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FIELD EXPERIMENTS IN SPRAYING APPLE ORCHARDS

UNDER THE DIRECTION OF
J. C. BLAIR
BY
B. S. PICKETT
O. S. WATKINS
W. A. RUTH
L. E. FOGLESONG
A. J. GUNDERSON

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INTRODUCTION

By B. S. PICKETT, Assistant Chief in Pomology

Objects of Field Experiments in Spraying Apple Orchards

The apple crop is subject to a large number of fungous diseases and to depredations from many insects. In the state of Illinois it commonly happens that the losses from some one or more of these fungi or insects amount to a considerable part or even to the whole of the crop in any one season. According to the Thirteenth Census of the United States, there were in Illinois in 1909, 9,900,627 apple trees of bearing age, producing a total crop of over 3,093,321 bushels. While this low production per tree may be attributed to a number of causes, the most serious single cause for the reduction of the crop is to be found in failure to protect the trees from the ravages of fungi and insects. During the summer and autumn of 1912, a large number of unsprayed orchards in the leading orchard sections of Illinois were visited by the writer, and in no case was there found any fruit fit for barreling, whereas sprayed orchards in the same localities were bearing abundant crops of excellent quality. No one can doubt that attention to this one factor, spraying, in apple growing would easily increase the production of apples in Illinois by 100 percent.

The chief insects affecting the fruit of the apple in Illinois are the codling moth (*Carpocapsa pomonella*), the plum curculio (*Conotrachelus nenuphar*), and the San Jose scale (*Aspidiotus perniciosus*). The foliage is attacked by a number of insects, such as green apple aphis (*Aphis mali*), canker worm (*Paleacrita vernata*), fall web-worm (*Hyphantria cunea*), apple-leaf miner (*Tischeria malifoliella*), pistol case-bearer (*Coleophora malivorella*), apple flea-weevil (*Orchestes canus*), green fruit worms (*Xylina antennata* et al), and many others. The principal diseases affecting the fruit of the apple are apple scab (*Venturia inaequalis*), apple blotch (*Phyllosticta solitaria,* E. & E.), sooty blotch (*Leptothyrium pomi,* Mont. & Fr.), fly-speck (*Leptothyrium pomi,* Mont. & Fr.), bitter rot (*Glomerella rufomaculans*), and cedar rust (*Gymnosporangium macropus*). Apple

scab, apple blotch, and cedar rust also attack the foliage. Besides these diseases there is apple-leaf spot, or frog-eye fungus (*Sphæropsis malorum*), which, tho chiefly destructive to the foliage, occasionally attacks the fruit in the form of black rot.

It has long been understood that certain chemicals are destructive to the spores of various fungi; that poisons of various kinds, but more especially substances containing arsenic, will kill chewing insects; and that certain insects which do not chew their food can be killed by applying some substances directly to their bodies. In order to ascertain the effectiveness of the different fungicides and insecticides which have been advocated or suggested in many quarters, the Horticultural Department of this station has conducted experiments on a large scale, under field conditions, using commercial machinery, and continuing the tests from year to year. As a result of these studies, bulletins on the following subjects have appeared: "The Curculio and the Apple," by C. S. Crandall, Bulletin 98; "Spraying Apples, Relative Merits of Liquid and Dust Applications," by C. S. Crandall, Bulletin 106; "Spraying for the Codling Moth," by J. W. Lloyd, Bulletin 114; "Bitter Rot of Apples," by J. C. Blair, Bulletin 117; "Bitter Rot of Apples," by T. J. Burrill, Bulletin 118; "Bordeaux Mixture," by C. S. Crandall, Bulletin 135. Each of these pieces of work involved a special study of some one phase of apple spraying. In later experiments, therefore, it became the purpose of the department to coordinate the results of earlier investigations into general systems of spraying, the attempt being made to evolve methods of practice which would be practical from a commercial standpoint and which would effectively apply to the solution of the most important spraying problems. With this idea in view an effort was made to answer the following questions thru the medium of the field experiments:

1. What is the general effectiveness of applications of standard spray mixtures, including Bordeaux, lime sulfur, and arsenate of lead, in the control of fungi and insects on the apple?
2. What are the relative values of Bordeaux and lime sulfur as sprays for the apple?
3. Can Bordeaux injury be lessened or prevented by frequent sprayings with the same spray, or by maintaining over the Bordeaux a coating of lime thruout the season?
4. Is it possible to interchange Bordeaux and lime sulfur, in a spray schedule, to advantage, using Bordeaux for one or more applications and lime sulfur for the remaining applications?
5. What is the most effective and at the same time the most economical dilution of lime sulfur as a fungicide spray?
6. Is homemade concentrated lime sulfur as efficient as the ordinary commercial concentrated lime sulfur?

7. What is the fungicidal value of self-boiled lime sulfur, and how does it compare with lime sulfur made in the usual manner?

8. Will the addition of copper sulfate to lime sulfur increase the fungicidal value of the spray?

9. Is an application of lime sulfur made at the strength used for San Jose scale, applied while the trees are dormant, of any value as a preventive of apple scab?

10. What is the most effective poison which can be advantageously combined with standard fungicides for the control of chewing insects, particularly the codling moth and the plum curculio?

11. Does arsenate of lead when used alone possess any fungicidal value?

12. Does arsenate of lead when added to Bordeaux or lime sulfur increase their fungicidal value?

13. Are there differences between various brands of arsenate of lead which would make one brand more useful than another, either alone or in combination with the standard fungicides?

14. Of what value are certain new sprays, both as fungicides and as insecticides?

15. How often and at what times should summer sprays be applied?

ORGANIZATION

The attempt to answer these various questions for the several leading orchard sections of the state required the organization of the work on a large scale. In order to secure results which would be thoroly reliable, it was deemed necessary to make field experiments in each of the leading orchard sections; viz., in the extreme western part of the state, in the extreme southern part of the state, and in the orchard section in the gray-soil region which, in a general way, centers about the counties of Marion, Clay, and Richland. In order to counteract seasonal differences, it was planned to conduct experiments in these sections for several successive years, and with one exception this plan was followed. In the results which are given in this bulletin there are presented the data derived from four years' experimentation. In the course of these four years, experiments were carried on at five different points, in ten series of plats, in seven different orchards.

Obstacles and difficulties along the following lines presented themselves in one form or another at various times thruout the experimental work:

1. The climatic conditions in different parts of the state vary to a considerable extent, thus making it hard to summarize and average results for any particular season.

2. It is nearly always difficult to secure orchards of uniformly vigorous growth with trees arranged in such a manner that the varieties in each plat will be comparable with those in adjoining plats.

3. Uniform conditions in regard to age of trees, slope, and drainage are difficult to obtain, particularly in conjunction with other requirements calling for absolute uniformity.

4. A reasonably uniform infection of diseases or infestation of insects is necessary to insure reliable results, a matter extremely difficult to determine before an experiment is commenced. Certain fungi and certain insects cannot be expected to distribute themselves uniformly, and special methods must be adopted in the arranging of plats and checks to avoid errors in the study of the control of these particular pests.

5. The making of uniform records of experiments in spraying is extremely difficult. Different observers are apt to attach different degrees of importance to the various points on which data are to be obtained.

6. Many things which materially affect results in spraying experiments are easily passed over. Successful spraying depends so much upon detail in the correct preparation of mixtures, in the proper agitation of the mixture in the spray tank, in the careful and thoro application to the trees, and on the weather conditions which prevail not only at spraying time but thruout the entire following season, that results may readily be obtained which can be accounted for only in the light of all the conditions prevailing thruout the experiment.

The organization for work in these field experiments in spraying apple orchards was designed particularly to avoid or to counteract the difficulties which it was felt certain would be met. Especial care was exercised in choosing orchards which were representative of the sections in which they were located, which were uniform as to variety, age, vigor of trees, and previous soil and spraying treatment, and which were of such size and form as would permit laying out experimental plats to advantage. The men in charge of these experiments were all graduates of the University of Illinois, or were trained in the Department of Horticulture at this university. All the men were taught similar methods of preparing the standard spray mixtures used in the experiments and all were familiar with the types of spray apparatus used. The results of the data gathered were freely discussed by all the men concerned, and from year to year, suggestions were made for the better recording of data and for new lines of work. Thus each succeeding year's work has been carried forward in the light of the experience of past years.

The accompanying map shows the location of the Agricultural Experiment Station at Urbana, and of the various experiments conducted during the last four years.

Detailed descriptions of the orchards are given under the reports of each experiment.

The following tabulation gives the location of the experiments and the names of the men in charge:

CHART 1.—MAP OF ILLINOIS, SHOWING THE LOCATION OF THE AGRICULTURAL EXPERIMENT STATION AND OF THE VARIOUS EXPERIMENTAL ORCHARDS

LOCATION OF EXPERIMENTS AND MEN IN CHARGE

Year	Place	County	Horticultural division	Owner of orchard	In charge of orchard
1909	Griggsville	Pike	Western Central	Mr. John Sawdon	L. Earl Foglesong
1910	Centralia	Marion	Southern	G. H. Perrine & Sons	L. Earl Foglesong
1910	Neoga	Cumberland	Southern	H. A. Aldrich & Co.	O. S. Watkins
1911	Centralia	Marion	Southern	G. H. Perrine & Sons	L. Earl Foglesong
1911	Neoga	Cumberland	Southern	H. A. Aldrich & Co.	O. S. Watkins
1911	Griggsville	Pike	Western Central	Mr. G. Warton	Alfred J. Gunderson
1912	Anna	Union	Southern	Mr. F. P. Anderson	L. Earl Foglesong
1912	Neoga	Cumberland	Southern	H. A. Aldrich & Co.	O. S. Watkins
1912	Griggsville	Pike	Western Central	Mr. F. Turnbull	Alfred J. Gunderson
1912	Flora	Clay	Southern	Mrs. John Egginton	W. A. Ruth

STANDARD SPRAYS: FORMULAS AND PREPARATION

The standard sprays used thruout these experiments were Bordeaux, lime sulfur, and arsenate of lead. In all cases thruout this bulletin where the formulas and preparation are not distinctly described in connection with the sprays spoken of, the sprays were prepared as here described.

Bordeaux.—Eight pounds copper sulfate, 8 pounds freshly-slaked lump lime, 100 gallons water. Except in the case of the experiments at Flora in 1912, the mixture was prepared by dissolving the copper sulfate in half the total quantity of water used, and mixing the slaked lime with the other half. The diluted solution and the diluted mixture were then poured together simultaneously thru a sieve, either into the mixing tank or directly into the spray tank.

Lime Sulfur, Commercial, for Summer Sprays.—Eight pounds sulfur in 100 gallons spray (3 gallons commercial concentrated lime sulfur to 97 gallons water, or 3 gallons commercial concentrated lime sulfur in 100 gallons of the dilute summer spray).

Lime Sulfur, Homemade, for Summer Sprays.—Eight pounds sulfur in 100 gallons spray (5½ gallons stock solution homemade lime sulfur to 94½ gallons water, or 5½ gallons stock solution homemade lime sulfur in 100 gallons spray).

Lime Sulfur, Homemade, for Dormant Spray.—Twenty-nine pounds sulfur in 100 gallons spray (20 gallons stock solution homemade lime sulfur to 80 gallons water, or 20 gallons stock solution homemade lime sulfur in 100 gallons spray).

Stock Solution, Homemade Lime Sulfur.—One hundred pounds sulfur, 50 pounds lime, water to make 66 gallons.[1] Homemade lime sulfur was prepared by placing in a large kettle 15 gallons water and 50 pounds good lime, free from air-slaked particles. When the lime was slaking vigorously, 100 pounds of powdered sulfur were poured in, and mixed thoroly with the lime. Sufficient water was added gradually to prevent the lime from drying out during the process of

[1]Illinois formula.

slaking. As soon as the lime was thoroly slaked and the sulfur thoroly mixed, enough water was added to bring the total volume to 66 gallons or a little more. Boiling was continued for 30 to 45 minutes, water being added from time to time to keep the volume at 66 gallons. By following this method it was found possible to get the maximum amount of sulfur into solution. In most of the experimental work, the boiling was done in large iron kettles heated over simple outdoor fireplaces constructed for the purpose. In the experiments at Centralia, however, the homemade lime sulfur was obtained from the cooking plant of G. H. Perrine and Sons.

Arsenate of Lead.—Four pounds arsenate of lead paste in 100 gallons water, Bordeaux, or lime sulfur. The arsenate of lead was worked up with a small quantity of water into a mixture that would pour readily and mix evenly with the water or fungicide when subjected to the action of the agitator in the spray tank.

TIMES OF APPLICATION

Thruout this bulletin applications are spoken of as dormant-tree, or winter sprays, and first, second, third, fourth, fifth, and sixth summer sprays.

The dormant-tree, or winter, application, refers to the spray applied particularly for the control of San Jose scale, and always consists of lime sulfur at the dilutions mentioned under the preceding section. It may be applied at any time after the trees shed their leaves in the fall and before the buds show green in the spring. Usually, however, this application is made during March.

The summer sprays are not, strictly speaking, summer sprays, as the first three are usually applied during April and May. They are referred to as summer sprays as a matter of convenience, because all are applied after leaf growth has started. The first of these is commonly referred to as the cluster-bud spray, because it is made after the cluster buds open and the individual flower buds within the cluster buds have separated slightly from each other. The second spray is made immediately after the fall of the petals and while the lobes of the calyx cups are still distended. At this time the calyx cups point upward or outward rather than downward. The third summer spray is made about ten days after the second. Later summer sprays are made for the control of the second brood of codling moth, for bitter rot, and, in some cases, for apple blotch. The spray for the second brood of codling moth is applied from July 1 to 10 in the extreme southern portion of the state, from July 4 to 12 in the apple region included in Marion, Clay, Richland, and adjoining counties, and from that time until the middle of August at the extreme northern part of the state, depending somewhat upon the season.

Sprays for bitter rot are commenced during the last week in June, if the disease is anticipated, and continued at intervals of ten days until four applications have been made. If a separate spray is required for apple blotch, it may be applied ten days to two weeks after the third regular summer spray, or about four weeks after the fall of the petals.

TERMINOLOGY; DEFINITIONS; MISCELLANEOUS EXPLANATIONS

Bordeaux.—The term "Bordeaux" is used thruout this bulletin in place of the term heretofore applied, viz., Bordeaux mixture. The authors feel that in connection with the literature on spraying the term is now so well understood that there is no necessity for the use of the longer name. It must, moreover, be used with so great frequency in a publication of this kind that the omission of the word "mixture" may be justified on the ground of convenience.

Combined Fungicides and Insecticides.—When Bordeaux, lime sulfur, or other fungicides have been used in combination with arsenate of lead or other insecticides, the names of the insecticide and the fungicide are written consecutively without separation by means of a hyphen or other punctuation; as, Bordeaux arsenate of lead, and lime sulfur arsenate of lead.

Bordeaux Injury to Foliage.—Bordeaux injuries to foliage may be in the form of a yellowing of the leaves, or in the killing of portions of the leaf which turn brown and become dry. These dead patches appear along the margins of the leaves or near their tips, where the spray mixtures accumulate in considerable quantities, or in spots distributed over the leaf.[1]

Yellow-Leaf.—Trees affected by yellow-leaf show premature yellowing of the foliage. Usually only a comparatively small number of the leaves lose their color, but in severe cases one-fourth to one-third of all the foliage is lost. In most cases the injury is directly traceable to the use of Bordeaux as a spray; occasionally it seems to be due to some physiological cause not well understood. When it is caused by Bordeaux the leaves do not turn yellow immediately upon the application of the spray. The injury becomes noticeable in from one to two weeks after the application of the fungicide, or appears even after an interval of several weeks.

Lime-Sulfur Injury to Foliage.—Lime sulfur appears to kill patches on the margins of the leaves or near their tips, but yellowing of the foliage as a result of the use of lime sulfur does not occur.

Lime-Sulfur Burn or Scald.—Apples sprayed with lime sulfur, particularly during extremely hot weather, suffer occasionally from a form of injury known as burn, or scald. This injury appears on the sunny side of the fruit, frequently toward the stem end or in the

[1]Bordeaux Mixture, C. S. Crandall, Ill. Agr. Exp. Sta. Bul. 135, p. 220.

cavity, if the cavity is exposed to the sun. The injury takes the form of a browning of the skin and of the tissues immediately beneath the skin. It may even extend to the center of the apple. In severe cases the affected part of the apple splits across, sometimes in both directions, forming a cross-shaped incision. When the injury is only superficial, it sometimes heals beneath the injured skin, which sloughs off as the new epidermis grows just beneath it and displaces it. Thruout these experiments lime-sulfur burn was common only during the extremely hot summer of 1911; during the seasons of 1910 and 1912 it was recorded but rarely.

Russeting of the Fruit.—"Russeting" is a term descriptive of the appearance of portions of the skin of apples which normally should be smooth, and red or yellow in color. The apple may be affected in varying degrees of severity. In the milder forms russeting appears as a few fine russeted lines which spread themselves in a sort of network over larger or smaller parts of the surface of the apple, or it may appear as small black dots which give to the skin of the apple a rough appearance and feel. In cases of moderate severity russeted patches of considerable size appear on the fruit, with lines of russeting spreading out from them. Very severe russeting may cause deformed fruits and render the crop worthless except for bulk or cider stock. Russeting appears to be caused by any irritation to the skin of the fruits. It very frequently follows the application of Bordeaux and other sprays to which copper sulfate has been added. It is also recorded as occurring to some extent after applications of lime sulfur; not infrequently it is observed where no sprays whatever have been applied.

ARRANGEMENT OF SUBJECT MATTER

The data for each series of field experiments in spraying are given in separate reports. It will be noted that there is a decided similarity between the results from the various series, but it is not to be expected that each series will in every detail corroborate the results of every other series. The data are presented, therefore, with sufficient detail to show the scientific accuracy of the work and at the same time to make the results of permanent value, both to the commercial orchardist and to the investigator interested in studying the problems of insect and fungus control from either a practical or scientific standpoint. In addition to a summary which is generally made at the end of each report, a final summary at the end of the bulletin brings together the general results of the four years' experimentation and includes recommendations for spraying practice in Illinois apple orchards.

SPRAYING EXPERIMENTS IN 1910 AT NEOGA, CUMBERLAND COUNTY

BY O. S. WATKINS, ASSOCIATE IN HORTICULTURAL CHEMISTRY

OBJECTS

During the summer of 1910, spraying experiments were undertaken at Neoga, Illinois, the chief lines of investigation being tests to determine: (1) the relative efficiency of lime-sulfur mixtures and Bordeaux; (2) the efficiency of Bordeaux and milk of lime in reducing Bordeaux injury; (3) the comparative values of various commercial arsenates of lead. On a fourth group treatment was begun to test the value of certain new and proprietary sprays, including Pyrox, Sulfocide, Cucasa, arsenic sulfid, copper ferrocyanide, and Black Leaf 40, but owing to unfavorable weather conditions, no fruit data were obtained on any of the plats in this group.

LOCATION AND DESCRIPTION OF ORCHARD

The orchard selected for these experiments is situated two miles southwest of Neoga and is owned by H. A. Aldrich and Company of that town. It consisted of twenty acres of several varieties of trees, of which three hundred fifteen-year-old Ben Davis trees planted in a solid block were chosen for the experiment. The land upon which the orchard is located is more or less rolling, and a small stream passes thru it. The trees were in vigorous condition, having been given excellent care ever since they were planted.

ARRANGEMENT OF PLATS

The experimental block was divided into plats of four to six trees each, and the various plats were sprayed differently. Scattered among the plats, check trees, which were given no treatment, were kept for comparison with the sprayed trees. Problems of similar nature were grouped together, and in no group were there more trees than could be sprayed in a single day.

APPARATUS AND MATERIALS

All spray mixtures were made according to the methods recommended by the Illinois Agricultural Experiment Station, and are given in brief under the several groups. Owing to the large number of different sprays which were used and the small amount of each which was required, the material was applied by means of a barrel pump at 100 to 125 pounds pressure. Vermorel nozzles were used.

