Spray Injury Studies. II. Secondary Effects of Spray Injury To Apple Foliage
Michigan State University Agricultural Experiment Station
Special Bulletin
W.C. Dutton, Horticulture
Issued February 1932
37 pages

Special Bulletin No. 219 February, 1932

Spray Injury Studies II

SECONDARY EFFECTS OF SPRAY INJURY TO APPLE FOLIAGE

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SPRAY INJURY STUDIES II

Secondary Effects of Spray Injury to Apple Foliage

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The seriousness of injury by spraying materials to apple foliage must be judged by its effect on fruit-set, blossom-bud formation, wood growth, and spur formation, and on the development of fruit of desirable size, color, and quality. The effect of certain insecticides and fungicides on several of these functions has been studied in investigations with spraying materials. Most of these studies were made in orchards at Morrice and Belding. Descriptions of the orchards, methods and timing of applications, descriptions of materials and other general information have been presented in another publication (1) which also contains a comprehensive discussion of the types and amounts of injuries to foliage and fruit that may result from the use of several spraying materials. Data concerning the cumulative effects of spray injuries to apple foliage are presented in this report.

FRUIT-SET

Studies (8) several years ago showed that, under Nova Scotia conditions, lime-sulphur often seriously affected the set of apples to such an extent that yields were greatly reduced. Parrott and Schoene (7) reported considerably earlier that a summer application of lime-sulphur and lead arsenate had caused fruits to drop. Morse and Folsom (6) and Howlett and May (3) have also reported similar effects. Studies were begun in Michigan in 1924 to determine the relation of spraying materials to fruit-set. In most of these studies, three counts were made; first, when the buds had separated in the clusters or during the blooming period, to determine the original number of blossoms; second, after the first drop which usually occurs soon after the blooming period; and third, after the second or June drop to determine the final set.

Normal Spraying—The results to be considered first are from experiments in which the spraying was done in what is arbitrarily called a "normal" manner. This spraying was done with single nozzle spray guns, with pressures from 300 to 350 pounds and with the dosage such that the trees were thoroughly wet but not drenched. The spraying was done from the outside of the tree and in no instance from under the tree. In 1924, at Morrice (Table 12) the final set on Jonathan with lime-sulphur sprays (Plots 1, 2, and 3) was 13, 11, and 24 per cent; with dry mix and colloidal sulphur, which are free sulphur materials (Plots 4, 5, 6, and 7), the set was 20, 25, 22, and 15 per cent; and with bordeaux

(Plot 8) it was 18 per cent. On Hubbardston, with the lime-sulphur sprays, the set was 8, 7, and 7 per cent; with the free sulphur sprays, 6, 10, 11, and 10 per cent; and with bordeaux, 7 per cent. There was a definitely lower set with Hubbardston than with Jonathan but the differences between materials with Hubbardston are not consistent. With Jonathan, the average set for all plots is 16, 18 and 20 per cent respectively for lime-sulphur, bordeaux and free sulphur materials. The same bordeaux plots (Table 13, Plots 16 to 21) and another set of lime-sulphur plots (Table 13, Plots 10 to 15) show an average set of 18 per cent for bordeaux and 6 per cent for lime-sulphur. The first set of figures certainly do not show significant differences; in the latter the differences may be significant but the lowest set (6 per cent) is ample for a crop.

In 1925, at Morrice (Table 14), the final set on Jonathan sprayed with lime-sulphur (Plots 2, 3, 4, 5, 6, 7, and 8) was 3.7, 3.3, 2.8, 3.6, 1.3, 4.3, and 3.7 per cent. With bordeaux, the final set was 2.9 per cent (Plot 9). In the same year, the set on Hubbardston with the lime-sulphur sprays was 4.1, 1.9, 1.0, 2.7, 0.9, 1.4, and 3.0 per cent and was 2.7 per cent with bordeaux. There are certainly no significant differences here.

At Morrice again, in 1926, (Table 15) Jonathan set, with the lime-sulphur sprays (Plots 2, 3, 4, 5, 9, and 11), 4.0, 3.3, 5.5, 3.1, 2.0, and 4.0 per cent and with bordeaux (Plot 10) the set was 1.0 per cent. Hubbardston, with the lime-sulphur sprays, set 2.5, 1.3, 2.4, 3.2, 2.5, and 2.9 per cent in comparison with 1.6 per cent for bordeaux. Again the results are similar.

Fruit-set records were taken with Jonathan again at Morrice in 1927 (Table 16). With the lime-sulphur sprays (Plots 1, 2, 7, and 9), the final set was 7.9, 17.3, 13.0, and 5.3 per cent. Bordeaux sprayed trees (Plot 10) set 7.2 per cent and with lime-sulphur and aluminum sulphate (Plot 8), a spray developed in Nova Scotia, there was a set of 7.1 per cent which is well within the range of the plots receiving lime-sulphur sprays. There are no indications here that lime-sulphur has reduced the set of fruit.

Similar records are available for McIntosh and Baldwin at Belding. In 1925 (Table 17), the lime-sulphur sprayed trees of McIntosh (Plots 2, 3, 4, 5, and 6) set 7.3, 5.5, 5.3, 3.0, and 1.1 per cent. The plots with 3.0 and 1.1 per cent were on lighter soil than the other plots. The set with bordeaux (Plot 1) was 7.2 per cent. Baldwin, with bordeaux, set 19.5 per cent and the lime-sulphur plots had a final set of 19.0, 21.8, 15.9, 21.3, and 13.9 per cent. In 1926, with McIntosh (Table 18), the bordeaux sprayed trees set 4.1 per cent as compared to 3.0 and 3.7 per cent for lime-sulphur sprays (Plots 4 and 7). Fruit-set records are available for both varieties in 1927 (Table 19). With lime-sulphur (Plot 3) the set was 7.6 per cent, and with bordeaux (Plot 1) it was 6.1 per cent for McIntosh. On Baldwin, the set with lime-sulphur was 6.1, and with bordeaux it was 11.3 per cent. The results with McIntosh and Baldwin show that the set on trees sprayed with bordeaux and lime-sulphur were not significantly different.

This evidence indicates that there are not consistent and significant differences in fruit set with different spray treatments under Michigan conditions with "normal" spraying and when no unusual conditions prevail.

Data are available in several instances, however, where the dosage was very heavy or even excessive, where the method of application was different, or where some unusual condition prevailed.

Unusual Conditions—In 1929, at Belding, the spraying was done in the usual normal manner but at the time of the petal-fall and two weeks applications conditions were very favorable for lime-sulphur burn, and the susceptibility to injury was increased by the tenderness of the foliage and by considerable scab on the foliage. There were marked differences in fruit-set on Baldwin. The counts were made in the late summer and show the percentage of blossomnig spurs that had fruit persisting on them. Counts were made for two classes of spurs, on two and three year old wood and on older wood. Full details of materials and results are presented in Table 20, and are shown more concisely in Table 1.

Table 1.—Fruit-set on Baldwin, 1929.

Plot	Materials	Spurs with fruit (per cent)	
		On 2 and 3 year old wood	On older wood
1	Bordeaux	46	20
3	Lime-sulphur	20	7
4	Lime-sulphur Iron sulphate	19	4

These data show marked differences in fruit-set and they could not be traced to any influence other than the severe injury resulting from the use of lime-sulphur under unfavorable conditions. Since bordeaux sprayed trees bloomed heavier than those in Plots 3 and 4, it cannot be said that they had a higher percentage of set because of light bloom.

Unusual or abnormal conditions prevailed also at Belding with Mc-Intosh in 1926. The experimental block was located in a 100 acre orchard and the experimental spraying was done in the usual "normal" manner. Lime-sulphur was used, as indicated in Table 18, at the rate of 2½ gallons in 100 gallons of spray with the addition of two pounds of lead arsenate. The prepink, pink, petal-fall, and two weeks applications were made as usual with the rate of application such that the trees were well covered but not drenched. In other parts of the same orchard, where the spraying was done by the regular orchard crew, lime-sulphur was used at the rate of three gallons with water to make 100 gallons and with 2½ pounds of lead arsenate. The dosage was very heavy and six applications were made during the same period that four were applied to the normally sprayed plot. Fruit-set was determined in July after it had been observed that there was an excessive June drop from the heavily sprayed trees. The number of apples per 100 blossoming spurs is shown in Table 2.

Table 2.—Fruit-set on McIntosh, 1926.

	Method of Spraying	
	Normal	Excessive
Apples on each 100 spurs	74	44

Of interest in this connection is the relative leaf area per spur for the two treatments. The numbers of leaves persisting and the total leaf areas per spur at the time of the June drop are shown in Table 3.

Table 3.—Leaf area with normal and heavy spraying.

	Method of Spraying	
	Normal	Excessive
Leaves per spur (average)	8.3	6.8
Size of leaves (average)	12.8 sq. cm.	7.3 sq. cm.
Leaf area per spur (average)	106.2 sq. cm.	50.4 sq. cm.

The data presented in Tables 2 and 3 show a definitely heavier June drop with the excessive spraying and a positive correlation between leaf area and fruit set. It is doubtful whether the excessively sprayed leaves were so effective per unit of area as those normally sprayed. If this is true, there was a greater difference in the functioning of the two groups than is indicated by the leaf areas. The extent of the drop with the excessive spraying was not so great but that it might be considered as a rather severe thinning but the grade of the fruit was materially lowered because of severe russeting and poor color.

At Morrice, in 1924 (Table 13), in the "special methods" experiment where lime-sulphur and bordeaux were used at widely different concentrations and dosages there were no consistent and significant differences in fruit-set between the various amounts of lime-sulphur and bordeaux, but the average for the bordeaux plots was 18 per cent as compared to 6 per cent for lime-sulphur.

In 1923, at Beulah, Benzie county, records were obtained from Baldwin trees in a mature orchard where part of the trees had been sprayed with lime-sulphur and lead arsenate and part with bordeaux and lead arsenate.* The spraying had been done from the ground and was applied outward and upward from under the trees and then from outside

*An experiment carried on by H. A. Cardinell of the Horticultural Department, Michigan State College.

the tree. The dosage was heavy. It was a crop year for all the trees and there was uniformly heavy bloom. A heavy drop of leaves and fruit occurred after the two weeks application. Fruit and leaf counts were made in two portions of the trees; first, around the outside of the tree where there was full exposure to light; and, second, on the inside of the tree where the light exposure was not so good and where the effects of the "inside" spraying were greatest. Fruit-set counts were made only on spurs that bore blossoms that season and the leaf-counts only on spurs that had not borne blossoms that year.

