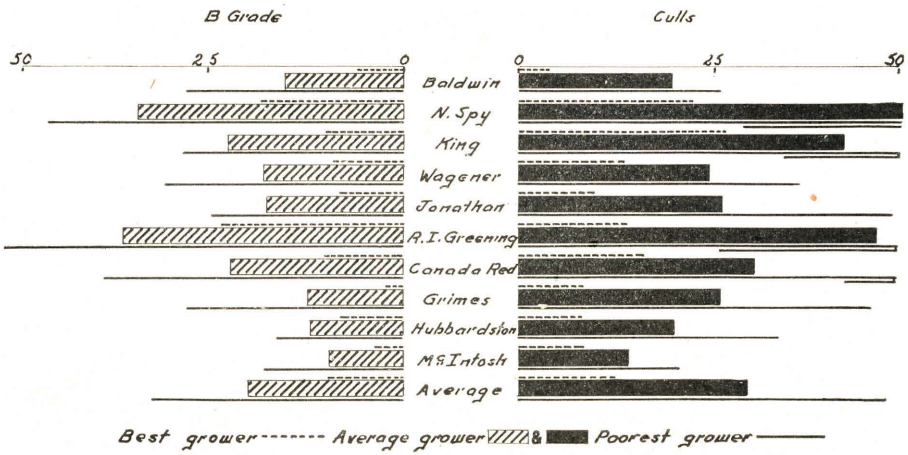


Figure 23.—The average percentage of the grade which was graded down because of limb rub is shown for the B- and cull grades for each variety for 1924. The range between the best and the poorest growers of each variety is also indicated.

Handling bruises:—Very few apples of the lower grades of King and Rhode Island Greening were placed in these grades because of handling bruises (Figure 24), but this kind of injury was important in

Table 6.—How different varieties are affected by a specific source of injury and how the fruit of different growers of one variety is affected. Year 1924.

Variety	Percentage of B-grade			Percentage of Culls		
	Poorest grower	Average grower	Best grower	Poorest grower	Average grower	Best grower
Source of injury—Lack of size:						
Baldwin	94.4	82.0	63.0	90.3	65.5	44.4
Northern Spy	54.8	30.4	7.7	35.7	21.2	13.0
King	21.6	11.5	1.5	10.0	2.5	0.1
Wagener	96.4	67.3	45.1	78.0	56.4	35.0
Jonathan	69.4	55.5	30.5	41.0	27.0	8.0
R. I. Greening	58.1	45.5	27.9	38.7	29.6	16.0
Canada Red	79.7	52.0	31.5	24.0	15.7	7.0
Grimes	98.0	69.0	38.0	48.0	38.0	12.0
Hubbardston	79.8	58.6	33.2	83.5	41.0	12.5
McIntosh	89.9	47.2	12.2	57.4	33.2	10.0
Average	74.2	51.9	29.1	50.7	33.0	15.8
Source of injury—Limb rub:						
Baldwin	29.7	15.1	6.1	26.8	20.5	4.4
Northern Spy	46.6	35.1	18.4	71.8	53.3	23.7
King	29.8	23.5	10.1	65.4	42.6	27.4
Wagener	31.6	18.2	9.8	37.1	25.1	14.3
Jonathan	25.8	17.5	8.3	48.9	27.0	10.2
R. I. Greening	58.7	36.5	24.1	73.7	46.9	14.5
Canada Red	39.7	22.2	10.5	56.3	31.1	16.0
Grimes	28.2	12.6	2.1	46.0	26.1	8.9
Hubbardston	16.7	12.5	8.3	34.8	20.5	8.3
McIntosh	18.6	9.9	3.7	21.6	14.8	7.7
Average	32.5	20.3	10.1	48.2	30.8	13.5
Source of injury—Handling bruises:						
Baldwin	13.0	8.5	5.1	12.5	6.6	2.4
Northern Spy	47.3	30.3	14.4	44.7	20.2	8.4
King	7.4	3.2	1.5	8.7	4.2	0.1
Wagener	22.3	10.6	2.7	61.6	20.5	3.1
Jonathan	29.8	10.5	2.1	9.4	3.7	1.4
R. I. Greening	5.9	4.5	2.8	3.8	1.7	0.5
Canada Red	12.9	7.9	4.1	15.0	8.5	2.7
Grimes	28.6	14.3	2.8	42.9	26.8	8.3
Hubbardston	13.7	9.8	2.1	16.9	10.4	3.6
McIntosh	39.8	20.4	6.6	39.2	26.7	9.2
Average	22.1	12.0	4.4	25.5	12.9	4.0
Cause of injury—Stings:						
Baldwin	20.9	14.4	8.0	24.3	15.2	5.7
Northern Spy	17.0	7.7	0.0	10.8	3.8	0.7
King	45.5	31.4	20.2	28.3	19.3	10.0
Wagener	13.2	9.7	7.0	15.9	9.9	4.0
Jonathan	7.9	5.8	0.7	4.9	2.4	1.6
R. I. Greening	18.9	13.2	6.1	17.6	10.6	4.1
Canada Red	10.3	4.1	2.3	7.0	3.9	2.1
Grimes	8.7	5.9	3.6	12.4	4.8	0.0
Hubbardston	21.2	10.7	2.6	19.3	9.2	3.9
McIntosh	6.8	3.8	1.5	8.6	3.1	0.0
Average	17.0	10.7	5.2	14.9	8.2	3.2
Cause of injury—Scab:						
Baldwin	21.6	10.4	2.4	22.5	11.5	2.1
Northern Spy	18.2	9.3	3.1	31.9	16.6	5.7
King	37.0	19.8	3.7	43.3	20.4	5.3
Wagener	5.7	2.4	0.0	4.5	2.1	0.0
Jonathan	4.1	1.6	0.5	20.6	5.2	0.0
R. I. Greening	16.2	10.1	2.7	16.7	11.0	0.0
Canada Red	36.4	22.7	0.8	60.3	43.7	5.2
Grimes	10.2	2.7	0.0	14.9	5.4	1.2
Hubbardston	5.5	2.9	0.3	10.5	4.3	0.7
McIntosh	70.3	27.8	7.1	60.6	40.6	6.8
Average	22.5	11.0	2.1	28.6	16.1	2.7
Cause of injury—Lack of color:						
Baldwin	6.4	3.2	0.2	30.0	5.2	0.0
Northern Spy	7.8	3.6	0.0	4.0	0.7	0.0
King	5.4	2.9	1.3	0.0	0.0	0.0
Wagener	10.0	7.1	1.3	48.9	17.8	0.0
Jonathan	2.7	0.7	0.0	0.0	0.0	0.0
R. I. Greening	0.0	0.0	0.0	0.0	0.0	0.0
Canada Red	1.6	0.9	0.0	0.0	0.0	0.0
Grimes	0.0	0.0	0.0	0.0	0.0	0.0
Hubbardston	37.9	19.5	4.1	24.7	12.7	0.0
McIntosh	12.8	5.0	0.0	9.4	4.3	2.1
Average	8.5	4.3	0.7	11.7	4.1	0.2