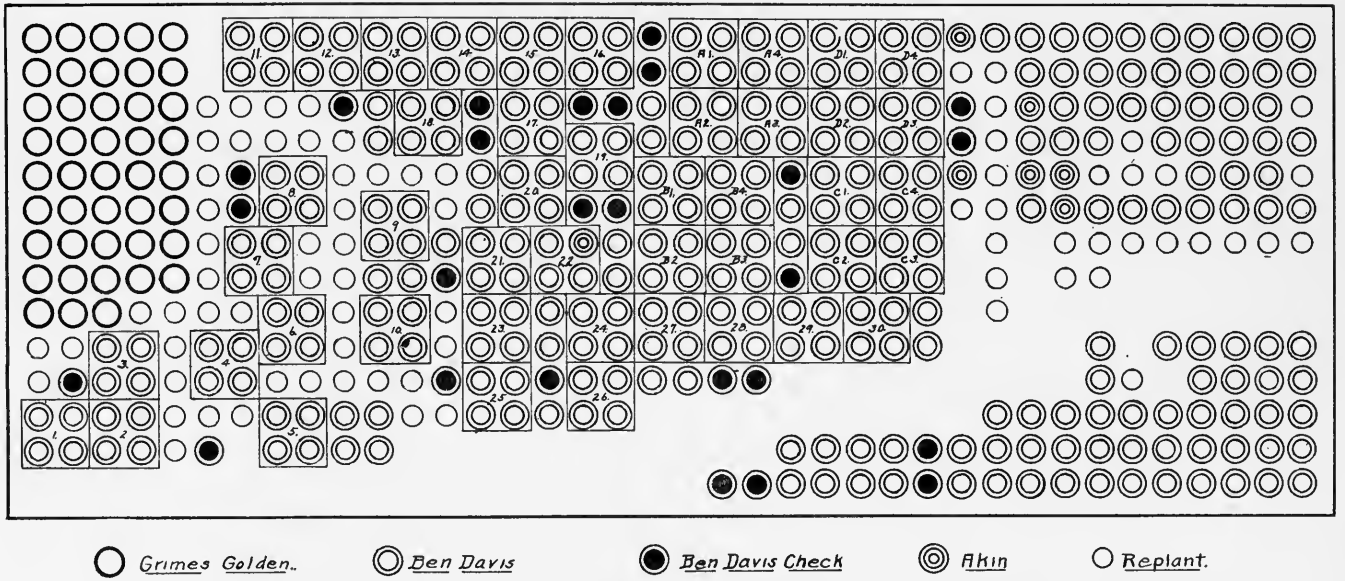

CHART 2.—PLAN OF PLATS IN ORCHARD OF H. A. ALDRICH AND COMPANY, NEOGA, 1910

CHARACTER OF RECORDS AND METHOD OF MAKING

Foliage notes were taken from time to time thruout the season, and the dropped apples were counted and examined. All fruit upon the trees at harvesting time was hand-picked, counted, and weighed. Owing to the generally small yield of fruit, practically the entire crop was examined. On a few plats certain trees bore a full crop, and in such cases, a representative tree was chosen, and all the apples on a certain portion of it, including those on the lowest and uppermost branches and those on the outermost and innermost branches of the tree, were picked and placed on the sorting table. From these, two samples of one hundred each were chosen and examined separately and the records compared. In case the records were not approximately the same, another sample of one hundred apples was selected and examined, and this process was repeated until the records were obtained upon an average sample. The results recorded are the average of all samples examined.

In examining the apples for blemishes, a record was kept of all markings, however small; in grading the standard adopted by the Illinois State Horticultural Society was adhered to.[1] The grade records were taken from the samples examined, and the percentages are based on the number of apples in each grade. This makes the percentage of No. 2's and culls somewhat larger than would be the case had the grading been in terms of bushels.

WEATHER CONDITIONS

The season was quite abnormal. March was a warm month, and as a result the trees came into blossom early in April, nearly a month before the average normal blooming date. A very heavy bloom was followed by an excellent set of fruit, but on April 23, when the apples had reached the size of hazel nuts, many of the small ones were frozen. Perhaps 15 to 20 percent of the crop in the experimental orchard survived the cold. The season was normal as regards rainfall, seldom more than ten days intervening between rains of one-half inch or more.

DISEASES AND INSECTS

The infection of apple scab could not have been worse, altho the fungus did not appear until about the middle of May, when the apples

[1] "For Ben Davis, a No. 1 apple shall not be less than 2½ inches in diameter, shall be practically free from action of worms, or not over 10 percent of the apples affected by scab or other defacement of surface; shall be hand-picked from the trees and not bruised, or skin-broken; shall be of a bright and normal color and shapely formed. No. 2 apples may be 2¼ inches in diameter, and not over 20 percent of the apples affected by defacement of surface by dry rot, scab, worms, or other defects; shall be hand-picked from the trees and not bruised or skin-broken; shall be of a bright and normal color and shapely formed. Adopted December 17, 1903."

were the size of hickory nuts. There was also an abundance of insects. Neighboring orchards which received no care produced no fruit and were defoliated before the first of September.

SPRAY DATES

The entire orchard was given a winter application of lime sulfur the latter part of March, just as the buds were beginning to swell; and from one to six summer applications of various sprays were made upon or near the following dates: April 7, April 26, May 10, May 27, June 21, and July 22.

RELATIVE EFFICIENCY OF LIME SULFUR AND BORDEAUX

During the last few years lime sulfur has attracted attention as a fungicide for the summer treatment of apples. In order to determine the adaptability of this spray for Illinois orchards five plats, each consisting of sixteen trees, and subdivided into plats of four trees each, were sprayed as follows:

Plat A: Homemade lime sulfur. This was made by boiling together, until all the sulfur was in solution, 10 pounds of lime, 20 pounds of sulfur, and about 13 gallons of water. This solution was then diluted so that 100 gallons of spray contained 8 pounds of sulfur.[1] The material was made up immediately before each application.

Plat B: Home-concentrated lime sulfur. This was made by boiling together, until all the sulfur was in solution, 50 pounds of lime, 100 pounds of sulfur, and 50 gallons of water. This solution was diluted so that 100 gallons of spray contained 8 pounds of sulfur.[2] The material was prepared early in the season and kept as a stock solution, some of it being used for each application. In order to determine whether or not there was any deterioration of home-concentrated lime-sulfur solution upon standing, the records obtained upon the fruit in these plats were compared with those from the A plats.

Plat C: Self-boiled lime and sulfur. This was made from 32 pounds of lime, 32 pounds of sulfur, and 200 gallons of water. The preparation of this spray differs from that used on Plats A and B, in that the only heat used to cook it is that furnished by the slaking lime.

Plat D: Commercial lime sulfur, 1 in 35.

Plat E: Standard Bordeaux, 8-8-100.

For the control of chewing insects, arsenate of lead was added to each of the above mixtures at the rate of 4 pounds per 100 gallons of spray.

EFFECT ON FOLIAGE

The early effects of the first three applications were quite similar. The first infection of scab did not occur until several days after the third application of spray had been made. Shortly after this application, there was considerable rain, which washed off much of the spray and at the same time afforded excellent conditions for the germination of scab spores. At the time the scab appeared there was very

[1] Based on analyses of similarly made solutions.

[2] Based on analyses of solutions used.

little spray material visible upon any of the trees which had been sprayed with the lime-sulfur mixtures, while there was a large amount visible on the trees in Plat E, which had received Bordeaux. Plats A, B, C, and D were almost as badly infected with scab as were the check trees, whereas Plat E showed very little scab.

With the exception of the self-boiled lime and sulfur, the later applications of the lime-sulfur sprays checked to a considerable extent the work of the scab, but at the same time caused much foliage injury. This injury was along the edges and at the tips of the leaves and in the scab spots; the later the application the more severe was the injury. The influence of the self-boiled lime and sulfur in the control of scab was very temporary; however, no spray injury followed its use. Bordeaux proved very adhesive, controlled the scab almost perfectly, and caused but little foliage injury. Of the five sprays used, Bordeaux proved the most efficient in protecting the foliage from scab, and self-boiled lime and sulfur the least effective. All the cooked lime-sulfur sprays possessed considerable fungicidal value, but because of their lack of adhesiveness their action was only temporary.

In spite of the fact that self-boiled lime and sulfur possesses very little fungicidal value in the control of apple scab, the plat sprayed with this material (Plat C) deserves special attention because of the fact that the general appearance of the trees at a distance was much better than that of any of the others under consideration. These trees were distinguished by the large size, the dark color, and the abundance of their foliage. They did not suffer so severely from the freeze as the others, since the application of lime and sulfur made April 22 formed a coating over the fruit and foliage which acted in some way as a shield against the cold.

EFFECT ON FRUIT

On all plats some fruit survived the freeze of April 23 except on Plat E, upon which Bordeaux had been used. As this plat was situated in the western part of the orchard, adjoining an open field, only a very few apples escaped being frozen.

Table 1 shows the relative fungicidal value of different lime-sulfur sprays in the control of scab on the fruit, and also the benefits derived from three, four, five, and six applications. These results fully corroborate those secured upon the foliage, as stated above. Unfortunately there were no Bordeaux-sprayed apples directly comparable with the fruit sprayed with lime sulfur, but judging from the effect of the Bordeaux upon the foliage, much less scab might be expected upon the fruit sprayed with that material. The apples from the B plats (sprayed with home-concentrated lime sulfur) showed somewhat less scab than those from the other plats, but even upon these the amount

TABLE 1.—EFFECTS OF LIME SULFUR, SELF-BOILED LIME SULFUR, AND BORDEAUX IN COMBINATION WITH ARSENATE OF LEAD, IN THE EXPERIMENTS AT NEOGA, 1910

Plat	Treatment	Applications	Total no. picked apples	Percentage of picked apples affected by			
				Scab	Curculio	Codling moth	Russet
A_1	10-20-13 lime sulfur di-	1, 2, 3	139	94	16	3.6	13
A_2	luted 1 in 18 with 4-	1, 2, 3, 4	33	81	24	3.0	18
A_3	100 arsenate of lead.	1, 2, 3, 4, 5	42	60	17	2.5	10
A_4	.....	1, 2, 3, 4, 5, 6	77	32	24	2.6	5
B_1	50-100-50 lime sulfur	1, 2, 3	96	68	25	4.0	13
B_2	diluted 1 in 28 with	1, 2, 3, 4	140	39	15	2.8	15
B_3	4-100 arsenate of lead	1, 2, 3, 4, 5	237	45	19	4.0	14
B_4	.....	1, 2, 3, 4, 5, 6	140	15	15	2.7	7
C_1	32-32-200 self-boiled	1, 2, 3	438	98	38	8.0	8
C_2	lime and sulfur with	1, 2, 3, 4	323	96	16	0.0	10
C_3	4-100 arsenate of lead	1, 2, 3, 4, 5	510	98	16	2.0	6
C_4	.....	1, 2, 3, 4, 5, 6	660	100	29	4.0	19
D_1	Commercial lime sulfur	1, 2, 3	343	87	26	1.0	10
D_2	diluted 1 in 35 with	1, 2, 3, 4	160	73	32	5.0	8
D_3	4-100 arsenate of lead	1, 2, 3, 4, 5	127	55	22	0.0	9
D_4	.....	1, 2, 3, 4, 5, 6	203	60	35	3.5	10
E_1	8-8-4-100 Bordeaux ar-	1, 2, 3					
E_2	senate of lead[1].....	1, 2, 3, 4					
E_3	.....	1, 2, 3, 4, 5					
E_4	.....	1, 2, 3, 4, 5, 6					
Check	No treatment.....	none	210	100	100	28.0	20

[1]All the fruit on Plat E was lost by freezing.

was exceptionally large. It must be understood, however, that the general infection that year could not have been worse, for the check trees, which received no spray, yielded no sound fruit and lost their foliage early in September. In order to have any picked fruit for examination from the unsprayed trees, it was necessary to gather it three or four weeks before the fruit on the sprayed trees was ready to harvest. At that time many of the apples were rotting on the check trees, and nearly all of them were deformed and undersized. Much of the injury shown in the russet column was no doubt caused by the cold weather. An examination of the codling-moth injuries shows that the action of the arsenate of lead in the control of this insect was about the same when used in any of the four sprays.

It would appear from these data that none of the lime-sulfur sprays used was efficient in the control of apple scab in this particular season. If the danger of spray injury could be eliminated, any of

the cooked solutions might prove efficient when only light attacks of scab are experienced. Under no conditions would it seem wise to use self-boiled lime and sulfur for diseases of the apple.

EFFICIENCY OF BORDEAUX AND MILK OF LIME IN REDUCING BORDEAUX INJURY

In 1905 the Illinois Agricultural Experiment Station began an investigation to determine the cause of Bordeaux injury, and, if possible, to find a remedy for it. Among the treatments which gave the most promise of reducing this injury was the after-spray with milk of lime; that is, the following of the regular Bordeaux application, as soon as dry, with an application of milk of lime.[1]

In order to determine if this could be accomplished on a commercial scale, the following treatments were given seven plats, arsenate of lead being included in each, 4 pounds to each 100 gallons:

Plat 11: Milk of lime alone. This treatment was given in lieu of the regular sprayings with Bordeaux in order to determine the effect of lime alone.

Plat 12a: Three applications of 6-6-100 Bordeaux, each followed as soon as dry by 8-100 milk of lime. In place of the fourth regular spraying with Bordeaux, milk of lime was substituted.

Plat 12b: The same applications as those given Plat 12a with one additional application of Bordeaux followed with milk of lime.

Plats 13a and 13b: The same applications as those given Plats 12a and 12b, respectively, except that 8-8-100 Bordeaux was used.

Plat 14: The first three regular applications of 8-8-100 Bordeaux, the third followed by milk of lime.

Plat 15: The first three regular applications of 8-8-100 Bordeaux.

Plat 16: Four applications of 8-8-100 Bordeaux, the second, third, and fourth applications being followed with 8-100 milk of lime. An extra application of 8-100 milk of lime was given four weeks after the third application of Bordeaux and three weeks before the fourth.

Plat 17: This plat received the first three regular applications of 6-6-100 Bordeaux.

EFFECT ON FOLIAGE

Early in the season Plat 11 had an abundance of large healthy leaves, but as the season advanced the injuries from fungous diseases and from insects became as severe as upon the check trees. Plats 12 and 13 were in excellent condition thruout the entire season. There was no foliage injury of any kind, and the applications of lime materially increased the adhesiveness of the Bordeaux. There was no noticeable difference between the actions of 8-8-100 and 6-6-100 Bordeaux.

Plats 14, 15, and 17 suffered so severely from the freeze that they never fully recovered from the effects of it. The amounts of scab and

[1]C. S. Crandall, Ill. Agr. Exp. Sta. Bul. 135, p. 280, 1909.

insect injury were quite small for all plats, and very few yellow leaves appeared on any of them. Plat 16 recovered from the effects of the freeze quite rapidly. The trees of this plat were well coated with the spray material at the time of the freeze, and since adjoining trees sprayed only with Bordeaux suffered severely, due credit must be given the lime for the part it played in shielding them.

EFFECT ON FRUIT

On those trees receiving applications of lime before the freeze, considerable fruit escaped being frozen. The examination of this fruit gave the results presented in Table 2.

TABLE 2.—EFFECTS OF USING MILK OF LIME IMMEDIATELY AFTER APPLYING BORDEAUX OF VARYING STRENGTHS AND BORDEAUX WITHOUT MILK OF LIME, IN THE EXPERIMENTS AT NEOGA, 1910

Plat	Treatment	Applications	Total no. picked apples	Percentage of picked apples affected by			
				Scab	Curculio	Codling moth	Russet
12a	6-6-4-100 Bordeaux arsenate of lead.....	1, 2, 3					
	Milk of lime used.....	1, 2, 3, 4	688	5.3	18.4	1.5	15.3
12b	6-6-4-100 Bordeaux arsenate of lead.....	1, 2, 3, –, 5					
	Milk of lime used.....	1, 2, 3, 4, 5	530	5.2	16.7	4.5	15.2
13a	8-8-4-100 Bordeaux arsenate of lead.....	1, 2, 3					
	Milk of lime used.....	1, 2, 3, 4	881	2.0	2.0	1.0	11.0
13b	8-8-4-100 Bordeaux arsenate of lead.....	1, 2, 3, –, 5					
	Milk of lime used.....	1, 2, 3, 4, 5	249	0.0	3.0	0.7	6.7
16	8-8-4-100 Bordeaux arsenate of lead.....	1, 2, 3, –, 5					
	Milk of lime used.....	2, 3, 4, 5	366	6.0	26.0	6.0	12.0
17	6-6-4-100 Bordeaux arsenate of lead.....	1, 2, 3	94	5.2	30.8	6.3	25.5

NOTE.—Plats 11, 14, and 15 yielded too little fruit to justify comparison with the other plats.

It will be seen by comparing, under the column, "Total no. picked apples," the plats in which the Bordeaux was followed by the milk of lime and Plat 17, in which only Bordeaux was used, that the application of milk of lime had a decidedly beneficial effect in protecting the apples from the freeze. There is also no doubt that the after-spray of milk of lime prolongs the efficiency of the Bordeaux arsenate of

lead by increasing its adhesiveness. Altho the difference in the percentage of scab between the plats sprayed with 6-6-100 and with 8-8-100 Bordeaux, as used in Plats 12 and 13, was not great, there was a slight advantage in favor of the 8-8-100 Bordeaux. There was also a slight advantage in the use of arsenate of lead in preventing curculio and codling-moth injuries. Moreover, it appeared that the after-spray with lime had a tendency to reduce the amount of russeting, as in all plats in which the lime was used, the amount of russet was considerably less than where the Bordeaux arsenate of lead alone was used. However, such a conclusion based upon these data should be considered tentative, since much of the russet might have been due to the cold weather.

CHEMICAL ANALYSIS OF SOME COMMERCIAL BRANDS OF ARSENATE OF LEAD

Arsenate of lead has been one of the leading insecticides for use in combating chewing insects for a number of years. Within the last few years, commercial manufacturers have made and offered for sale prepared arsenates of lead, about which many requests for information have been received at this station. The brands which were found upon the market in this state in January, 1910, were collected and analyzed, with the results presented in Table 3.

TABLE 3.—CHEMICAL ANALYSES OF COMMERCIAL ARSENATES OF LEAD

Brand	Percentages					
	As received			Moisture free		
	Moisture	Lead oxid	Arsenic oxid	Lead oxid	Arsenic oxid	Soluble arsenic oxid
Sherwin-Williams	48.18	35.77	12.76	69.02	24.62	All less than ¾ of 1 percent
Grasselli	40.20	39.52	16.29	66.08	27.07	
Star	40.20	40.99	16.95	68.54	28.34	
Niagara	42.05	38.42	16.70	66.29	28.81	
Blanchard	32.96	43.05	19.71	64.21	29.40	
Disparene	51.08	31.19	14.97	63.75	30.60	
Swift	45.56	35.53	17.04	65.26	31.31	
Hemingway	39.05	37.96	19.15	62.28	31.41	
Rex	46.41	33.82	17.13	63.10	31.96	
Target	41.50	35.96	18.93	61.46	32.35	
Eagle	47.75	34.12	17.05	65.30	32.63	
Vreeland	43.22	35.53	19.25	62.57	33.90	
Vreeland powdered	trace	62.70	33.76	62.70	33.76	

These arsenates of lead were purchased directly from the manufacturers, and were all received in the form of pastes, with the exception of Vreeland powdered. An examination of the results of the analyses shows an appreciable variation in the composition of the different samples, the percentage of arsenic oxid ranging from 12.76 in Sherwin-Williams to 19.71 in Blanchard, and the lead oxid from 31.19

in Disparene to 43.05 in Blanchard. The amount of soluble arsenic oxid is shown to be quite low in all samples. Calculated on the dry basis, there is a variation in arsenic oxid from 24.62 to 33.90 percent, and in lead oxid from 61.46 to 69.02 percent.

Chemically speaking, there are a number of different arsenates of lead, but there are only two which are used commercially,[1] the triplumbic arsenate, represented by $Pb_3(AsO_4)_2$ and commonly called neutral or ortho arsenate of lead, and plumbic hydrogen arsenate of lead, represented by $PbHAsO_4$ and commonly called acid arsenate of lead. Most of the above samples are a mixture of these two; in some the neutral predominates, while in others there is more of the acid. Only one, Sherwin-Williams, showed the arsenic oxid and lead oxid in the proportions to form the triplumbic arsenate. As arsenic is the ingredient in arsenate of lead which gives it value as an insecticide, the above analyses show that the manufacturers, as a rule, have attempted to put out products containing the maximum amount of arsenic.

