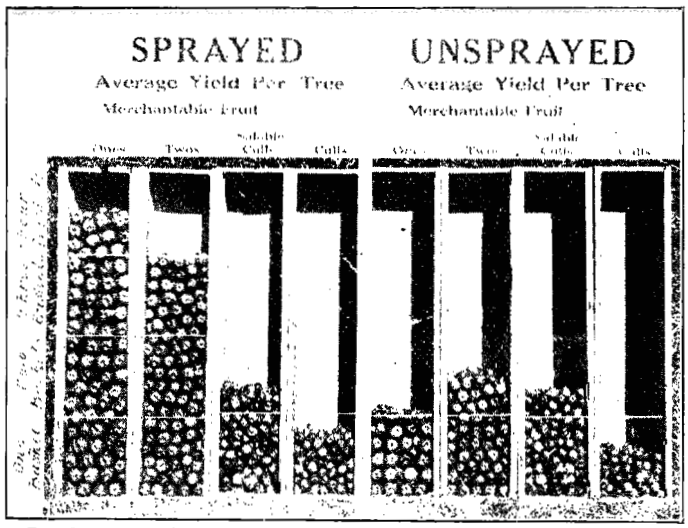
Kansas State Agricultural College

EXPERIMENT STATION.—Bulletin 174

ED. H. WEBSTER, *Director*

FARM BULLETIN



Results of spraying Jonathans. Average of lime-sulphur sprayed tree as compared with unsprayed tree.

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Spraying the Apple Orchard

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MANHATTAN, KANSAS
JANUARY, 1911

Summary.

1. Commercial results from seven widely separated orchards, including both commercial and home types and composed of the varieties of apples recognized as standard in Kansas, carefully sprayed show an average gain of four bushels in actual yield of merchantable fruit per tree, or 37 per cent compared with untreated parts of the same orchards.

2. Not only is the actual and relative amount of merchantable fruit materially increased, but the average percentage of number 1's and number 2's, which are the high-priced grades, is also increased by 15 per cent and 6.6 per cent, respectively.

3. The average net profit from spraying is shown to be $1.62 per tree, or $97.20 per acre when the fruit is sold as "orchard run," and to be almost doubled if properly graded and marketed.

4. All seriously injurious insects and fungous diseases have been markedly reduced and most of them have been made almost negligible.

5. Prepared lime-sulphur plus arsenate of lead has produced the best results on apples subject to Bordeaux injury and nearly free from apple blotch, while Bordeaux mixture plus arsenate of lead gave best results on varieties attacked by apple blotch.

Spraying the Apple Orchard.

Introduction

OBJECTS AND AIMS.

Kansas has a large but much neglected resource in her apple orchards. For every year of the past twenty[2] or more she has had over five million trees in bearing, reaching in 1899 more than seven and one-half millions. In the "bumper" apple year of 1906 the state-wide yield was only 6,378,006 bushels, or a little less than one bushel per bearing tree. The figures of state apple yield, which are available only since 1904, show a complete failure in 1907, and an average yield for five years of three and one-half million bushels, or a little more than one-half bushel per tree in bearing during the same period.

Many factors have contributed to bring about neglect of our apple orchards. Late frosts have year after year prevented the setting of much of the fruit, and the "worms" and fungi have rendered much of that which did set unfit for use.

It is for the purpose of showing the farmer and fruit grower how he may save that part of the crop which is usually sacrificed to insects and fungi that the Agricultural College has gone into the field and carried out this spraying. The results of the spraying have been uniformly good, the owners of the sprayed orchards are well pleased, and many of their neighbors are planning to use the sprag pump next year. It is hoped that the orchard spraying of the past season is the beginning of a movement which may not end until the orchard resources of Kansas are properly developed and used.

ORGANIZATION BY MEANS OF WHICH THE WORK WAS DONE.

The eleven orchards selected for spraying were treated according to a definite schedule formulated by Mr. A. L. Quaintance, representing the Bureau of Entomology, and Mr. W. M. Scott, representing the Bureau of Plant Industry of the United States Department of Agriculture, and Professors Dickens and Headlee

[1]This bulletin was planned by the authors, written by T. J. Headlee, and corrected and criticised by Albert Dickens. All illustrations, unless otherwise indicated, are original.

[2]The authors are indebted to Hon. Walter Wellhouse, secretary of the Kansas State Horticultural Society, for data on number of bearing trees for the past twenty years and the apple yield since 1904.

and Mr. Holsinger, representing the Agricultural College. In all cases the work was done in cooperation with orchard owners —the owners hoping to get an increased crop and to learn how better to care for their orchards, while the Agricultural College and the government hoped to encourage the utilization of apple orchards in the production of better and more apples, the College hoping also to accumulate data to serve as a basis for a State-wide campaign for the proper utilization of our orchard resources.

The work reported in this bulletin was begun by the Agricultural College purely as a demonstration, under the direction of and on the funds furnished by the Farmers' Institute and Extension Department, but it quickly became apparent that the situation was so unusually favorable for making a systematic test of spraying methods that the intended demonstration took on an experimental cast. By this new arrangement the Farmers' Institute and Extension Department furnished most of the funds and the services of Mr. Holsinger, while the Experiment Station furnished the balance of the funds and the services of Professors Dickens and Headlee, who were made responsible for the outcome of the test.

The orchard belonging to Mr. W. E. Boshcen, of Troy, Kansas, was handled by Mr. Holsinger alone. Six orchards, belonging to the State Insane Asylum, Mr. Godding, Mr. R. W. Coleman, Hun. F. H. Stannard, Mr. W. E. Barns, and Mr. John Coughlin, were handled by Messrs. Quaintance and Scott and their assistants, Mr. J. L. Stahl and Mr. Chas. H. Gable. The five remaining orchards, belonging to Snyder & Roediger, Mr. J. B. Fergus, Mr. J. T. Tredway, Mr. Isham Buckmaster, and Mrs. Woodworth, were treated by Professors Dickens and Headlee and Mr. Holsinger, Professor Headlee giving special attention to the Snyder & Roediger orchard, where headquarters was established. Mr. Rees Hillis was placed in immediate charge of the operations at the Snyder & Roediger plant, and was expected to help out at the other points. For a short time, Mr. Ralph Caldwell served as a coworker with Mr. Hillis, and during the balance of the season various graduate students of the Department of Horticulture, among whom may be mentioned Mr. Eugene Blair, Mr. Van Smith, Mr. J. R. Cooper, and Mr. D. E. Lewis, served in that capacity.

Late frost destroyed the fruit in the orchards of the State Asylum, Mr. Godding, Hon. F. H. Stannard and Mrs. Woodworth to such an extent that the treatment in these places had to be

[1]The data from this orchard are not available and are not, therefore, included in this account.

abandoned. Although injury was suffered in the other places, enough fruit set to render the continuance of the work worth while. In all, eight orchards were treated throughout the season and satisfactory results secured.

It was the understanding reached during the conference that the results obtained by each cooperator should be furnished to the other cooperators, and that the publication should be joint or separate as seemed best, providing, in case of separate publication, proper credit should be given.

FIG. 1.—Between rows in the Jonathan block. Snyder & Roediger orchard.

Results.

RETURNS DURING THE PAST SEASON.

Five of these orchards might be classified as commercial, because they possessed enough of single varieties to form blocks of considerable size, while two were distinctly of the home type, being composed of a few trees of each of many varieties. In the home orchard of Mr. J. B. Fergus there were, according to the owner, thirty-three varieties. The general plan was so to select the demonstration blocks that three comparable plats could be secured, and to treat one with Bordeaux plus arsenate of lead, another with lime-sulphur plus arsenate of lead, and to leave the third untreated as a check. Of course local conditions compelled considerable deviation from the original plan.

With the exception of the first spraying with lime-sulphur, which was omitted, the Coughlin and Barnes orchards received the regular treatment. With the exception of the first application of both Bordeaux and lime-sulphur, the Coleman, Fergus, Tredway and Buckmaster orchards and the Jonathan block in the Snyder & Roediger orchard were treated according to schedule. The Ingram block in the Snyder & Roediger orchard received the four scheduled applications.

For determining the effect of spray, as shown in the increased yield of marketable fruit, as many trees as the size of our force would permit were selected in each different treatment in each orchard, the apples picked, and commercial results determined. The marketable fruit picked in the Snyder & Roediger, the Fergus, the Tredway, and the Buckmaster orchards was graded in 1's, 2's, and salable culls. For obtaining a reliable estimate of the effect of spraying upon the injurious insects and diseases, six trees in each treatment in each orchard were selected and a careful record kept of all the apples which set. In all cases the trees selected were as nearly typical as possible, and the results obtained are a close approximation of what occurred in the orchards generally.

Summary of Commercial Results, Orchard of John Coughlin, Argentine, Kansas, 1910.

Yield of 15 trees, 5 per plat. Variety, Gano.

Plat.	No. bushels merchantable fruit.	Per cent merchantable.	No. bushels of cull fruit.	Per cent culls.
Bordeaux	7.85	54.32	6.60	45.68
Lime-sulphur	8.30	60.36	5.45	39.64
Check	0.60	7.14	7.80	92.86

Yield of 15 trees, 5 per plat. Variety, Shackleford.

Bordeaux	22.14	74.27	7.67	25.73
Lime-sulphur	15.76	74.03	5.53	25.97
Check	1.59	42.63	2.14	57.37

Summary of Commercial Results, Orchard of W. E. Barnes, Vinland, Kansas, 1910.

Yield of 30 trees, 10 per plat. Variety, Missouri Pippin.

Bordeaux	30.50	86.65	4.70	13.35
Lime-sulphur	29.25	85.15	5.10	14.85
Check	5.15	49.76	5.20	50.24

Summary of Commercial Results, Orchard of R. W. Coleman, Olathe, Kansas, 1910.

Yield of 15 trees, 5 per plat. Variety, Jonathan.

Bordeaux	2.24	28.21	5.70	71.79
Lime-sulphur	7.37	55.97	5.80	44.03
Check	0.84	12.57	4.45	87.43

Summary of Commercial Results, Orchard of Snyder & Roediger, Parker, Kansas, 1910.

Yield of 30 trees, 10 per plat. Variety, Jonathan.

Bordeaux	71.30	92.80	5.50	7.20
Lime-sulphur	78.70	92.40	6.40	7.60
Check	37.80	89.00	4.60	11.00

Summary of Commercial Results, Orchard of Snyder & Roediger, Parker, Kansas, 1910.