Table 6.—Continued

Variety	Percentage of B-grade			Percentage of Culls		
	Poorest grower	Average grower	Best grower	Poorest grower	Average grower	Best grower
Cause of injury—Aphis:						
Baldwin	6.5	3.8	0.4	38.9	13.5	1.8
Northern Spy	1.4	0.5	0.0	15.4	2.8	0.0
King	6.8	1.7	0.0	2.0	0.5	0.0
Wagener	0.8	0.1	0.0	3.1	1.0	0.0
Jonathan	74.5	40.0	8.1	98.0	77.8	22.4
R. I. Greening	0.0	0.0	0.0	0.0	0.0	0.0
Canada Red	0.0	0.0	0.0	2.9	1.8	0.8
Grimes	0.5	0.1	0.0	3.4	1.3	0.0
Hubbardston	0.2	0.1	0.0	0.9	0.2	0.0
McIntosh	0.0	0.0	0.0	0.0	0.0	0.0
Average	9.1	4.6	0.8	16.5	9.9	2.5
Cause of injury—Russet:						
Baldwin	10.2	4.9	2.1	4.3	2.6	0.4
Northern Spy	0.2	0.1	0.0	0.0	0.0	0.0
King	13.6	4.7	0.0	8.1	2.0	0.0
Wagener	8.4	2.9	0.0	43.5	14.5	0.0
Jonathan	29.9	13.7	0.5	90.0	34.4	0.0
R. I. Greening	3.7	2.1	1.5	3.0	1.0	0.0
Canada Red	0.0	0.0	0.0	0.0	0.0	0.0
Grimes	9.9	5.5	0.0	14.8	6.7	1.3
Hubbardston	24.0	7.4	0.0	54.1	9.5	0.0
McIntosh	14.7	3.2	0.0	29.8	8.1	0.3
Average	11.5	4.4	0.4	24.7	7.9	0.2
Cause of injury—Worms:						
Baldwin	4.6	1.4	0.2	9.4	2.7	0.8
Northern Spy	2.4	0.4	0.1	8.0	4.3	0.1
King	13.9	5.4	0.1	57.8	30.6	7.8
Wagener	1.2	0.7	0.1	13.9	2.9	0.1
Jonathan	1.1	0.5	0.1	5.1	2.4	0.1
R. I. Greening	9.4	4.9	2.4	16.2	8.1	2.0
Canada Red	3.8	0.8	0.1	5.1	1.9	0.1
Grimes	2.6	0.6	0.1	16.5	5.5	0.1
Hubbardston	7.2	3.3	0.5	30.1	12.6	2.0
McIntosh	11.5	5.4	2.1	33.4	10.8	0.1
Average	5.8	2.3	0.6	19.5	8.2	1.3
Cause of injury—Fruit worm:						
Baldwin	1.7	0.5	0.1	3.7	1.1	0.0
Northern Spy	4.4	2.1	0.0	8.9	4.3	0.2
King	2.9	1.6	0.0	5.4	2.7	0.0
Wagener	2.1	0.4	0.0	2.6	1.1	0.0
Jonathan	1.4	0.2	0.0	8.1	2.4	0.0
R. I. Greening	1.8	0.4	0.0	0.0	0.0	0.0
Canada Red	2.7	1.0	0.0	4.1	1.4	0.0
Grimes	1.9	0.4	0.0	5.8	4.1	0.0
Hubbardston	1.4	0.1	0.0	3.8	1.4	0.0
McIntosh	0.0	0.0	0.0	0.0	0.0	0.0
Average	2.0	0.7	0.1	2.4	1.8	0.1
Cause of injury—Lack of shape:						
Baldwin	0.6	0.1	0.0	0.9	0.2	0.0
Northern Spy	4.1	1.7	0.0	5.4	1.5	0.0
King	0.0	0.0	0.0	0.0	0.0	0.0
Wagener	10.2	6.5	1.7	19.6	5.7	0.0
Jonathan	0.0	0.0	0.0	0.0	0.0	0.0
R. I. Greening	0.0	0.0	0.0	0.0	0.0	0.0
Canada Red	4.1	2.1	0.0	0.0	0.0	0.0
Grimes	3.3	0.5	0.0	3.4	0.7	0.0
Hubbardston	0.0	0.0	0.0	1.3	0.2	0.0
McIntosh	3.7	0.8	0.0	0.0	0.0	0.0
Average	2.6	1.2	0.2	3.1	0.8	0.0
Cause of injury—Curculio:						
Baldwin	0.0	0.0	0.0	0.0	0.0	0.0
Northern Spy	1.4	0.2	0.0	4.8	1.1	0.0
King	0.0	0.0	0.0	0.0	0.0	0.0
Wagener	0.0	0.0	0.0	1.2	0.2	0.0
Jonathan	0.0	0.0	0.0	0.0	0.0	0.0
R. I. Greening	0.0	0.0	0.0	0.0	0.0	0.0
Canada Red	0.0	0.0	0.0	0.0	0.0	0.0
Grimes	0.0	0.0	0.0	0.0	0.0	0.0
Hubbardston	0.0	0.0	0.0	0.0	0.0	0.0
McIntosh	0.0	0.0	0.0	0.0	0.0	0.0
Average	0.1	0.1	0.0	0.6	0.1	0.0