In order to obtain reliable data upon the comparative values of the different arsenates of lead, it was deemed necessary to test them in the field. Since it was impossible to try all of these which were analyzed, a few representative ones, based on analyses, were selected. These were tested in two groups, in one of which they were applied with Bordeaux, and in the other of which they were applied with lime sulfur.

COMPARATIVE VALUES OF VARIOUS COMMERCIAL ARSENATES OF LEAD WITH BORDEAUX

The following arsenates of lead, all in paste form with the exception of Vreeland powdered, were applied with 8-8-100 Bordeaux, 4 or 6 pounds being used to each 100 gallons as indicated:

Plat		
6:	Sherwin-Williams	4–100
7:	Sherwin-Williams	6–100
10:	Vreeland powdered	4–100
14:	Grasselli	4–100
20:	Grasselli	6–100
21:	Lion	4–100
22:	Lion	6–100
23:	Vreeland	4–100
24:	Vreeland	6–100
25:	Hemingway	4–100
26:	Hemingway	6–100
27:	Star	4–100
28:	Star	6–100
29:	Eagle	4–100
30:	Eagle	6–100

[1] U. S. Dept. Agr., Bur. of Chem., Bul. 131, p. 17.

Owing to a delay in the receipt of Hemingway and Sherwin-Williams arsenates of lead, Plats 6, 7, 25, and 26 did not receive the first application; otherwise, the first three regular applications were given to all plats. These plats all suffered severely from the freeze.

EFFECT ON FOLIAGE

Very little could be determined from the foliage, as insect injuries were practically the same on all plats.

EFFECT ON FRUIT

On a number of plats so few apples survived the freeze that the fruit was not worth consideration. Table 4 shows the records which were obtained by examining apples from the plats bearing fruit.

TABLE 4.—EFFECTS OF VARIOUS COMMERCIAL ARSENATES OF LEAD IN COMBINATION WITH BORDEAUX, IN THE EXPERIMENTS AT NEOGA, 1910

Plat	Treatment	Applications	Total no. picked apples	Percentage of picked apples affected by	
				Curculio	Codling moth
6	4–100 Sherwin-Williams arsenate of lead with 8–8–100 Bordeaux	2, 3	694	35	7
7	6–100 Sherwin-Williams arsenate of lead with 8–8–100 Bordeaux	2, 3	412	20	6
10	4–100 Vreeland powdered arsenate of lead with 8–8–100 Bordeaux	1, 2, 3	152	36	8
20	6–100 Grasselli arsenate of lead with 8–8–100 Bordeaux	1, 2, 3	228	30	2
21	4–100 Lion arsenate of lead with 8–8–100 Bordeaux	1, 2, 3	204	52	8
22	6–100 Lion arsenate of lead with 8–8–100 Bordeaux	1, 2, 3	398	68	4
23	6–100 Vreeland arsenate of lead with 8–8–100 Bordeaux	1, 2, 3	345	60	18
Check	No treatment	none	210	100	28

Because of the small amounts of fruit harvested from the plats of this group, no definite conclusions are justified. However, it is interesting to note that, as a rule, six pounds of arsenate of lead were not any more efficient in preventing injuries from the codling moth and curculio than four pounds. It is also evident from these data that the first application, which was made just before the bloom, had no influ-

ence upon these two insects, since Plats 6 and 7, which did not receive this application, showed, from a practical standpoint, the least amount of injury.

COMPARATIVE VALUES OF VARIOUS COMMERCIAL ARSENATES OF LEAD WITH LIME SULFUR

When arsenate of lead is added to lime-sulfur solution, a chemical reaction between the two takes place. The extent and nature of this reaction differs in the case of the different arsenates.[1] In order to determine whether or not there was any difference in the action upon the trees due to this variation in reaction, plats were treated as shown in Table 5. The first application was omitted, owing to a delay in the receipt of some of the arsenates of lead.

EFFECT ON FOLIAGE

Considering the effects on the foliage, lime sulfur in combination with Sherwin-Williams arsenate of lead, as used on Plat 1, gave the best results. This mixture was the most adhesive, permitted the least scab, and caused very little foliage injury. The arsenates of lead used on the other plats acted much alike. The fourth application caused some foliage injury, which was a little more severe upon trees receiving lime sulfur and Hemingway and Star arsenates of lead than upon those which received lime sulfur in combination with the Vreeland brands. Any difference in insect injury to the foliage was too small to be noticed.

EFFECT ON FRUIT

The trees in these plats withstood the cold fairly well, and recovered quite rapidly from all apparent injury. On all plats some fruit survived the freeze. It was picked and examined October 26, with the results presented in Table 5.

The fruit data recorded corroborate the notes taken on the foliage. They show that fruit from those trees receiving lime sulfur combined with the Sherwin-Williams arsenate of lead (Plat 1) suffered the least from scab, curculio, and russet. The next in order is that from trees treated with the Vreeland brands, between which there is little difference, except in the amount of scab. In the prevention of scab, the dry arsenate of lead in combination with lime sulfur (Plat 4) was somewhat more effective than the paste arsenate of lead similarly used. Neither the Star nor the Hemingway brand, in combination with lime sulfur, exerted much influence in the control of scab. Of these two the Star brand was the more efficient in preventing curculio and

[1] C. E. Bradley and H. V. Tartar, Further Studies of the Reactions of Lime-Sulfur Solution and Alkali Waters on Lead Arsenates. Jour. Indus. and Eng. Chem., Vol. 2, No. 7, p. 328, 1910.

TABLE 5.—EFFECTS OF VARIOUS COMMERCIAL ARSENATES OF LEAD IN COMBINATION WITH LIME SULFUR, IN THE EXPERIMENTS AT NEOGA, 1910

Plat	Treatment	Applications	Total no. picked apples	Percentage of picked apples affected by			
				Scab	Curculio	Codling moth	Russet
1	4–100 Sherwin-Williams arsenate of lead with lime sulfur, 1–40	2, 3, 4	267	58	19	6	6
2	4–100 Hemingway arsenate of lead with lime sulfur, 1–40	2, 3, 4	318	98	54	14	46
3	4–100 Star arsenate of lead with lime sulfur, 1–40	2, 3, 4	1225	100	27	3	36
4	4–100 Vreeland dry arsenate of lead with lime sulfur, 1–40	2, 3, 4	489	83	31	4	22
5	4–100 Vreeland arsenate of lead with lime sulfur, 1–40	2, 3, 4	337	68	30	6	24
Check	No treatment	none	210	100	100	28	20

codling-moth injuries. Both caused considerable russet, tho the apples sprayed with the Hemingway brand showed more russet than those receiving the Star brand. Since the treatment given these plats was identical except in the brand of arsenate of lead used, the variation in the results must be due, in part at least, to differences in the reactions resulting when the different arsenates of lead were mixed with the lime-sulfur solution.

From these results we must conclude that, for the summer spraying of apples, the neutral arsenate of lead (to which class the Sherwin-Williams appears to belong) in combination with lime-sulfur solution produces a spray which is more efficient and safer to use than one made by combining lime sulfur with arsenates of lead containing higher percentages of arsenic, which are known as acid arsenates of lead.[1]

SUMMARY OF RESULTS AT NEOGA, 1910

1. Bordeaux, made from 8 pounds of copper sulfate, 8 pounds of lime, and 100 gallons of water, was a more efficient fungicide for use upon apples than any of the lime-sulfur sprays used.

2. A concentrated lime-sulfur solution equivalent in efficiency to commercial solutions can be made and stored by the grower. There was no deterioration of the homemade concentrated lime sulfur on standing.

[1]See footnote on following page.

3. Self-boiled lime and sulfur was easily washed off and possessed very little fungicidal value in the control of apple scab.

4. Injuries to foliage and fruit following the use of Bordeaux were lessened by following the applications of Bordeaux, as soon as dry, with 8-100 milk of lime.

5. Applications of milk of lime had a stimulating effect upon the foliage and shielded the fruit from the freeze of April 23.

6. With a lime-sulfur solution, neutral or ortho arsenate of lead gave better results than arsenates of lead containing higher percentages of arsenic oxid.[1]

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[1]The following extract from an article by W. H. Volck, "The Significance of Lead Arsenate Composition," published in *Science* N.S. Vol. 33, No. 857, pp. 866-870, June 2, 1911, has a bearing upon this point: "The acid arsenates are stable under acid conditions, but are transposed into the ortho-arsenate, the most stable compound, under neutral and alkaline conditions. The transposition involves the liberation of arsenic oxid or soluble arsenates. The significance is at once apparent. When arsenate of lead is applied as a spray it is subjected to neutral and alkaline conditions. This is especially true if the water used in spraying contains alkalies. That is, the conditions favorable to the transpositions of the acid arsenates into the ortho-compound obtain. As fast as the neutral waters of fogs, and rains wash away the liberated arsenic oxid, or when the latter is absorbed by the plant tissues themselves, the conditions are restored for more to be formed. The ultimate result is the complete transposition of the acid arsenates to the ortho-compound and the liberation of the excess arsenic oxid."

SPRAYING EXPERIMENTS IN 1911 AT NEOGA, CUMBERLAND COUNTY

BY O. S. WATKINS

OBJECTS

During the summer of 1911 spraying experiments were again carried on at Neoga along lines of investigation similar to those of 1910. Tests were made to ascertain the efficiency of (1) lime sulfur and Bordeaux; (2) the substitution of lime sulfur for Bordeaux in one or two of the first three regular summer applications; (3) drenching applications of Bordeaux and the use of milk of lime in reducing Bordeaux injury; (4) lime sulfur used at various strengths; (5) commercial arsenates of lead used with (a) Bordeaux and (b) lime sulfur; (6) the use of lime sulfur arsenate of lead and copper sulfate mixed and of certain new fungicides, including Cucasa, Sulfocide, and copper ferrocyanide.

LOCATION AND DESCRIPTION OF ORCHARD

The same orchard at Neoga was again chosen for carrying on the experiments, and the same block of trees was used as in 1910. As before, the orchard was divided into plats of four to six trees each and the various plats were sprayed differently. Check trees were left with which to compare the sprayed trees.

APPARATUS AND MATERIALS

The method of preparing the spray mixtures and the manner of applying them were the same as described for 1910.

CHARACTER OF RECORDS AND METHOD OF MAKING

The character of the records and the method of making them were the same as in 1910. See page 60.

WEATHER CONDITIONS

The conditions of 1911 were abnormal as regards rainfall. The summer was exceptionally dry, very little rain falling between the middle of June and the first of September, while both September and October were wet months. The trees came into bloom early in May, and during most of the blooming period there was a cold rain which continued for several days. Unfavorable as these conditions were for pollination, there was a good set of fruit. The injury caused by insects was very slight, and the only serious infection of scab came during the blooming period. The foliage and fruit on neighboring unsprayed orchards did not fall prematurely, as was the case in 1910,

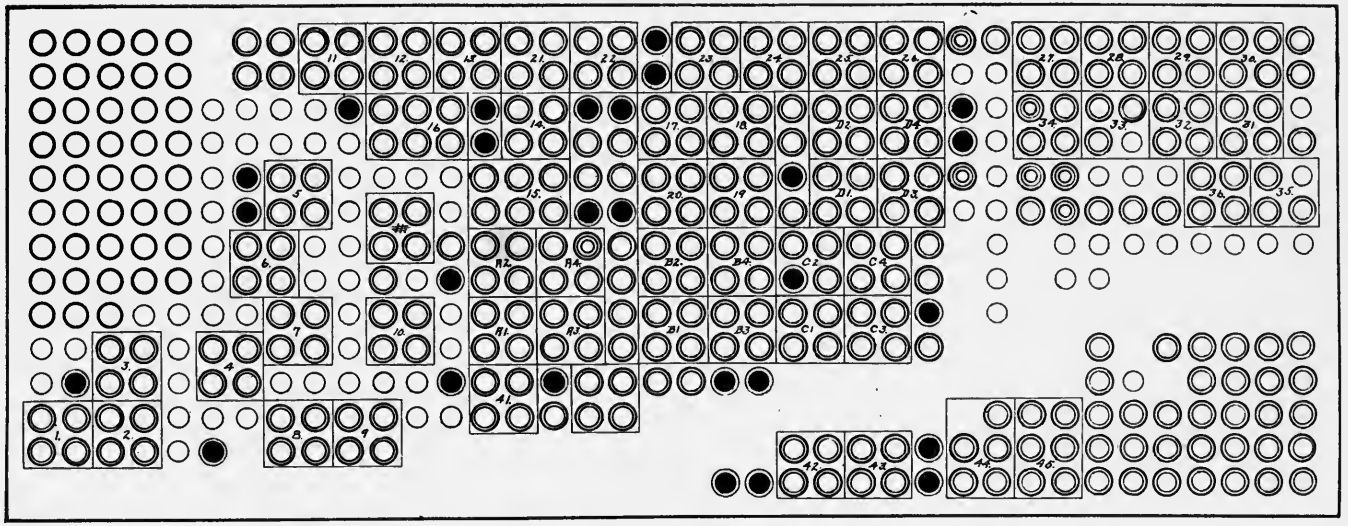

CHART 3.—PLAN OF PLATS IN ORCHARD OF H. A. ALDRICH AND COMPANY, NEOGA, 1911

and at the close of the season the check trees in the experimental orchard were as healthy in appearance as the sprayed trees.

SPRAY DATES

A winter application of lime sulfur was given the entire orchard about the middle of April; and from one to five summer applications were made upon or near the following dates: April 20, May 18, June 3, June 25, August 15.

RELATIVE EFFICIENCY OF LIME SULFUR AND BORDEAUX

During the last few years lime sulfur has been attracting attention as a fungicide for the summer treatment of apples. In order to determine the adaptability of this spray for Illinois orchards, the following experiment was carried out:

Plats A, B, and C, consisting of sixteen trees each, were subdivided into plats of four trees each. It was the original intention to give A_1, B_1, and C_1, three applications; A_2, B_2, and C_2, four applications; A_3, B_3, and C_3, five applications; and A_4, B_4, and C_4, six applications as in 1910. The plan was changed, however, so that Plats A_1, A_2, B_1, B_2, C_1, and C_2 each received three applications; A_3, B_3, and C_3, four applications; and A_4, B_4, and C_4, five applications, as shown in Table 6.

From the experiments in 1910 it was learned that self-boiled lime and sulfur would not control apple scab, and also that the home-concentrated solution was as efficient as the ordinary homemade spray; it was deemed unnecessary, therefore, to repeat these treatments in 1911.

EFFECT ON FOLIAGE

The only noticeable infection of scab came before many of the leaves were out, and as the amount was small in all cases, it was impossible to detect any difference in this respect between the three plats. This lack of scab no doubt reduced the amount of foliage injury caused by the spray, as infected leaves are the first to turn brown when spray is applied.[1] At no time during the season did any yellow leaves appear upon the trees sprayed with Bordeaux. The first two applications of lime sulfur to Plats A and B caused no injury whatever, and the amount following the third application was very small. The fourth application burned about 30 percent of the leaves at the tips and along the edges, and the fifth application affected about 50 percent in the same way. The injury was more severe in Plat B, upon which the commercial lime sulfur had been used, than upon Plat A, which had received the home-concentrated solution; but in each case the trees rapidly recovered. The adhesiveness of the Bordeaux was much better than that of either of the lime-sulfur sprays, and the amount of spray injury caused by it was negligible.

[1] C. S. Crandall, Ill. Agr. Exp. Sta. Bul. 135, p. 225, 1909.

EFFECT ON FRUIT

The fruit in these plats was picked and examined October 16 and 17, with the results presented in Table 6. This table shows the relative efficiency of lime sulfur and Bordeaux on these plats and the value of three, four, and five applications. Since the object of the experiment was to determine the comparative value of the different mixtures for the prevention of apple scab, special attention should be given to the scab column. The Bordeaux used on Plat C gave the best result, while the commercial lime sulfur as used on Plat B gave somewhat better results than the home-concentrated solution used on Plat A. The fifth application with commercial lime sulfur appears to have been of no value. There was very little russeting of fruit, partly, perhaps, because of the fact that there was so little harm done by insects and fungous diseases.[1]

The burn recorded in the last column was caused by lime sulfur arsenate of lead, and upon specimens affected was quite serious. The third application of spray, made about the first of June, was responsible for most of the injury. The burn appeared as dark brown, sunken areas, usually circular in shape, in which the tissue was tough and leathery, making the injury readily distinguishable from ordinary sunscald. After it first appeared it developed very rapidly, sometimes affecting almost the whole fruit. As the apples increased in size, the burned part had a tendency to split away; it sometimes sloughed off entirely. In such cases a russeted scar remained, which somewhat healed over as the season advanced. The injury was more severe upon trees sprayed with commercial lime sulfur than upon those receiving the home-concentrated solution. This burn was unlike anything previously reported. It differed from lime-sulfur injury on foliage, which always appears very shortly after application of the spray, in that it was not apparent until about ten days after any application had been made. Between the time of application and the first appearance of the injury, there intervened several very hot days. There was only a trace of rain in that time, but upon several mornings there were excessively heavy dews.

The grade columns in Table 6 are noteworthy in that they show the percentage of No. 1 apples in the C plats (sprayed with Bordeaux arsenate of lead) to be considerably greater than in either of the other plats. Those picked from the check trees were exceptionally good for unsprayed apples and were harvested at the regular time. This was rather unexpected, as usually by picking time most of the fruit in untreated plats either has fallen or has rotted on the trees.

A noticeable fact not shown in the table was the variation in color between the fruit harvested from the different plats. The apples

[1]The author believes that foliage injured by insects or fungi is more readily injured by sprays than is healthy foliage.

TABLE 6.—EFFECTS OF LIME SULFUR OF TWO DILUTIONS AND BORDEAUX IN COMBINATION WITH ARSENATE OF LEAD, IN THE EXPERIMENTS AT NEOGA, 1911

Plat	Treatment	Applications	Total no. picked apples	Total bu. picked apples	Percentage grades			Percentage picked apples affected by			
					No. 1	No. 2	Culls	Scab	Other fungi[1]	Russet	Burn
A_1, A_2	50–100–66 lime sulfur diluted 1–18 with 4–100	1, 2, 3	7080	33.87	58	24	18	51	41	3	0
A_3	arsenate of lead	1, 2, 3, 4	1050	5.00	63	27	10	44	23	1	2
A_4		1, 2, 3, 4, 5	5605	25.37	73	21	6	31	3	5	7
B_1, B_2	Commercial lime sulfur diluted 1–35 with 4–100	1, 2, 3	8456	35.87	66	26	8	39	34	1	7
B_3	arsenate of lead	1, 2, 3, 4	1931	7.87	78	18	4	28	9	0	7
B_4		1, 2, 3, 4, 5	6770	29.12	72	24	4	33	31	2	4
C_1, C_2	8–8–100 Bordeaux with 4–100 arsenate of lead	1, 2, 3	12540	58.87	78	17	5	25	7	1	0
C_3		1, 2, 3, 4	4664	22.25	86	11	3	25	0	6	0
C_4		1, 2, 3, 4, 5	4320	19.25	79	19	2	15	0	4	0
Check	No treatment	none	2532	8.50	11	54	35	76	100	0	0

[1]Other fungi consisted chiefly of flyspeck and sooty blotch.

NOTE.—All percentages are based on numbers unless otherwise expressed.

which were sprayed with Bordeaux arsenate of lead were much better colored than those which received lime sulfur arsenate of lead sprays.

SUBSTITUTION OF LIME SULFUR FOR BORDEAUX IN ONE OR TWO OF THE FIRST THREE REGULAR SUMMER APPLICATIONS

The experiments thus far considered appear to show that Bordeaux for use as a fungicide upon apples is superior to any of the lime-sulfur sprays. However, since applications of Bordeaux are occasionally followed by a russeting of the fruit and a premature defoliation, it cannot be considered an ideal spray. Lime sulfur has been shown to possess certain fungicidal properties, but it has the great disadvantage, aside from possible injurious effects, of lack of adhesiveness. In order to see if it would be possible to substitute lime sulfur for one or more of the regular applications of Bordeaux, applications were made as shown in Table 7.

EFFECT ON FOLIAGE

Very little information could be gained from the foliage notes, as the amount of injury of all kinds was small on all plats. Immediately after the third application of lime sulfur arsenate of lead had been made, June 3, the trees receiving it showed some foliage injury, but not enough to be considered important. Ten days later, however, a very serious burning of the fruit developed.