Yield of 20 trees, 10 per plat. Variety, Ingram.

PLAT.	No. bushels merchantable fruit.	Per cent merchantable.	No. bushels of cull fruit.	Per cent culls.
Bordeaux	46.40	91.80	3.90	8.20
Check	25.60	60.60	3.99	39.40

Yield of 9 trees, 3 per plat. Variety, Missouri Pippin.

Lime-sulphur	25.44	72.80	9.48	27.20
Bordeaux	27.48	83.50	5.43	16.50
Check	15.66	65.00	8.40	35.00

Summary of Commercial Results, Orchard of Isham Buckmaster, Ft. Scott, Kansas, 1910.

Yield of 12 trees, 4 per plat. Varieties: Ben Davis, Winesaps.

Bordeaux	33.80	96.80	1.08	3.20
Lime-sulphur	34.20	96.30	1.36	3.70
Check	15 84	81.90	3.48	18.10

Yield of 6 trees, 2 per plat. Variety, Missouri Pippin.

Bordeaux	9.00	73.60	3.24	26.40
Lime-sulphur	3.48	77.67	1.00	22.33
Check[1]				

[1]Dropped off on account of blotch.

Summary of Commercial Results, Orchard of J. B. Fergus, Mildred, Kansas, 1910.

Yield of 18 trees, 6 per plat. Varieties treated: Ben Davis, York Imperial, Dominie, Maiden Blush. Varieties check: Ben Davis, Jonathan, Missouri Pippin.

Bordeaux	74.60	95.90	3.50	4.10
Lime-sulphur	90.00	87.30	12.00	12.70
Check	.35	5.00	6.80	95.00

Summary of Commercial Results, Orchard of J. T. Tredway, La Harpe, Kansas, 1910.

Yield of 12 trees, 6 per plat. Varieties treated: Ben Davis, York Imperial, Winesaps, Missouri Pippin. Varieties check: Winesap, Ralls Genet, Missouri Pippin, Red Winter Sweet.

Bordeaux	44.34	88.20	5.94	11.80
Check	16.98	65.80	8.82	34.20

In order that the reader may more easily and quickly grasp the meaning of these tables, the following summary has been prepared:

Summary of gains in commercial fruit yield through careful spraying.

Variety.	Increase in actual yield in bushels per tree.		Increase in percentage of merchantable fruit.	
	Bordeaux	Lime-sulphur	Bordeaux	Lime-sulphur
Gano	1.45	1.54	47.2	53.2
Shackleford	4.11	2.83	31.6	31.4
Jonathan	.32	1.35	15.6	43.4
Jonathan	3.40	4.14	3.8	3.4
Ingram	2.08		31.2	
Missouri Pippin	2.54	2.41	36.9	35.4
Missouri Pippin	3.94	3.26	18.5	7.8
Missouri Pippin	4.50	1.74	73.6	77.7
Mixed—Ben Davis, Winesap	4.49	4.59	14.9	14.4
Mixed—Ben Davis, York Imperial, Dominie, Maiden Blush, Jonathan, Missouri Pippin	12.37	14.94	90.9	82.3
Mixed—Ben Davis, Winesap, Missouri Pippin, York Imperial, Ralls Genet, Red Winter Sweet	4.56		22.4	
Totals	43.76	36.80	386.6	349.0
Average	3.98	4.09	35.1	38.8

The preceding tables and summary show conclusively that careful spraying increases markedly both the actual and the relative amount of merchantable fruit. The increase in the actual amount of merchantable fruit ranged from .32 to 14.9 bushels per tree, with an average of 4 bushels. The increase in relative amounts of merchantable fruit ranged from 3.4 per cent to 94.3 per cent, with an average of 37 per cent of the total yield. This would mean, granting that the average net selling price of "orchard run" of the standard varieties is about 50 cents per bushel, that careful spraying brought an average gross profit of $2 per tree. The following table shows that the average cost of treatment per tree varied from 5 to 15 cents, with an average of 9.5 cents. The cost is much larger than would be necessary where the grower is prepared for spraying — has good machinery, has it in good order, and has his water close at hand. The cost of labor is the large item in the bill of spraying, and if the arrangements are so nearly perfect that the men will lose the smallest possible

amount of time, the spraying will be done for the lowest cost. Granting, however, that spraying costs an average of 9.5 cents per tree and that four treatments are made, there would remain a net profit of $1.62 per tree. Counting sixty trees to the acre, this would mean a net return from careful spraying of $97.20 per acre.

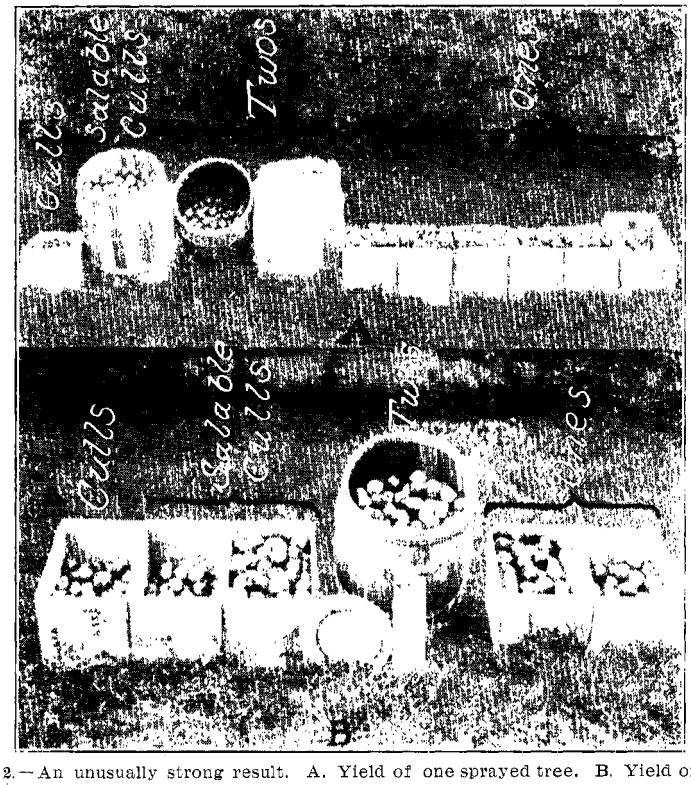

FIG. 2.—An unusually strong result. A. Yield of one sprayed tree. B. Yield of six unsprayed trees.

Table to show actual average cost per tree of spraying in demonstration orchards. This table is based upon data taken in the Snyder & Roediger and the Fergus orchards. It seemed unnecessary to take other orchards into consideration, as the former was a good commercial orchard and the latter an excellent home orchard. For barrel or power sprayer three men and one team were used. The men were paid $2 for a day and the team cost $1.50.

Bordeaux and Arsenate of Lead.

No. of treatment.	VARIETY.	Orchard.	Date of treatment.	No. trees treated...	Length of time in days.....	Type of sprayer used.	Type of material used.	Distance from water.	No. gals. per tree...	Av. cost per tree.		
										For material.	For labor.	Total.
1.....	Ingram...	Snyder & Roediger.	3-31-10	66	.560	Geared power.....	Bordeaux (3-4-50) plus 2 lbs. arsenate of lead.	.5 mile.....	3.8	$0.0300	$0.0630	$0.0930
1.....	Mixed....	Fergus.....	3-28-10	74	.670	"Eclipse" No. 6....	Bordeaux (3-4-50) plus 2 lbs. arsenate of lead.	At orchard	3.4	.0265	.0675	.0940
Average cost per tree of 1st. treatment.....										.0280	.0650	.0930
2.....	Ingram...	Snyder & Roediger.	4-19-10	88	.860	"Eclipse" No. 6....	Bordeaux (3-4-50) plus 2 lbs. arsenate of lead.	.5 mile.....	4.0	.0300	.0730	.1030
2.....	Jonathan.	Snyder & Roediger.	4-13-10	75	1.130	"Eclipse" No. 6....	Bordeaux (3-4-50) plus 2 lbs. arsenate of lead.	.5 mile.....	5.3	.0410	.1130	.1540
2.....	Mixed....	Fergus.....	4-12-10	138	1.300	"Eclipse" No. 6....	Bordeaux (3-4-50) plus 2 lbs. arsenate of lead.	At orchard.	4.6	.0350	.0710	.1060
Average cost per tree of 2nd treatment.....										.0353	.0857	.1210
3.....	Ingram...	Snyder & Roediger.	5-18-10	88	.780	"Eclipse" No. 6....	Bordeaux (3-4-50) plus 2 lbs. arsenate of lead.	.5 mile.....	4.1	.0310	.0670	.0980
3.....	Jonathan.	Snyder & Roediger.	5-4-10	75	.450	Gasoline power sprayer.....	Bordeaux (3-4-50) plus 2 lbs. arsenate of lead.	.5 mile.....	6.1	.0470	.0450	.0920
3.....	Mixed....	Fergus.....	5-11-10	165	1.750	"Eclipse" No. 6....	Bordeaux (3-4-50) plus 2 lbs. arsenate of lead.	At orchard.	6.8	.0530	.0790	.1320
Average cost per tree of 3rd treatment.....										.0437	.0636	.1073
Average cost per tree for Bordeaux treatment.....										.1070	.2143	.3213