Table 4.—Fruit-set and leaf-fall on Baldwin at Beulah, 1923.

Fruit	Lime-sulphur		Bordeaux	
	Inside	Outside	Inside	Outside
Spurs with fruit persistent (per cent).......	18	56	57	74
Average number apples on these spurs......	1.06	1.11	1.16	1.22
Apples per 100 spurs......................	19	62	66	90
Average number leaves per spur............	3.6	4.2	4.7	5.1

These data show for lime-sulphur sprayed trees a much smaller percentage of spurs with persisting fruit and slightly fewer apples per spur than for bordeaux sprayed trees. These two factors considered together make for the extreme differences in the apples per 100 spurs. In this connection, there are two outstanding facts; first, spurs on the outside of the trees with both treatments show a much heavier set of fruit than spurs on the inside of the trees; and, second, there was a much lighter set with lime-sulphur than with bordeaux. Comparing inside spurs, there were 19 apples with lime-sulphur and 66 with bordeaux; and comparing outside spurs, there were 62 apples with lime-sulphur and 90 with bordeaux. The number of persisting leaves is more or less correlated with the number of apples found. The fruit on the lime-sulphur sprayed trees was larger than with bordeaux, as the greater June drop amounted to a good thinning but unfortunately the effect of the lime-sulphur injury did not stop at that point. In the succeeding year (1924), neither group of trees bloomed to any extent, but, in 1925, the trees that were sprayed in 1923 with lime-sulphur bloomed only lightly while the bordeaux trees bore the expected heavy bloom. This is obviously an instance of too much lime-sulphur where both dosage and method of application were contributing factors.

The general conclusion is that lime-sulphur usually does not affect significantly the set of apples under Michigan conditions but under unusual conditions the June drop may be increased. Concentration of material and frequency of application or, in other words, the amount of lime-sulphur applied and the method of application, seem to be important factors. Excessive injury due to susceptible foliage or unfavorable weather conditions may also be important. Large amounts of lime-sulphur do not, however, necessarily mean that an excessive drop will occur.

Blossom-bud Formation—The effect of foliage injury on the formation of blossom buds is an important measure of the seriousness of foliage injury. In 1924, at Morrice, Jonathan, Wagener, and Hubbardston trees were sprayed as shown in Table 13. Leaf-fall records for Hubbardston show losses of 23 and 35 per cent respectively for the light and moderate applications of weak lime-sulphur. The loss on unsprayed trees was 23 per cent. The losses with moderate and heavy applications of strong lime-sulphur were 63 and 76 per cent. Light and moderate applications of weak bordeaux were followed by only 14 and 21 per cent of leaf-fall. There are, thus, three groups. In two, there was no injury of consequence while in the third defoliation was severe. Leaf records are not available for Jonathan but the condition was similar to that with Hubbardston.

The proportion of spurs bearing blossoms in the spring of 1925 is shown in Table 5. Since the Jonathan trees bore little fruit in 1924, the production of that year was not considered in making these counts. Production records for Hubbardston for 1924 are available and the counts shown are for trees that bore no crop or only a light crop that season. The counts were made on spurs borne on wood two to six years old.

Table 5.—Leaf-fall and blossom-bud formation, Morrice, 1925.

Extent of injury	Spurs with blossoms (per cent)	
	Jonathan	Hubbardston
Injury slight (lime-sulphur)	58	35
Injury severe (lime-sulphur)	14	22
Injury slight (bordeaux)	51	48

There were differences of consequuence between slight and severe injury. The leaf losses indicated in the preceding paragraph were for the entire season but leaf-fall in the severely injured plots was less on September 3 and much less on August 5 than indicated for the entire season in Table 13. Inasmuch as blossom bud differentiation usually begins in July, it is hardly probable that the leaf-fall that had occurred up to August 5 could account for the difference in blossom bud formation. A probable explanation is that the functioning of the leaves, prior to August 5, had been seriously impaired.

At Belding, beginning in 1923, one group of trees was sprayed each year with bordeaux and lead arsenate and another group with lime-sulphur and lead arsenate. At Morrice, one plot was sprayed each year with bordeaux and lead arsenate from 1925 to 1930, inclusive, and an adjacent plot with lime-sulphur and lead arsenate. The foliage conditions were always much better in the bordeaux plots than on trees sprayed with lime-sulphur and a concise record of the numbers of persisting leaves in late summer is presented in Table 6.

Table 6.—Comparative foliage condition with bordeaux and lime-sulphur.

Year	Leaves persistent on spurs in late summer							
	Jonathan		Hubbardston		Wagener		Baldwin	
	Bordeaux	Lime-sulphur	Bordeaux	Lime-sulphur	Bordeaux	Lime-sulphur	Bordeaux	Lime-sulphur
1924	....	....	5.8	4.5	4.0	2.6	....	....
1925	7.7	4.6*	6.5	4.9*	....	....	5.7	4.9
1926	6.6	5.0*	6.9	4.6*	....	....	4.8	4.5
1927	5.0	2.7*	....	....	....	....	4.4	1.8
1928	6.2	3.3*	6.5	4.7*	3.1	1.6*	3.6	2.4
1929	3.8	2.3*	4.3	2.4*	3.7	1.3*	3.9	1.2
1930	4.9	4.1	....	....	....	....	....	....

*Average of two plots.

The proportion of spurs bearing blossoms on Baldwin at Belding is shown for two groups of spurs (Table 7); first, the "younger" spurs on wood of 1923 to 1927; and, second, the "older spurs" on wood of 1922 and older. These records were made in 1929.

These data show a slight difference for 1923 which was a crop year, but there were few blossoms present with either treatment in 1924 as might be expected after a full crop in 1923. In 1925, however, a full crop would normally be anticipated but the lime-sulphur sprayed trees produced relatively few blossoms while the bordeaux sprayed trees were full of bloom. Neither plot produced much in 1926 but both bore satisfactory bloom in 1927 although the bordeaux plot bloomed more heavily. Since 1928 was an off year, little bloom was borne; but, in 1929, trees under both treatments produced bloom adequate for a full crop but with considerably heavier bloom on older spurs in the bordeaux plot. The set of fruit, however, was very poor on lime-sulphur sprayed trees. This has been discussed under the heading of "Fruit-set." The actual production of fruit will be shown in a succeeding paragraph. The amounts of bloom borne each year with the two treatments are shown graphically in Figure 1.

Table 7.—Blossom-bud occurrence on spurs on Baldwin at Belding.

Year	Spurs blossoming (per cent)			
	Lime-sulphur		Bordeaux	
	Older spurs	Younger spurs	Older spurs	Younger spurs
1923	47	....	54	....
1924	5	....	8	....
1925	5	0.5	47	9
1926	0.3	1	1	1
1927	54	43	72	57
1928	2	2	4	5
1929	61	49	81	41

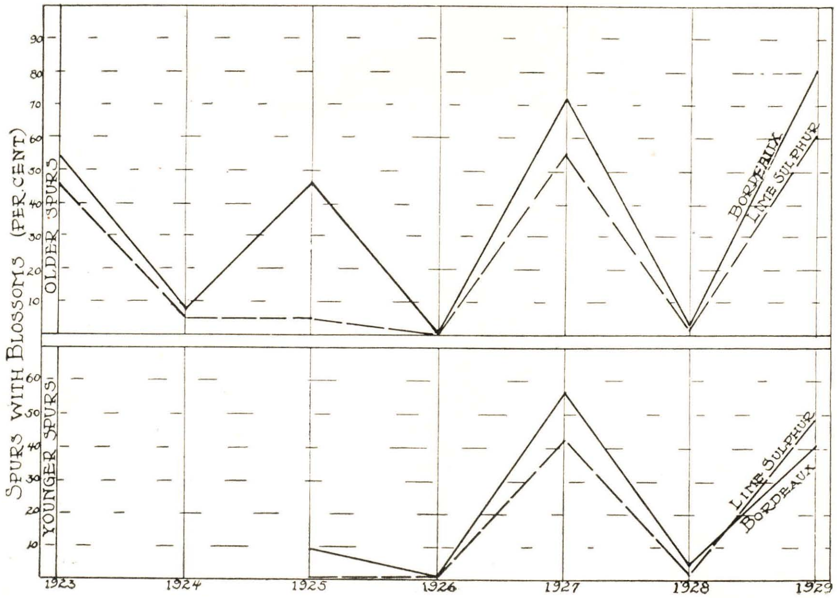

Fig. 1.—Spur performance with Baldwin.

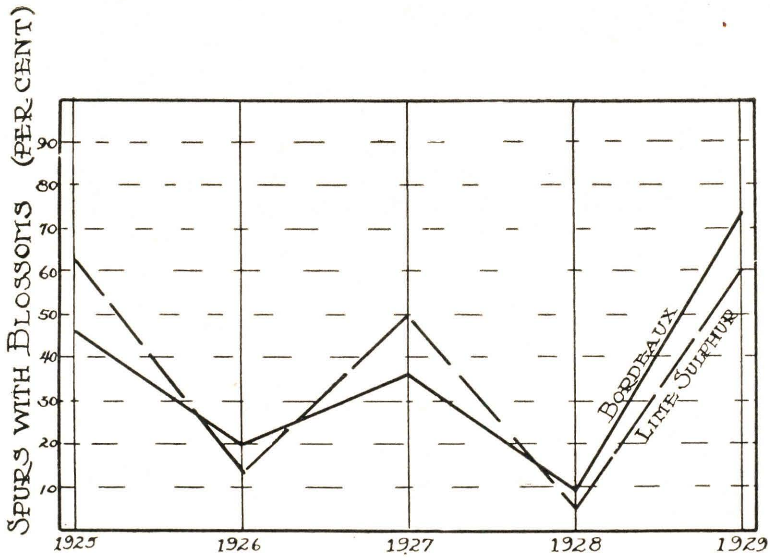

Fig. 2.—Spur performance with Jonathan.

The relation of the continuous use of lime-sulphur and bordeaux to blossom-bud formation with Jonathan and Wagener, at Morrice, is shown in Tables 8 and 9 and Figures 2 and 4.

Table 8.—Blossom-bud occurrence on spurs of Jonathan at Morrice.

Year	Spurs bearing blossoms (per cent)	
	Lime-sulphur	Bordeaux
1925	62	47
1926	14	20
1927	50	37
1928	6	5
1929	60	74

Table 9.—Blossom-bud occurrence on spurs of Wagener at Morrice.