EFFECT ON FRUIT

The fruit on these plats was picked and examined on October 17, with the results presented in Table 7. These data show that the most satisfactory results were secured when Bordeaux was used for the first and third applications and lime sulfur for the second (Plat 24). Under this treatment there was a very low percentage of scab and no spray injury of any kind; and only one percent of the apples were culls. The fruit on Plat 22, which received the first and second applications of lime sulfur and the third of Bordeaux, was very good, and differed only slightly from that picked from Plat 24.

EFFICIENCY OF BORDEAUX USED IN DIFFERENT WAYS IN REDUCING BORDEAUX INJURY

It has been the experience of some growers who are in the habit of drenching their trees when spraying with Bordeaux that very little of the fruit russeted. In order to secure data on this point, a test was made to determine the difference in the amount of russet caused by drenching and by light but thoro applications. Investigations[1] have shown that the most severe russeting of fruit caused by Bordeaux is the result of the applications being made shortly after the fall of

[1]U. P. Hedrick, N. Y. (Geneva) Agr. Exp. Sta. Bul. 287, p. 163.

TABLE 7.—EFFECTS OF LIME SULFUR FOR SOME APPLICATIONS AND BORDEAUX FOR OTHER APPLICATIONS, IN THE EXPERIMENTS AT NEOGA, 1911

Plat	Treatment	Applications	Total no. picked apples	Total bu. picked apples	Percentage grades			Percentage picked apples affected by			
					No. 1	No. 2	Culls	Scab	Other fungi	Russet	Burn
21	Lime sulfur arsenate of lead	1, 2, 3	3862	18.37	50	24	26	30	5	16	14
22	Lime sulfur arsenate of lead Bordeaux arsenate of lead	1, 2 3	4262	21.37	78	16	6	12	1	1	0
23	Lime sulfur arsenate of lead Bordeaux arsenate of lead	1, 3 2	3243	16.00	61	17	22	17	5	5	21
24	Bordeaux arsenate of lead Lime sulfur arsenate of lead	1, 3 2	6718	25.87	82	17	1	12	0	0	0
25	Bordeaux arsenate of lead Lime sulfur arsenate of lead	1 2, 3	8727	36.75	59	30	11	20	19	17	19
26	Bordeaux arsenate of lead	1, 2, 3	9870	37.50	71	20	9	18	0	7	0
Check	No treatment	none	1589	6.00	11	42	47	85	99	0	0

NOTE.—The lime sulfur used was made according to the formula 50–100–66 diluted 1–18 with 4–100 arsenate of lead. The Bordeaux arsenate of lead used was made according to the formula 8–8–4–100. See pp. 54-55.

the petals. In continuing the treatments of 1910 made in order to determine the best method of reducing the injury following the use of Bordeaux, four plats were treated as shown in Table 8.

EFFECT ON FOLIAGE

The fungous and insect injuries to the foliage were so slight in all plats that no differences could be distinguished. The drenching applications made on Plat 34 were much more adhesive than the regular applications made on Plat 35 and seemed to exert a stimulating action. The foliage in Plat 34 was unusually large and vigorous, and of a very dark green color. No yellow-leaf appeared on that plat, and only about 5 percent of the leaves on Plat 35 were so affected. There was no noticeable difference resulting from the treatments given Plats 36 and 37, the general appearance of both being the same thruout the entire season. No yellow-leaf appeared at any time upon either plat.

EFFECT ON FRUIT

The fruit from the trees in Plats 34, 35, 36, and 37 was picked and examined October 17. The results, presented in Table 8, show that the heavy application of Bordeaux arsenate of lead was much preferable to the usual lighter application. The efficiency of the mixture was not only greater in controlling scab, but the amount of russeting, for which the spray was no doubt responsible, was much less. The results from Plats 36 and 37 seem to indicate that it matters very little whether the lime follows the second or the third application. The apples in Plat 37 graded slightly better than those in Plat 36. Since these results are not entirely in accord with those obtained in 1910, the subject needs further investigation.

LIME SULFUR USED AT VARIOUS STRENGTHS

In the preceding experiments where lime sulfur was used, the solution in all cases contained 8 pounds of sulfur in solution in each 100 gallons of spray. In order to determine the efficiency and safety of lime-sulfur solutions of various strengths, plats were sprayed with commercial lime sulfur as shown in Table 9.

EFFECT ON FOLIAGE

Very little difference was noted in the foliage in the various plats. In each case there was a slight injury following the third application, but in no plat did it prove permanent.

TABLE 8.—EFFECTS OF A DRENCHING SPRAY USING BORDEAUX WITH ARSENATE OF LEAD, AND OF FOLLOWING THE SECOND AND THIRD APPLICATIONS OF BORDEAUX ARSENATE OF LEAD WITH APPLICATIONS OF MILK OF LIME, IN THE EXPERIMENTS AT NEOGA, 1911

Plat	Treatment	Applications	Total no. picked apples	Total bu. picked apples	Percentage grades			Percentage picked apples affected by			
					No. 1	No. 2	Culls	Scab	Curculio	Codling moth	Russet
34	8–8–4–100 Bordeaux arsenate of lead, drenched	1, 2, 3	4085	17.75	78	20	2	14	2	18	2
35	8–8–4–100 Bordeaux arsenate of lead.....	1, 2, 3	3640	16.75	65	27	8	26	2	12	14
36	8–8–4–100 Bordeaux arsenate of lead, lime after 3d	1, 2, 3	5505	20.25	80	17	3	39	2	5	2
37	8–8–4–100 Bordeaux arsenate of lead, lime after 2d	1, 2, 3	8985	33.12	86	13	1	32	0	1	2

TABLE 9.—EFFECTS OF LIME SULFUR OF VARIOUS DILUTIONS IN COMBINATION WITH ARSENATE OF LEAD, IN THE EXPERIMENTS AT NEOGA, 1911

Plat	Treatment	Applications	Total no. picked apples	Total bu. picked apples	Percentage grades			Percentage picked apples affected by			
					No. 1	No. 2	Culls	Scab	Other fungi	Russet	Burn
42	1–50 lime sulfur with 4–100 arsenate of lead..	1, 2, 3	1545	6.25	70	21	9	38	43	1	1
43	1–40 lime sulfur with 4–100 arsenate of lead..	1, 2, 3	2585	11.25	56	32	12	66	10	0	0
44	1–20 lime sulfur with 4–100 arsenate of lead..	1, 2, 3	4767	20.50	63	17	20	71	8	3	2
46	1–30 lime sulfur with 4–100 arsenate of lead..	1, 2, 3	2544	11.00	66	26	8	39	34	1	7

EFFECT ON FRUIT

The records of the fruit, which was picked and examined October 13, are presented in Table 9. The weakest solution used, one gallon of concentrated solution to 50 gallons of water, a spray containing about 2½ pounds of sulfur per 50 gallons, seemed to be the proper dilution for scab under conditions as they existed during 1911. In this plat there were not only fewer scabby apples, but a larger percentage of No. 1 apples than is credited to any other plat. A noticeable feature was the small amount of injury resulting from the strong solution used on Plat 44. There were in each 100 gallons of spray used on this plat about 16 pounds of sulfur, which is twice the amount generally considered safe for use upon apples. In order to determine the effect of these dilutions in seasons of more abundant rainfall, further investigations are necessary.

COMMERCIAL ARSENATES OF LEAD WITH BORDEAUX

In 1911 various commercial arsenates of lead were tested in combination with Bordeaux, as shown in Table 10.

EFFECT ON FOLIAGE

Very little could be learned from examination of the foliage as the amount of insect injury to the leaves was unimportant. There were no noticeable differences in the adhesiveness of the mixtures.

EFFECT ON FRUIT

Table 10 presents the results of the examination of fruit.

As in 1910, very little can be determined from the results obtained, since the variation between the different plats was only 7 percent in curculio injury, and but 3 percent in codling-moth injury. The variation in the percentage of russeting may be due in part to the brand of arsenate of lead which was used, as other conditions were the same.

COMMERCIAL ARSENATES OF LEAD WITH LIME SULFUR

As a further test of the action of the various arsenates of lead when applied in combination with lime sulfur, various brands were added to commercial lime sulfur and tested as shown in Table 11.

EFFECT ON FOLIAGE

There was some foliage injury on all plats from time to time throughout the summer, but only in Plat 5, which received Grasselli arsenate of lead alone, was it of a permanent nature. Here there was very little injury until about the middle of September, when the leaves

TABLE 10.—EFFECTS OF COMMERCIAL ARSENATES OF LEAD IN COMBINATION WITH BORDEAUX, IN THE EXPERIMENTS AT NEOGA, 1911

Plat	Treatment	Applications	Total no. picked apples	Total bu. picked apples	Percentage grades			Percentage picked apples affected by		
					No. 1	No. 2	Culls	Curculio	Codling moth	Russet
11	4–100 Swift arsenate of lead with 8–8–100 Bordeaux	1, 2, 3	8365	36.12	75	22	3	1	8	19
12	4–100 Vreeland arsenate of lead with 8–8–100 Bordeaux	1, 2, 3	7835	32.12	61	23	16	3	5	4
13	4–100 Vreeland dry arsenate of lead with 8–8–100 Bordeaux	1, 2, 3	15565	62.37	77	18	5	3	5	11
14	2–100 Vreeland dry arsenate of lead with 8–8–100 Bordeaux	1, 2, 3	10200	40.00	60	28	12	7	7	30
15	4–100 Hemingway arsenate of lead with 8–8–100 Bordeaux	1, 2, 3	5245	22.00	57	33	10	4	7	8
16	4–100 Sherwin-Williams arsenate of lead with 8–8–100 Bordeaux	1, 2, 3	3132	13.75	71	20	9	0	7	7
Check	No treatment	none	937	4.00	10	30	60	6	6	0

turned brown along the edges and at the tips. They retained this appearance thruout the remainder of the season, and about 25 percent of the foliage fell prematurely. The materials used on Plats 7, 8, and 9 were slightly more adhesive than those used on the other plats.

EFFECT ON FRUIT

These plats all had an abundance of fruit, which was picked October 24 and 25, and examined with the results shown in Table 11.

The most noticeable feature of this table is the variation in the amount of scab. Plats 7, 6, and 3, which were sprayed with Sherwin-Williams, Swift, and Vreeland arsenates of lead, respectively, were least infected with scab, having 16, 18, and 19 percent of scabby apples. Owing to the small amount of insect injury, little can be said as to the comparative insecticidal value of the different brands of arsenates of lead used. There was a varying amount of russet and burn credited to the different plats, but the difference was not great. However, since neither arsenate of lead nor lime sulfur, when used alone, caused any burning, this injury appeared to be due to the reaction resulting when the two are combined.

Attention is called especially to the records obtained from Plat 5, which received arsenate of lead alone, and Plat 10, which received lime sulfur alone. It will be seen from these results that both lime sulfur and arsenate of lead when used alone possess some fungicidal value, but that when combined they produce a much more efficient spray. Attention is also directed to the large amount of codling-moth injury recorded against Plat 10 as compared with the check plat, suggesting a possible attraction of the codling-moth adults to trees sprayed with lime sulfur. In fact, the fruit in this plat suffered worse from codling moth than any of the check trees thruout the entire orchard.

Altho the results recorded in the different columns do not show wide variation among the different plats, they are in accord with those obtained in 1910, which showed that, in combination with lime-sulfur solution, the neutral arsenate of lead produced a spray which was more efficient and safer to use than those arsenates of lead higher in arsenic oxid.

CERTAIN NEW FUNGICIDES AND INSECTICIDES

In order to test the value of lime sulfur arsenate of lead when mixed with copper sulfate and also the value of certain new fungicides, various homemade and proprietary mixtures were applied as shown in Table 12.

EFFECT ON FOLIAGE

All mixtures of lime sulfur arsenate of lead and copper sulfate showed quite plainly upon the trees, and varied in color from dark

TABLE 11.—EFFECTS OF COMMERCIAL ARSENATES OF LEAD IN COMBINATION WITH LIME SULFUR, IN THE EXPERIMENTS AT NEOGA, 1911

Plat	Treatment	Applications	Total no. picked apples	Total bu. picked apples	Percentage grades			Percentage picked apples affected by				
					No. 1	No. 2	Culls	Scab	Curculio	Codling moth	Russet	Burn
1	4–100 Vreeland dry arsenate of lead with lime sulfur	1, 2, 3	9473	42.62	68	23	9	28	8	11	5	11
2	2–100 Vreeland dry arsenate of lead with lime sulfur	1, 2, 3	5945	26.75	80	17	3	20	6	11	2	1
3	4–100 Vreeland paste arsenate of lead with lime sulfur	1, 2, 3	5944	27.87	82	17	1	19	19	7	2	5
4	4–100 Eagle arsenate of lead with lime sulfur	1, 2, 3	4595	20.75	72	19	9	35	13	9	11	7
5	4–100 Grasselli arsenate of lead alone	1, 2, 3	1352	5.50	63	24	13	52	4	1	1	0
6	4–100 Swift arsenate of lead with lime sulfur	1, 2, 3	4175	22.50	86	12	2	18	3	8	5	5
7	4–100 Sherwin-Williams arsenate of lead with lime sulfur	1, 2, 3	5905	27.87	78	17	5	16	7	0	3	2
8	2–100 Grasselli arsenate of lead with lime sulfur	1, 2, 3	4395	17.25	73	20	7	25	13	5	1	5
9	4–100 Hemingway arsenate of lead with lime sulfur	1, 2, 3	4617	23.50	65	26	9	36	4	8	8	4
10	Lime sulfur alone	1, 2, 3	2380	12.25	55	33	12	41	12	26	15	0
Check	No treatment	none	1396	5.00	0	57	43	89	15	16	0	0

NOTE.—Commercial lime sulfur diluted 1 in 40 used on all plats.

brown to almost black. Plats 18 and 19 looked very much alike; on Plat 17 the spray showed a somewhat darker brown, and on Plat 20 almost black. Permanent injury from these sprays was negligible, altho for several days after the application to Plat 20 had been made, its foliage presented a scorched appearance. This, however, soon disappeared, and thruout the remainder of the season the trees appeared very healthy. There was an abundance of foliage of good size and of a dark green color on all these plats. The mixtures applied were all of about equal adhesiveness and remained visible thru most of the summer.

Cucasa, when dried upon the trees, resembled Bordeaux but did not prove quite so adhesive. There was some foliage injury at different times during the summer on the trees sprayed with this mixture, and about 20 percent of the leaves turned yellow and fell. The material used was some that was carried over from 1910, and might have been less satisfactory than the fresh product.

Copper ferrocyanide is a new spray of considerable promise made from copper sulfate and potassium ferrocyanide. The two salts were dissolved separately, and when poured together produced a flocculent red precipitate of copper ferrocyanide. This mixture gave a red cast to the leaves which was plainly visible. The foliage was quite dense, of good size, much darker green, and glossier than that on any other plat in the orchard. No injury of any kind was noticed at any time during the season. It is thought that this mixture possesses both insecticidal and fungicidal value, but owing to the scarcity of insect pests and fungous diseases, as well as conditions conducive to foliage injury, the results obtained this year were rather indefinite. The cost of the material at the strength used is about one-third that of lime sulfur arsenate of lead.

EFFECT ON FRUIT

The recorded data show that of the four sprays used on Plats 17, 18, 19, and 20, made by combining lime sulfur arsenate of lead and varying amounts of copper sulfate, those used on Plats 17 and 19 controlled scab exceptionally well. The spray injury as shown by the russet and burn columns was negligible. The grading was fairly good for all plats. The results seem to indicate that the mixtures made from lime sulfur arsenate of lead with 4 pounds of copper sulfate and with the Bordeaux arsenate of lead, as used on Plats 17 and 19, respectively, are probably the best combinations. Lime sulfur arsenate of lead with 2 pounds of copper sulfate was too weak to control the fungous diseases properly, and when made with 6 pounds of copper sulfate produced a very bulky precipitate which prevented a thoro coating of all parts of the fruit and foliage.

The fungicidal value of Cucasa was almost equal to that of Bordeaux; no russeting of the fruit followed its use. Copper ferro-

TABLE 12.—EFFECTS OF CERTAIN NEW SPRAYS AND PROPRIETARY MIXTURES, IN THE EXPERIMENTS AT NEOGA, 1911

Plat	Treatment	Applications	Total no. picked apples	Total bu. picked apples	Percentage grades			Percentage picked apples affected by			
					No. 1	No. 2	Culls	Scab	Other fungi	Russet	Burn
17	Lime sulfur arsenate of lead with 4–100 copper sulfate	1, 2, 3	2980	14.62	78	19	3	7	3	1	1
18	Lime-sulfur arsenate of lead with 2–100 copper sulfate	1, 2, 3	4773	20.62	70	23	7	22	16	2	3
19	Lime sulfur arsenate of lead with 2–2–100 Bordeaux	1, 2, 3	3158	14.50	81	17	2	8	0	3	0
20	Lime sulfur arsenate of lead with 6–100 copper sulfate	1, 2, 3	7175	32.62	85	14	1	25	30	4	0
27	7½–40 Cucasa with 4–100 arsenate of lead	1, 2, 3	4520	21.25	70	28	2	24	0	0	0
28	1–1–100 copper ferrocyanide	1, 2, 3	7725	31.50	83	15	2	29	13	0	0
40[1]	1–250 Sulfocide with 8 oz.–100 Paris green	1, 2									
26[2]	8–8–4–100 Bordeaux arsenate of lead	1, 2, 3	9870	37.50	71	20	9	18	0	7	0
Check	No treatment	none	1589	6.00	11	42	47	85	99	0	0

[1]The injury on this plat was so severe following the second application that it was necessary to discontinue the treatment.

[2]This plat was used as a standard of comparison.

cyanide, the material applied to Plat 28, was used sparingly, as nothing was known regarding its action upon the foliage and fruit. These were the first data obtained by the station from fruit sprayed with this mixture and were very encouraging. The apples picked from this plat were colored perfectly and had an unusually polished finish.

While most of these new sprays gave promising results, no recommendations can be made until they have been further tested.

SUMMARY OF RESULTS AT NEOGA, 1911

1. Bordeaux made from 8 pounds of copper sulfate, 8 pounds of lime, and 100 gallons of water was more efficient than any of the lime-sulfur sprays used.

2. Applications of lime sulfur in combination with arsenate of lead, made later than two or three weeks after the fall of the petals, caused serious injury to the fruit.

3. The most satisfactory treatment for apples consisted of (1) 8-8-4-100 Bordeaux arsenate of lead for the application immediately preceding the bloom; (2) lime-sulfur solution, 100 gallons of which contained 8 pounds of sulfur, in combination with 4 pounds of arsenate of lead, for the application immediately after the fall of the petals; and (3) 8-8-4-100 Bordeaux arsenate of lead for the application made about ten days after the fall of the petals.

4. Injuries to foliage and fruit following the use of Bordeaux were lessened by: (1) following the applications of Bordeaux, as soon as dry, with 8-100 milk of lime; and (2) using the "drench" spray of Bordeaux.

5. A solution of lime sulfur containing 5 pounds of sulfur in each 100 gallons, and combined with arsenate of lead, prevented scab better than stronger solutions.

6. For use with a lime-sulfur solution, an arsenate of lead high in lead oxid gave better results than arsenates containing high percentages of arsenic oxid.

7. A mixture of lime-sulfur solution and arsenate of lead was more efficient in preventing apple scab than lime sulfur used alone.

8. Arsenate of lead when used alone exercised some fungicidal action, but caused considerable foliage injury.

9. Lime sulfur arsenate of lead in combination with copper sulfate gave an efficient spray and caused no injury to either fruit or foliage.

10. Sulfocide in combination with Paris green caused very serious foliage injury.

11. Cucasa proved almost as efficient as Bordeaux in preventing infection of scab; it caused no russeting of the fruit, but decidedly injured the foliage.

12. Copper ferrocyanide, made from copper sulfate and potassium ferrocyanide, controlled scab and insects very efficiently.