No. of treatment.	VARIETY.	Orchard.	Date of treatment.	No. trees treated.	Length of time in days.	Type of sprayer used.	Type of material used.	Distance from water.	No. gals. per tree.	Av. cost per tree. For material.	For labor.	Total.
Arsenate of Lead Alone.												
4	Jonathan.	Snyder & Roediger.	6-20-10	101	.500	Gasoline power sprayer	Arsenate of lead 2 lbs. to 50 gal. water.	.5 mile	4.7	.0180	.0370	.0550
4	Ingram	Snyder & Roediger.	6-21-10	88	.389	Gasoline power sprayer	Arsenate of lead 2 lbs. to 50 gal water.	.5 mile	4.5	.0170	.0330	.0500
4	Mixed	Fergus	6-23-10	187	.667	Gasoline power sprayer	Arsenate of lead 2 lbs. to 50 gal. water.	At orchard	5.9	.0220	.0270	.0490
Average cost per tree of 4th treatment										.0190	.0320	.0510
Average cost per tree for Bordeaux treatment, including 4th treatment										.1260	.2463	.3723
Lime-sulphur and Arsenate of Lead.												
1	Mixed	Fergus	3-29-10	16	.111	"Eclipse" No. 6	1.5 gals lime-sulphur to 50 gals. water plus 2 lbs. arsenate of lead.	At orchard.	3.1	.0318	.0518	.0836
2	Mixed	Fergus	4-12-10	21	.200	"Eclipse" No. 6	1.5 gals. lime-sulphur to 50 gals. water plus 2 lbs. arsenate of lead.	At orchard.	4.8	.0710	.0480	.1190
2	Jonathan.	Snyder & Roediger.	4-14-10	26	.375	"Eclipse" No. 6	1.5 gals. lime-sulphur to 50 gals. water plus 2 lbs. arsenate of lead.	.5 mile	5.1	.0480	.1080	.1560
Average cost per tree of 2nd treatment										.0600	.0780	.1380
3	Jonathan.	Snyder & Roediger.	5-4-10	26	.150	Gasoline power sprayer	1.5 gals. lime-sulphur to 50 gals. water plus 2 lbs. arsenate of lead.	.5 mile	6.9	.0700	.0430	.1130
3	Mixed	Fergus	5-11-10	22	.250	"Eclipse" No. 6	1.5 gals. lime-sulphur to 50 gals. water plus 2 lbs. arsenate of lead.	At orchard.	5.7	.0580	.0850	.1430
Average cost per tree of 3rd treatment										.0640	.0640	.1280
Average cost per tree for lime-sulphur treatment										.1558	.1938	.3496
Average cost per tree for 4th treatment with arsenate of lead alone										.0190	.0320	.0510
Average cost per tree for lime-sulphur treatment, including 4th treatment										.1748	.2258	.4006

Summary for preceding table.

Bordeaux.

No. of Treatment.	Av. No. gallons used.	Average cost per tree.		
		For material.	For labor.	Total.
1	3.60	$0.0280	$0.0650	$0.0930
2	4.63	.0353	.0857	.1210
3	5.67	.0437	.0636	.1073
Total	13.90	.1070	.2143	.3213
4	5.03	.0190	.0320	.0510
Grand Total	18.93	.1260	.2463	.3700

Lime-sulphur.

1	3.10	$0.0318	$0.0518	$0.0836
2	4.95	.0600	.0780	.1380
3	6.30	.0640	.0640	.1280
Total	14.35	.1558	.1938	.3496
4	5.03	.0190	.0320	.0510
Grand Total	19.38	.1748	.2258	.4000

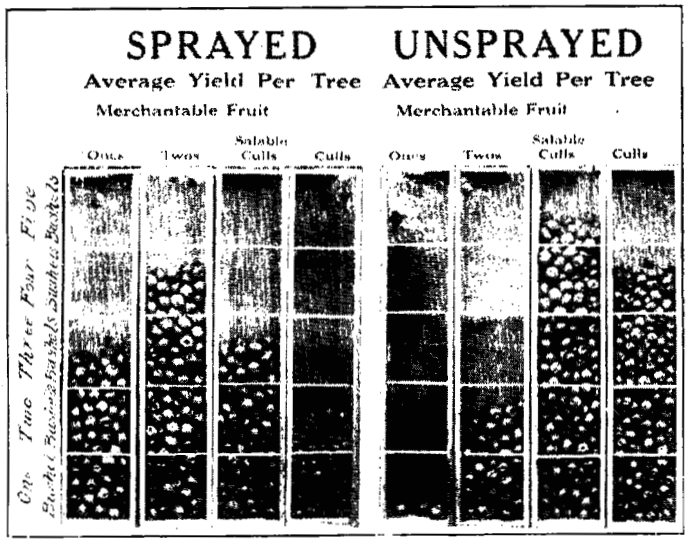

FIG. 3.—Results of spraying Ingrams. Average yield per tree of sprayed as compared with unsprayed, graded into ones, twos, salable culls, and culls. Note the great increase in the ones and twos.

These results come when apples are sold as "orchard run," but the best returns from careful spraying of the apple orchard appear only when the apples are graded, for the reason that the benefit lies largely in the production of larger amounts of the high-priced grades.

Commercial results in graded fruit are available only from the Snyder & Roediger, Fergus, Tredway, and Buckmaster orchards, and our discussion of this phase of the question must therefore be based upon the data gathered in those orchards.

Percentage of 1's, 2's and salable culls in merchantable fruit obtained from sprayed and unsprayed trees in Snyder & Roediger, Fergus, Tredway, and Buckmaster orchards in 1910.

VARIETY.	Orchard.....	Treatment...	No. of trees taken into consideration.....	Per cent of No. 1's.....	Per cent of No. 2's.....	Per cent of salable culls.
Jonathan	Snyder & Roediger...	Bordeaux	63	18.7	62.7	18.6
Jonathan	Snyder & Roediger...	Lime-sulphur.	12	45.5	38.6	15.9
Jonathan	Snyder & Roediger...	Untreated...	11	24.2	43.7	32.1
Ingram	Snyder & Roediger...	Bordeaux	65	31.4	43.2	25.4
Ingram	Snyder & Roediger...	Untreated...	11	.5	25.3	74.2
Missouri Pippin	Snyder & Roediger...	Lime-sulphur.	3	11.7	48.1	40.2
Missouri Pippin	Snyder & Roediger...	Bordeaux	3	19.2	33.6	47.2
Missouri Pippin	Snyder & Roediger...	Untreated...	3	14.2	42.4	43.4
Mixed	Fergus	Bordeaux	6	35.6	53.2	11.2
Mixed	Fergus	Lime-sulphur.	5	33.2	58.4	8.4
Mixed	Fergus	Untreated...	6	.....	.....	100.0
Mixed	Tredway	Bordeaux	6	30.2	59.7	10.1
Mixed	Tredway	Untreated...	6	24.6	37.7	37.7
Mixed	Buckmaster.....	Bordeaux	6	33.2	56.0	10.6
Mixed	Buckmaster.....	Lime-sulphur.	6	42.5	51.8	5.7
Mixed	Buckmaster.....	Untreated...	6	14.9	67.8	17.3
Average	.....	Bordeaux	.....	27.9	51.0	21.1
Average	.....	Lime-sulphur.	.....	32.9	49.6	17.5
Average	.....	Untreated...	.....	15.8	43.8	40.4

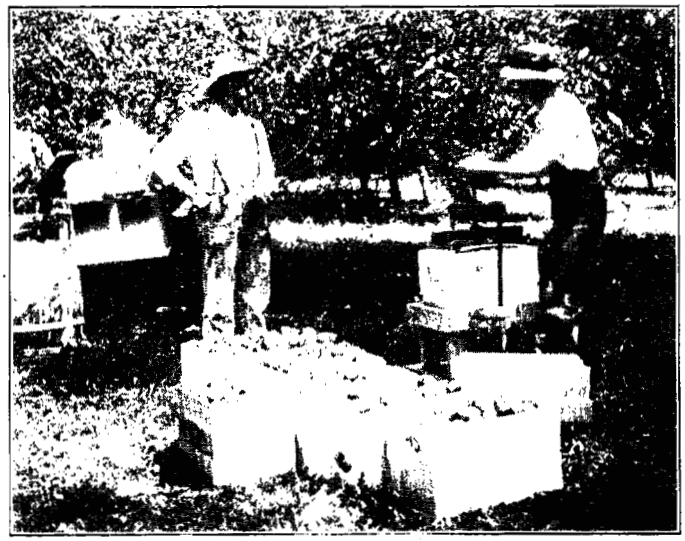

FIG. 4.—Boxing the ones.

This table shows clearly that when the merchantable apples are properly graded the average of the sprayed trees shows 12.1 to 17.1 per cent more of number I's, 5.8 to 7.2 per cent more of number 2's, and 19.3 to 22.9 per cent less of salable culls. For the sake of illustration, let us take an average lime-sulphur-sprayed Jonathan apple tree which bears 7.87 bushels of merchantable fruit. Forty-five and five-tenths per cent, or 3.58 bushels, are num-

ber l's, 38.6 per cent, or 3.04 bushels, are number 2's, and 15.9 per cent, or 1.25 bushels, are salable culls. Sold as "orchard run," without grading, the 7.87 bushels would bring about $3.94, while if sold as grades, might well bring number 1's $1.50 per bushel, number 2's $0.80 per bushel, and salable culls $0.20 per bushel, amounting to $8.05, a difference of $4.11. Or, let us take 100 bush-

FIG. 5.—Barreling the twos.

els of marketable Jonathans from trees treated with lime-sulphur. Forty-five and five-tenths bushels are number 1's, 38.6 bushels are number 2's, and 15.9 bushels are salable culls. If sold as "orchard run," the entire 100 bushels would bring $50. If sold as grades, they would bring $1.60 for l's, $0.80 for 2's, and $0.20 for culls, amounting to $102.31. This means an increase of more than 50 per cent to pay for the trouble of grading.

The results obtained this year can be duplicated or bettered by any one who will take the necessary amount of trouble to familiarize himself thoroughly with the methods used. There is no reason why the farmer should not have plenty of apples of good quality for his family. There is no reason in the presence of injurious insects and fungi to prevent commercial orchardists from establishing themselves in large numbers in Kansas. There is much good orchard land to be had at comparatively low cost.

FIG. 6.—The neighbors examined the results of demonstration spraying at picking time.

How These Results Were Obtained.

Protecting the Apple from Insect and Fungous Enemies.

PRINCIPAL INSECT ENEMIES.

The codling-moth and the plum curculio are the only insects that we need to consider, because such leaf feeders as the apple-leaf crumpler, apple tree tent caterpillar, canker-worms, and fall web-worm are controlled incidentally by the sprays intended for the former. Close observations upon the codling-moth and curculio were limited to the Snyder & Roediger orchard at Parker, Kansas.

By the time we were ready to begin work, April 16, which was almost four weeks after the Jonathan trees were in full bloom, the earliest of the moths were already on the wing. From this date until June 18 frequent collections of larvæ and pupæ were made from the trunks of the trees. In all, ninety-eight larvæ and pupæ were taken, and of these, forty produced healthy moths, the majority of which had emerged by June 5. For eight of the forty the length of pupal stage was determined. It ranged from fourteen to seventy-four days, with an average of thirty-six days.