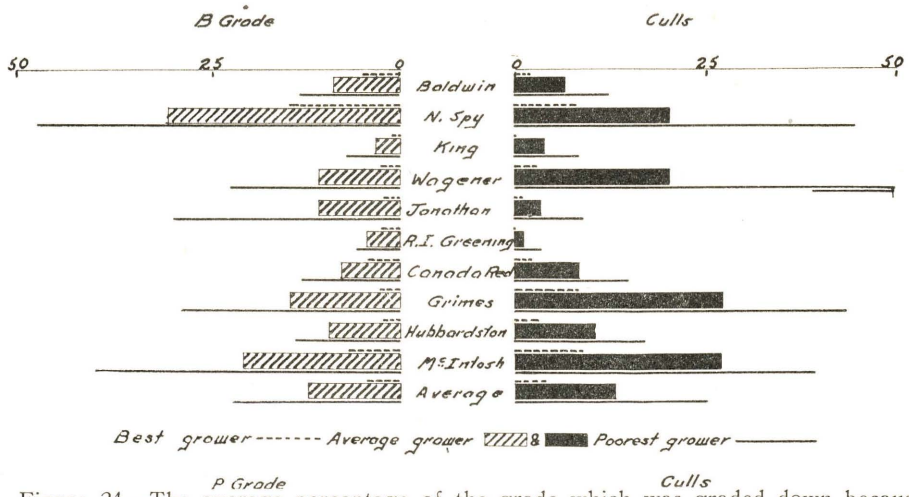


Figure 24.—The average percentage of the grade which was graded down because of handling bruises, is shown for B- and cull grades for each variety for 1924. The range between the best and the poorest growers of each variety is also indicated.

the case of Northern Spy, McIntosh, Grimes, and Wagener. The relative prevalence of handling bruises on the low grade fruit of the best and the poorest grower of each variety is worthy of note. This is particularly true with such varieties as Wagener, Jonathan, and Grimes. In one sense, such a comparison places Grimes at a disadvantage because bruises show up very soon after they are made and are more conspicuous than equally serious bruises on other varieties. However, because of this very conspicuousness of bruises on this variety the trade discriminates against it and the fruit must be sorted accordingly as it passes over the grading table.

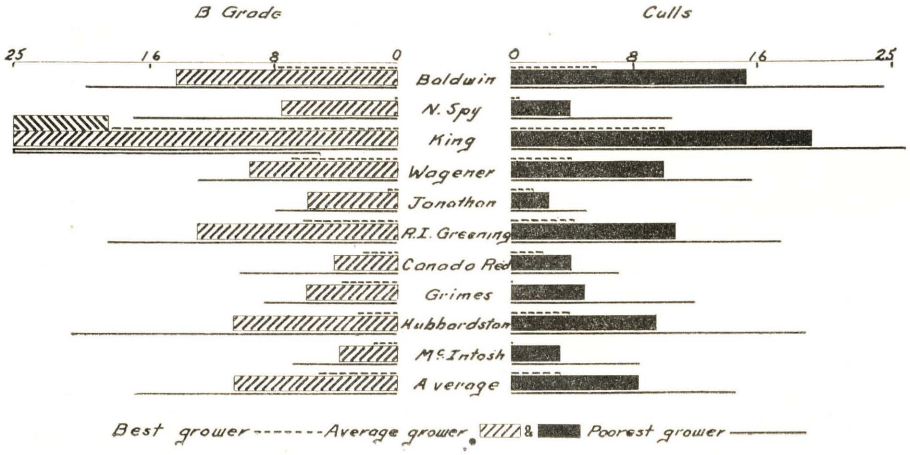


Figure 25.—The average percentage of the grade which was graded down because of worm stings is shown for B- and cull grades for each variety for 1924. The range between the best and the poorest growers of each variety is also indicated.

Stings:—Figure 25 shows how the different varieties were affected by stings. Small percentages of the low grade McIntosh, Canada Red, Jonathan and King were kept out of the A-grade because of blemishes of this type. More stings were found among the low grade Kings than among the B- and cull grades of the other varieties. The best Northern Spy grower had no stings among his B-grade of this variety and less than one per cent of his culls showed this injury. The best growers of Grimes and McIntosh did not produce any apples of these varieties with stings of sufficient importance to warrant placing the fruits in the cull crates.