Year	Spurs bearing blossoms (per cent)	
	Lime-sulphur	Bordeaux
1925	2	6
1926	21	44
1927	15	9
1928	10	59
1929	45	38
1930	2	48

With Jonathan, there were no differences of consequence at any time but, with Wagener, the differences were marked. In 1925, the first year of this treatment, there was practically no bloom in either plot and this, of course, was not due to the spray treatment that year. During the period of 1926 to 1930, the averages of spurs bearing blossoms were 18 and 40 per cent, respectively, for the lime-sulphur and bordeaux plots.

The number of spurs present in 1930 on wood of each year is shown in Table 10 and in Figures 3 and 5.

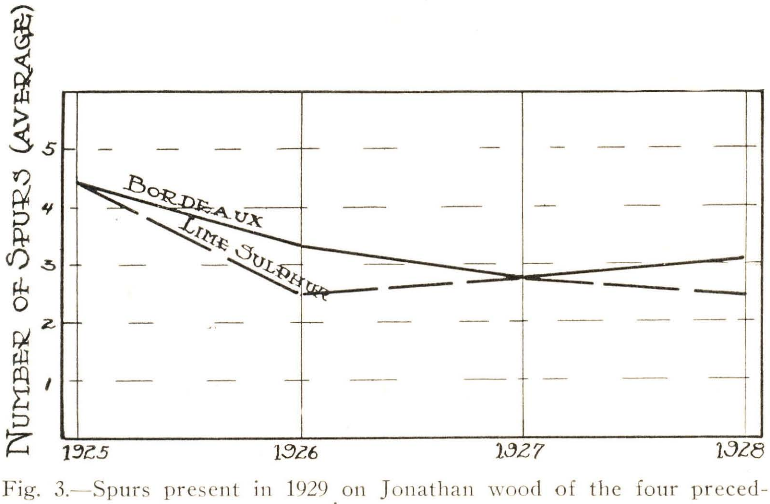

Fig. 3.—Spurs present in 1929 on Jonathan wood of the four preceding years.

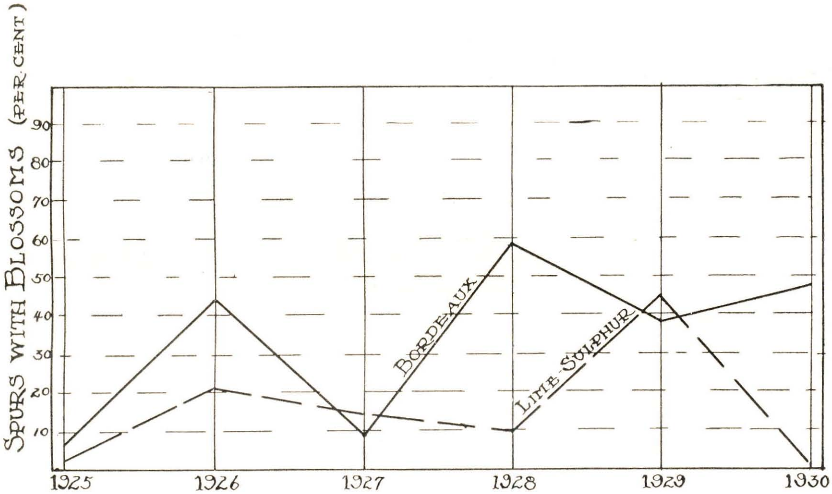

Fig. 4.—Spur performance with Wagener.

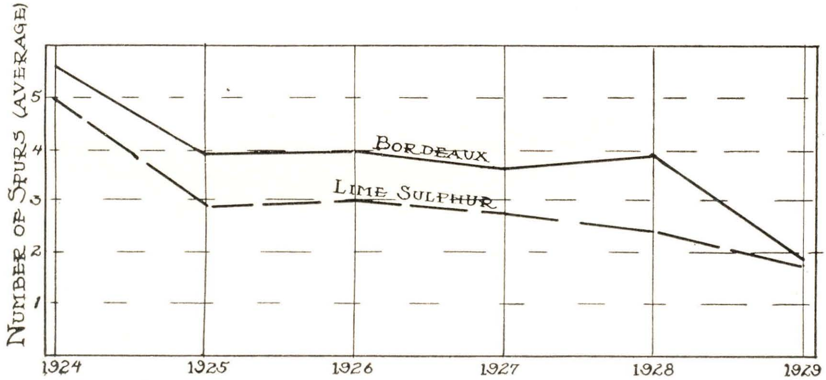

Fig. 5.—Spurs present in 1930 on Wagener wood of the six preceding seasons.

Table 10.—Spurs on Jonathan and Wagener.

Variety	Spraying Treatment	Spurs on wood of each year (average)					
		1924	1925	1926	1927	1928	1929
Jonathan	Lime-sulphur	....	4.4	2.5	2.8	2.5	....
	Bordeaux	....	4.4	3.3	2.8	3.1	....
Wagener	Lime-sulphur	5.0	2.9	3.0	2.8	2.4	1.8
	Bordeaux	5.6	3.9	4.0	3.7	3.9	1.9

Significant differences are not shown with Jonathan but there were definitely more spurs with Wagener on the bordeaux sprayed trees.

Production of Fruit—The production records for Baldwin at Belding for 1925 to 1929, inclusive, show the total yields in pounds and the amount of fruit that dropped at or just before the harvest period (Tables 23 and 24). The records for Jonathan (Table 21) show total yield and drops for 1925 to 1930 and counts for 1927 to 1930. For Hubbardston (Table 22), total yield and drops for 1925 to 1929 are shown, and partial records for Wagener are presented in the text.

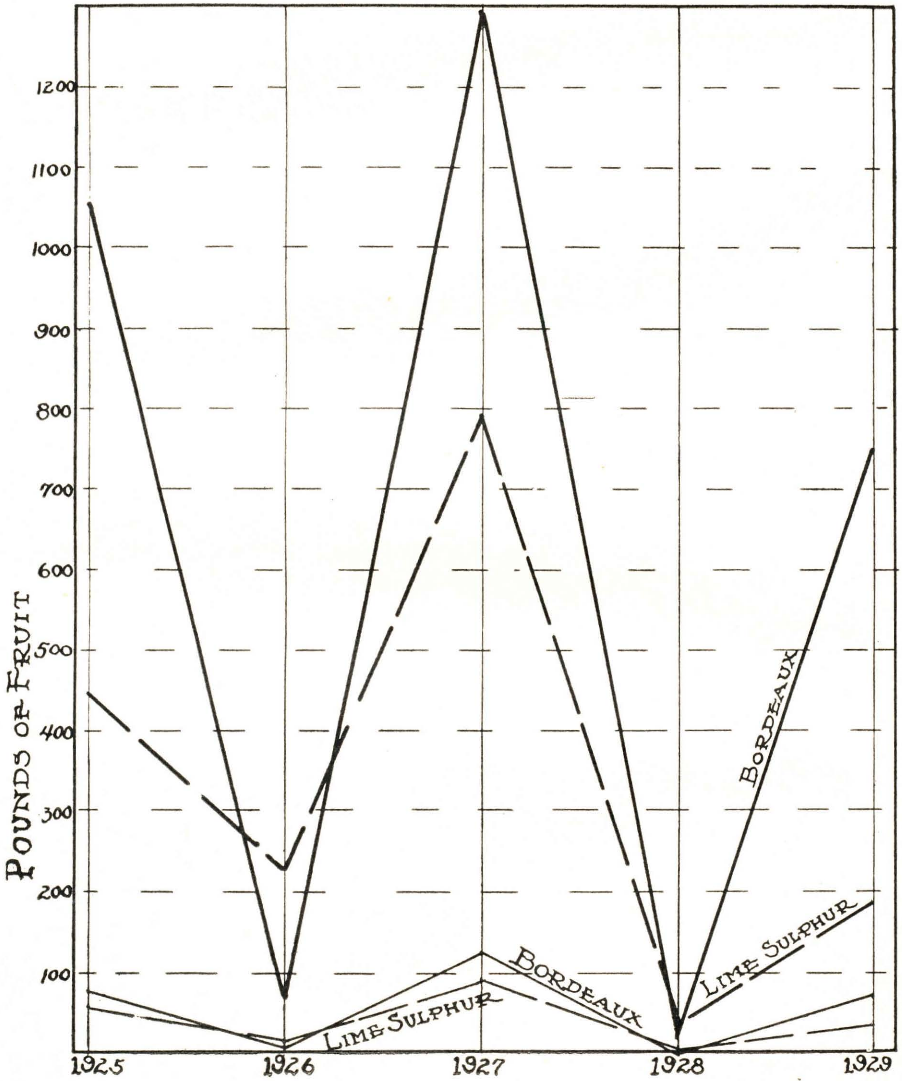

Fig. 6.—Production of fruit with Baldwin. The heavy lines show total production and the light lines at bottom show the pounds of "drops."

With Baldwin, there was a marked difference in production between the bordeaux and lime-sulphur plots. The percentages of spurs bearing blossoms in 1923 were practically the same for both treatments (See Figure 1). In 1924, neither plot carried many blossom buds and there was practically no fruit on any of the trees. In 1925, the first year for which production records were taken, the yield for the bordeaux plot was heavy with an average of 1052 pounds per tree, but was light on the lime-sulphur plot with only 449 pounds per tree. In 1926, a normal "off" year for the block, there was a tree average of 75 pounds for the bordeaux plot and 229 pounds for the lime-sulphur plot. In 1927, a "crop" year, the averages per tree were 1297 and 791 pounds, respectively, for the bordeaux and lime-sulphur plots. 1928 was another "off" year for both plots. In 1929, the trees in the bordeaux plot bloomed profusely while those in the lime-sulphur plot bore slightly less bloom but enough for a full crop. The actual production per tree in the bordeaux plot was 749 pounds while the lime-sulphur sprayed trees produced only 198 pounds each. The great difference in yield between the two plots is accounted for by the heavy June drop that occurred in the lime-sulphur plot as a result of lime-sulphur injury to the foliage in the petal-fall and two-weeks applications.

The average annual production per tree for the five-year period, 1925 to 1929, inclusive, was 645 and 341 pounds, respectively, for the bordeaux and lime-sulphur plots. The total production per tree for the same period was 3225 and 1705 pounds, respectively, for the bordeaux and lime-sulphur plots. The average annual production is shown graphically in Figure 6.

The production of fruit in Jonathan (Table 21 and Figure 7) did not vary significantly between the two treatments. The total production per tree varied 99 pounds and the average annual production only 16 pounds, the slightly greater production being in the lime-sulphur plot. The comparative results with Hubbardston (Table 22 and Figure 8) were similar to those just discussed for Jonathan.