The work of the larvæ produced by this first brood of moths was noticed when the first dropped apples were examined early in July. Shortly before July 11 these larvæ began to leave the apples in considerable numbers. The emergence of this brood

of "worms" reached its height shortly after the middle of July. Most of these larva promptly transformed to pupæ. Careful observation of fifty-six cases shows that the pupal stage occupied an average of nine days. The emergence of the second brood of moths reached its height about the first of August. The larvæ produced by this brood reached their height of emergence from the apples about the middle of September. In the latter part of August our records show a considerable increase in the number

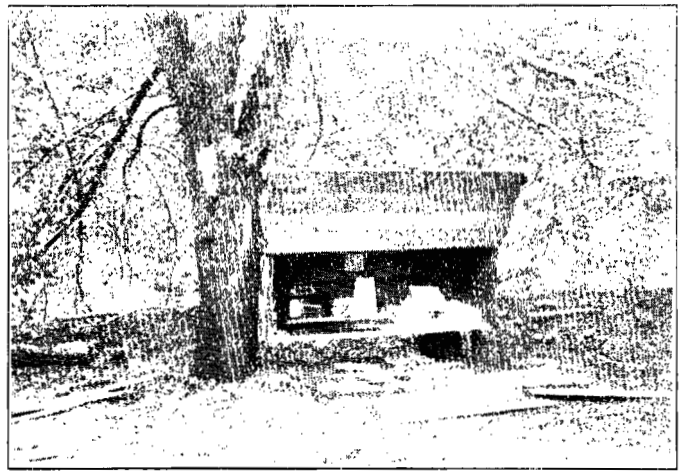

FIG. 7.—Where the development of the codling-moth was followed.

of moths emerging. Very few of the larva which emerged from the apples after the middle of August transformed to pupæ.

Curculio injury appeared in the apple at the first examination of the dropped fruit early in July, and this early drop was largely wormy with curculio grubs. Late in the season some harm was done to the apple by feeding of the second brood of beetles. It is evident, however, that a satisfactory remedy for this insect must be directed at the first brood, and must be applied during the early part of the season, while the apples are yet small.

PRINCIPAL FUNGOUS ENEMIES.

Apple scab, sooty blotch, apple blotch, black rot, and bitter rot were serious enough to require attention. Apple scab appeared on the unsprayed Ingrams and did much harm, but was rayely noted on the other varieties. Likewise, the work of sooty blotch damaged the Ingrams mainly. Apple blotch was mainly confined to Missouri Pippins, although it appeared on the fruit of other varieties. Black rot made its appearance on all varieties, but did little harm.

Bitter rot attacked a few of the Jonathan trees and destroyed most of the fruit on the infected trees. It struck only a few trees and they were well separated from each other.

METHODS USED.

The method used for the destruction of these insects and fungi is the outcome of a vast amount of experience accumulated by workers in this line in all parts of the United States. When we take into consideration the fact that this treatment must destroy both plant and animal parasites, yet leave the host or tree unharmed, it is not difficult to understand that the problem is sufficiently complex to render the accumulation of a large number of facts necessary before an efficient method could be developed. The procedure for this purpose has three very important phases — the nature of the material which should be used, the time when it should be applied, and the manner of its application.

MATERIAL.

The material is composed of two active substances, one of which is intended to destroy the insects and the other to control fungi. The first is arsenic, put up in the form of arsenate of lead. This is a stomach poison which must be placed on the substances which the insects will later consume. This form of arsenic has been adopted because it has so small an amount of free arsenious acid that it does not burn foliage or fruit, and because it clings to the foliage and fruit exceedingly well and consequently resists the washing of the rains.

The second substance is copper sulphate, sometimes known as blue stone, or blue vitriol. It is used in combination with milk of lime to form Bordeaux mixture, the active principle of which consists of copper hydroxide. The copper hydroxide spreads well over foliage and fruit and adheres closely thereto. It resists the washing of the rains well. It is thought that small amounts of this copper are brought into solution and thus in contact with the spores of fungous diseases, destroying them. That property of Bordeaux mixture which causes it under certain favorable conditions seriously to injure susceptible varieties has led to the trial of substitute substances. The most promising of these is the prepared or concentrated lime-sulphur solutions. Although we know little or nothing about exactly how the lime-sulphur kills the disease spores, the fact of its ability to control most of the apple diseases has been firmly established.

These substances were applied in two combinations — two pounds of lead arsenate mixed thoroughly with fifty gallons of 3-4-50 Bor-

deaux, and two pounds of lead arsenate and one and one-half gallons of prepared lime-sulphur solution, testing 33" Baume thoroughly mixed with fifty gallons of water. The method of mixing the lead arsenate was the same in each combination. The required amount was weighed out in a bucket and mixed with a little water until it would flow readily; it was then poured into the tank of Bordeaux or the diluted lime-sulphur and thoroughly stirred by setting the agitator in vigorous motion. The Bordeaux was made up in the usual manner. Stock solutions of copper sulphate and lime were made in barrels each containing one pound of the substance to one gallon of water. Two dilution tanks made of barrels were employed. In making up fifty gallons, three gallons of stock solution of copper sulphate were placed in the copper sulphate dilution tank. Four gallons of the milk of lime were placed in the lime dilution tank. Sufficient water was added to each tank to make twenty-five gallons in each. The plugs were then removed from the drain pipes and the dilute copper sulphate and milk of lime were allowed to run together through the burlap strainer into the spray tank. The lead was then added. In preparing fifty gallons of the lime-sulphur, about fifty gallons of water were placed in the spray tank. One and one-half gallons of the prepared lime-sulphur mixture were measured out and mixed thoroughly with the water. The lead arsenate was added as before.

It is important to obtain for the stock lime solution a type of unslacked lime that will leave no lumps or coarse particles after slacking. The Sherwin-Williams and Grasseli Chemical Company's prepared lime-sulphur solutions were used, and both were satisfactory. Swift's Arsenate of Lead and Grasseli Chemical Company's product were employed with equally satisfactory results.

TIME.

The time when the applications should be made is determined by knowledge, based upon the life history of the insects and fungi in question, of when such treatments are likely to be most effective.

From the time the bud opens until the apple approaches picking time it is open to the attack of fungous diseases — first scab, then blotch, sooty blotch and fly speck, black rot and, later, bitter rot. For a similar period the foliage and, to a less extent, the fruit are open to the attacks of various foliage-consuming larvæ. From a few weeks after the apples set until almost picking time, they are constantly attacked by codling-moth larvæ. From setting of the apples for a period of about one and one-half months they are subject to curculio "stinging," and late in the season they are fed

upon by the new brood of curculio. The method most likely to protect the apple would seem to be to keep the foliage and fruit covered with spray throughout the season, and this could be best accomplished by spraying at regular and short intervals. Other considerations modify this schedule, however. The fact that eighty per cent of the first brood of codling-moth larva, and a large percentage of the second, enter the blossom end of the apple,

FIG. 8.—The gas engine at work (Photo by C. V. Holsinger.)

connected with me fact that for several days after the petals drop this blossom end is wide open and easily filled with poison, which will soon be enclosed and held ready for all "worms" that enter, renders treatment at this time of greatest importance. Likewise, the concentration of serious curculio attack during a short period beginning with the setting of the apples, and attempts of apple scab and apple blotch to establish themselves in the tender tissue, render early treatment very important.

APPLICATION.

The mixtures were applied by means of barrel, geared, and gas-engine sprayers. The pressure ranged from 80-120 pounds in the barrel pump, through 100-160 pounds in the geared sprayer, to 140-225 pounds in the gas-engine outfit. All Bordeaux and lime-sulphur sprays were delivered as a fine mist, which gave the trees a good, even coat. Spraying was continued until all parts of each tree were thoroughly covered. In the second application the spray was shot down into the open blossom ends. From four to eight gallons per tree were used.

SCHEDULE OF APPLICATION.

First Application. —As the cluster buds open but before blossoming, spray thoroughly with Bordeaux mixture and lead arsenate or with prepared lime-sulphur and lead arsenate.

Second Application. —As soon as the majority of the petals have fallen spray thoroughly with Bordeaux mixture and lead arsenate or with prepared lime-sulphur and lead arsenate.

Third Application. —Three weeks after the falling of the petals spray thoroughly with Bordeaux mixture and lead arsenate or with prepared lime-sulphur and lead arsenate.

Fourth Application. —Ten weeks after the falling of the petals spray thoroughly with arsenate of lead alone, using two pounds to fifty gallons of water.

RESULTS.

In determining the efficiency of the spraying mixtures for the control of insects and fungous diseases more than a quarter of a million apples were individually examined. To be exact, 256,240 apples in the seven orchards were taken into consideration. Large numbers have been used in the hope that the effect of local conditions might be eliminated and the results be made representative. For each block under treatment three summaries are presented, the first dealing with the dropped fruit, the second with the picked fruit, and the third with the total of both dropped and picked. Owing to the fact that insect and fungous attacks operate for a time, then cease to be active, coupled with the fact that dropping of infested fruit is correlated with the physiological condition of the tree, which is immediately dependent upon surrounding conditions, the consideration of the whole amount of fruit which set was the only means by which we could reach a true conception of what the sprays accomplished.

FIG. 9.—"In determining the efficiency of the spraying mixtures . . . more than a quarter of a million apples were individually examined." Examining the fallen fruit.

FIG. 10.—"In determining the efficiency of the spraying mixtures . . . more than a quarter of a million apples were individually examined." Examining the picked apples.

Spraying Results, Orchard of John Coughlin, Argentine, Kansas, 1910.

Bordeaux Plat, Trees 2, 5, 6, 9, 10. Variety, Gano.

	Total No.	Codling-moth	Per cent.	Curculio	Per cent.	Scab	Per cent.	Apple blotch	Per cent.	Sooty blotch	Per cent.	Bitter rot	Per cent.	Black rot	Per cent.	Spray injury	Per cent.	Sound fruit	Per cent.
Windfalls	1018	103	10.10	755	74.1	83	8.10	1	.09									89	8.80
Picked fruit	2447	156	6.30	2318	94.1	164	6.69	20	.80									18	.70
Grand total	3465	259	7.40	3073	85.8	247	7.10	21	.60									107	3.08

Lime-sulphur Plat, Trees 2, 5, 6, 9, 10. Variety, Gano.