Scab:—The best grown Wageners showed no scab and the best grown Jonathans, Grimes, and Hubbardstons had negligible amounts. Moreover, very few fruits of these four varieties produced by the average growers (Figure 26) showed scab spots. Scab was a very important reason for grading down with McIntosh, Canada Red, and King, but the better growers obtained good control of this disease even with these susceptible varieties. For instance, the B-grade Canada Red of the best grower of that variety had less than one per cent of scab-injured apples and only five per cent of his culls showed scab. On the other hand, the poorest grower of this variety had 36.4 per cent of his B-grade and 60.3 per cent of his cull grade fruits placed in these grades because of scab. The scab data for the best and the poorest McIntosh growers are equally contrasting.

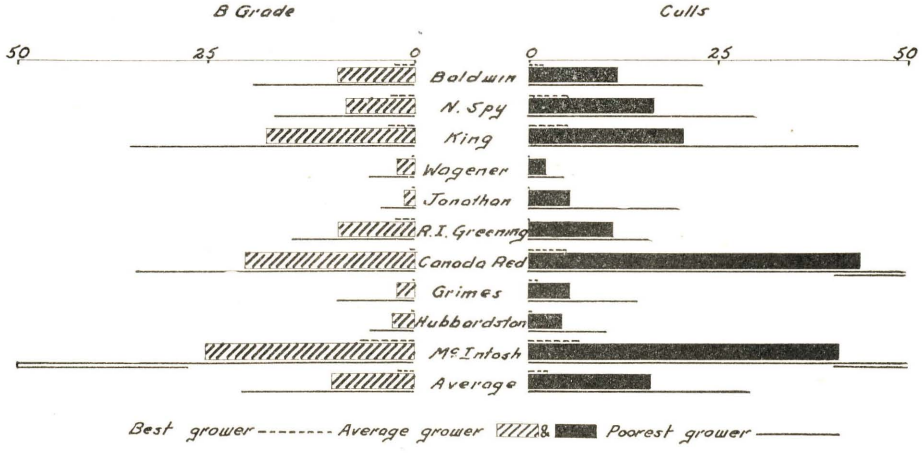


Figure 26.—The average percentage of the grade which was graded down because of scab, is shown for B- and cull grades for each variety for 1924. The range between the best and the poorest grower of each variety is also indicated.

Russet:—Figure 27, which shows how russet affects different varieties, is included because of the contrasting differences in variety susceptibility and because some growers produced practically russet-free apples of each of the varieties. Jonathan, apparently the most susceptible of the ten varieties, serves as a good illustration. None of the apples of the best grower were placed in the cull grade because of russet and only one-half per cent of the B-grade were so placed be-

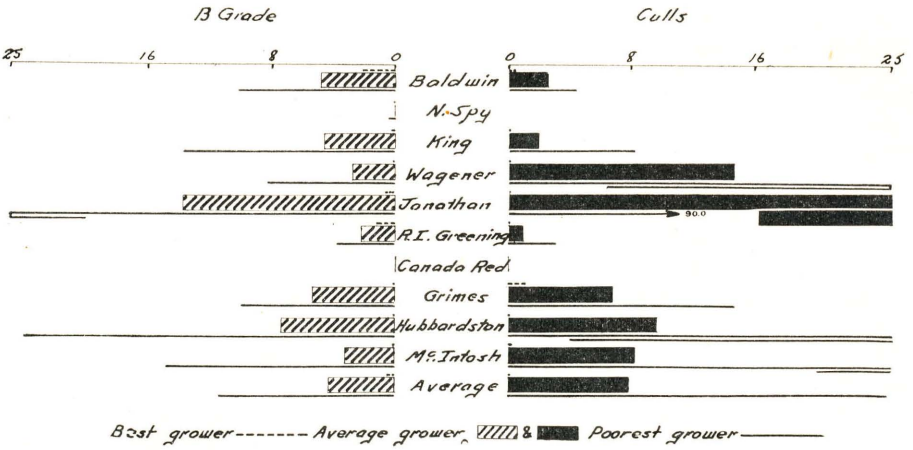


Figure 27.—The average percentage of the grade which was graded down because of russet is shown for B- and cull grades for each variety for 1924. The range between the best and the poorest grower of each variety is also indicated.

cause of this injury. The figures for the average growers are 13.7 and 34.4 per cent and for the poorest grower 29.9 and 90.0 per cent for the B- and cull grades respectively. Similarly, the best Hubbardston grower had no russet but the poorest grower had 24.0 per cent of the B-grade and 54.1 per cent of the culls graded down because of russeting; Northern Spy and Canada Red are apparently the most resistant of the ten varieties to this type of blemish.

Graphs are not presented for the less important causes of injury, such as aphis, worms, lack of color, fruit worms, poor shape, and curculio. However, the data are so arranged in Table 6 that varietal susceptibility and comparison between the best, the average, and the poorest growers can be readily made.

INDIRECT CAUSES OF CULLS

Most of the blemishes and deficiencies which appear as the fruit is run over the sorting table are due to what has been done or what has not been done in the orchard, to conditions of soil or season over which the grower may or may not have had control, or to injuries incident to harvesting and handling operations. It is as important to identify and assign to each of these factors its relative importance as it is to determine the effect of the different deficiencies and blemishes themselves upon the apples which go into the A-grade or upon the apples which find their way into the cider barrel. As stated before, however, this aspect of the investigation could not be subjected to the same mathematical standards as were employed in some of the other work. An apple is either wormy or is not and it can be counted accordingly; an orchard can hardly be recorded as just pruned or unpruned. Reliance must be placed in impressions and general conclu-

sions after the careful weighing of much evidence some of which is conflicting. It is believed, however, that the observations and records in the packing house together with the field studies make possible some fairly definite statements as to the relative importance of some of the indirect causes of low apple grades.