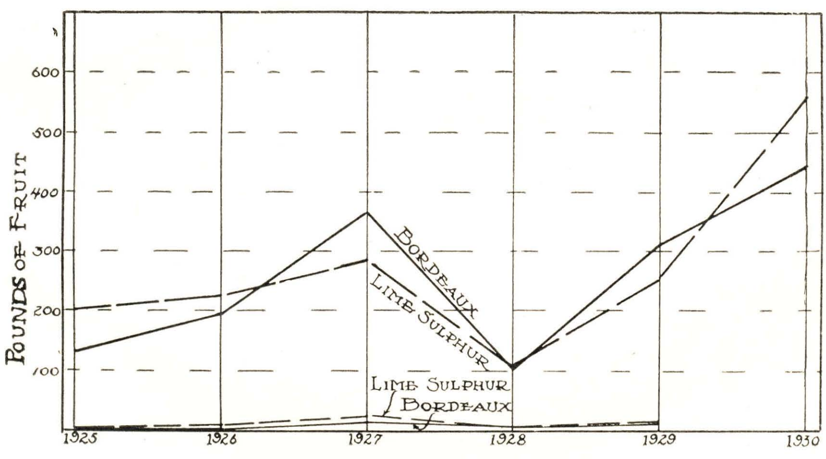

Fig. 7.—Production of fruit with Jonathan. The heavy lines show the total production and the light lines the pounds of "drops."

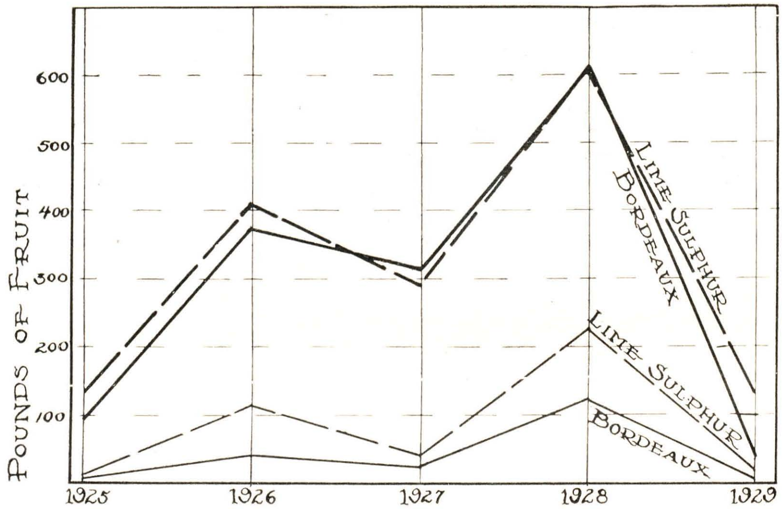

Fig. 8.—Production of fruit with Hubbardston. The heavy lines show total production and the light lines the pounds of "drops."

Production records for Wagener are incomplete, but some are available for 1928, 1929, and 1930. In 1928, trees in the bordeaux plot and in the plot sprayed continuously with lime-sulphur and iron sulphate bore much more fruit than trees in the lime-sulphur plots. In 1929 a group of lime-sulphur sprayed trees averaged 124 pounds per tree, while a group of trees in the bordeaux plot and another in the lime-sulphur and iron sulphate plot averaged 174 pounds. In 1930, the yield on certain lime-sulphur trees was again 124 pounds per tree while, on the bordeaux trees, it was 276 pounds.

Drops—The amounts of fruit that dropped just before the harvest period were recorded for Baldwin, Jonathan, and Hubbardston and are shown in Tables 21, 22, 23, and 24. No record of drops is shown for Jonathan in 1930 because a severe windstorm occurred just before harvest was begun. Figure 7, for Jonathan shows small differences between the two treatments, though the curve for the lime-sulphur plot is slightly higher in most years. With Hubbardston (Figure 8), the curve showing the absolute amount of drops is higher every year for the lime-sulphur plot. The total production did not vary greatly between the two treatments with these two varieties. With Baldwin, where there were large differences in total yield, the absolute amount of drops was larger in the crop years in the bordeaux plot but in such instances the total production was 60 to 275 per cent greater in the bordeaux plot; it was, therefore, to be expected that the absolute amount of drops would be greater.

The percentages of the total crop that dropped for each variety are shown in Figures 9, 10, and 11, respectively, for Hubbardston, Baldwin, and Jonathan. With Hubbardston (Figure 9), there was little difference in 1925 and 1929. The total production was very light in both years (Figure 8). In 1926, 1927, and 1928, when there were moderate to heavy crops; the percentage of drops was greater in every instance on the trees that had been sprayed with lime-sulphur and had suffered considerable foliage injury. With Baldwin (Figure 10), in the crop

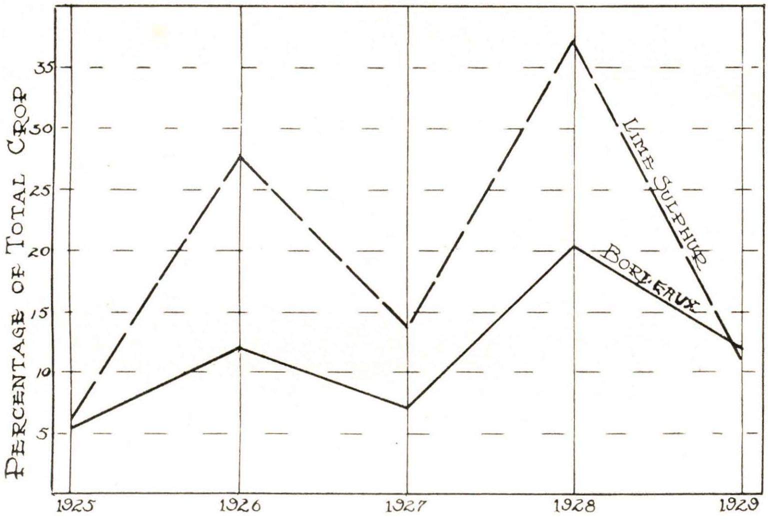

Fig. 9.—Percentage of total crop that dropped. Hubbardston.

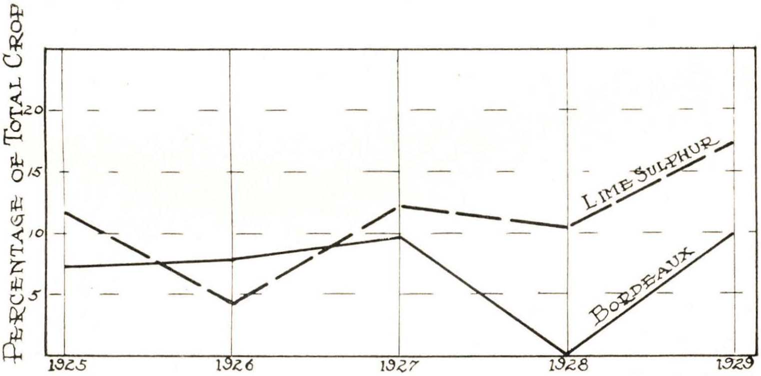

Fig. 10.—Percentage of total crop that dropped. Baldwin.

years, 1925, 1927, and 1929, the percentage of drops was higher in each instance in the lime-sulphur plot than in the bordeaux plot. The results with Jonathan are not specially significant but the percentage of drops (Figure 11) was higher with lime-sulphur in three of the four years when "drop" records are available and when there was a moderate to full crop of fruit (Figure 7). Definite records of drops are not available for Wagener but the general observation has been that on trees of this variety that were severely defoliated, the fruit did not mature normally and much of it was held tenaciously.

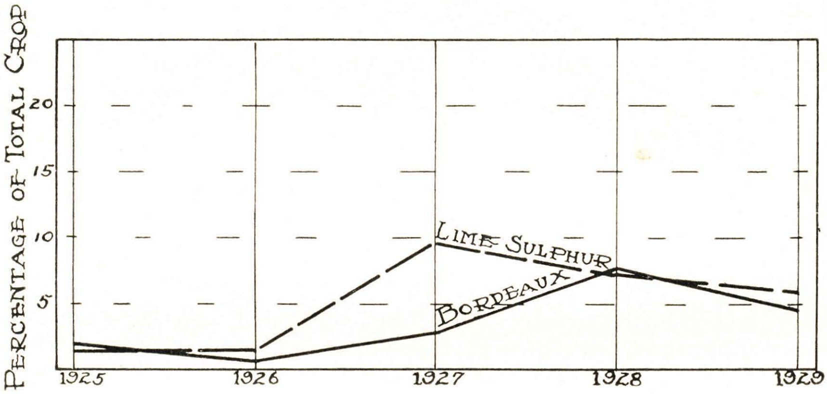

Fig. 11.—Percentage of total crop that dropped. Jonathan.

Size of Fruit—The size of the fruit was not determined in all instances but with Baldwin at Belding the fruit on bordeaux sprayed trees was usually smaller, in the heavy crop years, than on lime-sulphur sprayed trees but this could well be accounted for by the much heavier crop carried by the trees in the bordeaux plot. No records are avail-

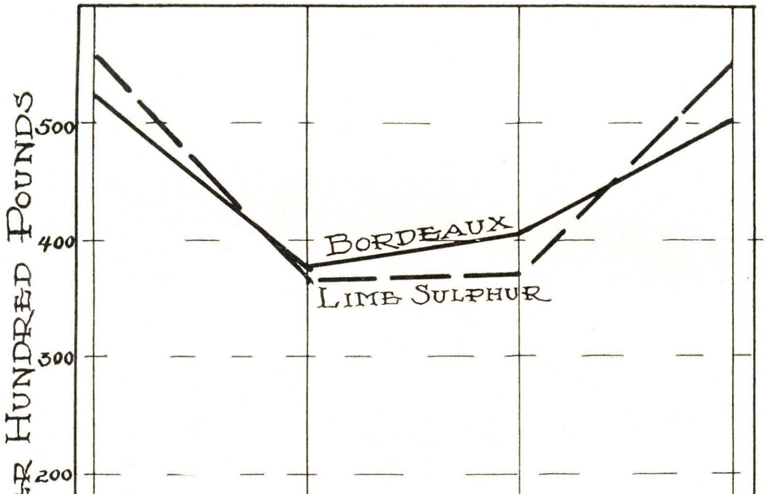

Fig. 12.—Size of Jonathan apples.

able for Hubbardston, and no differences were observed. With Jonathan, counts were made in 1927, 1928, 1929, and 1930. The counts and the number of apples per 100 pounds of fruit are shown in Table 21 and Figure 12. In 1927 and 1930, the number was slightly smaller for the bordeaux plot and, in 1928 and 1929, it was slightly smaller for the lime-sulphur trees.