Windfalls	708	78	11.01	632	89.2	50	7.06											27	3.80
Picked fruit	2590	228	8 60	2501	96.5	229	8.64	162	6.20										
Grand total	3298	306	9.20	3133	94.9	279	8.40	162	4.90									27	.80

Check Plat, Trees 3, 5, 6, 9. Variety, Gano.

Windfalls	1259	602	47.80	1251	99.3	541	42.90	71	5.60										
Picked fruit	1284	733	57.00	1283	99.9	850	66.20	143	11.10										
Grand total	2543	1335	52.40	2534	99.6	1331	54.60	214	8 40										

Bordeaux Plat, Trees 1, 3, 4, 7, 8. Variety, Shackleford.

Windfalls	1957	113	5.70	1723	88.0	74	2.70	15	.76									152	7.70
Picked fruit	3927	60	1.50	3675	93.5	127	3.20	43	1.09									85	2.16
Grand total	5884	173	2.90	5398	91.7	201	3.40	58	.98									237	4.02

Lime-sulphur Plat, Trees 1, 2, 4, 7, 8. Variety, Shackleford.

Windfalls	1332	61	4.50	1244	93.3	129	9.60	115	8.60									20	1.50
Picked fruit	2804	74	2.60	2236	79.7	208	7.40	162	5.80									269	9.50
Grand total	4136	135	3.20	3480	81.8	337	7.40	277	5.60									289	6.90

Check Plat, Trees 1, 2, 4, 7, 8. Variety, Shackleford.

	Total No.	Codling-moth	Per cent.	Curculio	Per cent.	Scab	Per cent.	Apple blotch	Per cent.	Sooty blotch	Per cent.	Bitter rot	Per cent.	Black rot	Per cent.	Spray injury	Per cent.	Sound fruit	Per cent.
Windfalls	1653	705	42.60	1630	98.60	714	43.20	377	22.8	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Picked fruit	487	150	30.80	475	97.30	268	55.00	61	12.5	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Grand total	2140	855	39.90	2105	98.30	982	45.40	438	20.1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

Spraying Results, Orchard of W. E. Barnes, Vinland, Kansas, 1910.

Bordeaux Plat, Trees 12-17, 19, 21, 30, 31, 32. Variety, Missouri Pippin.

Windfalls	2245	176	7.80	358	15.90	.....	.....	295	13.1	.....	.....	.....	.....	.....	.....	.....	.....	1426	63.50
Picked fruit	9841	125	1.20	1512	15.30	5	.05	984	9.9	.....	.....	.....	.....	.....	.....	.....	.....	7215	72.40
Grand total	12086	301	2.40	1870	15.30	5	.04	1279	15.8	.....	.....	.....	.....	.....	.....	.....	.....	8641	71.50

Lime-sulphur Plat, Trees 7-12, 26-29. Variety, Missouri Pippin.

Windfalls	2013	70	3.47	310	15.40	1	.05	297	14.7	.....	.....	.....	.....	.....	.....	.....	.....	1335	66.30
Picked fruit	9654	49	.50	1439	14.90	7	.07	995	10.3	.....	.....	.....	.....	.....	.....	.....	.....	7164	74.20
Grand total	11667	119	1.01	1749	14.10	8	.06	1292	11.0	.....	.....	.....	.....	.....	.....	.....	.....	8499	72.80

Check Plat, Trees 1-6, 22-25. Variety, Missouri Pippin.

Windfalls	9996	3735	37.30	4850	48.50	74	.70	8445	84.4	.....	.....	.....	.....	.....	.....	.....	.....	7	.07
Picked fruit	2810	301	10.70	1428	50.80	10	.35	2219	78.9	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Grand total	12806	4036	31.30	6278	49.00	84	.65	10664	83.2	.....	.....	.....	.....	.....	.....	.....	.....	7	.05

Spraying Results, Orchard of R. W. Coleman, Olathe, Kansas, 1910.

Bordeaux Plat, Trees 1-5. Variety, Jonathan.

Windfalls	427	75	15.20	300	70.20	1	.20	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	103	24.10
Picked fruit	1283	646	50.30	1155	90.02	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Grand total	1710	721	42.10	1455	85.08	1	.05	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	103	6.02

Lime-sulphur Plat, Trees 1-5. Variety, Jonathan.

	Total No.	Codling-moth	Per cent.	Curculio	Per cent.	Scab	Per cent.	Apple blotch	Per cent.	Sooty blotch	Per cent.	Bitter rot	Per cent.	Black rot	Per cent.	Spray injury	Per cent.	Sound fruit	Per cent.
Windfalls	265	18	6.79	223	84.1	6	2.26	1	.37	.....	.....	.....	....	.....	.....	.....	.....	21	7.29
Picked fruit	2451	270	11.00	2110	86.0	23	.93	37	1 50	.....	.....	.....	.....	.....	.....	.....	.....	61	2.48
Grand total	2716	288	10.60	2333	85.8	29	1.06	38	1.35	.....	.....	.....	.....	.....	.....	.....	.....	82	3.01

Check Plat, Trees 6-10. Variety, Jonathan.

Windfalls	747	88	11.70	716	95.8	18	2.40	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	15	2.00
Picked fruit	871	455	51.80	852	97.8	64	7.30	42	4.80	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Grand total	1618	543	33.50	1568	96.9	82	5.09	42	2.59	.....	.....	.....	.....	.....	.....	.....	.....	15	.90

Spraying Results, Orchard of Snyder & Roediger, Parker, Kansas, 1910.

Bordeaux Plat, Trees 7-12. Variety, Jonathan.

Windfalls	2158	171	7.80	1174	54.4	3	.130	3	.130	109	5.05	163	7.5	7	.32	775	35.40	620	82.70
Picked fruit	15547	79	.50	5413	38.4	.....	.....	.....	.....	7	.04	542	3.4	.....	.....	6923	44.50	9506	61.10
Grand total	17705	250	1.40	6587	37.2	3	.016	3	.016	116	.65	705	3.9	7	.03	7698	43.40	10126	57.10

Lime-sulphur Plat, Trees 1-6. Variety, Jonathan.

Windfalls	3413	157	4.60	1418	41.5	1	.029	4	.11	.....	.....	91	2.6	7	.2	75	2.19	1738	50.90
Picked fruit	16263	68	.42	3789	23.2	.....	.....	74	.45	752	4.60	233	1.4	.....	.....	482	2.30	11347	69.70
Grand total	19676	225	1.10	5207	26.4	1	.001	78	.39	752	.38	324	1.6	7	.03	557	2.80	13085	66.50

Check Plat, Trees 13-18. Variety, Jonathan.

Windfalls	3644	865	23.70	2890	79.3	30	.82	14	.38	225	6.10	372	10.2	11	.300	.....	.....	500	13.70
Picked fruit	7519	336	4.40	2814	37.2	.....	.....	12	.15	1494	19.80	151	2.0	1	.013	.....	.....	2711	36.00
Grand total	11163	1201	10.70	5704	51.0	30	.26	26	.23	1719	15.30	523	4.6	12	.100	.....	.....	3211	28.70

Bordeaux Plat, Trees 25-30. Variety, Ingram.

	Total No.	Codling-moth	Per cent.	Curculio	Per cent.	Scab	Per cent.	Apple blotch	Per cent.	Sooty blotch	Per cent.	Bitter rot	Per cent.	Black rot	Per cent.	Spray injury	Per cent.	Sound fruit	Per cent.
Windfalls	417	34	8.2	165	39.5	40	9.58	.....	.....	3	.7	27	6.4	.....	.....	.....	.....	148	35.4
Picked fruit	8050	1736	21.5	2068	25.0	1730	21.49	.....	.....	1639	20 3	876	10.8	.....	.....	.....	.....	4804	59.6
Grand total	8467	1770	20.9	2233	26.3	1770	20.90	.....	.....	1642	19.2	903	10.6	.....	.....	.....	.....	4952	58.5

Check Plat, Trees 19-24. Variety, Ingram.

Windfalls	2125	665	31.2	1750	82 3	1729	81.30	.....	.....	812	38.3	376	17.6	65	3.05	.....	.....	80	3.7
Picked fruit	10161	2895	18.6	4278	42.1	4628	45.50	.....	.....	6705	65.9	508	4.9	250	2.40	.....	.....	586	5.7
Grand total	12286	3560	28.9	6028	49.0	6357	51.60	.....	.....	7517	61.1	884	7.2	315	2.50	.....	.....	666	5.4

Spraying Results, Orchard of Isham Buckmaster, Fort Scott, Kansas, 1910.

Bordeaux Plat, Trees 2, 12. Variety, Ben Davis.

Windfalls	387	25	6.5	113	29.2	1	.250	12	3 10	.....	.....	35	9.0	1	.250	144	37.2	200	51.6
Picked fruit	2051	131	6.3	410	20.0	.....	.....	38	1.36	.....	.....	78	3.8	.....	.....	.....	.....	1596	77.8
Grand total	2438	156	6.4	523	21.4	1	.041	50	2.05	.....	.....	113	4.6	1	.041	144	5.9	1796	73.6

Lime-sulphur Plat, Trees 4, 9 Variety, Ben Davis.

Windfalls	500	47	9.4	125	25.0	7	1.40	66	13.20	.....	.....	72	14.4	12	2.40	73	14.6	171	34.2
Picked fruit	3175	271	8.5	666	20.9	42	1.30	894	28.10	.....	.....	268	8.4	.....	.....	.....	.....	2100	66.1
Grand total	3675	318	8 6	791	21.5	49	1.37	960	26.10	.....	.....	340	9.2	12	.30	73	1.7	2271	2.6

Check Plat, Trees 13, 16. Variety, Ben Davis.

Windfalls	911	275	30.1	645	70.8	77	8.46	320	35.10	.....	.....	215	23.6	87	9.50	.....	.....	66	7.2
Picked fruit	858	245	28.6	422	49.1	40	4.60	514	55.90	.....	.....	157	18.2	.....	.....	.....	.....	264	30.7
Grand total	1769	520	29.3	1067	60.2	117	6.60	834	47.10	.....	.....	372	21.2	87	4.30	.....	.....	330	18.6

Bordeaux Plat, Trees 1, 6. Variety, Missouri Pippin.