Soil:—Size of fruit, or more accurately lack of size, has been mentioned repeatedly as responsible for a comparatively large percentage of the culling that is done in the packing house. Indeed this is the deficiency of outstanding importance. It is, moreover, the deficiency that is most difficult to account for in the sense of being able to attribute definite amounts or proportions to definite causes. Age of tree, size of crop, closeness of planting, fertility and depth of soil, thinning, pruning, soil management methods, and many other factors influence size.

The evidence gained from a field study of the 24 orchards included in this investigation does not warrant a statement as to even the approximate percentage of the small sized apples that is due mainly to poor soil. The impression was gained, however, that of all the factors mentioned in this connection it is the most important. Thin, infertile, light soils do not consistently produce large-size apples. It is believed that those who contemplate making new plantings should carefully consider the evident relationships between soil and size of fruit before definitely deciding to set a particular piece of land to apples. Producers who have been harvesting rather small-sized fruit from trees growing in shallow, infertile, or drouthy soils can well afford to consider the practicability of such changes in soil management methods as will increase both available nutrient and moisture supply.

Thinning:—Size can generally be improved by thinning. It may not always pay to thin all varieties but there is considerable evidence which indicates that if trees are inclined to bear heavy crops of undersized apples that it will pay to thin them. This is especially true of those varieties whose A-grade brings considerably more than the B-grade. Nitrogen-carrying fertilizers have a tendency to cause a heavy setting of fruit. Naturally, the apples which come from trees bearing these heavy loads are very often lacking in size. Though nitrogen-carrying fertilizers are used in many orchards, seldom is the application followed by thinning. It was found that of the 24 growers from whom detailed records were obtained only three made it a practice to thin regularly and the efforts of these three were generally confined to two or three varieties. Furthermore, much of the thinning is done too late to obtain the greatest possible benefit. One orchardist made the statement that in a block of Wagener, half of which was thinned, the percentage of low grade fruit produced was 100 per cent greater in the unthinned than in the thinned trees and that money was made only on the A-grade fruit. This grower was a thorough believer in thinning, but according to his own statement he often let other work interfere with, or prevent altogether, his thinning. Many other growers told the same story. There is good reason to believe that the judicious practice of thinning would increase the net income from many Michigan orchards.

Pruning:—Lack of size and limb rub are responsible for more than

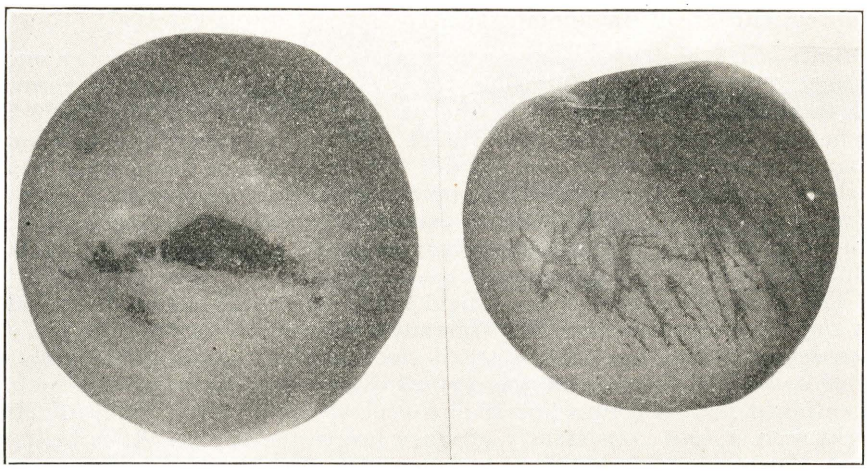


Figure 28.—Injuries resulting from limb rub. The Northern Spy (left), has rested lightly against a limb and there has been but little movement. The type of injury shown on the right results when an apple occasionally brushes lightly against a twig or a spur. Note that the scars are confined to one cheek of the apple.

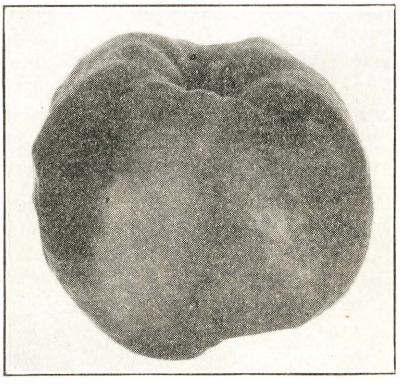


Figure 29.—A result of the work of the rosy apple aphis on Jonathan. This variety is very susceptible to this kind of insect injury.

half of the low grade fruit. It is generally believed that both of these defects can be reduced by proper pruning, though on account of other variable factors, it is rather difficult to determine just how much can be accomplished in this direction by pruning old trees. One block of old trees was observed in which several rows received a heavy thinning out of small branches. The fruit which came from them seemed very little better from the standpoint of size, amount of limb rub and color than that which came from unpruned trees in the same orchard. Evidence from other sources, however, indicates that some improvement in size is effected by judicious pruning.

Spraying:—The control of scab obtained by a grower in a "scab year" is a good index to the effectiveness of his spraying. In 1924, a "scab year", 11 per cent of the B-grade fruit and 16 per cent of the cull fruit was placed in those grades because of scab. However, some growers produced fruit less than one per cent of which was affected by this disease. This proves that commercial control is possible and indicates that many growers are falling short when it comes to effective spraying. This ineffectiveness is due to several things. In the first place, it is impossible to obtain satisfactory results with inadequate equipment for timeliness of application is of the utmost importance in pest control. A number of the 24 orchards studied were poorly equipped to carry on this essential operation. It was found that the average spraying outfit in use in these 24 orchards was 3.6 years old. There were some new ones; there were others that were six, seven, and eight years old. The old outfits in almost every case had low "rated capacities" and were often in poor mechanical condition. They might do well enough for small home plantations but too often they were found on farms where there were 20, 30, or 40 acres of orchard. Under these conditions, it is no wonder that good commercial control of insects and fungus diseases was not always obtained. Many Michigan growers could reduce materially the percentage of their culls by purchasing additional spraying equipment. It seems likely that money spent for more adequate equipment would in many cases return big dividends.