SPRAYING EXPERIMENTS IN 1912 AT NEOGA, CUMBERLAND COUNTY

BY O. S. WATKINS

OBJECTS

Neoga was again chosen in 1912 for carrying on spraying experiments, the chief lines of investigation being tests to gain further information upon: (1) the fungicidal value of winter applications of lime sulfur; (2) the relative fungicidal values of lime sulfur and Bordeaux; (3) the advisability of interchanging Bordeaux arsenate of lead and lime sulfur arsenate of lead; (4) the efficiency of arsenate of lead without a fungicide for the second application; (5) the value of different strengths of commercial lime sulfur; (6) the fungicidal value of lime sulfur and arsenate of lead when used separately; and (7) the individual value of the several applications.

LOCATION AND DESCRIPTION OF ORCHARD

The experiments of 1912 were carried on in the same orchard as in 1910 and 1911, but in a more desirable block of trees which had come into full bearing since the selection of the former site. The trees were twelve years old and in a very vigorous condition, having been given excellent care ever since they were planted. The block used consisted of three hundred Ben Davis trees. It was divided into plats generally numbering four trees each.

CHARACTER OF RECORDS AND METHOD OF MAKING

Foliage notes were taken from time to time thruout the season, and the dropped apples were counted and examined. All fruit upon the trees at harvesting time was hand-picked, counted, and weighed, and the entire yield from a representative tree in each plat was examined. In examining the apples for blemishes, a record was kept of all markings, however small. In the tables, the term "slight scab" refers to a very slight speck, or a scab so small as to pass the commercial grader unnoticed. By "serious scab" is meant a spot or number of spots sufficiently large to keep the fruit affected from the grade in which it otherwise would have been counted. The No. 1 apples were graded according to the standards described in the Federal Apple Package and Grade Act, the No. 2's by an arbitrary standard conforming as nearly as possible to the average No. 2 pack of the commercial grower. The culls included all not in the No. 1 and 2 grades.

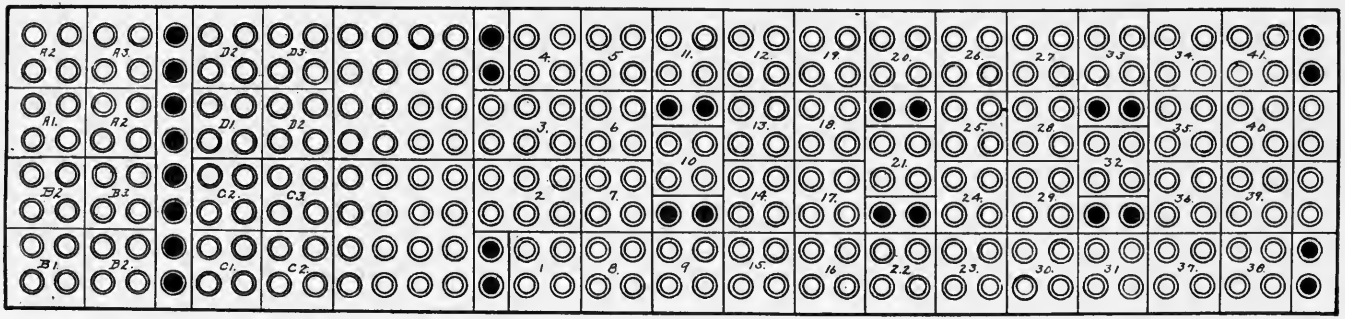

CHART 4.—PLAN OF PLATS IN ORCHARD OF H. A. ALDRICH AND COMPANY, NEOGA, 1912

WEATHER CONDITIONS

The weather conditions of 1912 were very nearly normal. There was a great deal of rain thruout the entire summer, but at no time was it in such an amount or of such duration as to be disastrous for orchard operations. The harvest season was ideal for taking care of the fruit, as only two days out of several weeks were lost on account of inclement weather.

The trees came into bloom early in May. The weather was excellent for pollination, and a very good set of fruit resulted. During the latter part of the blooming period a heavy rain occurred, which made conditions very favorable for the development of the apple-scab fungus. At this time scab was first visible upon the foliage, but it was four weeks later that the first scabby apple was detected. The attacks were quite serious at times, but at no time was the fungus active over a very long period, a few bright days generally intervening between the stages which were advantageous for its development. The unsprayed or check trees lost most of their fruit and foliage several weeks before harvest time, and that fruit which remained on the trees till picking time was very scabby and showed considerable insect injury. The codling moth caused very little injury, and altho the curculio did some damage, it was more or less irregular in its attacks.

SPRAY DATES

All trees which were to receive a winter application were sprayed April 13, with commercial lime-sulfur solution diluted 1 in 15. From one to five summer applications were made upon or near the following dates: April 27, May 11, May 23, June 25, and August 6.

FUNGICIDAL VALUE OF WINTER LIME SULFUR

The winter application of lime sulfur has usually been made only on those orchards which are infested with San Jose scale. The beneficial effect of such treatment upon the general appearance of the trees has been sufficient to attract attention. It has also been observed that in certain seasons orchards receiving a spraying of lime sulfur for San Jose scale are less subject to severe attacks of scab than adjoining orchards from which the winter treatment has been omitted. In order to obtain data upon the fungicidal value of this treatment, two plats, each consisting of sixteen trees, were subdivided into sub-plats of four or eight trees each and treated as shown in Table 13.

EFFECT ON FOLIAGE

A small amount of injury to the green tips of the leaves which received the winter application followed the treatment given Plat B.

TABLE 13.—EFFECTS OF WINTER APPLICATIONS OF LIME SULFUR FOLLOWED BY SUMMER SPRAYS OF LIME SULFUR ARSENATE OF LEAD, IN THE EXPERIMENTS AT NEOGA, 1912

Plat	Treatment	Applications	Total no. picked apples	Total bu. picked apples	No. picked apples per bushel	Percentage grades of picked apples						Percentage of picked apples affected by			
						No. 1		No. 2		Culls		Scab			Russet
						Based on number	Based on bushels	Based on number	Based on bushels	Based on number	Based on bushels	Slight	Serious	Total	
B_1	Winter lime sulfur, 1–15, and 1–40–4–100 lime sulfur arsenate of lead	1, 2, 3	6326	35.29	179	69.15	74.07	20.15	17.34	10.70	8.59	16.26	5.99	22.25	3.04
B_2		1, 2, 3, 4	6307	32.16	196	72.43	80.47	16.12	11.85	11.45	7.68	13.78	1.43	15.21	2.28
B_3		1, 2, 3, 4, 5	5083	26.11	194	73.55	76.70	17.42	16.24	9.03	7.06	21.09	6.44	27.53	2.43
C_1	1–40–4–100 lime sulfur arsenate of lead	1, 2, 3	3936	20.41	192	77.14	81.59	14.71	12.50	8.15	5.91	12.96	6.89	19.85	1.36
C_2		1, 2, 3, 4	4297	20.09	213	74.73	79.37	16.57	14.05	8.70	6.58	17.35	7.38	25.73	1.13
C_3		1, 2, 3, 4, 5	2599	12.13	214	68.38	74.05	22.04	18.81	9.58	7.14	20.52	7.93	28.45	3.14

NOTE.—Grasselli lime sulfur and arsenate of lead were used in all general spraying.
All percentages are based on numbers unless otherwise expressed.

This was not serious, altho the first leaves were dwarfed thruout the entire season; otherwise there was no noticeable difference between the appearance of the trees in Plats B and C. Scab was first noticed on the foliage during the latter part of the blooming period; and the infection was apparently the same in each plat. The foliage was dense and quite vigorous, and held on until removed by frost. The amount of foliage injury for which the spray was responsible was very temporary and negligible.

EFFECT ON FRUIT

There was a very heavy set of fruit on all plats. It was picked and examined October 11, with the results presented in Table 13. The percentage of apples in each grade as determined from the total number is indispensable to those interested in experimental data and comparisons, but as the commercial grower is particularly interested in the percentage as based on the number of bushels, these percentages are also given.

The use of a winter application of lime sulfur exerted no beneficial effect in checking scab, as is seen by comparing the records of Plat B, which received this application, with those of Plat C, which was not so treated. There was a very slight variation in favor of Plat B, but the difference was so small as to be easily within a possible limit of error.

RELATIVE EFFICIENCY OF LIME SULFUR AND BORDEAUX

Since weather conditions determine to such a large extent the efficiency of a fungicide, an experiment was again conducted to gain further data upon the comparative fungicidal value of lime sulfur and Bordeaux. Two plats, consisting of sixteen trees each, were subdivided into plats of four or eight trees and treated as shown in Table 14.

EFFECT ON FOLIAGE

The earliest infection of scab was noted during the latter part of the blooming period. Intervening between the first and second applications several rains occurred which made conditions ideal for scab development, and at the same time washed off much of the first spray. Thruout the entire season the trees in Plat B showed more scab than those in Plat A, but in neither plat was the amount sufficient to be injurious. Upon the plats receiving the fourth and fifth applications, the foliage showed practically no scab spots thruout the latter part of the summer. The foliage was very dense and vigorous in all plats, and spray and insect injuries were negligible.

EFFECT ON FRUIT

The trees in these plats gave a very good yield of fruit. While on the trees, the apples sprayed with lime sulfur appeared to be better

TABLE 14.—EFFECTS OF BORDEAUX AND LIME SULFUR IN COMBINATION WITH ARSENATE OF LEAD, IN THE EXPERIMENTS AT NEOGA, 1912

Plat	Treatment	Applications	Total no. picked apples	Total bu. picked apples	No. picked apples per bushel	Percentage grades of picked apples						Percentage of picked apples affected by			
						No. 1		No. 2		Culls		Scab			Russet
						Based on number	Based on bushels	Based on number	Based on bushels	Based on number	Based on bushels	Slight	Serious	Total	
A_1	8-8-4-100 Bordeaux arsenate of lead	1, 2, 3	5363	29.08	180	58.21	61.67	29.81	27.66	11.98	10.67	6.74	5.11	11.85	.30
A_2		1, 2, 3, 4	8526	48.54	175	72.55	78.85	16.28	13.53	11.17	7.62	16.15	4.80	20.95	2.00
A_3		1, 2, 3, 4, 5	4156	23.65	175	61.04	67.73	25.78	22.65	13.18	9.72	12.82	3.01	15.83	1.50
B_1	1-40-4-100 commercial lime sulfur arsenate of lead	1, 2, 3	6326	35.29	179	69.15	74.07	20.15	17.34	10.70	8.59	16.26	5.99	22.25	3.04
B_2		1, 2, 3, 4	6307	32.16	196	72.43	80.47	16.12	11.85	11.45	7.68	13.78	1.43	15.21	2.28
B_3		1, 2, 3, 4, 5	5083	26.11	194	73.55	76.70	17.42	16.24	9.03	7.06	21.09	6.44	27.53	2.43
Check	No treatment	none	400	1.60	250	.00	.00	1.50	2.50	98.50	97.50	1.75	97.50	99.25	.00

colored than those sprayed with Bordeaux, but after the fruit was placed on the sorting table, it was found that the color on the apples sprayed with Bordeaux was more evenly distributed over a larger proportion of the surface. However, the apples sprayed with lime sulfur were much smoother and presented a better polish, while upon close inspection many of the apples sprayed with Bordeaux showed numerous minute black specks.

Records were obtained upon insect injuries and certain fungous diseases, but as the attacks were irregular and have no direct bearing upon the experiment, they were omitted from Table 14, in which the fruit data of this experiment are presented.

Considering first the grade columns of Table 14, lime sulfur arsenate of lead in 1912 did very effective work, being somewhat better than Bordeaux arsenate of lead. The comparative efficiency of the two mixtures as fungicides is designated by the scab columns. Any difference here is slightly in favor of Bordeaux arsenate of lead, but it is too small to warrant much emphasis. The amount of russet was decidedly small in all plats. The absolute necessity of spraying is shown by a glance at the records of the apples picked from trees receiving no treatment.

The use of more than three applications seemed unnecessary at Neoga in 1912, as the variation between the percentages of No. 1 apples in the different plats was neither so regular nor so varied that any definite conclusions might be drawn.

EFFICIENCY OF LIME SULFUR ARSENATE OF LEAD SUBSTITUTED FOR BORDEAUX ARSENATE OF LEAD IN ONE OR TWO OF THE FIRST THREE REGULAR SUMMER APPLICATIONS

For a number of years, Bordeaux has been the standard fungicide for most diseases of the apple. During the last few years, the use in Illinois of lime sulfur as a substitute for Bordeaux has always proved more or less satisfactory, particularly in certain parts of the state. In order to see if a combination of the two sprays might prove efficient, that is, the using of Bordeaux for one or more applications and lime sulfur for the others, in an attempt to remove the undesirable qualities of each spray and still have a satisfactory schedule, three plats were treated as shown in Table 15.

EFFECT ON FOLIAGE

At all times during the season, Plat 4 showed considerably more scab upon the foliage than did any of the other plats. This was especially true before the third application had been made. A small number of yellow leaves formed on the trees in Plats 3 and 4 shortly after the third application, but these soon fell, and no permanent injury of any kind was apparent. Some of the leaves on trees in Plat 1 be-

TABLE 15.—EFFECTS OF LIME SULFUR ARSENATE OF LEAD SUBSTITUTED FOR BORDEAUX ARSENATE OF LEAD IN ONE OR TWO OF THE FIRST THREE SUMMER APPLICATIONS

Plat	Treatment	Applications	Total no. picked apples	Total bu. picked apples	No. picked apples per bushel	Percentage grades of picked apples						Percentage of picked apples affected by			
						No. 1		No. 2		Culls		Scab			
						Based on number	Based on bushels	Based on number	Based on bushels	Based on number	Based on bushels	Slight	Serious	Total	Russet
1	1–40–4–100 lime sulfur arsenate of lead 8–8–4–100 Bordeaux arsenate of lead...	2, 3 1	7387	38.14	194	75.14	75.37	19.94	17.76	4.92	6.87	11.90	6.69	18.59	7.01
3	1–40–4–100 lime sulfur arsenate of lead 8–8–4–100 Bordeaux arsenate of lead...	2 1, 3	3425	15.60	219	58.25	64.99	24.09	21.13	17.66	13.88	10.62	17.19	27.81	4.05
4	1–40–4–100 lime sulfur arsenate of lead 8–8–4–100 Bordeaux arsenate of lead...	1, 2 3	1899	9.60	197	58.98	66.66	21.47	19.80	19.55	13.54	8.56	16.64	25.20	2.05
Check	No treatment	none	400	1.60	250	.00	.00	1.50	2.50	98.50	97.50	1.75	97.50	99.25	.00

came brown spotted after the third application, but this was noticeable for only a few days.

EFFECT ON FRUIT

The fruit upon the trees in these plats made a good appearance, that on Plat 4 being the poorest. The crop was harvested and examined on October 15, with the results presented in Table 15.

The use of Bordeaux arsenate of lead for the first application and lime sulfur arsenate of lead for the second and third applications, as in Plat 1, proved the most satisfactory treatment of this group. The trees so treated yielded fewer scabby apples (18.59 percent as compared with 27.81 percent and 25.2 percent for Plats 3 and 4); and the percentage of No. 1 apples was nearly 20 percent greater than that shown by either of the other treatments. There was a slight variation in color in favor of Plats 3 and 4 over Plat 1. The large amount of russet in Plat 1 compared to the other plats was rather unexpected. The effect of spraying upon the size of the apples may be seen by comparing the number per bushel in the various plats. The unsprayed apples were about 20 percent smaller than the sprayed apples.

EFFICIENCY OF ARSENATE OF LEAD WITHOUT A FUNGICIDE FOR THE SECOND APPLICATION

Because of the tender condition of the small apples at the time of the second application and the injury occasionally following the use of Bordeaux arsenate of lead at that time, the question is often raised, Is it absolutely necessary to use a fungicide in the second application? In order to obtain information upon this point, plats were treated as shown in Table 16.

EFFECT ON FOLIAGE

As the season advanced, there was a very decided difference in the general appearance of the trees in Plats 5 and 6 and those in the other two Plats, C and 10, in which the treatment differed only in regard to the omission of the fungicide in the second application. This difference could be distinguished at some distance, as the foliage in the two former plats was ragged, and about one-half of it fell prematurely. The most serious attack of scab experienced was at the blooming period, and by the time the third application of Bordeaux arsenate of lead and lime sulfur arsenate of lead was made on Plats 5 and 6, the foliage of the trees in these plats was so badly infected with scab that considerable injury followed this application. In the case of Plat 5, which received the lime sulfur arsenate of lead, the injury in the form of brown spots in the leaves where the scab spots were, developed within a few hours after the third application. In the case of Plat 6, which received Bordeaux arsenate of lead, no in-

TABLE 16.—EFFECTS OF USING ARSENATE OF LEAD WITHOUT A FUNGICIDE FOR THE SECOND SUMMER SPRAY (THE CALYX SPRAY), IN THE EXPERIMENTS AT NEOGA, 1912

Plat	Treatment	Applications	Total no. picked apples	Total bu. picked apples	No. picked apples per bushel	Percentage grades of picked apples						Percentage of picked apples affected by			
						No. 1		No. 2		Culls		Scab			
						Based on number	Based on bushels	Based on number	Based on bushels	Based on number	Based on bushels	Slight	Serious	Total	Russet
C	1-40-4-100 lime sulfur arsenate of lead	1, 2, 3	3936	20.41	192	77.14	81.59	14.71	12.50	8.15	5.91	12.96	6.89	19.85	1.36
10	8-8-4-100 Bordeaux arsenate of lead...	1, 2, 3	3025	16.90	179	66.87	71.96	17.86	15.60	15.27	12.44	7.27	13.04	20.31	3.32
5	1-40-4-100 lime sulfur arsenate of lead	1, 3													
	4-100 arsenate of lead	2	2554	11.14	229	23.76	27.64	19.34	20.47	56.90	51.89	13.91	63.44	77.35	.34
6	8-8-4-100 Bordeaux arsenate of lead...	1, 3													
	4-100 arsenate of lead	2	2277	12.52	182	40.76	44.23	30.20	30.77	29.04	25.00	11.67	41.92	53.59	2.43

jury was apparent for several days, when many of the leaves turned yellow. The trees in both Plats 5 and 6 lost more or less foliage early in the season, and thruout the remainder of the year presented a less healthy and vigorous appearance than did those in Plats C and 10.

EFFECT ON FRUIT

The apples from the trees in Plats 5 and 6 were of very poor quality. The fruit on all the plats was picked and examined October 15, with the results given in Table 16.

The necessity of a fungicide in the second application, the spray immediately after the bloom, is made evident by these results. During 1912 this one application was very effective in the control of scab, which had appeared shortly before it was made. From the results, it would seem that arsenate of lead exerted no fungicidal control whatever, since those plats receiving no fungicide in the second application had over twice as many scabby apples as those plats receiving a fungicide at that time. The prolonged efficiency of Bordeaux as compared with lime sulfur arsenate of lead, when used for the first application, is likewise shown, as those apples receiving Bordeaux arsenate of lead in the first application were considerably freer from scab, and yielded nearly twice as many No. 1's as those trees receiving lime sulfur arsenate of lead preceding the bloom. The difference in the size of the apples from Plats 5 and 6 was also noticeable, those from Plat 6 being over 20 percent larger than those from Plat 5.

VALUE OF DIFFERENT STRENGTHS OF COMMERCIAL LIME SULFUR

Since the introduction of lime sulfur for the summer treatment of apples, the question regarding the most effective dilution to use has been raised. In order to gain information upon this point, applications were made as shown in Table 17.

EFFECT ON FOLIAGE

Up to the middle of the summer there was no apparent difference in the general appearance of the trees in these plats, and the number of leaves showing scab was quite small. No injury of any kind followed the use of any of these strengths. All the foliage was dark green and dense, and attracted the attention of all visitors, even the trees which received the weakest solution possessing almost perfect foliage. During the second week of August, however, serious infection of scab began to show on all the trees in all plats excepting Plat 16, and from that time the general appearance became less and less attractive, until at harvest time all the trees but those in Plat 16 were nearly one-third defoliated, and what leaves remained were scabby and ragged.