	Total No.	Codling-moth	Per cent.	Curculio	Per cent.	Scab	Per cent.	Apple Blotch	Per cent.	Sooty blotch	Per cent.	Bitter rot	Per cent.	Black rot	Per cent.	Spray injury	Per cent.	Sound fruit	Per cent.
Windfalls	1317	71	5.30	541	41.0	5	.37	777	58.9	.....	.....	449	34.09	64	4.80	61	4.30	103	7.8
Picked fruit	4860	349	7.20	1401	28.8	106	2.10	1968	40.4	.....	.....	633	13 02	.....	.....	150	3.08	2659	52.6
Grand total	6177	420	6.70	1 942	24.1	111	1.79	2745	44.4	.....	.....	1082	17.50	64	1.03	211	3.40	2762	44.7

Lime-sulphur Plat, Trees 2, 5. Variety, Missouri Pippin.

Windfalls	5193	23	.45	1124	21.6	7	.13	4581	88.2	.....	.....	2554	49.10	1354	26.0	27	.50	68	1.1
Picked fruit	1201	151	13.07	508	42.2	.....	.....	466	38.8	.....	.....	204	16.90	.....	.....	.....	.....	442	36,7
Grand total	6394	174	2.80	1632	25.5	7	.10	5047	78.9	.....	.....	2758	43.10	1354	21.10	27	.40	510	7.9

Check Plat, Trees 17, 18. Variety, Missouri Pippin.

Windfalls	2819	305	10.80	2266	80.3	1196	42.40	2766	98.1	.....	.....	960	34.05	1059	37.50	.....	.....	46	1.6
Picked fruit	65	16	24.60	15	23.0	8	12.30	43	66.1	.....	.....	10	15.30	.....	.....	.....	.....	.....	.....
Grand total	2884	321	11.10	2281	75.6	1204	41.40	2809	97.3	.....	.....	970	30.80	1059	36.70	.....	.....	46	1.5

Bordeaux Plat, Trees 7, 11. Variety, Winesap.

Windfalls	767	47	6.12	251	32.7	11	1.43	.....	.....	.....	.....	176	22.90	.....	.....	274	35.70	282	36.7
Picked fruit	7944	422	5.31	1271	15.9	104	1.30	.....	.....	.....	.....	47	5.90	.....	.....	6908	86.90	6452	81.2
Grand total	8711	469	5.38	1522	17.4	115	1.30	.....	.....	.....	.....	223	2.50	.....	.....	7182	82.30	6734	77.3

Lime-sulphur Plat, Trees 8, 10. Variety, Winesap.

Windfalls	556	45	8.09	128	23.0	10	1.70	21	3.7	.....	.....	87	15.60	.....	.....	.....	.....	265	47.6
Picked fruit	5814	304	5.28	2638	45.3	79	1.30	228	3.9	45	.77	76	1.30	.....	.....	105	1 80	4386	75.4
Grand total	6370	349	5.47	2766	43.3	89	1.30	249	3.9	45	.70	163	2.50	.....	.....	105	1.60	4651	73.0

Check Plat, Trees 14, 15. Variety, Winesap.

	Total No.	Codling-moth	Per cent.	Curculio	Per cent.	Scab	Per cent.	Apple blotch	Per cent.	Sooty blotch	Per cent.	Bitter rot	Per cent.	Black rot	Per cent.	Spray injury	Per cent.	Sound fruit	Per cent.
Windfalls	2449	379	10.9	1016	41.00	425	17.30	17	.6	.....	.....	261	10.6	3	.10	.....	.....	348	13.80
Picked fruit	3948	966	24.4	1203	30.40	708	17.60	54	1.3	177	4.4	152	3.8	.....	.....	.....	.....	1807	45.60
Grand total	6397	1345	21.2	2219	36.20	1133	17.70	71	1.1	177	2.7	413	6.4	3	.04	.....	.....	2155	33.60

Spraying Results, Orchard of J. B. Fergus, Mildred, Kansas, 1910.

Bordeaux Plat, Trees 1-4. Varieties: Ben Davis, York Imperial, Dominie.

Windfalls	8685	127	1.4	821	9.40	70	.80	113	1.3	.....	.....	379	4.3	33	3.70	262	3.0	7244	83.20
Picked fruit	11150	496	4.4	1887	16.80	130	1.10	127	1.1	122	1.1	115	1.0	.....	.....	1036	9.0	8989	80.60
Grand total	19835	623	3.1	2708	13.60	200	1.00	240	1.2	122	.6	494	2.4	33	.16	1298	6.5	16233	81.80

Lime-sulphur Plat, Trees 7-10. Varieties: Ben Davis, Dominie, York Imperial.

Windfalls	4596	412	8.9	910	11.09	85	1.80	505	11.0	15	.3	93	12.2	100	21.70	202	4.2	1968	41.07
Picked fruit	13645	1555	11.3	2687	19.06	116	.80	1567	11.4	2527	18.2	83	4.2	.....	.....	2104	15.3	9085	66.50
Grand total	18241	1967	10.7	3597	19.07	201	1.10	2072	11.3	2542	13.9	124	6.8	100	.50	2306	12.6	10993	60.40

Check Plat, Trees 12, 14, 17, 18. Varieties: Ben Davis, Jonathan.

Windfalls	5606	840	14.9	5071	90.40	38	.60	665	11.8	98	1.7	1389	24.5	46	.80	.....	.....	356	6.10
Picked fruit	1192	513	43.0	460	38.50	26	2.10	71	5.9	65	15.4	181	15.1	.....	.....	.....	.....	55	4.60
Grand total	6798	1353	19.9	5531	81.30	64	.90	736	10.8	163	2.3	1570	23.0	46	60	.....	.....	411	6.04

Spraying Results, Orchard of J. T. Tredway, La Harpe, Kansas, 1910.

Bordeaux Plat, Trees 1-6. Varieties: York Imperial, Ben Davis, Winesap, Missouri Pippin.

Windfalls	5816	1344	23.1	1039	17.80	30	.50	1432	24.4	.....	.....	1176	20.2	162	2.70	533	9.1	1810	31 10
Picked fruit	11713	1013	8.6	1787	15.20	.....	.....	1892	16.1	261	2.2	409	3.4	.....	.....	3147	26.7	8552	73.00
Grand total	17529	2357	13.4	2826	16.00	30	.17	3324	19.1	261	1.4	1585	9.0	162	.90	3680	20.9	10362	59.50

Check Plat, Trees 7-12. Varieties: Red Winter Sweet, Winesap, Ralls Genet, Missouri Pippin.

	Total No.	Codling-moth	Per cent	Curculio	Per cent	Scab	Per cent	Apple blotch	Per cent	Sooty blotch	Per cent	Bitter rot	Per cent	Black rot	Per cent	Spray injury	Per cent	Sound fruit	Per cent
Windfalls	8624	3430	39.7	3091	35.8	744	8.6	1662	19.2	20	.2	1072	12.3	196	2.2	......	......	387	4.4
Picked fruit	7070	1922	27.1	1529	21.4	1500	21.2	646	9.1	2572	36.3	375	5.3	......	......	......	......	2617	37.0
Grand total	15694	5352	34.1	4620	23.0	2244	14.2	2308	14.7	2592	16.5	1447	9.2	196	1.2	......	......	3004	19.1

That the reader may grasp the general effects of this treatment, the percentage of the total yield injured by each species of important insect and fungous disease under Bordeaux, lime-sulphur, and check treatment has been determined and set down in the form of a summary. For example, the total number of apples under Bordeaux treatment has been determined, the total number of apples under Bordeaux treatment which are infested with codling-

FIG. 11.– Effect of spraying with Bordeaux mixture on apple scab. A. Unsprayed Ingrams badly infested with scab. B. Sprayed Ingrams absolutely free from disease.

moth has been determined, and the percentage which the latter is of the former has been worked out. Thus we obtain the following summary:

INSECT OR DISEASE	Bordeaux, per cent	Lime-sulphur, per cent	Check, per cent
Moth	7.21	5.09	26.80
Curculio	28.97	32.40	52.50
Scab	2.58	1.30	17.98
Apple blotch	7.42	13.35	23.80
Sooty blotch	2.05	4.38	21.35
Bitter rot	4.90	6.34	10.84
Black rot	0.25	1.93	3.01
Spray injury	19.43	4.02	.....
Fruit absolutely free from insect and fungous injury	59.60	53.04	12.90

The unsprayed trees showed 26.9 per cent of all the apples which set wormy with codling-moth. The treatment with Bordeaux and arsenate of lead reduced this to 7.2 per cent, while the use of lime-sulphur and arsenate of lead reduced it to 5 per cent. The unsprayed trees showed 52 per cent of all the apples which set injured by curculio. Treatment with the Bordeaux combination reduced this to 28.9 per cent, while treatment with the lime-sulphur reduced it to 32 per cent. The unsprayed trees showed 18 per cent of all fruit which set injured by apple scab. Treatment with

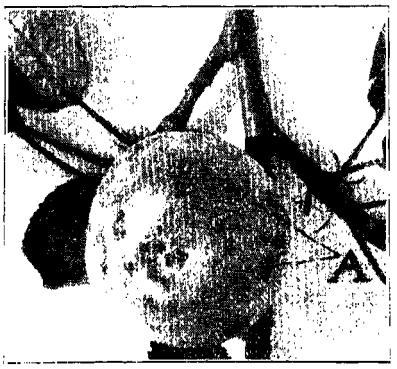

FIG. 12.—"Apple scab appeared on the unsprayed Ingrams and did much harm." A. Scab spot.

the Bordeaux combination reduced this to 2.5 per cent, while the lime-sulphur reduced it to 1.3 per cent. The unsprayed trees showed 23 per cent of all the apples which set injured by apple blotch. Treatment with the Bordeaux combination reduced this to 7.4 per cent, while the lime-sulphur reduced it to 13 per cent.