Care in handling:—An unnecessarily high percentage of the apples brought to the exchange showed handling bruises. These bruises were probably apparent on Grimes at an earlier date than upon any other variety. Bruises on this variety show up as dark spots within a few hours after the injury. Although the bruises were not so readily apparent, other varieties showed considerable bruising, and bruises on A- and B-grade fruit which escape the notice of the sorters do not escape the notice of the consumer. The producer may receive A-grade prices for some of this damaged fruit, but in the end he is penalized as much or more than he would have been had the apples gone directly into the cider barrel.

The problem of handling bruises is therefore more serious than it appears from the actual grading records, and it was decided to find in what operations most of the damage occurred. Contrary to what would be expected, it was found that apples which were hauled to the exchange in motor-driven trucks were generally more badly bruised than those which came in wagons. This led the writer to take a position along the main road leading to the exchange at a point where

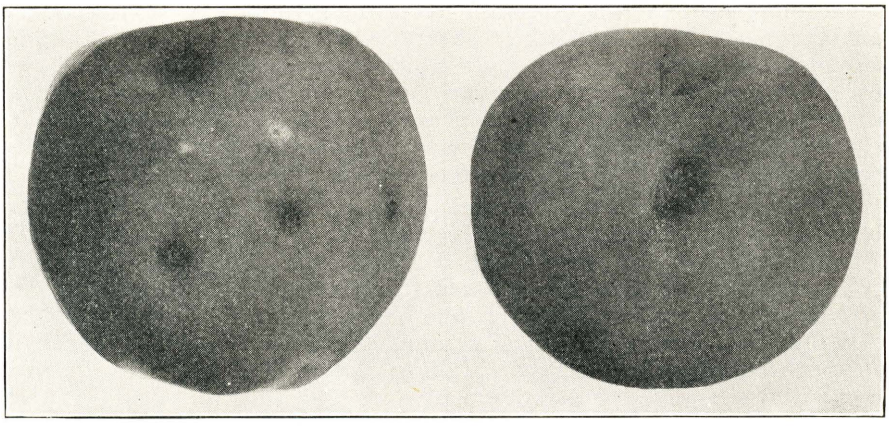


Figure 30.—The Baldwin apple (left) shows four characteristic "stings." The codling moth larva punctures the skin but does not succeed in gaining entrance to the fruit or, if it does enter, dies soon afterwards. This injury probably occured in late July. The Rhode Island Greening (right) shows the result of an early codling moth sting, resulting in an enlarged and cracked injury.

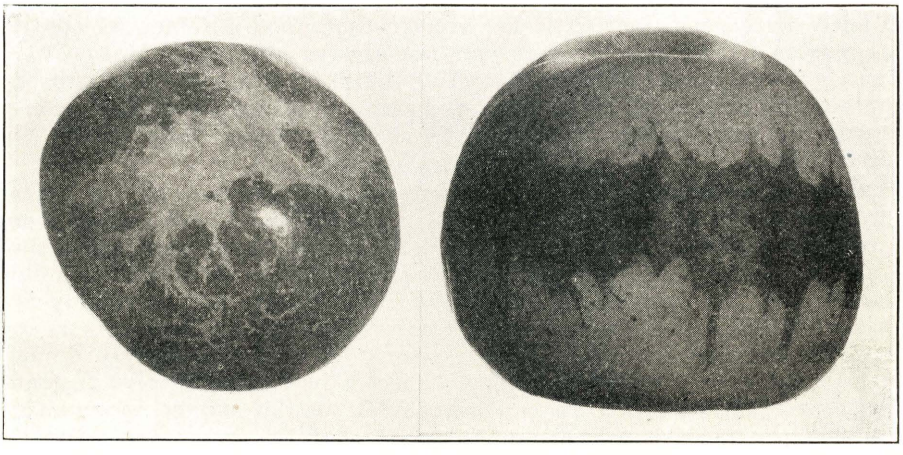


Figure 31.—The russet scar which has spread out in an irregular patch over the cheek of the Canada Red (left) is a result of frost injury which occured early in the season. The Rhode Island Greening (right) was in a more advanced stage of development at the time of frost injury than the Canada Red. The "frost ring" entirely surrounds the fruit.

there was a rough spot just between two hills. It was not long until a heavily loaded truck appeared. The driver apparently wanted to make the up-grade "on high" so, as he came down hill, he put on speed. The truck hit the bump at the bottom so hard that the heavy load of fruit forced the body of the truck down upon the axle with a heavy jar. Every apple in the load was jolted against its neighbor with enough force to make at least a slight bruise and some of those which rested against the bottom or sides of crates were probably bruised enough to break the skin.

The observer watched a number of loads go over this particular spot; most of them went over it in a way which undoubtedly did considerable damage to the fruit. Often, the crates near the top of the load would bounce as much as six inches from those just below. One driver, hauling a load of Northern Spy, one of the varieties most easily bruised, hit the rough place in the road with such impact that one of the crates bounced up about eight inches, balanced a moment on the end-gate and then fell off. This particular crate of fruit may not have been worth more than a dollar, but certainly hundreds and possibly thousands of dollars worth of fruit were damaged at this one spot in the road and this was not the only bad place in the hundred miles of highway over which the fruit brought to this exchange was carried.