The greatest difference in size was observed with Wagener. In 1928, the following differences were observed:

Lime-sulphur (2½ gals. in 100). 492 apples per 100 lbs.
Lime-sulphur and iron sulphate, 382 apples per 100 lbs.

The lime-sulphur and iron sulphate trees had much better foliage and bore more apples, which, as indicated, were larger than those from the lime-sulphur sprayed trees where there were fewer apples and fewer leaves.

In 1929 and 1930, the results were as shown in Table 11. The records

Table 11.—Size of fruit of Wagener.

Year	Spraying Treatment	Apples per tree	Pounds per tree	Apples per 100 lbs.
1929	Lime-sulphur (2½ gal.–100)	642	124	517
	Lime-sulphur and iron sulphate	745	174	428
	Bordeaux	727	174	417
1930	Lime-sulphur (2½ gal.–100)	498	124	401
	Bordeaux	1299	276	470

for 1929 show that the size of the fruit was much smaller in the lime-sulphur plot in spite of the smaller number and a lower yield in pounds. In 1930, the fruit on the trees in the lime-sulphur plot was larger than that on the bordeaux sprayed trees but the bordeaux trees were heavily loaded with fruit, as indicated by the fact that there were 1299 apples per tree as compared to only 498 for the lime-sulphur plot. The effect of the over-load of fruit on the bordeaux sprayed trees was probably accentuated by the extreme drought that prevailed.

Color of Fruit—It is very difficult to record accurately color development. Definite differences in the color of the fruit, however, have been observed frequently. This difference, in general, consisted of the delayed or non-appearance of a bright yellow ground color and of a reduced development of red pigment. The fruit on badly defoliated trees of Wagener, for example, never developed the bright red that came on fruit grown on trees with normal foliage. The red on this fruit was dull and of a bronze shade, and the ground color was green instead of yellow. The red pigment did not develop normally in spite of the fact that the exposure of the fruit to the sunlight was much greater than on trees with heavier foliage but with more highly colored fruit. It was true, of course, that on trees with the heavier foliage there was some fruit on the inside of the trees that was exposed very little to the sun and consequently did not develop much red color. These differences in color were noted, not only on Wagener, but on Hubbardston, Jonathan, McIntosh, Baldwin, and other varieties.

In most instances, there was the least satisfactory development of color with trees that lost the greatest numbers of leaves and where there was the greatest injury to those remaining. This was true with different treatments on one variety or with a uniform spray treatment on different varieties. Of the varieties studied, Wagener is probably the most sensitive to the effect of injury and Hubbardston the least and these varieties show extremes in susceptibility to many types of foliage injury. These findings seem entirely consistent with those of Magness and his co-workers (2) (4) (5) to the effect that a certain minimum amount of foliage is essential to insure satisfactory development of color, size and quality in the fruit.

It has been observed further, however, that leaf area is probably not the only factor affecting color because trees with similar crops and with approximately the same numbers of leaves present during the period when the fruit is maturing but with different amounts or kinds of spray residue on the leaves show marked differences in color. In 1930, at Morrice, with Jonathan, lime-sulphur (2½ gal. in 100) and lime-sulphur (1 gal. in 100) caused about the same leaf-fall but with the higher concentration there was much more residue on the leaves and the fruit was much duller in color. Where bordeaux was used throughout the season there was a high leaf-count and good leaf condition but the residue on the leaves was heavy and the color was not quite so brilliant as on unsprayed trees or on those sprayed with weak lime-sulphur. It is believed, but not proved, that some of this difference may have been due to a water deficiency in the leaves that were affected by the spraying material. This was the condition observed in 1930 when very severe drought conditions prevailed but in other years there has been excellent color on trees sprayed with bordeaux throughout the season or in the last application.

The color development has been excellent on trees sprayed with the lime-sulphur and iron sulphate in all early sprays and bordeaux in the last application. Very good color and finish have resulted from the use of flotation sulphur, other free sulphur sprays such as dry-mix, wettable sulphurs, and colloidal sulphurs and from calcium mono-sulphide. Good color development has followed the use of low concentrations of dry and liquid lime-sulphur.

A material that usually causes considerable injury does not do this every year or in every orchard and, in such instances, the development of color is not appreciably affected. This is especially true of the higher concentration of lime-sulphur when used on young, vigorous trees.

The development of injuries to the fruit, such as russeting by bordeaux or other materials, or of blossom-end injury such as may occur on Jonathan or other varieties following the use of a low concentration of liquid or dry lime-sulphur or of flotation sulphur, is not necessarily reflected in the development of color. It is true, of course, that color does not develop normally in such local injured areas, though the general color development may be to the highest degree.

Annual Rings—Measurements were made of the width of the annual rings of branches from trees under the two continuous spray treatments previously mentioned; lime-sulphur ($2\frac{1}{2}$ gal. in 100) with lead arsenate (2 or 3 lbs.) and bordeaux and lead arsenate. Measurements were made on Jonathan and Wagener from Morrice and Baldwin from Belding. The measurements were made on sections cut from wood

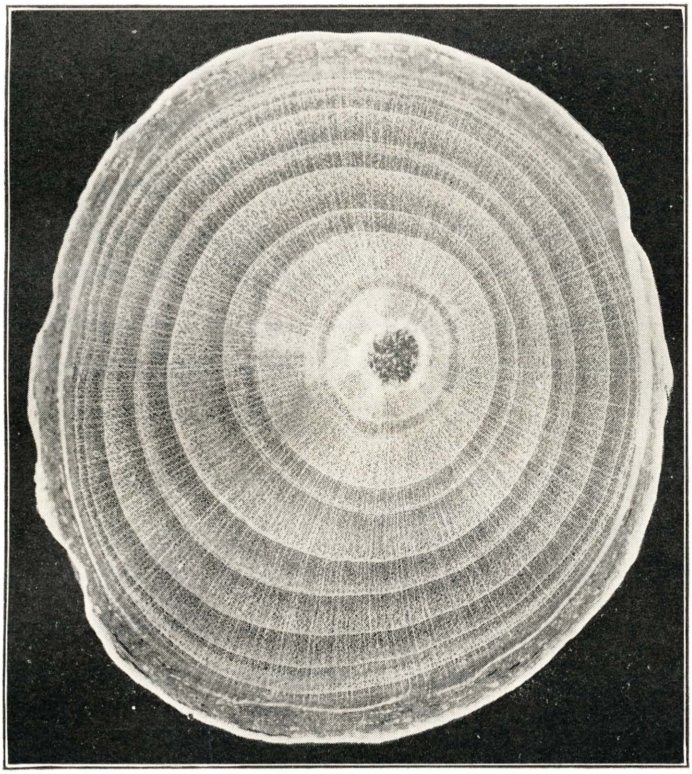

Fig. 13.—Negative print of cross section of apple branch (six diameters). Each year's growth was measured at four points.

old enough to show the annual rings indicated for each variety. These sections were made on a sliding microtome and then were stained and mounted in balsam. Negative prints (Figure 13) were made directly from these sections with a magnification of six diameters. Measurements of each ring were made, at four points, from these prints. About 50 sections for each treatment with each variety were studied. The measurements, showing the spring wood, summer wood and total growth for each ring are presented in Table 25.

With Jonathan and Wagener the spraying treatments began in 1925. The amount of spring wood with Jonathan is similar for both spraying

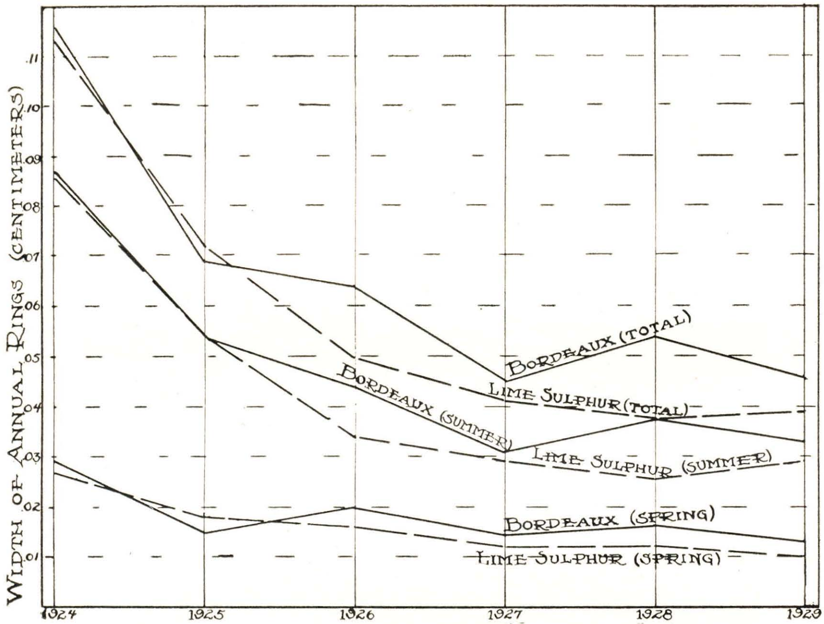

Fig. 14.—Increase in thickness of annual rings. Jonathan.

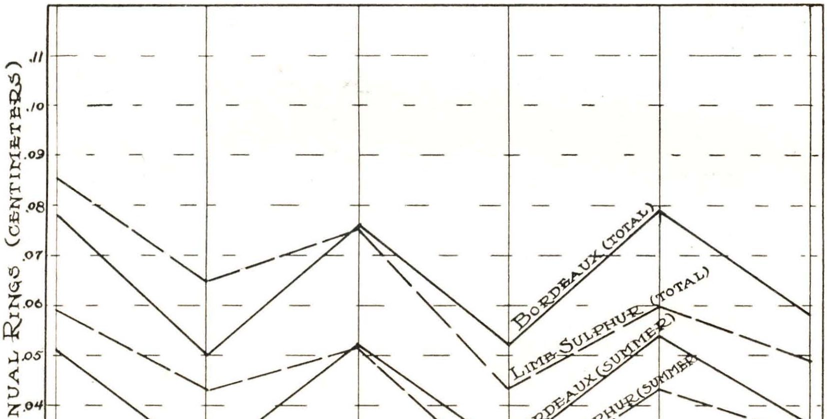

Figure 15.—Increase in thickness of annual rings. Wagener.

treatments in 1924 and 1925 (See Figure 14), but is less every year thereafter on lime-sulphur sprayed trees. The amount of spring wood on Wagener (Figure 15) averaged about the same for the two treatments in 1924 and 1925, but each year thereafter was less with lime-sulphur.