Feeling that apple blotch is perhaps the most difficult of all of the fungous diseases which the apple orchardist must meet, we determined to find out the relative value of Bordeaux and lime sulphur in preventing this disease in orchards where it had been sufficiently prevalent for years to destroy practically the entire crop. A block of 156 Missouri Pippin trees, located in the midst

FIG. 13.—"Apple blotch was mainly confined to Missouri Pippins." A. Blotch spot.

of a 100-acre orchard of the same variety, was selected for the experiment. This block was so chosen that each of the rows composing it would be subjected apparently to exactly the same environment, and it mas divided into five rows. The first received no treatment whatever, the second was thoroughly sprayed twice

with 3-4-80 Bordeaux, the first treatment being given at the dropping of the petals and the second treatment three weeks later. The third was sprayed thoroughly three times with 3-4-50 Bordeaux, the first spray being applied at the dropping of the petals, the second three weeks later, and the third ten weeks after the first. The fifth was sprayed two times with one and one-half gallons of commercial lime-sulphur to fifty gallons of water, the first spray being given at the dropping of the petals and the second three weeks later. The fourth was sprayed three times with one

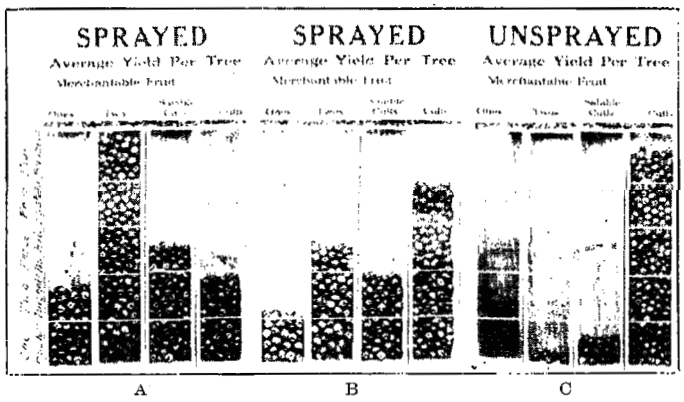

FIG. 14.—Average commercial returns from spraying Missouri Pippins which were located in a hundred-acre orchard badly infested with apple blotch. The poor showing of the unsprayed trees is due to blotch. Late frosts prevented a full set of fruit. A. Sprayed three times with the Bordeaux combination. B. Sprayed three times with the lime-sulphur combination. C. Unsprayed.

and one-half gallons of commercial lime-sulphur solution to fifty gallons of water, the first being applied at the dropping of the petals, the second three weeks later, and the third ten weeks after the first. In all cases the mixtures were delivered as a mist under a pressure ranging from 120 to 180 pounds with a gas-engine sprayer, and an especial effort was made to give the trees in every case an even and continuous coat. Arsenate of lead at the rate of two pounds to fifty gallons of water was used in the first two sprayings of each row. Although the check received no poison and the commercial results are on that account open to suspicion as being modified by insect injury, careful observation has convinced us that apple blotch is mainly to blame for the low commercial yield of the check. The following tables will show the results of this treatment in commercial returns and in counts made of the individual apples.

Returns in Merchantable Fruit as "Orchard Run."

Row.	Treatment.	Percentage of Merchantable Fruit.
1	None	13.0
2	Bordeaux twice	59.0
3	Bordeaux three times	83.5
5	Lime-sulphur twice	57.0
4	Lime-sulphur three times	57.0

Returns in Merchantable Fruit when graded in 1's, 2's, and Salable Culls.

Row.	Treatment.	Percentage of Merchantable Fruit Which Graded:		
		1's.	2's.	Salable Culls.
1	None	0.0	17.6	82.4
2	Bordeaux twice	3.4	64.4	32.2
3	Bordeaux three times	18.2	54.5	27.3
5	Lime-sulphur twice	5.0	41.8	53.2
4	Lime-sulphur three times	18.8	48.7	32.5

Effect of the Sprays as Determined by Examination of Every Apple Which Set on Each of Four Trees From Each Row.

Row.	Treatment.	Percentage of Apples Free From Apple Blotch.		
		Windfalls.	Picked.	Total.
1	None	11.6	12.6	11.7
2	Bordeaux twice	36.9	52.0	45.1
3	Bordeaux three times	61.6	77.3	72.0
5	Lime-sulphur twice	15.7	20.5	16.5
4	Lime-sulphur three times	25.0	48.8	34.5

Such sprayed fruit as was infested showed fewer and smaller spots than the unsprayed.

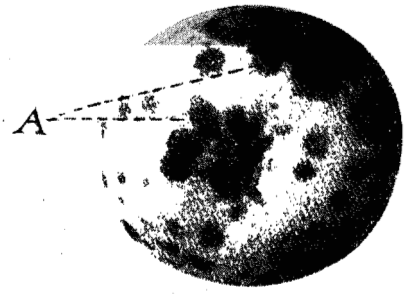

FIG. 15.—"Likewise the work of sooty blotch and fly speck damaged the Ingrams mainly." A. Sooty spots.

Both lime-sulphur and Bordeaux checked the apple blotch materially, even in this badly infested orchard. Three applications are much more satisfactory than two, and Bordeaux is much more effective than lime-sulphur.

Sooty blotch has been satisfactorily controlled by the spraying. Although these sprays were not applied with a view of controlling bitter rot, and were put on too early in the season to be very effect-

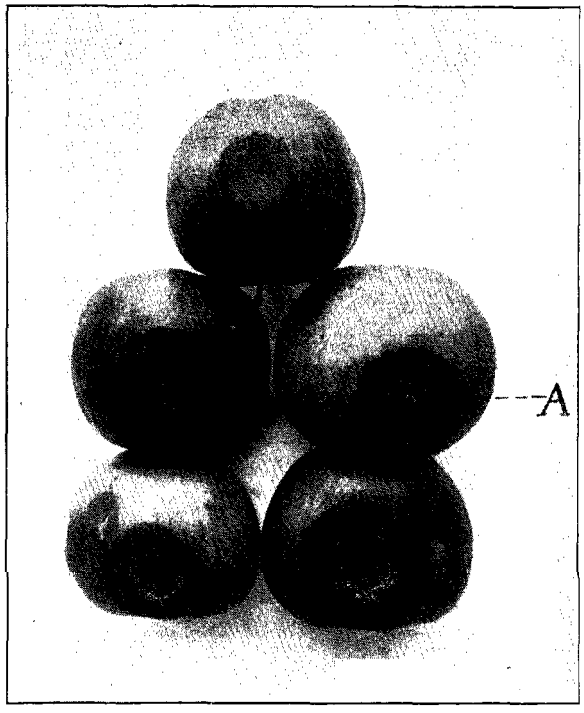

FIG. 16.—"Bitter rot attacked a few of the Jonathan trees." A. One of the rot spots.

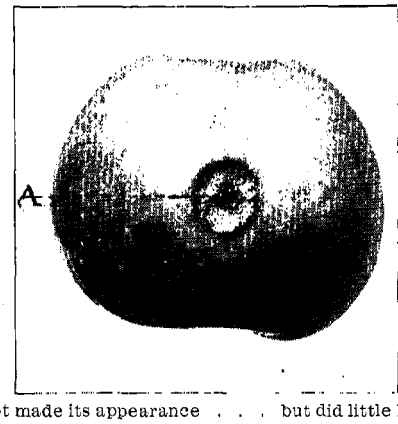

FIG. 17.—"Black rot made its appearance . . . but did little harm." A. Rot spot.

ive, they materially reduced the percentage or fruit injured by this disease. So little black rot appeared that the effect of spraying on this disease was not striking.

Twenty-four and nine-tenths per cent of all the fruit, which set on trees sprayed with Bordeaux combination showed

more or less spray injury, while 5.6 per cent of all the fruit which set on trees sprayed with lime-sulphur showed spray injury.

Only 12.9 per cent of all the fruit which set on trees that were unsprayed came through entirely free from insect and fungous injury, while 59.6 per cent of that on the trees treated with the Bordeaux combination was uninjured, and 53 per cent of that which set on trees treated with the lime-sulphur combination was untouched.

Commercially the harm from Bordeaux burning lies in the reduction of the percentage of merchantable fruit that will grade number 1. In our experience the Bordeaux treated and burned trees will produce about as much merchantable fruit as the lime-sulphur treated, but the percentage of number 1's in the former is smaller than in the latter, while the percentage of number 2's of the former is larger than that in the latter.

It is hardly within the province of this bulletin to consider the causes of Bordeaux burning, but in view of the fact that its use is always likely to be followed by more or less burning, a few remarks relative to the conditions under which it burns may not be out of place. Previous work on this subject has shown that Bordeaux injury is usually severe when the application is followed closely by wet weather, and that certain varieties are very susceptible to injury while others are almost or quite immune. These findings agree exactly with the experience of the writers. While carrying out orchard spraying as assistant

Relation of varieties to Bordeaux injury observed during the past season.

Almost or quite uninjured.	Injured.
Ingram.	Jonathan. Winesap. Missouri Pippin Ben Davis York Imperial

entomologist in the state of New Hampshire, the junior author applied two sprays of Bordeaux and arsenate of lead to MacIntosh Red apples without any resulting injury whatever. Within twenty-four hours after the third application a heavy rain fell and in ten days the damage was very large, the leaves and fruit being badly spotted. Likewise the second treatment of Jonathans at Parker showed (the first was not given) no injury, but within forty-eight hours of the completion of the third treatment a heavy rain came and in two weeks thereafter much burning of fruit and foliage became apparent. As soon after this heavy rain as the sprayer

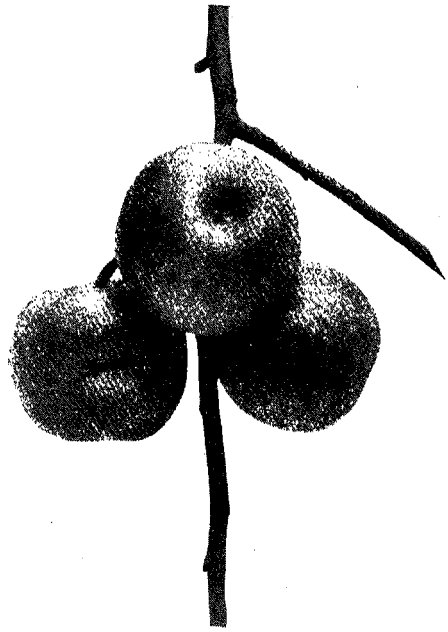

FIG. 18.—Any variety susceptible to Bordeaux injury when treated with Bordeaux is likely to suffer. Missouri Pippins russeted by Bordeaux.