One would naturally think that drivers who manifested such an apparent indifference to the condition of their loads as delivered at the packing house could not possibly be interested in the way the apples graded out or in the prices for which they sold. In these cases, however, the drivers were not transient laborers but the owners themselves, the very men who had spent their best efforts for almost a year in producing fruit that would meet the requirements of the A-grade and bring them a reasonable return for their labor. Now, because of a desire to save a little time, they step on the accelerator at a critical moment when they should be applying the brakes and in a few seconds converted their best apples into cider stock. All told, perhaps a total of an hour's time in the course of the season was saved by various drivers speeding over this particular rough stretch. The growers probably received at least one thousand dollars less for the damaged fruit than they would have. There are few single hours spent at productive labor on the farm which yield a return of a hundredth part of this amount.

It is costly to prune, fertilize, spray, and care for an orchard. Every bushel of fruit represents effort and expense; and to damage this fruit through carelessness, after it has been thinned, sprayed, brought to maturity, picked, and is on the way to the packing house, is certainly not good business. However, there can be no denying that this very thing often happens, and, unfortunately, it is too often the rule.

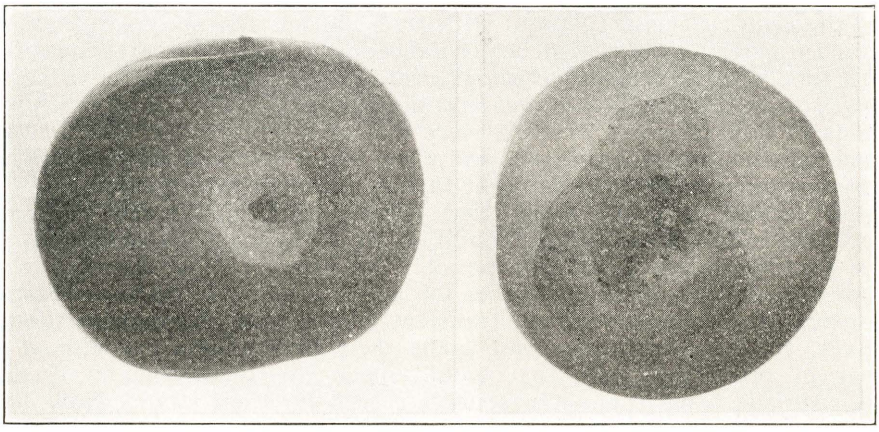


Figure 32.—The scars resulting from the feeding of several species of spring-hatched caterpillars are similar and have been referred to as fruit worm injuries. A deep pit results when a feeding apple worm penetrates to the core of the fruit (left). The most common type of apple worm scars observed are russet in appearance and are found at the stem end of the apple (right).

DISCUSSION

Theoretically it should be and probably is the ideal of the grower to produce fruit that is all A-grade. Practically, such an ideal is impossible of attainment. All he can really hope to do is approach it more or less closely. The evidence secured in this investigation indicates that at least in many orchards it is both possible and practicable to produce apples that year in and year out average 75 per cent or more A-grade. Under existing conditions in Michigan orchards, grade depends to no small extent on soil, and there are a good many commercial plantations on land that probably cannot be made to yield such a percentage of high quality fruit. About a third of the culling is due to blemishes which the best growers largely prevent by proper spraying, and another sixth is due to bruises that can be avoided by careful handling. The difference between the spraying that was done by owners of the best and poorest grading orchards, of the 24 studied, was not in materials or number of applications. The spraying differed in the thoroughness and timeliness of the applications. More equipment and greater man power made it possible for some of the orchard owners to thoroughly spray their trees at the proper time. Exact figures are not available but there is reason to believe that the cost of spraying per tree and per bushel was little, if any, higher in the good than in the poor grading orchards. Were the owners of some of the poor grading orchards to spray more effectively, it might necessitate the expenditure of some additional capital but this is to be regarded as an investment rather than an expense. It would be returned many times in the greater price received for the better grade fruit. The improvement in grading records that could be obtained by a little greater care in handling would require nothing additional in the way of equipment and involve very little extra expense. In brief, these two factors that together account for about half of the culling that is done are almost completely under the individual grower's control, and the improvement in grade that can be effected through these means is one that adds very little to production cost. It hardly needs to be pointed out that the margin of profit which may be obtained by greater care in connection with these two operations is correspondingly large.

The culling which is necessary because of poor size can likewise be reduced, though perhaps not to the same extent as that occasioned by inefficient spraying and handling. Pruning and, more particularly, thinning are useful in this connection. Deficiencies in size that are due to poor soil are more difficult to deal with effectively and economically. However, certain fertilizers, tillage, and mulching treatments which provide the trees with a more adequate nutrient and moisture supply are useful.

How far the grower is warranted in going in these directions without running the risk of having the better grades cost more than they are worth raises an involved question in orchard management. Old trees or trees on poor soil cannot be expected to yield as high grade fruit as those that because of age or soil are in a more vigorous con-

dition. The production of 60 or even 50 per cent A-grade fruit in one orchard may represent as great skill in growing as the production of 80 per cent A-grade fruit represents in another. For the grower whose orchard is of the first kind, seriously to attempt to raise his grade very much above 50 or 60 per cent A-grade level will prove relatively expensive and probably impracticable. Indeed it may prove as costly as it is for others to grow 20 per cent A-grade fruit when with a little extra care they could deliver a 50 per cent A-grade product to the packing house.

These statements are not made to encourage the production of low grade fruit. The evidence here presented shows that a considerable percentage of the fruit now going into the B- and cull grades can be so grown and handled as to meet A-grade specifications and all this can be done with profit. On the other hand, it is equally clear that it is impracticable and unprofitable to produce more than a certain percentage of the A-grade. What the profitable percentage is varies with the orchard, its varieties, age, planting distance, and, last but not least, soil. Growers can well afford to study their own orchards from this point of view and modify or adjust their growing practices and harvesting operations accordingly.