With Baldwin, the continuous use of lime-sulphur and bordeaux began in 1923 but the first growth records are for 1924. The growth of spring wood (Figure 16) is slightly less than for bordeaux in four years and slightly more in two years.

These data show that the amount of spring wood is less, in most instances, on trees sprayed continuously with lime-sulphur than on

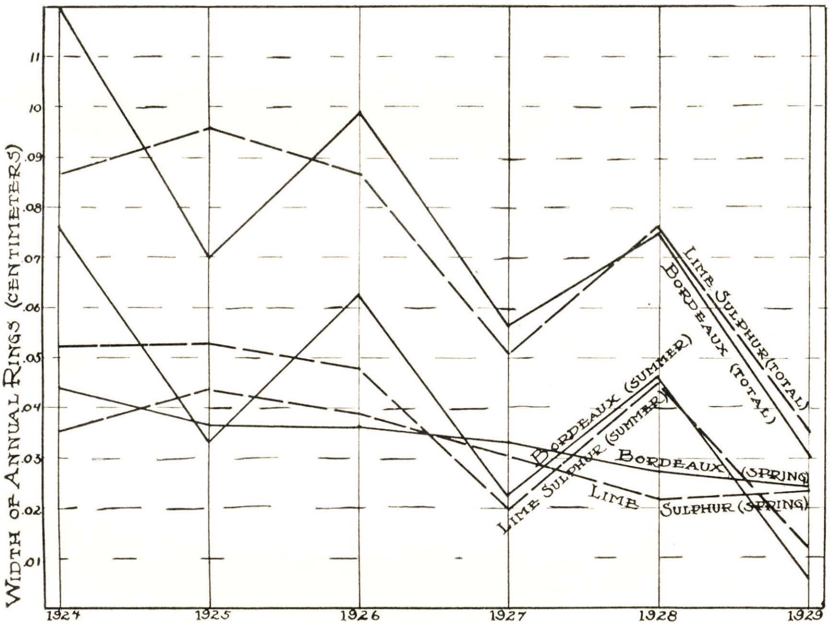

Fig. 16.—Increase in thickness of annual rings. Baldwin.

trees sprayed with bordeaux. The most significant indication, however, concerning spring wood is that it is very uniform from year to year and therefore probably is produced, in part at least, from stored foods and is not affected greatly by crop or other factors at the time it is laid down. The fact that lime-sulphur sprayed trees, that nearly always suffered considerable foliage injury, produced less spring wood in most instances may indicate that the reduced functioning of the leaves in one year is reflected in reduced wood growth early the next season because of a deficiency in stored foods. This condition, however, has not been demonstrated experimentally.

The data for summer wood present a very different condition in certain respects. First, the amount of summer wood is almost always greater than that of spring wood; second, the amount of summer wood is not uniform from year to year but varies inversely with the production of fruit; and, third, foliage injury has often caused a reduction in the amount of summer wood.

The amount of summer wood with Jonathan (Figure 14) is greater than the spring wood in every instance and the same is true of Wagener (Figure 15). With Baldwin (Figure 16), the amount of spring wood was greater than with Jonathan and Wagener, and the amount of summer wood was less than the spring wood only when there was a full crop or with the combined condition of a crop and the large deficiency of precipitation that prevailed in 1929.

The lack of uniformity in the amount of summer wood is shown with Jonathan (Figure 14) in which are shown alternate years of large and small growth and this alternation is rather definitely correlated with

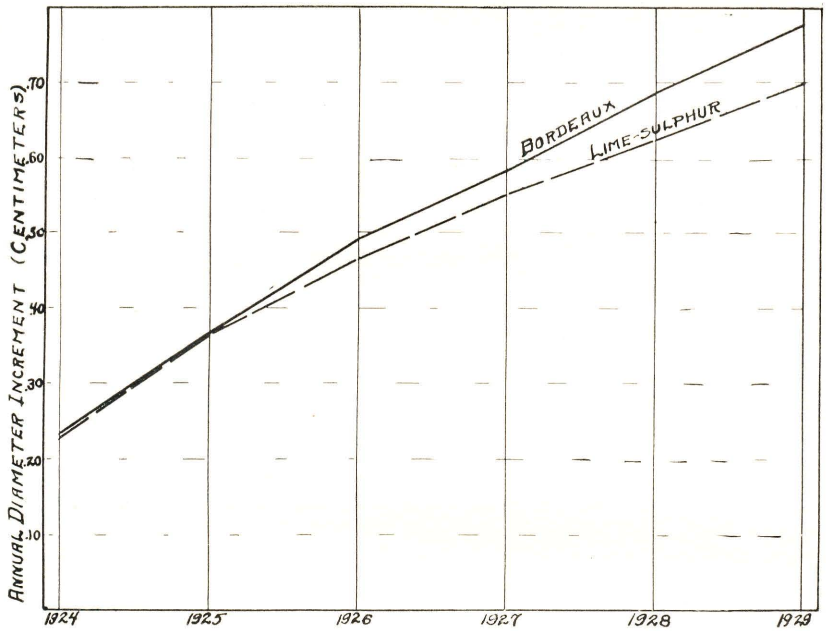

Fig. 17.—Cumulative effect of foliage injury on the increase in diameter of Wagener branches.

high and low production of fruit, the high points in the growth curve being in the year when production was relatively low. Summer wood growth likewise lacks uniformity in Wagener (Figure 15) but there is not the definite alternation that prevailed with Jonathan. With Baldwin (Figure 16), the summer wood growth in the bordeaux plot was relatively high in 1924 when there was practically no crop. In 1925, there was a heavy crop in this plot and the summer wood was low, and the same condition prevailed in 1927 and 1929 when there were full crops; but, in the other light crop years, the summer wood growth was high as in 1924. In the lime-sulphur plot, the production of fruit was irregular and the growth curve is equally irregular.

The amounts of summer wood with Jonathan and Wagener (Figures 14 and 15) are less with lime-sulphur in each year after 1925 regardless of crop. With Baldwin (Figure 16), there was less summer wood with lime-sulphur than with bordeaux in every "off" year, 1924, 1926, and 1928. In the crop years, there is some apparent irregularity. In 1925 and 1929, the summer growth was greater with lime-sulphur, but, in those years, the bordeaux trees bore heavily as compared to only light or moderate crops in the lime-sulphur plot. In 1927, when the lime-sulphur sprayed trees bore more heavily than in any other year but not so heavily as the bordeaux trees, the summer growth was slightly less than for the bordeaux trees. There is definite indication, therefore, that the amount of summer wood is reduced by the injury resulting from the use of lime-sulphur and lead arsenate at the concentration applied on these particular plots.

The cumulative effect on wood growth of foliage injury is shown for Wagener in Figure 17. The rates of growth on both lots of trees were equal in 1924 and 1925. The use of the materials studied began in 1925 and the difference in the rate of increase was greater in each succeeding year. The same general difference occurred with the other varieties studied.

DISCUSSION

The evidence here submitted indicates clearly that the secondary and cumulative effects of spray injury to apple foliage may be of more than academic importance. The combinations of materials most commonly used may cause injury. Safer combinations, that are effective, are being sought. Much injury may be avoided, however, by the exercise of good judgment on the part of the grower to adapt the generally recommended spraying treatments to fit local, varietal, and seasonal conditions. The number of applications, the rate of application, and the concentrations of materials may sometimes be varied to advantage and other materials even may be substituted. Much injury may be avoided by not spraying when conditions are favorable for the development of injury and by not overspraying.

SUMMARY

Fruit-set has not been affected under normal conditions, but under certain unusual conditions the set of fruit has been reduced. Heavy application, frequent application, high concentration, spraying heavily from under the trees, and severe lime-sulphur burn in the petal-fall or in the two weeks applications are factors that may cause an excessive loss of fruit in the June drop.

Severe injury to foliage often affects unfavorably the formation of blossom buds. Moderate amounts of injury may also cause the same result.

Production of fruit may be affected in two ways by spraying materials, by reducing fruit-set and by inhibiting the formation of blossom buds.

The premature dropping of fruit just before the harvest period is often greater where considerable foliage injury has occurred.

The size of the fruit may be affected unfavorably by serious foliage injury.

Color development in apples on trees that have suffered moderate to severe foliage injury is usually checked. The ground color is likely to remain green and the red does not develop fully.

Growth of wood, determined by measurements of annual rings, is checked where the leaf area has been reduced by spray injury.

ACKNOWLEDGEMENTS

Credit is due the owners and managers of the orchards at Morrice and Belding for their very fine cooperation. Due appreciation is extended to Messrs. George Winegar and Son of Morrice, and to Brinton F. Hall and Don Dean of Belding.

The writer has been ably assisted throughout this work by several men. Special credit is due Paul Kremmin, M. B. Hoffman, A. H. Teske, Walter Toenjes, Leland Scott, and Glenn Starcher who have helped with the spraying and in obtaining records. J. H. Waring, B. G. Sitton, Glenn L. Ricks, D. A. Byrd, and G. F. Gray have assisted in various ways. Credit is also due Director V. R. Gardner and Professor F. C. Bradford for many helpful suggestions.

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Table 12.—Experiments at Morrice, 1924.

Plot	Materials	Amount in 100 gal.	Flowers set (per cent)			
			Jonathan		Hubbardston	
			1st drop	2nd drop	1st drop	2nd drop
1........	Lime-sulphur*....................	2½ gal.	20	13	10	8
2........	Lime-sulphur*.................... Casein spreader..................	2½ gal. 1 lb.	23	11	9	7
3........	Lime-sulphur*.................... Quick lime.......................	2½ gal. 10 lbs.	28	24	8	7
4........	Dry-mix*.........................	25 lbs.	25	20	7	6
5........	Lime-sulphur* (pre-pink and pink applications).................. Dry-mix* (petal-fall, two weeks and second-brood applications)........	2½ gal. 25 lbs.	32	25	11	10
6........	Colloidal sulphur I*...............	10 lbs.	32	22	12	11
7........	Colloidal sulphur II*...............	½ gal.	24	15	12	10
8........	Bordeaux* (average of six plots shown in Table 13...............	....	25	18	9	7
9........	Check............................	....	19	9	5	5

*Lead arsenate was used, unless otherwise indicated, at the rate of 2 lbs. in each 100 gal. of spray in the pink and all succeeding applications.

Table 13.—Experiments at Morrice, 1924.