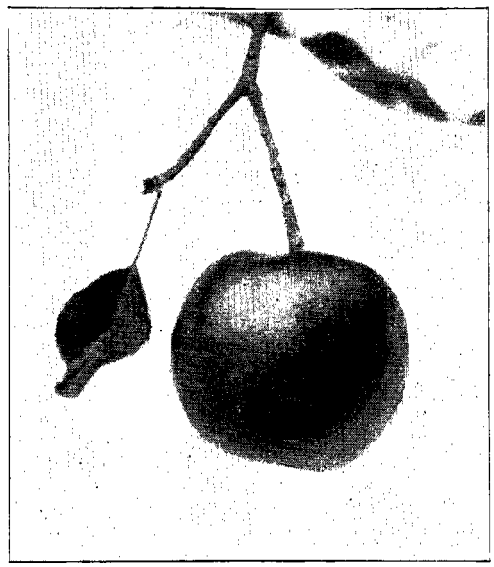

FIG. 19.—Lime-sulphur treated Jonathan.

could be pulled into the orchard the mixed planting at Mildred treated with Bordeaux, and, not followed by a rain for a week or more, not a trace of burning appeared. Any variety susceptible to Bordeaux injury treated with Bordeaux mixture is very likely to suffer. The preceding table and summary clearly show that all ordinary diseases except apple blotch are almost as well, equally well, or better controlled by use of litne-sulphur than by Bordeaux mixture. Why, then, should not lime-sulphur be used on all varieties susceptible to Bordeaux injury and not likely to be seriously attacked by blotch? Why not use lime-sulphur on Jonathan, Ben Davis, and Winesap? The greater efficiency of Bordeaux in the control of apple blotch and the susceptibility of the Missouri Pippin to the attack of blotch would render the use of Bordeaux on this variety advisable, although burning may result.

Recommendations

It should go without saying that the orchard from which one expects to get fine apples should be well pruned, well cultivated, and well fed. No amount of spraying will make trees which do not set apples, either because of lack of proper growing conditions or frost, produce fruit. Spraying is intended merely to insure a large percentage of the apples which do set against the ravages of insects and fungous diseases. To render spraying worth while all measures which look toward a strong set of apples must be taken.

NUMBER OF SPRAYS.

In view of the fact that these sprays are intended to destroy fungous diseases which develop throughout the growing season, it appears that at least four sprays should be used and that they should be concentrated at the beginning of the season in such a manner that the foliage and fruit may be covered by a protective substance when the disease spores are sprouting and trying to attack the rapidly growing and consequently tender fruit and foliage. Indeed, when bitter rot is expected, the fourth spraying should consist of either Bordeaux mixture and arsenate of lead, or commercial lime-sulphur and arsenate of lead, instead of merely arsenate of lead.

TIME OF SPRAYING

There is a right time to spray. The first spraying, which is intended to destroy the apple scab fungus, canker-worms, bu worms, and leaf-feeders, generally should be applied just after the cluster cups open and just before the flower buds unfold. The second spray, which is intended principally for codling-moth and

secondarily for curculio and scab and blotch fungi, should be given at the dropping of the blossoms and before the calyx lobes close. This may begin when the blossoms are one-half to two-thirds down. The third spraying, which is intended for codling-moth, curculio, scab, blotch, black and bitter rot, should be given about three weeks after the blossoms fall, because by this time the first brood of codling-moth larvæ is hatching and the fungus-killing mixtures have probably been largely washed from the trees. The fourth spraying, when bitter rot is not anticipated, consists of arsenate of lead alone. It is intended primarily for second brood codling-moth larvæ and secondarily for general leaf and fruit feeders. It should be applied about ten weeks after the blossoms fall.

SPRAYING MACHINERY.

Spraying machinery is intended to deliver the spray mixtures in such a way as to cover the trees thoroughly in the shortest possible time. This is accomplished by placing the liquid under pressure and delivering it through a small aperture whereby it is broken up into a fine mist which can be driven upon all parts of the tree. The first consideration, then, is the power, and the second the pump, the hose, extension rods, and the nozzles.

The power is usually derived from man work, gasoline engine, or compressed air. The first is the cheapest and most practical when less than five hundred trees are concerned, but when 500 to 2000 trees must be treated a gasoline engine is needed, and when more than two thousand trees are to be sprayed compressed air should be employed.

It is quite possible that some growers, owing to scarcity of labor, will find the gas engine most practical for a smaller number of trees than 500. The objection to the gas engine for more than 2000 trees lies in the fact that more than one outfit must be employed, necessitating the employment of an engineer for each, who, if satisfactory, is usually high priced. It is better when several outfits are needed to purchase a good gas or steam engine and a compressor, by means of which an abundance of power can be produced for all outfits. In our experience, spraying done by means of a gas engine outfit when the engine runs well, costs, other things being equal, a little more than one-half as much as when done by hand power. The reduction in cost should be almost as great when compressed air is employed.

Whether the source of power is muscle or gasoline, the spray is put under pressure by means of a force pump. A satisfactory pump, regardless of the power to be employed, should have the

following points: (1) all parts that come in contact with the spraying fluid should be made of brass, which will not be corroded by any of them; (2) the air chamber should be so large that the liquid will be delivered in a steady stream, instead of in a succession of spurts; (3) all working parts, especially the valves, should be so made that they can be easily gotten at and cleaned; (4) the parts should be so arranged that they will have the minimum chance of breakage should the pump fall. This applies particularly to the barrel pump, which is always likely to tumble off the wagon or cart, and can best be insured by having a pump the working parts of which are mainly in the barrel; (5) when gas engine is geared to pump, both pump and engine should be immovably fastened upon the same base, preferably of iron or steel.

The hose should be long enough to permit the operator to reach every part of the tree. In our experience twenty-five feet lengths have proven most generally useful. Ordinary garden hose connections are not satisfactory when much pressure is to be employed, because the part which is thrust into the hose is too short and too smooth. Under heavy pressure such connections are likely to slip and make trouble. Hose connections having an especial length and roughness of shaft are desirable. The hose should end in an extension rod of some sort, either bamboo, brass-lined, or ordinary gas pipe uncovered. The extension rod should bear one or more nozzles, depending upon the amount of pressure to be used. Two types of spray are used—the strong, dashing type, when the solid stream does not break up for five or six feet after leaving the nozzles, and the mist type, from which the liquid is delivered as a fog. The first type is produced by the Bordeaux nozzle and the second by the Vermorel or "Friend" nozzles. In our experience the "Friend" type of nozzle has proven a little the more satisfactory, because it never catches in the branches of the tree. All joints' from pump to nozzle opening should be made so tight that no liquid can escape.

SPRAYING MATERIALS.

We spray the apple orchard to destroy insects and fungi that would, if unchecked, reduce or completely destroy the crop. The insects that do most of the damage to foliage and fruit bite off and consume pieces of fruit and foliage. They can be destroyed by placing a stomach poison at the proper time on the food which they use. Arsenic combined with lead (arsenate of lead) has been found best for this purpose, because it adheres for a long time to fruit and foliage and has so little free arsenious acid in it that we have never known it to burn appreciably.

The important destructive fungi begin their attack on fruit and foliage in the same way. A small spore is blown upon the surface of the fruit or leaf. Under the influence of moisture the spore bursts and a growing sprout emerges. It finds its way through the tissue of the fruit, grows inside the tissue and produces spores which, escaping from the dead tissue, spread the disease to other and healthy tissue. If, while the spore is sprouting, it be brought into contact with a substance deadly to it, it will perish. Of course, this deadly substance must be just strong enough to kill the young fungous-plant and not strong enough to injure the foliage and fruit of the apple. Copper sulphate, or blue vitriol, when combined with milk of lime, forming Bordeaux mixture, has been found to kill the injurious fungi and not very seriously injure the apple. Of recent years, however, accumulated experience has shown beyond doubt that even the weak Bordeaux will, if its application be closely followed by rain, badly burn both the foliage and fruit of certain susceptible varieties. This fact has led to a search for a substitute. Of those tried, lime-sulphur has proven most promising. For all the common apple diseases except apple blotch, lime-sulphur properly used has proven a satisfactory substitute for Bordeaux.

Our experience would lead us to recommend the use of Bordeaux plus arsenate of lead on varieties of apples especially susceptible to blotch, or upon those not subject to Bordeaux injury, and lime-sulphur plus arsenate of lead on varieties not likely to be badly infested by blotch. We would further recommend the 3-4-50 formula for Bordeaux plus two pounds of arsenate of lead, or one and one-half gallons commercial lime-sulphur to fifty gallons of water plus two pounds of arsenate of lead.

METHOD OF APPLICATION.

The method of application should be made to vary with the object to be gained. All sprays except the one given at the dropping of the petals are intended to coat as completely as possible both foliage and fruit with the mixtures. They are therefore delivered as a fine mist from both ground and tower in such a manner as best to effect this object. The spray at the dropping of the petals is intended to fill the open calyx end of the apple with poison, because eighty per cent of the first brood and a large percentage of the second brood of apple worms enter the fruit through this door, and because soon the calyx lobes will roll together, enclosing the poison and holding it there for all comers. When this spray is delivered the young apple stands with the calyx opening upward,

and the filling can be best accomplished by shooting the spray into it from above downward under great pressure. There is a difference of opinion among experimenters as to whether the second spray, delivered as a dash, is more effective than if delivered as a mist.

With the ordinary spraying machinery, efficient spraying can not be done with pressure of less than 80 pounds, and the work can be much more satisfactorily and rapidly done with a pressure of 200. Good types of barrel pumps will give pressures ranging from 60 to 120 pounds, with an average of about 80. Gasoline and compressed air sprayers will give pressure from 120 to 225 pounds.

SCHEDULE OF APPLICATIONS.

First application.—Apply as a mist between the opening of the cluster cups and the opening of the blossoms.

Second application.—Apply lime-sulphur as a mist or as a dash, or Bordeaux as a mist at the dropping of the petals and before the calyx closes. Deliver the spray from above downward and make every effort to fill the calyx cup with poison.

Third application. —Apply as a mist about three weeks after the blossoms fall. Apply both from above and below and make every effort to give the fruit and foliage a complete, even coat of the spray.

Fourth application. —Apply as a mist about ten weeks after the blossoms fall. Apply both from above and below and make every effort to give the fruit and foliage a complete, even coating of the spray.

Use 3-4-60 Bordeaux plus two pounds of arsenate of lead for first three sprays on varieties of apples immune from Bordeaux injury or likely to be severely injured by apple blotch. Use one and one-half gallons of prepared lime-sulphur plus two pounds of arsenate of lead to fifty gallons of water for the first three sprayings on varieties susceptible to Bordeaux injury and not likely to be seriously attacked by apple blotch. Make Bordeaux mixture and mix lead and lime-sulphur as described on pages 269-270.