In general, it may be said that the grading down, the culling, due to insect and fungus blemishes and handling bruises is largely preventable and comparatively costly. Perhaps, in addition to saying that it is comparatively costly, it should be said that its prevention is inexpensive, practicable, and to be recommended. Culling due to sunscald, frost, and hail is a largely unavoidable part of the hazard in fruit growing. That due to poor size is only partly under the grower's control and when and where that control is relatively inexpensive it should be exercised, otherwise not.

SUMMARY

1. In the average year, the average Michigan apple grower produces 56.5 per cent A-grade, 28.1 per cent B-grade, and 15.4 per cent cull fruit. Some growers produce fruit more than 70.0 per cent of which meets the requirements of the A-grade; some produce fruit, less than 25 per cent of which meets the requirements of the A-grade. There is ample room for the average grower to improve the quality of his product.

2. Varieties differ greatly in the way in which their tree-run product grades out. The four-year average grading records of the ten varieties studied expressed as percentages of the entire crop which met A-grade requirements were: Baldwin, 38.0; Northern Spy, 41.7; King, 46.4; Wagener, 56.0; Jonathan, 58.7; Rhode Island Greening, 59.4; Canada Red, 60.5; Grimes, 61.0; Hubbardston, 67.6 and McIntosh, 76.3.

3. During this period a bushel of A-grade apples brought the grower an average return of $1.19; a bushel of B-grade, a return of $0.79; a bushel of culls a return of $0.20.

4. The most common causes for low grade apples in the order of their importance were: size, limb rub, handling bruises, stings and apple scab.

5. Certain of these factors were of relatively greater importance with some varieties than with others. Lack of size led to relatively more culling with the Baldwin than with King; limb rub was especially serious on Rhode Island Greening; and handling bruises were very common on Northern Spy.

6. Improvement in certain orchard practices, notably spraying, will reduce the losses caused by diseases and insects.

7. Thinning, pruning, and greater attention to soil management methods will result in some increase in size, though, under existing conditions, it will be found impracticable to try fully to compensate for soil deficiencies.

SUPPLEMENT

Michigan Apple Grades

MICHIGAN "A". Each apple shall have good color for the variety. Apples must not be less than two and one-half inches in diameter except as otherwise provided; not more than ten per cent may be below the color requirement, and not more than ten per cent below grade requirements for other defects. Apples that conform to MICHIGAN A grade (excepting minimum size requirement) and which are sized to within one-half inch in variation may be marked "MICHIGAN UNIFORM A."

B GRADE. Shall consist of one variety, which are firm, handpicked, well grown, fairly well formed, ring faced, apparently free from serious damage caused by dirt, bruises, hail, disease, insects or mechanical or other means except those incident to proper packing. Each apple must be not less than two and one-quarter inches in diameter, except as otherwise provided; not more than fifteen per cent may be below the grade requirements.

Color Requirements

Solid Red Varieties, such as Arkansas Black, Gano (Black Ben Davis), King David, Spitzenburg (Esopus), Winesap, and other solid red varieties shall have thirty-three and one-third per cent for Michigan "A".

Striped or Partial Red Varieties, such as Alexander, Delicious, Fameuse (Snow), King (Tompkins), Jonathan, Red Canada (Steele Red), and Stayman, shall have twenty-five per cent for Michigan "A". Baldwin, Ben Davis, McIntosh, Northern Spy, Rome, Wagener, Wealthy, and York Imperial shall have fifteen per cent for Michigan "A". Gravenstein, Hubbardston, Oldenburg (Duchess), Twenty-Ounce, and Wolf River, ten per cent for Michigan "A".

Red Cheeked or Blushed Varieties, such as Maiden Blush, Winter Banana, and other red cheeked and blushed varieties, shall have a tinge of color for Michigan "A".

Yellow, Russet, or Green Varieties, such as Rhode Island Greening, Golden Russet, Newtown Pippin (Albemarle Pippin), Tolman Sweet, Grimes Golden, and other yellow, russet, or green varieties, shall have characteristic color.

Definition of Terms and Sizes

"Well grown" means mature, but not over-ripe. Mature means having reached the stage which will insure the completion of the ripening process.

"Well formed" means characteristic shape of the variety.

"Fairly well formed" means not to cause more than ten per cent additional waste in paring them than "well formed."

"Free from serious damage" means that no defects materially deform or discolor the fruit or injure its keeping quality. Scab, spots, fruit spots, or other defects exceeding an aggregate area of one-half inch in diameter shall be considered serious damage.

The words "closed container", as used in this act, shall be construed as a basket, box, barrel, or any package the contents of which cannot be inspected when prepared for market.

Such apples as Red Astrachan, Yellow Transparent, Chenango, Maiden Blush, Black Gilliflower, Grimes, Jonathan, Fameuse, King David, Spitzenburg, Tolman Sweet, Red Canada, and Golden Russet shall not be less than two and one-quarter inches in diameter in Michigan "A" grade or two inches in Michigan "B" grade.

ACKNOWLEDGEMENTS

The writer is indebted to Messrs. V. R. Gardner and R. E. Marshall, of the Department of Horticulture, for many helpful suggestions and criticisms during the progress of the work and in the final preparation of this paper. Sincere thanks are due also, to the officers of the Fennville Fruit exchange, Messrs. J. A. Barron, E. F. Paine, J. E. Bale and W. W. Post, who facilitated in many ways the work of collecting the data on which this paper is based.