TABLE 17.—EFFECTS OF USING LIME SULFUR OF VARIOUS DILUTIONS IN COMBINATION WITH ARSENATE OF LEAD, IN THE EXPERIMENTS AT NEOGA, 1912

Plat	Treatment	Applications	Total no. picked apples	Total bu. picked apples	No. picked apples per bushel	Percentage grades of picked apples						Percentage of picked apples affected by			
						No. 1		No. 2		Culls		Scab			
						Based on number	Based on bushels	Based on number	Based on bushels	Based on number	Based on bushels	Slight	Serious	Total	Russet
14	1–80–4–100 lime sulfur arsenate of lead	1, 2, 3	4517	20.04	225	41.56	44.83	33.45	34.24	24.99	20.93	9.84	40.59	50.53	1.08
15	1–60–4–100 lime sulfur arsenate of lead	1, 2, 3	4217	21.40	197	49.75	54.21	22.61	22.59	27.64	23.20	7.53	33.48	41.01	1.81
16	1–40–4–100 lime sulfur arsenate of lead	1, 2, 3	4762	25.20	188	58.70	67.02	23.28	19.00	18.02	13.98	17.29	22.52	39.81	2.16
17	1–20–4–100 lime sulfur arsenate of lead	1, 2, 3	3971	19.45	204	49.86	53.31	23.37	22.18	28.77	25.41	12.20	30.76	42.96	.30
Check	No treatment	none	400	1.60	250	.00	.00	11.20	13.75	88.80	86.25	10.50	81.25	91.75	.00

EFFECT ON FRUIT

The fruit from these plats, excepting Plat 16, appeared before picking to be of very poor quality and lacking in good color, and on being placed on the sorting table it proved to be no better. All the plats were harvested and the fruit was examined October 17, with the results presented in Table 17.

The dilution commonly recommended of one gallon of commercial lime-sulfur solution to 40 of water, or thereabouts, gave the most satisfactory results in this experiment. It will be seen in comparing the apples sprayed with solutions both stronger and weaker than 1 to 40, that there seems to be very little difference, as the variation in the number of No. 1's is about 8 percent, and the greatest difference of scab is less than 10 percent. This experiment opens up a new line of investigation; namely, the determining of the effect of varying amounts of arsenate of lead with a definite dilution of lime sulfur, since it is evident that the amount of reaction resulting between lime sulfur and arsenate of lead determines to some extent the efficiency of the mixture. It may be assumed from these data that the proper reaction from a dilution of commercial lime sulfur, 1 to 40, with 4 pounds of arsenate of lead per 100 gallons of spray results in a very satisfactory fungicide.

FUNGICIDAL VALUE OF LIME SULFUR AND ARSENATE OF LEAD WHEN USED SEPARATELY

Experiments in previous years have shown lime sulfur arsenate of lead to be much more effective as a fungicide than lime sulfur used alone.[1] In order to gain further data on this point, three plats were sprayed as shown in Table 18.

EFFECT ON FOLIAGE

By the time of the second application the foliage of the trees in Plats 33 and 35 was badly infected with scab, while that in Plat 29 showed only a small amount. As a result of this serious infection the second and third applications to Plats 33 and 35 caused so much spray injury that practically all the foliage was brown spotted and ragged, and by the middle of the summer these trees were over 50 percent defoliated. At the end of the season they presented very little difference in appearance from the check trees.

EFFECT ON FRUIT

With the exception of Plat 29, the fruit from these plats was of very poor quality. It was picked and examined October 18, with the results presented in Table 18.

[1]See p. 87.

TABLE 18.—EFFECTS OF LIME SULFUR AND ARSENATE OF LEAD USED SEPARATELY AND IN COMBINATION, IN THE EXPERIMENTS AT NEOGA, 1912

Plat	Treatment	Applications	Total no. picked apples	Total bu. picked apples	No. picked apples per bushel	Percentage grades of picked apples						Percentage of picked apples affected by			
						No. 1		No. 2		Culls		Scab			
						Based on number	Based on bushels	Based on number	Based on bushels	Based on number	Based on bushels	Slight	Serious	Total	Russet
29	1–40–4–100 lime sulfur arsenate of lead	1, 2, 3	4312	23.16	186	58.70	67.02	23.28	19.00	18.02	13.98	17.27	22.52	39.79	2.16
33	1–40 lime sulfur.....	1, 2, 3	1520	7.44	204	17.80	21.63	22.19	23.39	60.01	54.98	8.49	62.32	70.81	.41
35	4–100 arsenate of lead	1, 2, 3	2131	8.12	262	4.88	8.72	10.44	14.28	84.68	77.00	6.26	79.46	85.72	.26

TABLE 19.—EFFECTS OF THE INDIVIDUAL SUMMER APPLICATIONS OF BORDEAUX AND LIME SULFUR IN COMBINATION WITH ARSENATE OF LEAD, IN THE EXPERIMENTS AT NEOGA, 1912

Plat	Treatment	Applications	Total no. picked apples	Total bu. picked apples	No. picked apples per bushel	Percentage grades of picked apples						Percentage of picked apples affected by			
						No. 1		No. 2		Culls		Scab			
						Based on number	Based on bushels	Based on number	Based on bushels	Based on number	Based on bushels	Slight	Serious	Total	Russet
37	8–8–4–100 Bordeaux arsenate of lead	1	2870	14.31	200	31.16	34.02	26.14	27.80	42.70	38.18	8.16	41.60	49.76	.00
38	8–8–4–100 Bordeaux arsenate of lead	2	2002	10.04	198	16.42	19.11	12.91	14.70	70.67	66.19	9.99	57.74	67.73	.36
39	8–8–4–100 Bordeaux arsenate of lead	3	2000	9.20	217	12.57	16.45	11.00	13.28	76.43	70.27	10.14	65.55	75.69	.28
40	1–40–4–100 lime sulfur arsenate of lead	2	3891	19.12	203	13.91	16.88	20.18	22.72	65.91	60.40	15.59	70.33	85.92	.45
41	1–40–4–100 lime sulfur arsenate of lead	3	2347	8.54	273	4.86	7.10	11.34	15.22	83.80	77.68	6.00	88.37	94.37	.00
Check	No treatment	none	480	1.34	358	.00	.00	.00	.00	100.00	100.00	.00	100.00	100.00	.00

The increased efficiency of lime sulfur combined with arsenate of lead over lime sulfur alone was plainly evident, as is shown by the data presented. Arsenate of lead used alone was of practically no fungicidal value in this experiment.

Attention is called to a comparison of Plat 29 in Table 18, and Plat C in Table 16, page 97. The treatments of these two plats varied only in the time of spraying, as each was given three applications of 1-40-4-100 lime sulfur arsenate of lead. Plat 29 was, in each case, sprayed three to four days later than Plat C, and since Plat C yielded nearly 20 percent more No. 1's than Plat 29, and showed 50 percent less scab, the time of application is again shown to be an important factor which must not be lost sight of.

INDIVIDUAL VALUE OF THE SEVERAL APPLICATIONS

In order to show the value of each of the first three regular summer applications when used separately, five plats were treated as shown in Table 19. The applications were made at the time considered most effective for each.

EFFECT ON FOLIAGE

The trees of Plat 37, which received the first application of Bordeaux arsenate of lead, showed the healthiest foliage of all the plats. Altho only a very small percentage of the foliage of the trees in this plat received any spray, the early infection of scab was held in check remarkably well, and only a small percentage of the foliage was lost before the normal defoliation. The trees in the other plats were all badly infected with scab at the time the applications were made, and altho the disease appeared to be held in check temporarily, the effect of the spray extended over only a short period.

As a result of the application, the trees in each of the plats receiving the second or third spraying only showed considerable injury. On the trees sprayed with lime sulfur this became apparent within a few hours, but with the Bordeaux-sprayed trees several days elapsed before the injury developed. The trees in Plats 38 and 39 lost about 40 percent of their foliage, and those in Plats 40 and 41 about 25 percent. At the close of the season, the foliage in all plats was ragged, and insect and fungous injuries were very apparent.

EFFECT ON FRUIT

The appearance of the apples on the trees in these plats before picking, except in Plat 37, was little better than that on the check trees. The fruit was picked and examined October 28, with the results presented in Table 19.

This table shows the ineffectiveness of single applications. In 1912 the first application proved considerably more effective in the control of scab than the second or third, as it was applied shortly before the first outbreak of the infection. This treatment also produced nearly 100 percent more No. 1's than any of the other treatments. Single applications of Bordeaux arsenate of lead are somewhat more efficient than the same applications of lime sulfur arsenate of lead.

SUMMARY OF RESULTS AT NEOGA, 1912

1. No beneficial results in the control of scab were obtained from the winter application of lime sulfur.
2. Lime sulfur arsenate of lead was slightly less efficient in the control of scab than Bordeaux arsenate of lead.
3. Three, four, and five applications of lime sulfur arsenate of lead yielded as many No. 1 apples as the same number of Bordeaux arsenate of lead applications.
4. The most satisfactory treatment consisted of Bordeaux arsenate of lead for the first application, and lime sulfur arsenate of lead for the second and third applications.
5. Arsenate of lead alone possesses practically no fungicidal value, and because of possible injury to the foliage should never be used as an apple spray except in combination with a fungicide.
6. Commercial lime-sulfur solution diluted 1 in 40, and applied with 4-100 arsenate of lead, is much more effective than any other dilution.
7. Lime sulfur arsenate of lead is a very much more effective fungicide than lime sulfur alone.
8. The time of application is a determining factor in the effectiveness of lime sulfur arsenate of lead.
9. It is inadvisable to omit any of the first three regular applications.

SPRAYING EXPERIMENTS IN 1912 AT FLORA, CLAY COUNTY

BY W. A. RUTH, ASSOCIATE IN HORTICULTURAL CHEMISTRY

OBJECTS

About half the spraying experiment at Flora in 1912 was devoted to a comparison of Bordeaux and lime sulfur. The remainder of the experiment consisted in a comparison of Sherwin-Williams, Hemingway, and Grasselli arsenates of lead, tests of copper ferrocyanide, and a trial of the mixtures resulting from the addition of copper sulfate and lead acetate to lime sulfur.

LOCATION AND DESCRIPTION OF ORCHARD

The orchard in which the experiments were carried out was situated four and one-half miles west of Flora, in the southwestern part of Clay county, a little north and east of the center of the southern horticultural district, which includes the southern third of the state. The trees were sixteen years old and were planted 30 feet apart each way. There were 17 rows north and south, and from 40 to 45 rows east and west. The north four rows and the south six rows were Ben Davis; the center seven rows were Jonathan. Mr. John Egginton, the original owner of this orchard, was the pioneer fruit grower of the locality. For several years after the trees were planted, the orchard was cared for by Mr. Egginton; since 1906 it had been in the hands of the Experiment Station. The trees were in a thrifty condition.

The orchard sloped gradually and evenly to the west, the extreme western end being about thirty feet lower than the eastern end. The spraying experiments were confined to the upper, or eastern, half of the orchard. Tests made early in the season, on still nights, showed no appreciable difference between the temperature of the lower and upper ends of the part in which the spraying experiments were carried out, showing that there was good air drainage, and that there was not sufficient difference in elevation to cause a possible difference in conditions favoring russeting or fungous infection.

The trees in the western end, which were not included in the experiments, were sprayed three times. An open field of fourteen acres lay directly to the north, and an older orchard, unsprayed, joined the experimental plats on the south. A fourteen-acre orchard of trees twenty-six years old, used by the station for fertilizer experiments, lay to the east.

TREATMENT

Table 20 specifies the materials used for the applications on each plat. Plats 4 to 11, which constitute the principal part of the experi-

TABLE 20.—SPRAY MATERIALS USED IN THE EXPERIMENTS AT FLORA, 1912[1]

Plat	First application (April 23-24)	Second application (May 10-13)	Third application (May 27-29)	Fourth application (July 1-5)
1	Lime sulfur and lead acetate	Lime sulfur and lead acetate	Lime sulfur and lead acetate	Bordeaux
2	Lime sulfur[2]	Lime sulfur[2]	Lime sulfur[2]	Bordeaux[2]
3	Lime sulfur[3]	Lime sulfur[3]	Lime sulfur[3]	Bordeaux[3]
4	Lime sulfur	Lime sulfur	Lime sulfur	Bordeaux
5	Lime sulfur	Lime sulfur	Bordeaux	Bordeaux
6	Lime sulfur	Bordeaux	Lime sulfur	Bordeaux
7	Lime sulfur	Bordeaux	Bordeaux	Bordeaux
8	Bordeaux	Bordeaux	Bordeaux	Bordeaux
9	Bordeaux	Bordeaux	Lime sulfur	Bordeaux
10	Bordeaux	Lime sulfur	Lime sulfur	Bordeaux
11	Bordeaux	Lime sulfur	Bordeaux	Bordeaux
12	Copper ferro-cyanide	Copper ferro-cyanide	Copper ferro-cyanide	Copper ferro-cyanide
13	Copper ferro-cyanide alone[4]	Copper ferro-cyanide alone	Copper ferro-cyanide alone	Copper ferro-cyanide alone
14	Lime sulfur and copper sulfate	Lime sulfur	Lime sulfur	Bordeaux

[1]Grasselli paste arsenate of lead was used in combination with the fungicide on all plats except where noted, at the rate of 4 pounds to 100 gallons of spray.

[2]Hemingway paste arsenate of lead was used on this plat, at the rate of 4 pounds to 100 gallons of spray.

[3]Sherwin-Williams paste arsenate of lead was used on this plat at the rate of 4 pounds to 100 gallons of spray.

[4]No arsenate of lead was used on this plat.

ment, were treated for the purpose of testing the relative merits of Bordeaux and lime sulfur. On all these plats Grasselli arsenate of lead was used, thereby keeping the insecticide constant. Lime sulfur and Bordeaux were interchanged in all possible ways for the first three applications.

The fourth application, in all cases, with the exception of the two plats, 12 and 13, on which copper ferrocyanide was used, consisted of Bordeaux arsenate of lead. A small yield necessitated a choice of either Bordeaux or lime sulfur for this application. Bordeaux was used because it was thought that by this time the fruit would be out of danger of russet,[1] and because of the danger of burning the fruit by using lime sulfur during the hot weather. If the yield had been heavier, lime sulfur would have been applied to one half of each plat at this time, and Bordeaux to the other half, in order to determine more fully their relative efficiency in the control of blotch as well as their tendency to cause foliage and fruit injury.

Plat A, shown in Chart 5, which was to have been used to compare the results of heavy and light spraying, was abandoned, as far as experimental purposes were concerned, because weather conditions early in the season interfered with its being sprayed properly.

[1]Hedrick, U. P., N. Y. (Geneva) Agr. Exp. Sta. Bul. 287, p. 163, 1907.

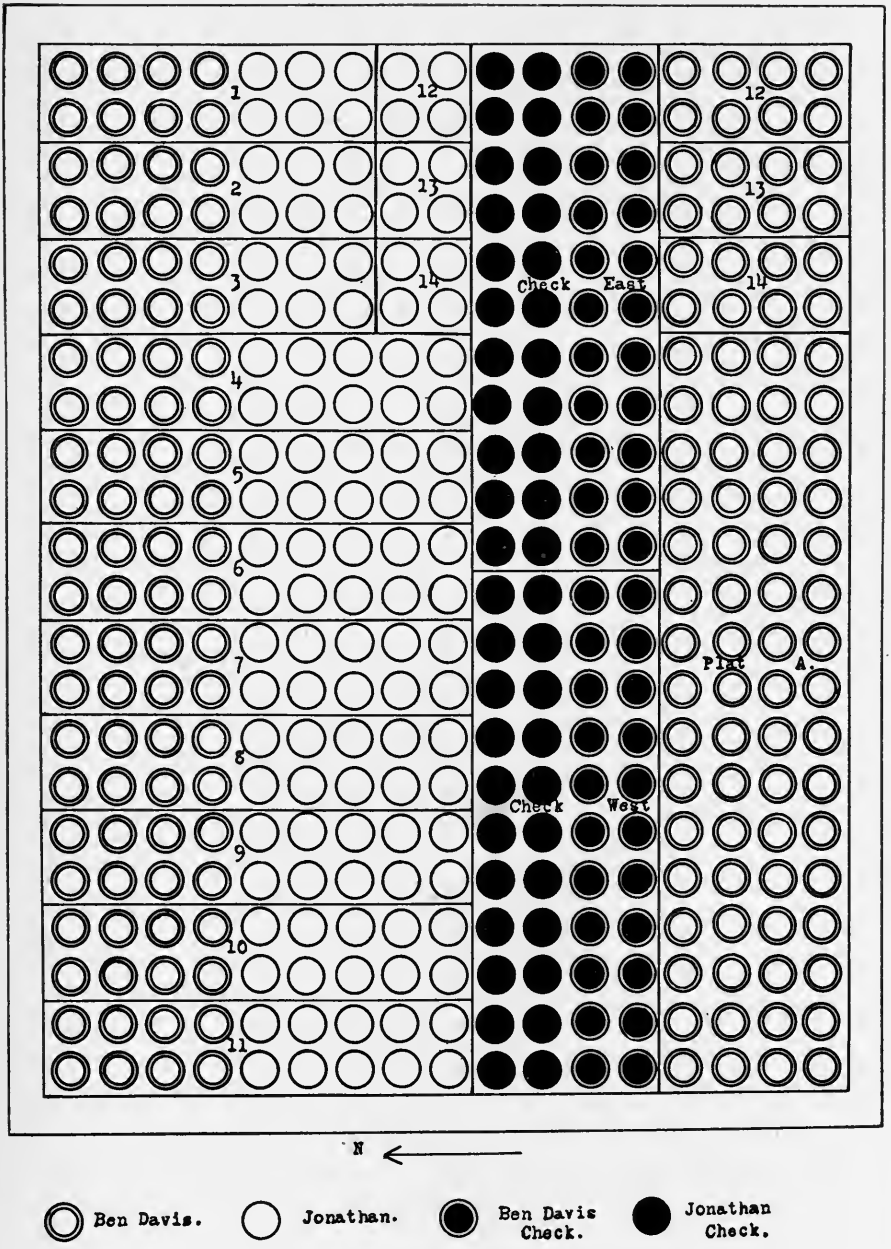

CHART 5.—PLAN OF PLATS IN ORCHARD OF MRS. JOHN EGGINTON, FLORA, 1912

For arrangement of plats see Chart 5.

The first application of spray was made just before the trees bloomed, April 23-24; the second, within ten days after the petals fell, May 10-13; the third, three weeks, May 27-29, and the fourth, eight weeks, July 1-5, after the petals fell. The foliage was dense and required exceptionally heavy applications of spray, even before the bloom. An average of 5.5 gallons of spray was used per tree for the first application, 8.5 gallons per tree for the second, 7 gallons for the third, and 7.5 gallons for the fourth. The foliage was sprayed until it began to drip.

So far as possible, Plats 4 to 11, inclusive, were sprayed on the same days. Plats 1, 2, 3, and 14 were then sprayed, followed by Plats 12 and 13.

APPARATUS AND MATERIALS

Bean whirlpool nozzles were used except for the application immediately following the fall of the petals (the second), when Friend "Drive Spray" nozzles were used. The material was applied with a power outfit at a pressure of 225 to 250 pounds.

The lime sulfur was made according to the Illinois formula (50 pounds lime, 100 pounds sulfur, boiled at a volume of 66 gallons), and diluted at the rate of 1 in 18.

The Bordeaux used was the standard 8-8-100 mixture. It was made by pumping about 50 gallons of water into the tank with the tank filler, adding the stock solution of lime thru the strainer with the tank filler going, adding the arsenate of lead, making up to 100 gallons, and then slowly adding the stock solution of copper sulfate, containing 1 pound to the gallon, to the stream from the tank filler as it entered the strainer. The force of the water from the tank filler and the whirling and splashing in the strainer were relied upon to dilute the copper sulfate before it entered the diluted lime. Tests with the mixture from the tank showed that it remained in suspension as long as a mixture made by any other method.

The copper ferrocyanide used was made at equal and full dilution, at the rate of 2 pounds of copper sulfate and 2 pounds of potassium ferrocyanide to 100 gallons of water. The fully diluted potassium ferrocyanide was run into the fully diluted copper sulfate.

The mixture of copper sulfate, lime sulfur, and arsenate of lead for Plat 14 contained 4 pounds of copper sulfate in 100 gallons of the ordinary diluted lime sulfur arsenate of lead. It was made by pouring the stock solution of copper sulfate slowly into the water running from the tank filler into the strainer, after the lime sulfur and arsenate of lead, previously placed in the tank, had been diluted to about half the final volume. The method used for making the lead acetate, lime sulfur, arsenate of lead spray was the same except that lead acetate was used instead of copper sulfate. Four pounds of lead acetate were used to each 100 gallons of spray.