Plot	Materials	Amount in 100 gal.	Rate of application	Relative amounts active ingredients	Leaves on spurs (average)						Flowers set (per cent)			
					Hubbardston					Wagener	Jonathan		Hubbardston	
					June 1	June 30	Aug. 5	Sept. 3	Sept. 30	Sept. 30	1st drop	2nd drop	1st drop	2nd drop
9......	Check..........	....	....	....	7.8	6.3	6.3	6.2	6.0	....	19	9	5	5
10......	Lime-sulphur... Lead arsenate...	1½ gal. 1½ lbs.	Light	1	7.9	6.6	6.6	6.2	6.1	4.6	12	11	12	10
11......	Lime-sulphur... Lead arsenate...	1½ gal. 1½ lbs.	Moderate	2	8.0	6.1	6.1	5.2	5.2	3.2	9	5	9	8
12......	Lime-sulphur... Lead arsenate...	1½ gal. 1½ lbs.	Heavy	3	8.2	5.7	5.7	4.4	4.4	2.6	11	9	6	5
13......	Lime-sulphur... Lead arsenate...	3 gal. 3 lbs.	Light	2	8.2	6.2	6.2	4.8	4.6	2.1	8	5	13	12
14......	Lime-sulphur... Lead arsenate...	3 gal. 3 lbs.	Moderate	4	8.1	5.7	5.7	3.3	3.0	1.9	9	6	3	2
15......	Lime-sulphur... Lead arsenate...	3 gals. 3 lbs.	Heavy	6	7.3	5.0	5.0	1.9	1.7	0.8	5	3	9	7
16......	Bordeaux....... Lead arsenate...	2–4–100 1 lb.	Light	1	7.6	7.1	6.7	6.6	6.5	4.7	34	26	9	7
17......	Bordeaux....... Lead arsenate...	2–4–100 1 lb.	Moderate	2	7.5	6.6	6.1	6.1	5.9	4.4	19	15	12	8
18......	Bordeaux....... Lead arsenate...	2–4–100 1 lb.	Heavy	3	7.8	6.8	6.1	6.1	6.0	4.0	14	9	6	6
19......	Bordeaux....... Lead arsenate...	6–12–100 3 lbs.	Light	3	7.9	6.8	5.8	5.8	5.8	3.8	35	26	12	10
20......	Bordeaux....... Lead arsenate...	6–12–100 3 lbs.	Moderate	6	7.7	6.6	5.6	5.6	5.5	3.6	17	14	9	6
21......	Bordeaux....... Lead arsenate...	6–12–100 3 lbs.	Heavy	9	7.6	6.7	6.1	6.1	6.1	3.8	32	22	8	7

Table 14.—Experiments at Morrice, 1925.

Plot	Materials	Amount in 100 gal.	Blossoms set (per cent)			
			Jonathan		Hubbardston	
			1st drop	2nd drop	1st drop	2nd drop
1.......	Sulfocide*.................. Casein spreader.............	2/3 gal. 3 lbs.	11.7	7.9	7.5	5.7
2.......	Lime-sulphur*..............	2½ gal.	4.8	3.7	5.7	4.1
3.......	Lime-sulphur*.............. Casein spreader.............	2½ gal. 1 lb.	4.2	3.3	2.6	1.9
4.......	Lime-sulphur*.............. Quick lime..................	2½ gal. 5 lbs.	3.2	2.8	1.2	1.0
5.......	Lime-sulphur*.............. Iron sulphate...............	2½ gal. 1¼ lbs.	4.4	3.6	5.0	2.7
6.......	Lime-sulphur*.............. Cane sugar..................	2½ gal. 5 oz.	3.4	1.3	0.9	0.9
7.......	Dry lime-sulphur A*.........	8 lbs.	7.6	4.3	1.8	1.4
8.......	Lime-sulphur* (same as plot 2)	2½ gal.	5.5	3.7	3.6	3.0
9.......	Bordeaux†*.................	4–8–100	4.5	2.9	2.9	2.7
10.......	Check......................	....	1.3	1.1	5.6	3.9

*Lead arsenate was used, unless otherwise indicated at the rate of 2 lbs. in each 100 gal. of spray in the pink and all later applications.

†Quick lime was used in making this bordeaux.

Table 15.—Experiments at Morrice, 1926.

Plot	Materials	Amount in 100 gal.	Flowers set (per cent)			
			Jonathan		Hubbardston	
			1st drop	2nd drop	1st drop	2nd drop
1.......	Lime-sulphur (pre-blossom and calyx applications)* Wettable sulphur (2 weeks and second brood application)	10 lbs.	....	....	18.5	1.7
2.......	Lime-sulphur*..............	2½ gal.	22.9	4.0	18.4	2.5
3.......	Lime-sulphur*.............. Casein spreader.............	2½ gal. 1 lb.	23.7	3.3	19.1	1.3
4.......	Lime-sulphur*.............. Quick lime..................	2½ gal. 5 lbs.	23.6	5.5	14.9	2.4
5.......	Lime-sulphur*.............. Iron sulphate...............	2½ gal. 1¼ lbs.	19.3	3.1	21.7	3.2
9.......	Lime-sulphur............... Lead arsenate...............	2½ gal. 2 lbs.	20.2	2.0	19.9	2.5
10.......	Bordeaux*–†................	2–2–100	19.1	1.0	15.6	1.6
11.......	Dry lime-sulphur A*.........	10 lbs.	22.6	4.0	18.6	2.9
14.......	Check......................	....	15.0	2.1	15.7	2.4

*Lead arsenate was used, unless otherwise indicated at the rate of 2 lbs. in each 100 gal. of spray in the pink and all later applications.

†Quick lime was used in making this bordeaux.

Table 16.—Experiments at Morrice, 1927.

Plot	Materials	Amount in 100 gal.	Flowers set (per cent)	
			Jonathan	
			1st drop	2nd drop
1........	Lime-sulphur (rain water from cistern used for this plot)*..	2½ gal.	13.1	7.9
2........	Lime-sulphur (well water was used for this and all succeeding plots)*............................	2½ gal.	28.4	17.3
7........	Lime-sulphur*.................................... Iron sulphate....................................	2½ gal. 9 lbs.	23.2	13.0
8........	Lime-sulphur*.................................... Aluminum sulphate................................	2½ gal. 9 lbs.	19.2	7.1
9........	Lime-sulphur*....................................	2½ gal.	16.4	5.3
10........	Bordeaux (ortho)*................................	4 lbs.	13.9	7.2
11........	Lime-sulphur (pink applications)*................. Mulsoid sulphur (petal-fall, two weeks and second brood applications)............................	2½ gal. 8 lbs.	18.6	7.9
12........	Lime-sulphur (pink and petal-fall application)*...... Mulsoid sulphur (two weeks and second brood applications)....................................	2½ gal. 8 lbs.	13.7	7.2
13........	Check..	....	20.0	13.0

*Lead arsenate unless otherwise indicated was used in all plots at the rate of 2 lbs. in 100 gal.

Table 17.—Experiments at Belding, 1925.

Plot	Materials	Amount in 100 gal.	Flowers set (per cent)			
			McIntosh		Baldwin	
			1st drop	2nd drop	1st drop	2nd drop
1........	Bordeaux*-†................	4-8-100	20.9	7.2	53.4	19.5
2........	Lime-sulphur*.............. Casein spreader.............	2½ gal. 1 lb.	15.9	7.3	53.2	19.0
3........	Lime-sulphur*..............	2½ gal.	15.1	6.6	53.1	21.8
4........	Lime-sulphur*.............. Quick lime..................	2½ gal. 5 lbs.	13.3	5.3	55.4	15.9
5........	Lime-sulphur*.............. Iron sulphate..............	2½ gal. 1½ lbs.	9.4	3.0	49.2	21.3
6........	Lime-sulphur*.............. Cane sugar.................	2½ gal. 5 oz.	4.6	1.1	43.2	13.9
7........	Check......................	....	14.6	6.5	58.4	26.5

*Lead arsenate was used at the rate of 2 lbs. in each 100 gal. of spray in the pink and later applications.

†Quick lime was used in making this bordeaux.

Table 18.—Experiments at Belding, 1926.

Plot	Materials	Amount in 100 gal.	Flowers set (per cent)	
			McIntosh	
			1st drop	2nd drop
2.........	Bordeaux*-†.................................	2-2-100	21.8	4.1
4.........	Lime-sulphur*...............................	2½ gal.	20.0	3.0
6.........	Sulfocide*.................................. Casein spreader.............................	1½ gal. 2 lbs.	20.4	2.5
7.........	Lime-sulphur*............................... Iron sulphate...............................	2½ gal.	20.7	3.7

*Lead arsenate was used at the rate of 2 lbs. in each 100 gal. of spray in the pink and later applications.

†Made with quick lime.

Table 19.—Experiments at Belding, 1927.

Plot	Materials	Amount in 100 gal.	Flowers set (per cent)			
			McIntosh		Baldwin	
			1st drop	2nd drop	1st drop	2nd drop
1........	Bordeaux (Ortho)*..........	5 lbs.	9.3	6.1	23.6	11.3
2........	Lime-sulphur (pre-blossom and petal-fall applications)*. Dry-mix (2 weeks and second brood applications)........	2½ gal. 16 lbs.	10.5	5.1	20.8	8.1
3........	Lime-sulphur*..............	2½ gal.	12.1	7.6	19.6	6.1
4........	Lime-sulphur*.............. Aluminum sulphate..........	2½ gal. 9 lbs.	10.3	3.1	20.1	8.3
5........	Sulfocide*.................. Casein spreader.............	½ gal. 2 lbs.	8.5	5.1	23.7	8.6
6........	Lime-sulphur*.............. Iron sulphate...............	2½ gal. 9 lbs.	5.4	2.1	22.8	8.7
7........	Dry lime-sulphur A*.........	10 lbs.	7.1	3.5	17.3	8.2
8........	Dry lime-sulphur B*.........	10 lbs.	2.9	1.7	....	....
9........	Check.....................	....	10.8	3.1	24.2	8.0

*Lead arsenate was used at the rate of 2 lbs. in 100 gal. in the pink and all later applications.

Table 20.—Experiments at Belding, 1929.

Plot	Materials	Amount in 100 gal.	Spurs with fruit (per cent)	
			Spurs on	
			2 and 3 year old wood	Older wood
1.........	Bordeaux*–†.................................	2–2–100	46	20
2.........	Dry lime-sulphur A*.........................	10 lbs.	....	....
3.........	Lime-sulphur*...............................	2½ gal.	20	7
4.........	Lime-sulphur } (all applications except 2nd brood)*.. Iron sulphate } Bordeaux (2nd brood application)................	2½ gal. 1¼ lbs. 2–2–100	19	4

*Lead arsenate used with all materials.