CHARACTER OF RECORDS AND METHOD OF MAKING

The date, the hour of commencing and the hour of completing the spraying of each plat, the amount of spray applied, the pressure used, the direction and strength of wind, and the general weather conditions were recorded at the time of each application. Records were made from time to time on the fruit and foliage, describing the spray present, the first appearance and the progress of fungous infection, and the character of spray and insect injury. Maximum and minimum temperatures, the wet- and dry-bulb temperatures at 7 a. m., 12 m., and 6 p. m., and the rainfall, were recorded during the entire season.

Dropped apples were examined during September for insect, fungous, and spray injuries. Records from the picked apples were made on slight and severe infections of dead and live scab, blotch, sooty blotch, and flyspeck, slight and severe russeting, calyx and side injuries by codling moth, and slight and severe curculio injuries. There was no bitter rot. The term "severe" means an injury sufficient to class an individual apple as a cull under a careful system of grading. Slight and severe infections are considered together in the report of the results (Table 21).

Because of a very light bloom some of the Ben Davis plats did not yield much over one hundred apples, and most of the Jonathan plats between one hundred and two hundred apples, in one case less than one hundred. The entire crop was, therefore, examined.

WEATHER CONDITIONS

During April, May, and June, the rainfall was well distributed. There were no severe drops in temperature except on the morning of May 13, when a minimum of 33° was recorded in the thermometer box at the upper end of the orchard. There is a possibility that a thermometer so placed does not always record the lowest temperature among the trees themselves, so that a low temperature on that night may have been an active factor in the formation of russet. Favorable weather accompanied the first application, but the second, third, and fourth applications were interrupted by rain. There was also a heavy fall of rain just after the completion of each application. During the early part of July, there was an excessive amount of rain, but the remainder of the season was normal.

EFFECT OF SPRAYS ON FOLIAGE

The effect of the sprays on the foliage was studied from the standpoint of the amount of injury caused as well as the protection afforded.

Scab.—The foliage on all plats, unsprayed as well as sprayed, was practically free from scab.

Leaf Spot.—Leaf spot caused severe loss of foliage on the check plats during the latter part of the season. It was much more severe on the Ben Davis than on the Jonathans. Up to the first of September there had been very little loss of foliage from this fungus, but by the first of October the check Ben Davis trees had become practically defoliated. So far as could be told, all the treatments afforded complete protection, altho it must be borne in mind that lime sulfur was not used for the fourth application; the only sprays used at that time were Bordeaux and copper ferrocyanide. The necessity of spraying orchards in this locality to prevent defoliation by leaf spot is shown in Plates 3 and 4, page 208. The trees in good foliage were sprayed three times; before the bloom with Bordeaux arsenate of lead, just after the petals fell with lime sulfur arsenate of lead, and two weeks later with Bordeaux arsenate of lead. The others were not sprayed.

Insect Injuries.—An insect not often observed in former years by commercial growers in this locality, but which was present this year in large numbers, was the apple flea-weevil. It is described by Dr. S. A. Forbes[1] as follows:

"The apple flea-weevil is a small, dull blackish beetle nearly one-eighth of an inch long, resembling the common flea-beetles in general appearance; and, altho a true weevil or snout-beetle, it has the power of leaping like the flea-beetles. The larvae make winding burrows (mines) in apple leaves; the pupae are formed within the leaf; and the adults feed on the leaves, making numerous shallow pits which later become small holes. The eggs are apparently inserted in the outer part of the leaf in one of the principal veins."

By the middle of May, almost every leaf showed the work of the larval stage of this insect. During the latter part of May and the first part of June, one or two adult insects were to be found feeding on the under side of almost every leaf, where all the feeding was done. The insects had almost disappeared by June 24. Altho the third application was made on May 27 and 28, when the insects were most numerous, the sprays were ineffective in controlling them. The care taken in spraying, the high pressure of 225 to 250 pounds, and the large amount of spray used, should have controlled the apple flea-weevil, if it were possible to do so by means of arsenate of lead, Bordeaux, or lime sulfur. No especial pains were taken to spray the under sides of the leaves, however.

Bordeaux Injury.—Bordeaux injury did not appear until June 20, which was about three weeks after the third application. This relatively late appearance of injury, in spite of heavy rains which came soon after the second and third applications, and which it has been found are in general followed[2] by the appearance of the injury, may possibly be set down to the vigorous condition of the trees.[3] On June

[1]Forbes, S. A., Twenty-sixth Report, Illinois State Entomologist, pp. 83-85, 1911.

[2]Hedrick, U. P., N. Y. (Geneva) Agr. Exp. Sta. Bul. 287, pp. 166-169, 1907.

[3]Crandall, C. S., Ill. Agr. Exp. Sta. Bul. 135, p. 223, 1909.

20, leaf-yellowing showed slightly on the plats on which Bordeaux had been used for the second or third application, or both. There was none on Plat 10, which had received Bordeaux for the first application only. By June 24, the injury from the second and third applications had become very severe, a great many leaves turning yellow and a considerable number falling. On July 1 the attack of leaf-yellowing had about passed.

Following the fourth application, made between July 1 and July 5, there was no severe leaf-yellowing until the first week in August. On August 7 the injury had become very severe on all the Jonathans sprayed the fourth time with Bordeaux. This included all the sprayed plats except those sprayed with copper ferrocyanide, on which there was no injury at this time. There was much less injury on the Ben Davis trees than on the Jonathans. The attack had developed fully and the trees had lost most of their injured leaves by August 20, the damage having become somewhat severe on the Ben Davis and very severe on the Jonathans. No serious attacks of leaf-yellowing as a result of Bordeaux injury appeared after August 20.

Altho it is possible that the large amount of spray, together with the high pressure and rather coarse nozzles, was responsible for the severity of the Bordeaux injury to the fruit, reported later in Tables 21 and 22, the injury to the foliage was no greater than that caused in certain other orchards in the neighborhood where the pressures used were lower, and where smaller amounts of spray were applied. Comparisons with other orchards in respect to foliage injury are not wholly justified because of other varying factors, but there were no experiments in this orchard in which low pressures and small amounts of spray were used.

Injury from Other Sprays.—It was observed by Wallace[1] that injuries occur where lime sulfur is applied to foliage which has been attacked by apple scab. As no lime-sulfur injury occurred in any of the plats where lime sulfur was used in these experiments, and as there was no apple scab, the inference may be drawn from these results also that lime sulfur can be applied to healthy foliage with but slight danger of injuring it.

There was very little foliage injury due to the use of copper ferrocyanide. The spray was very adhesive. On August 20 the foliage on the copper-ferrocyanide plats (Plats 12 and 13) was much heavier than that on any of the other sprayed plats, all of which by this time had received Bordeaux.

Lime sulfur, copper sulfate, and arsenate of lead when used for the first application (Plat 14), caused no foliage injury. This spray acted similarly to Bordeaux in this respect.

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[1]Wallace, Errett, N. Y. (Cornell) Agr. Exp. Sta. Bul. 288, pp. 123-126, 1910.

Lime sulfur, lead acetate, and arsenate of lead when used for the first three applications (Plat 1), caused no foliage injury. The spray was black at first, but lost its color, looking in about ten days like the ordinary lime sulfur arsenate of lead.

EFFECT ON FRUIT

The effects of the treatments on the fruit are shown in Table 21.

Scab.—Scab first appeared May 18, when a very little was observed on the Ben Davis foliage. The development of scab on this variety was so slight that at picking time only 15.2 percent of the apples from the check plats showed infection, while the Jonathans were entirely free. All of the sprays controlled scab almost perfectly. The infection was so slight that no conclusions can be drawn from the results.

Blotch.—The outbreak of blotch was so severe that the year was a favorable one for studying its control under extreme conditions. On an average, 67.1 percent of the apples from the Jonathan check plats, and 72.7 percent of the apples from the Ben Davis check plats, showed blotch at picking time.

The first appearance of this fungus on the fruit was June 17, when it was observed on a very few Ben Davis apples. On July 17 approximately 10 percent of the apples of this variety showed infection, and it was just appearing on the Jonathans. The Jonathans at this time were showing about as much blotch as the Ben Davis had shown a month before.

Reference to Table 21 will show that all the treatments controlled the blotch on the Jonathans almost perfectly. It has been mentioned previously that the last application on all but the copper-ferrocyanide plats (Plats 12 and 13) was Bordeaux, and that this application was made July 1-5, while the first scattering infection of blotch on this variety was observed July 17. Bordeaux was thus present on the Jonathan apples at the period of greatest infection.

The control of blotch on the Ben Davis was scarcely as good as it was on the Jonathans, except where Bordeaux was the only or the principal fungicide applied. However, lime sulfur arsenate of lead when used for the first three applications, with Bordeaux for the fourth (Plats 2, 3, and 4), controlled a very large proportion of the infection, the fungus showing on only 3.5 to 4 percent of the apples so treated. Bordeaux, when used for all four applications, gave perfect control.

Where copper ferrocyanide and arsenate of lead were used (Plat 12), there was no blotch on the Jonathans, while there was 27.5 percent on the Ben Davis. Where copper ferrocyanide was used alone (Plat 13), 1.8 percent of the Jonathans showed blotch, while 35.5 percent of the Ben Davis were affected. The interval of five weeks

TABLE 21.—EFFECTS OF THE SPRAYS USED IN THE EXPERIMENTS AT FLORA, 1912[1]

Plat	Treatment	Percentage of picked apples affected by									
		Scab		Blotch		Sooty blotch		Flyspeck		Severe russet	
		Jonathan	Ben Davis	Jonathan	Ben Davis	Jonathan	Ben Davis	Jonathan	Ben Davis	Jonathan	Ben Davis
1	Lime sulfur and lead acetate 1st, 2d, 3d; Bordeaux 4th	..	...	...	...	...	...	...	...	...	...
2[2]	Lime sulfur 1st, 2d, 3d; Bordeaux 4th	..	.0	.0	3.5	...	.0	...	.0	...	19.4
3[3]	Lime sulfur 1st, 2d, 3d; Bordeaux 4th	0	.0	5.0	3.9	.0	.0	.0	.0	10.5	27.7
4	Lime sulfur 1st, 2d, 3d; Bordeaux 4th	0	.0	.7	4.0	.0	.0	.0	.0	3.5	13.3
5	Lime sulfur 1st, 2d; Bordeaux 3d, 4th	0	.0	.0	2.4	.0	.0	.0	.0	31.7	88.9
6	Lime sulfur 1st; Bordeaux 2d; lime sulfur 3d; Bordeaux 4th	0	.0	.0	.05	.0	.0	.0	.0	42.1	22.9
7	Lime sulfur 1st; Bordeaux 2d, 3d, 4th	0	...	.0	...	.0	...	.0	...	88.3	...
8	Bordeaux 1st, 2d, 3d, 4th	0	1.0	.0	.0	.0	.0	.0	.0	88.6	74.3
9	Bordeaux 1st, 2d; lime sulfur 3d; Bordeaux 4th	0	1.0	.0	.0	.0	.0	.0	.0	79.6	51.7
10	Bordeaux 1st; lime sulfur 2d, 3d; Bordeaux 4th	0	.0	.0	7.5	1.3	.0	.0	.0	13.8	24.8
11	Bordeaux 1st; lime sulfur 2d; Bordeaux 3d, 4th	0	.0	.0	0.9	.0	.0	.0	.0	53.3	50.9
12	Copper ferrocyanide 1st, 2d, 3d, 4th	0	.0	.0	27.5	.0	.0	.0	.0	35.8	57.1
13[4]	Copper ferrocyanide alone 1st, 2d, 3d, 4th	0	.0	1.8	35.5	5.6	4.4	1.2	2.2	27.3	46.6
14	Copper sulfate and lime sulfur 1st; lime sulfur 2d, 3d; Bordeaux 4th	0	...	.0	...	.0	...	.0	...	27.6	...
Check West	No treatment	0	23.0	77.0	70.5	83.0	62.0	71.0	64.0	22.0	26.5
Check East	No treatment	0	7.5	57.3	75.0	81.4	38.5	71.2	38.5	15.2	31.0
Average Check	No treatment	0	15.2	67.1	72.7	82.2	50.2	71.1	51.2	18.6	28.7

[1]Grasselli arsenate of lead, 4 pounds to 100 gallons, used except where noted. Some results not given because of crop failure.
[2]Hemingway arsenate of lead used, 4 pounds to 100 gallons.
[3]Sherwin-Williams arsenate of lead used, 4 pounds to 100 gallons.
[4]No arsenate of lead used.

between the third and fourth applications was too long to control it with this fungicide in this variety.

The treatment which seems to be of the most value when russet and foliage injury are considered, includes the use of lime sulfur for the applications following the fall of the petals, up to the time when the danger of Bordeaux russet is past. Plats 2, 3, 4, and 10 were treated in that manner, the fourth application, as stated, being Bordeaux. The amount of blotch on these plats ran between 0 on the lowest Jonathan plats to 7.5 percent on the highest Ben Davis plat, the greater amount being uniformly on the Ben Davis. Considering the comparative freedom from blotch on plats sprayed in this manner, and the long interval between the third and fourth applications, when infection on the Ben Davis apples was taking place, an extra application of lime sulfur arsenate of lead, to be made between what were this year the third and fourth applications, and coming about the middle of June, would apparently have afforded complete protection.

Sooty Blotch and Flyspeck.—Sooty blotch and flyspeck appear in the latter part of the summer, and as it is found that a treatment which will control one will control the other, they are considered together.

Sooty blotch was first observed during this season August 3. Altho the final spray was applied almost a month before the appearance of this fungus, both sooty blotch and flyspeck were controlled on all the Jonathan plats with the exception of 1.3 percent of sooty blotch on Plat 10 (Bordeaux, lime sulfur, lime sulfur, Bordeaux), and between 1.2 and 5.6 percent on Plat 13 (copper ferrocyanide alone).

Russet.—Heavy rains followed the second, third, and fourth applications. The weather was favorable for the formation of russet,[1] an average of 28.7 percent of the apples from the Ben Davis check plats and 18.6 percent from the Jonathan check plats being severely affected.

Two kinds of russet were observed on the apples from the sprayed plats. The most noticeable kind consisted in a more or less extensive corky surface, which, when extensive or rough enough to throw the individual apples into the cull grade, is given in the table as "severe russet." It is desirable to avoid this form of russet entirely if possible, because, even if the individual apples are not severely russeted, the presence of a slight amount greatly detracts from the appearance of a barrel or a box of the fruit. A black dotting constituted another form of russeting. It was scarcely noticeable at picking time, altho in the early part of the season this form of injury looked serious. Up to the time of the fourth application, it was confined to the plats which had received the second or third application of Bordeaux. After the fourth application (Bordeaux or copper ferrocyanide) it developed on all the plats.

[1]Hedrick, U. P., N. Y. (Geneva) Agr. Exp. Sta. Bul. 287, pp. 166-169.

The amount of russet varied with the treatment, russet following the use of Bordeaux when used for any of the applications. On Plat 4, where lime sulfur and Grasselli arsenate of lead were used for the first three applications and Bordeaux and Grasselli arsenate of lead for the fourth, there was 3.5 percent severe russet on the Jonathans and 13.3 percent on the Ben Davis. On the other hand, Bordeaux and Grasselli arsenate of lead, when used for all four applications (Plat 8), gave 88.6 percent severe russet on the Jonathans and 74.3 percent on the Ben Davis. The crop from this plat was practically ruined for boxing or even barreling purposes.

A question of great importance is the amount of russet caused by each of the first three applications of Bordeaux. In order to estimate this roughly, Plat 4 is again taken as a standard for comparison with plats on which more Bordeaux was used (Plats 5 to 11). Plat 4 received, as stated in the preceding paragraph, lime sulfur and Grasselli arsenate of lead for the first three applications and Bordeaux and Grasselli arsenate of lead for the fourth. Plats 5 to 11 received Bordeaux for the fourth, and Bordeaux instead of lime sulfur for one or more of the first three applications, with the same arsenate of lead as Plat 4. The comparison can be studied readily in Table 22. The figures represent the increase in percentage of apples showing severe russet over that found on the Jonathans (3.5 percent) and the Ben Davis (13.3 percent) from Plat 4.

TABLE 22.—PERCENTAGE INCREASE OVER PLAT 4 IN SEVERE RUSSET AS A RESULT OF USING BORDEAUX FOR APPLICATIONS BEFORE THE FOURTH IN THE EXPERIMENTS AT FLORA, 1912

Plat	Applications of Bordeaux	Jonathan	Ben Davis
10	1, -- -- 4	10.3	11.5
6	-- 2, -- 4	38.6	9.6
5	-- -- 3, 4	28.2	75.6
9	1, 2, -- 4	76.1	38.2
7	-- 2, 3, 4	84.8	....
11	1, -- 3, 4	49.8	37.6
8	1, 2, 3, 4	85.1	61.0

NOTE.—Dashes under the heading *Applications of Bordeaux* signify the use of lime sulfur.

It will be seen that the first application of Bordeaux in place of lime sulfur (Plat 10) increased the severe russet on the Jonathans 10.3 percent; the second application increased it 38.6 percent (Plat 6); and the third increased it 28.2 percent (Plat 5), the third application being less harmful on this variety than the second.

The Ben Davis apples, which were sprayed at all times in exactly the same way and at the same time as the Jonathans, did not show like results except for the first application (Plat 10), which gave an increase over Plat 4 of 11.5 percent in the severely russeted fruit. The second application (Plat 6) gave only 9.6 percent increase, while the third (Plat 5) gave the great increase of 75.6 percent.

Combinations of any two of the applications gave very severe injury. For example, the first and third applications of Bordeaux (Plat 11) gave an increase of 49.8 percent severely russeted Jonathans and 37.6 percent severely russeted Ben Davis. These percentages correspond with a total of 53.3 percent for the Jonathans and 50.9 percent for the Ben Davis, and mean that the use of Bordeaux just before the bloom and for the application three to four weeks after the petals fell resulted in the culling of one half of the crop on account of russet.

A point of great interest is the fact that the apples from the plats sprayed the first three times with lime sulfur and Grasselli arsenate of lead, and the fourth time with Bordeaux and Grasselli arsenate of lead, showed much less severe russet than the apples from the check plats. While the average severe russet for the Jonathan check plats was 18.6 percent and for the Ben Davis check plats 28.7 percent, only 3.5 percent of the Jonathans and 13.3 percent of the Ben Davis from Plat 4, which received the treatment specified above, showed severe russet. The reduction was approximately 15 percent on both varieties. The freedom from severe russet was accompanied by a smoother and higher finish than was shown by the apples from the checks. This difference in "finish" is not shown in the table.

Altho lime sulfur and Grasselli arsenate of lead were of value in lessening the amount of russet and in causing an improvement of the finish, Hemingway and Sherwin-Williams arsenate of lead did not show as good results, possibly largely because of weather conditions. In treatments similar to that given Plat 4, but where Hemingway or Sherwin-Williams arsenates of lead were used instead of Grasselli, Sherwin-Williams arsenate of lead (together with the fungicide) showed, on Plat 3, 10.5 percent of severe russet on the Jonathan and 27.7 percent on the Ben Davis. These amounts agreed closely with the amounts shown on the checks. Hemingway arsenate of lead, when used instead of Grasselli (Plat 2), gave somewhat better results than the Sherwin-Williams product, the amount of severe russet on the Ben Davis apples being reduced to 19.4 percent, which is 9.3 percent less than that shown on the checks. Plat 4 was always sprayed two or three days sooner than Plats 2 and 3, and since a heavy fall of rain occurred a day or two after Plat 4 was sprayed the second, third, and fourth times, before Plats 2 and 3 were sprayed, a strict comparison of the treatments given these three plats is prevented.