†Lime-sulphur and iron sulphate, as in Plot 4, substituted in petal-fall appiications.

Table 21.—Production of fruit on Jonathan, Morrice, 1925 to 1930

Spraying Treatment	Tree	1925		1926		1927				1928				1929				1930			Entire period	
		Total lbs.	Drops %	Total lbs.	Drops %	Total lbs.	Drops %	Count	Apples per 100 lbs.	Total lbs.	Drops %	Count	Apples per 100 lbs.	Total lbs.	Drops %	Count	Apples per 100 lbs.	Total lbs.	Count	Apples per 100 lbs.	Total lbs.	Annual average
Lime-sulphur and lead arsenate	1	228	0.4	303	1.0	214	5.1	921	431	130	8.5	287	220	170	8.2	541	319	742	4036	543	1787	297
	2	152	1.3	124	0.8	343	9.9	1786	521	84	5.9	422	502	285	10.5	1170	421	536	3022	568	1524	254
	3	232	0.9	151	1.3	331	10.6	2028	613	20	10.0	91	453	333	6.0	1375	413	600	3927	559	1667	278
	4	297	2.0	289	5.3	312	8.3	1637	524	31	6.4	151	487	232	6.0	940	405	561	2948	524	1722	287
	5	173	1.7	113	0	183	5.5	880	481	84	8.3	376	448	92	11.9	458	498	542	2945	544	1187	198
	6	215	2.3	196	1.5	416	13.5	2041	492	111	11.7	419	377	419	6.7	1299	309	347	1642	474	1704	284
	7	114	1.7	405	1.7	227	7.5	1076	474	316	5.1	1088	343	291	1.7	1012	348	627	3243	518	1980	330
Average........	.....	201	1.5	226	1.6	289	9.3	1481	560	111	7.2	405	365	260	6.7	971	373	565	3109	551	1653	275
Bordeaux and lead arsenate	1	74	2.7	305	1.0	95	4.2	.....	.....	174	8.6	436	250	75	14.6	310	414	399	1940	487	1122	187
	2	111	1.8	224	0	334	89.0	1670	500	131	8.4	698	503	257	7.6	1050	409	386	2163	558	1443	240
	3	100	1.0	270	0.7	499	3.2	2741	549	123	5.7	228	185	525	8.7	2122	409	683	3261	478	2200	366
	4	52	1.9	110	0.9	164	1.2	689	421	140	8.6	667	466	40	7.5	160	401	421	2480	583	927	154
	5	266	1.5	207	1.0	442	3.4	2453	556	46	13.0	234	509	250	5.6	1029	411	517	2508	486	1728	288
	6	191	2.6	48	2.1	488	1.4	2481	505	9	0	43	477	475	2.7	1937	407	197	798	405	1408	234
	7	145	2.0	218	0.4	541	2.9	2835	523	97	4.1	429	443	559	.....	2232	406	495	2412	487	2055	342
Average........	.....	134	1.9	197	0.7	366	3.9	2144	522	103	7.6	390	378	311	4.4	1262	407	442	2223	503	1554	259

Table 22.—Production of fruit on Hubbardston, 1925 to 1929, Morrice.

Spraying Treatment	Tree	1925		1926		1927		1928		1929		Entire period		
		Total lbs.	Drops %	Total lbs.	Drops %	Total lbs.	Drops %	Total lbs.	Drops %	Total lbs.	Drops %	Total lbs.	Average lbs.	Drops %
Lime-sulphur and lead arsenate	1	45	11.1	492	30.0	393	16.0	650	31.2	66	13.6	1646	329	26.0
	2	307	3.9	436	17.4	621	13.8	717	27.4	387	11.1	2468	493	16.7
	3	120	5.5	74	29.7	119	16.8	334	66.1	49	14.2	696	139	39.8
	4	49	20.4	780	31.0	76	15.8	1114	44.2	201	8.9	2220	444	34.9
	5	234	5.5	112	9.8	335	11.6	90	26.7	56	17.8	827	165	11.7
	6	50	8.0	571	33.8	234	11.1	793	29.8	32	9.4	1680	336	27.5
Average...........	....	134	6.3	410	28.0	296	13.8	616	37.1	131	11.4	1589	317	25.7
Bordeaux and lead arsenate	1	28	10.7	381	9.4	326	9.2	520	9.4	17	11.7	1272	254	9.4
	2	42	2.4	133	2.2	58	6.9	597	19.4	2	0	832	166	14.9
	3	338	4.7	30	3.0	461	4.8	460	3.9	80	10.0	1369	274	4.7
	4	24	12.5	450	16.6	106	18.9	672	18.0	0	0	1252	250	17.5
	5	100	5.0	294	6.8	318	5.3	759	26.3	63	15.8	1534	307	16.4
	6	70	11.4	739	10.4	578	5.9	920	26.7	71	11.2	2378	477	15.7
	7	65	4.6	334	22.1	353	7.9	404	32.1	15	13.3	1171	234	20.2
Average...........	....	95	5.8	337	12.1	314	7.0	618	20.3	35	12.1	1401	280	14.1

Table 23.—Production of fruit on Baldwin, 1925 to 1929, Belding.

Spraying Treatment	Tree	1925		1926		1927		1928		1929		Entire period	
		Total lbs.	Drops %	Total lbs.	Drops %	Total lbs.	Drops %	Total lbs.	Drops %	Total lbs.	Drops %	Total lbs.	Annual average
Bordeaux and lead arsenate	1	293	13.9	144	10.4	963	12.6	3	0	539	10.5	1942	388
	2	876	7.9	16	0	1292	12.7	6	0	740	3.4	2930	586
	3	973	11.1	302	6.9	1409	16.7	109	0	796	14.6	3589	718
	4	1018	9.7	397	6.8	1278	6.2	12	0	760	10.8	3465	693
	5	1196	5.8	0	0	1375	11.6	1	0	635	12.7	3207	641
	6	1518	4.9	0	0	1793	11.2	3	0	1187	9.1	4501	900
	7	1153	6.1	0	0	1429	9.9	0	0	869	11.4	3451	690
	8	1006	8.8	0	0	1168	10.6	18	0	568	13.7	2760	552
	9	942	8.4	0	0	1078	6.4	61	0	445	11.0	2526	505
	10	1380	9.5	65	3.1	1774	17.3	95	0	912	9.9	4226	845
	11	849	10.6	198	8.6	1174	8.0	3	0	806	12.4	3030	606
	12	980	5.4	85	5.9	885	5.5	8	0	708	13.3	2666	533
	13	1320	7.3	22	13.6	1356	5.0	15	0	1039	7.4	3752	750
	14	1322	3.2	0	0	1455	7.1	8	0	880	10.9	3665	733
	15	1463	4.4	0	0	1900	12.1	1	0	1232	11.6	4596	919
	16	961	5.2	0	0	962	10.2	40	0	447	6.3	2410	482
	17	1038	5.2	51	5.9	1528	8.1	5	0	935	12.2	3587	717
	18	746	16.7	146	15.7	1044	7.8	12	0	820	11.6	2768	553
	19	921	3.9	0	0	790	5.7	10	0	499	11.0	2220	444
Average..........................		1052	7.3	75	8.1	1297	9.7	21	0	747	10.1	3225	645

Table 24.—Productions of fruit on Baldwin, 1925 to 1929, Belding.

Spraying Treatment	Tree	1925		1926		1927		1928		1929		Entire period	
		Total lbs.	Drops %	Total lbs.	Drops %	Total lbs.	Drops %	Total lbs.	Drops %	Total lbs.	Drops %	Total lbs.	Annual average
Lime-sulphur and lead arsenate	1	0	0	65	6.1	472	12.9	0	0	53	20.7	590	118
	2	684	7.4	165	1.8	1119	11.6	0	0	346	17.0	2314	463
	3	722	9.0	1169	2.8	254	24.0	550	10.9	367	11.4	3062	612
	4	284	10.6	132	9.8	592	8.2	0	0	150	18.0	1158	231
	5	658	16.1	148	0	992	12.9	0	0	185	23.8	1983	376
	6	596	10.6	152	8.5	1026	8.8	0	0	133	18.0	1907	381
	7	48	0	19	10.5	172	26.7	0	0	17	35.3	256	51
	8	565	10.9	481	2.9	946	10.6	6	0	172	12.8	2170	434
	9	228	7.4	65	10.8	651	9.7	0	0	117	20.5	1061	212
	10	561	13.5	269	13.7	887	13.5	2	0	106	20.7	1825	365
	11	589	10.9	22	9.1	758	15.8	0	0	255	17.2	1624	325
	12	258	9.7	117	4.3	524	19.1	2	0	365	17.6	1266	253
	13	445	12.8	65	4.6	923	13.4	0	0	114	28.1	1547	309
	14	498	14.4	522	1.5	1131	11.7	0	0	230	25.2	2391	478
	15	596	16.6	44	22.6	1420	9.1	0	0	361	14.4	2421	484
Average		449	11.7	229	4.5	791	12.2	36	10.7	198	17.8	1705	341

Table 25.—Annual Rings of Jonathan, Wagener and Baldwin.

Variety	Spraying Treatment	Thickness of wood in each ring (centimeters)																	
		1924			1925			1926			1927			1928			1929		
		Spring	Summer	Total	Spring	Summer	Total	Spring	Summer	Total	Spring	Summer	Total	Spring	Summer	Total	Spring	Summer	Total
Jonathan	Lime-sulphur.......	.026	.059	.085	.022	.043	.065	.024	.052	.076	.019	.024	.043	.017	.043	.060	.015	.034	.049
	Bordeaux...........	.027	.051	.078	.021	.029	.050	.024	.053	.077	.021	.031	.052	.025	.054	.079	.021	.037	.058
Wagener	Lime-sulphur.......	.027	.086	.113	.018	.054	.072	.016	.034	.050	.012	.029	.041	.012	.026	.038	.010	.029	.039
	Bordeaux...........	.029	.087	.116	.015	.054	.069	.020	.044	.064	.014	.031	.045	.016	.038	.054	.013	.033	.046
Baldwin	Lime-sulphur.......	.035	.052	.087	.043	.053	.096	.039	.048	.087	.031	.020	.051	.022	.045	.077	.024	.012	.036
	Bordeaux...........	.044	.076	.120	.037	.033	.070	.037	.062	.099	.034	.023	.057	.028	.047	.075	.025	.006	.031