The active fungicidal principle of Bordeaux is copper; and it was thought that an excess of soluble copper, above that necessary to protect foliage from fungous infection, was responsible for Bordeaux injury. Two other copper compounds beside Bordeaux were therefore tried,—copper ferrocyanide, and the compound resulting from the addition of copper sulfate to lime sulfur. The spray sought was one which would be just soluble enough to liberate sufficient copper to prevent fungous infection, but no more. Altho a smaller amount of rus-

set resulted this year from the first application of Bordeaux than from the second or third, the compound of copper sulfate and lime sulfur gave a large amount of russet even when used for the first application, which might be expected to be the safest of all three from the standpoint of copper injury. On the plat on which it was used (Plat 14), 27.6 percent of the Jonathans were severely russeted, 13.8 percent more injury than the similar Bordeaux plat showed (Plat 10), and an increase of 24.1 percent over that shown by Plat 4, the similar lime-sulfur plat. Weather conditions at the time of the first application allow a comparison between the two plats. Plat 4 was sprayed April 23, and Plat 14, April 24. Both days were clear, with a moderate wind suitable for drying the spray on the foliage. April 25 was cloudy, and during the night of April 25-26 there were 1.27 inches of rain. Because of the severe russet resulting from the use of this spray, it does not seem probable that it will be found of value.

Copper ferrocyanide, the other copper compound which was tried in the effort to find a suitable copper spray, gave more russet than would have been expected in view of its very low solubility in water, its comparatively low fungicidal power, and the freedom of the plats sprayed with it from foliage injury. Less injury was occasioned by its use alone (Plat 13) than by its use in combination with arsenate of lead (Plat 12). By its use with arsenate of lead 57 percent of the Ben Davis apples, and 36 percent of the Jonathans were severely russeted.

It is unfortunate that so few apples were harvested from Plat 1, the plat on which lead acetate and lime sulfur was used, that no records could be taken. The unstable lead and sulfur compound formed when lead acetate is added to lime sulfur may be a valuable fungicide, and, because of its insolubility, may be expected to cause but little injury.

SUMMARY OF RESULTS AT FLORA, 1912

FOLIAGE

The effects of the sprays on the foliage may be summarized as follows:

1. Lime sulfur arsenate of lead caused no foliage injury.
2. Bordeaux arsenate of lead caused severe injury as a result of the second, third, and fourth applications, but not as a result of the first application.
3. Copper ferrocyanide alone and with arsenate of lead caused no serious foliage injury.
4. Copper sulfate and lime sulfur arsenate of lead, used for the first application, caused no foliage injury.
5. Lead acetate did not materially change the properties of lime sulfur arsenate of lead, so far as could be observed this year. The spray was black at first, but soon lost its distinctive color.

6. There was practically no scab on the foliage. Its absence may be responsible, in part at least, for the absence of lime-sulfur injury and, together with the vigorous condition of the trees, for the late appearance of Bordeaux injury.

7. Leaf spot caused the check Ben Davis trees to lose the most of their foliage during September. It was not so severe on the Jonathans. All of the fungicides used afforded protection from this fungus.

8. The apple flea-weevil was not controlled by the sprays used.

FRUIT

Scab.—There was no scab on the Jonathans. The slight amount on the Ben Davis was controlled by all the sprays.

Blotch.—The outbreak of blotch was severe. Lime sulfur, used for the third application, with Bordeaux for the fourth, was not quite as efficient as Bordeaux used for both the third and fourth applications in the control of blotch on the Ben Davis, but, with the exception of one plat, was as efficient in controlling it on the Jonathans. The interval between the third and fourth applications was between four and five weeks, during which time there was severe infection of the Ben Davis checks, altho none appeared on the Jonathan checks until about two weeks after the fourth application. It seems probable that an extra application of lime sulfur, coming between what were the third and fourth applications, would have given complete, or almost complete, protection. Copper ferrocyanide allowed a slight infection of the Jonathans and afforded some protection to the Ben Davis. Copper ferrocyanide and arsenate of lead controlled the blotch on the Jonathans and afforded more protection on the Ben Davis. The long interval between the third and fourth applications, and the appearance of blotch before the fourth application on the Ben Davis, may again account for the difference in the control of blotch on the two varieties.

Sooty Blotch and Flyspeck.—Altho the infection on the checks was severe these fungi were controlled on the plats sprayed with Bordeaux between July 1 and 5. Copper ferrocyanide and arsenate of lead applied at that time gave perfect control, but there was a small amount on both varieties where copper ferrocyanide was used alone.

Russet.—Severe russeting resulted on both varieties from the use of Bordeaux arsenate of lead for the first, second, and third applications. Another form of injury, consisting in a black dotting, resulted from the second, third, and fourth applications. At picking time, however, this was almost negligible. Copper ferrocyanide, and the copper-sulfate and lime-sulfur mixture caused severe russeting, copper ferrocyanide causing more when used with arsenate of lead than when used without. Lime sulfur was of benefit in preventing russet and in improving the finish of the apples of both varieties.

SPRAYING EXPERIMENTS IN 1909 AT GRIGGSVILLE, PIKE COUNTY

By L. EARL FOGLESONG, Assistant in Pomology

OBJECTS

Spraying experiments were conducted in the season of 1909 near Griggsville, in order to ascertain the relative efficiency of various commercial and homemade sprays in preventing or controlling insects and fungous diseases.

LOCATION AND DESCRIPTION OF ORCHARD

An orchard belonging to Mr. John Sawdon, located two miles south of Griggsville, which had been used in 1904 and 1906 by the Department of Horticulture, was selected for these tests. As there were not sufficient Ben Davis trees on which to run all the series, some trees of the Milam variety were used.

TREATMENT

The plats were sprayed with various insecticides and fungicides as shown in Tables 23 to 27. In all the series, except the one where the number of sprays was varied, five applications were made on or near the following dates:

First application: just before bloom, April 27, May 3
Second application: within ten days after fall of bloom, May 11-14
Third application: ten days later, May 21-27
Fourth application: June 24-29
Fifth application: July 14-16

All the plats in each series were sprayed the same day and as nearly under the same conditions of weather as possible, so that the data collected from leaf and fruit examinations would be comparable.

CHARACTER OF RECORDS AND METHOD OF MAKING

The fruit from each tree of the various experiments was examined carefully and recorded at the time of harvesting, and general notes were taken on the foliage from time to time thruout the summer. In the following tables, the percentages of apples injured by apple scab, curculio, russeting, and codling moth are given. As a total of only four or five apples were found with blotch, and but two with bitter rot, fruit affected by these diseases is not reported in the tables.

Comparison of Various Brands of Arsenate of Lead and Paris Green

The treatments used in Group 1, together with the fruit data recorded, are given in Table 23.

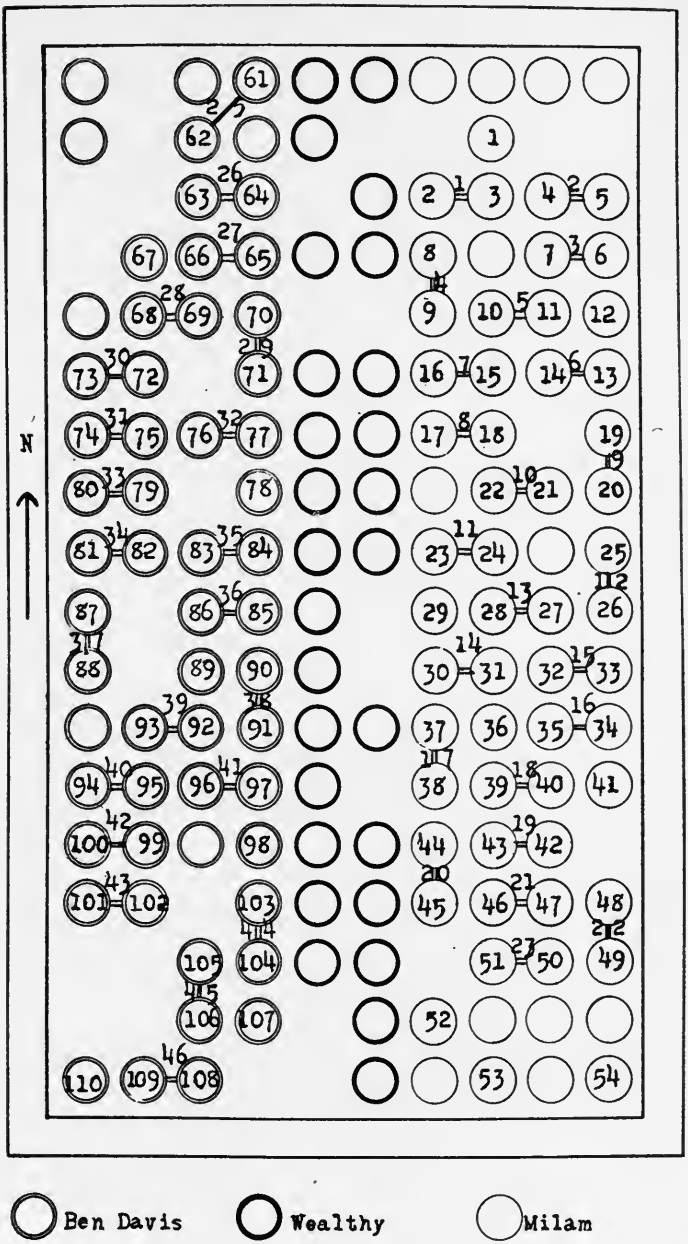

CHART 6.—PLAN OF PLATS IN ORCHARD OF MR. JOHN SAWDON, GRIGGSVILLE, 1909

TABLE 23.—EFFECTS OF SPRAYING WITH VARIOUS BRANDS AND STRENGTHS OF ARSENATE OF LEAD AND PARIS GREEN, IN THE EXPERIMENTS AT GRIGGSVILLE, 1909

Plat	Trees	Treatment	Percentage picked apples affected by		
			Scab	Codling moth	Curculio
Check	1	No treatment	99	12	98
1	2-3	Grasselli arsenate of lead, 6 lbs. to 100 gals. water	88	0	67
2	4-5	Grasselli arsenate of lead, 4 lbs. to 100 gals. water	92	0	65
4	8-9	Target brand arsenate of lead, 6 lbs. to 100 gals. water	90	0	68
5	10-11	Sherwin-Williams arsenate of lead, 6 lbs. to 100 gals. water	95	1	77
6	13-14	Homemade arsenate of lead, 2 lbs. to 100 gals. water	89	0	63
Check	12	No treatment	89	5	81
8	17-18	Sherwin-Williams Paris green, ½ lb., lime 2 lbs., to 100 gals. water	94	1	96
9	19-20	Ansbacher Paris green, ½ lb., lime 2 lbs., to 100 gals. water	97	0	78
10	21-22	Paris green, equivalent to arsenate of lead in Plat 5	90	1	85

EFFECT ON FRUIT

Scab.—Neither arsenate of lead nor Paris green in any of the brands or forms used showed any effect in the control of scab.

Codling Moth.—All brands of arsenate of lead and Paris green showed excellent control of codling moth.

Curculio.—Arsenate of lead in all forms reduced the percentage of curculio injury by amounts ranging from 4 to 35 percent (Plat 5 as compared with Check Tree 12, and Plat 6 compared with Check Tree 1). The average reduction in curculio injury for the arsenate of lead plats (Plats 1, 2, 4, 5, and 6) was 22 percent, as compared with the average of two check trees (Plats 1 and 12). The trees sprayed with Paris green showed no consistent reduction of curculio injury as a result of spraying.

Six pounds of arsenate of lead per 100 gallons of spray mixture were not more effective than 4 pounds per 100 gallons in controlling codling moth and curculio.

Homemade arsenate of lead proved more efficient, if anything, than the commercial product, but the results were not sufficiently different to recommend its adoption over the commercial arsenate of lead.

EFFECT ON FOLIAGE

Arsenate of lead caused no foliage injury, but the foliage of the trees in Plats 8 and 10, where Sherwin-Williams Paris green was used,

was severely burned. The foliage of Plat 9, sprayed with Ansbacher Paris green, was much less severely burned, tho some injury occurred in this plat late in the season following the fifth application. The foliage on Plats 8 and 10 was so severely injured as to reduce the size of the fruit noticeably. Plat 10, which suffered the most, even produced a second crop of leaves late in the season in an effort to replace foliage lost by spray injury.

COMPARISONS OF COMMERCIAL AND SELF-BOILED LIME SULFUR WITH AND WITHOUT ARSENICAL INSECTICIDES

The treatments used in Group 2, together with the fruit data recorded, are given in Table 24.

TABLE 24.—EFFECTS OF COMMERCIAL AND SELF-BOILED LIME SULFUR WITH AND WITHOUT ARSENICAL INSECTICIDES, IN THE EXPERIMENTS AT GRIGGSVILLE, 1909

Plat	Trees	Treatment	Percentage picked apples affected by		
			Scab	Codling moth	Curculio
11	23-24	Lime sulfur, commercial, with Paris green.....	53	4	84
12	25-26	Lime sulfur, commercial, alone.....	39	25	72
13	27-28	Lime sulfur, commercial, with arsenate of lead	72	4	73
Check	29	No treatment	95	11	97
14	30-31	Lime sulfur, self-boiled, 12–12–100, alone.....	89	22	91
15	32-33	Lime sulfur, self-boiled, 16–16–100, alone.....	87	18	84
16	34-35	Lime sulfur, self-boiled, 20–20–100, alone.....	87	30	75
17	37-38	Lime sulfur, self-boiled, 16–16–100, with arsenate of lead	85	1	78
Check	36	No treatment	89	13	91

EFFECT ON FRUIT

Scab.—The applications of commercial lime sulfur made on Plats 11, 12, and 13, reduced scab on an average by 37 percent as compared with the average in the check plats. Most of the scab on the sprayed plats was of so light a nature as would not readily be noticed, occurring largely in the form of an early attack of the disease which did not disfigure the apples at picking time. The disfiguring marks of scab were largely confined to the untreated apples. The spray was therefore much more effective than the figures in the table indicate. The self-boiled lime sulfur showed little value in preventing attacks of scab, the average scab infection for the self-boiled lime-sulfur plats being 87 percent, as compared with 92 percent, the average on the unsprayed trees.

Codling Moth.—Both Paris green and arsenate of lead exercised a most satisfactory control of this insect in every case. There was an

average infestation of 4 percent on the plat sprayed with Paris green (Plat 11) and of 2.5 percent on the plats sprayed with arsenate of lead (Plats 13 and 17), compared with an average of 12 percent on the untreated trees. Codling moth was evidently rather strongly attracted to the trees sprayed with lime sulfur; the fruit on these trees was more severely attacked by this insect than the fruit on the unsprayed trees, a difference that held consistently for all the plats sprayed with lime sulfur alone (Plats 12, 14, 15, and 16), which showed an average codling-moth infestation of 24 percent, or double the average infestation of the unsprayed trees.

Curculio.—The differences in curculio infestation between the treated plats were not consistent, but with the exception of Plat 14, all sprayed trees indicated some degree of control by the treatments, as compared with the untreated plats.

Even Plat 14, sprayed with self-boiled lime sulfur (12-12-100) alone, showed 3 percent less curculio injury than the average of the check plats. The addition of arsenate of lead and of Paris green to lime sulfur did not aid noticeably in controlling curculio, the average infestation in the plats where the poisons were used being 78 percent, as compared with 80.5 percent for the plats sprayed with lime sulfur alone. Contrary to the experience in the control of codling moth, lime sulfur appeared to exercise a repellent effect on the curculio. Plats sprayed with lime sulfur alone (Plats 12, 14, 15, and 16) showed an average infestation of 80.5 percent, as compared to an average infestation on the unsprayed trees of 94 percent.

Self-boiled lime sulfur proved to be an inefficient fungicide. Lime sulfur (commercial) showed considerable fungicidal value.

EFFECT ON FOLIAGE

The foliage was good thruout this group, but was perhaps slightly better in Plats 13 and 17, where arsenate of lead was added to the fungicide, than in the other plats in the series. There were no russeted apples in the plats in this group.

COMPARATIVE EFFECTIVENESS OF SPRAYING ONCE BEFORE THE BLOOM AND SPRAYING ONCE AFTER THE BLOOM

The treatments used in Group 3, together with the fruit data recorded, are given in Table 25.

EFFECT ON FRUIT

Scab.—In 1909 the spray which followed the fall of the petals was more effective in controlling scab than the spray which preceded the bloom.

Codling Moth.—As was to be expected, the spray which followed the fall of the petals was more efficient in reducing codling-moth in-

jury than the spray which preceded bloom. The noteworthy point in regard to this treatment was the effectiveness of the one application, only 3 percent of the apples in Plat 21 (sprayed after the fall of the petals) being injured by codling moth, as compared with 17 percent on the check plat.

TABLE 25.—EFFECTS OF INDIVIDUAL APPLICATIONS BEFORE AND AFTER THE BLOOM, USING BORDEAUX IN COMBINATION WITH ARSENATE OF LEAD, IN THE EXPERIMENTS AT GRIGGSVILLE, 1909

Plat	Trees	Treatment	Percentage of picked apples affected by			
			Scab	Codling moth	Curculio	Russet
Check	41	No treatment	89	17	83	0
20	44-45	Sprayed before bloom	85	12	88	1
21	46-47	Sprayed just after fall of petals	49	3	87	23

Curculio.—Both applications were evidently too early to exercise any control over the curculio.

Russet.—Practically no russeting resulted from the application preceding the bloom. As a result of the application following the fall of the petals, 23 percent of the apples were more or less russeted.

EFFECT ON FOLIAGE

Cankerworms appeared in the orchard just as the leaf buds were expanding, but were completely checked by the application preceding the bloom.

COMPARATIVE EFFECTIVENESS OF BORDEAUX WITH AND WITHOUT ARSENICAL INSECTICIDES

The treatments used in Group 4, together with the fruit data recorded, are given in Table 26.

EFFECT ON FRUIT

Scab.—This disease was immensely reduced in all the sprayed plats, the average reduction of the infection amounting to 52 percent. Bordeaux alone appeared to exercise a better control of scab than the combined Bordeaux and arsenate of lead or the combined Bordeaux and Paris green, as may be seen by comparing Plat 25 with Plats 35, 36, and 37. This idiosyncracy, in the light of other results, must be attributed to seasonal conditions or experimental error.

Codling Moth.—The addition of poisons to the Bordeaux reduced the injury from codling moth to an average of 4 percent (Plats 35, 36, and 37), as compared with an injury of 20 percent on the check

TABLE 26.—EFFECT OF BORDEAUX WITH AND WITHOUT ARSENICAL INSECTICIDES, IN THE EXPERIMENTS AT GRIGGSVILLE, 1909

Plat	Trees	Treatment	Percentage picked apples affected by		
			Scab	Codling moth	Curculio
25	61-62	Bordeaux alone	7	15	77
35	83-84	Bordeaux with arsenate of lead, 6 lbs. to 100 gals.	16	1	63
36	85-86	Bordeaux with arsenate of lead, 4 lbs. to 100 gals.	13	3	68
37	87-88	Bordeaux with Paris green, ½ lb. to 100 gals.	11	8	82
Check	89	No treatment	63	20	93

trees and 15 percent on trees sprayed with Bordeaux alone. Arsenate of lead proved more effective than Paris green, reducing the injury to an average of 2 percent (Plats 35 and 36) as compared with 8 percent on the trees sprayed with Paris green (Plat 37).

Curculio.—As compared with the check, where the curculio infestation amounted to 93 percent, the injury in the plats where arsenate of lead was used was reduced to an average of 65 percent and in the plat where Paris green was used to 82 percent. There was less curculio damage even in the plat where Bordeaux was used alone than in the check plat.

EFFECT ON FOLIAGE

More foliage injury occurred in Plat 37, sprayed with Paris green, than in the plats sprayed with arsenate of lead.

COMPARISON OF MISCELLANEOUS SPRAYS

The treatments used in Group 5, together with the fruit data recorded, are given in Table 27.

EFFECT ON FRUIT

Scab.—Homemade Bordeaux and Target brand Bordeaux were equally efficient in controlling scab. Bordeaux made with carefully slaked lime showed no superiority over Bordeaux made with carelessly slaked lime in lessening injury from this disease. The addition of iron sulfate to Bordeaux, which was added only to improve the adhesive qualities of the spray, did not increase the fungicidal value of the mixture. All sprays exercised a large degree of control over scab.

Codling Moth.—Arsenate of lead, used thruout the group, reduced the amount of codling-moth injury satisfactorily except in Plat 42, where iron sulfate was added to the spray. Infection in this plat, how-

TABLE 27.—EFFECTS OF MISCELLANEOUS PREPARATIONS, IN THE EXPERIMENTS AT GRIGGSVILLE, 1909

Plat	Trees	Treatment	Percentage of picked apples affected by			
			Scab	Codling moth	Curculio	Russet
26	63-64	Homemade Bordeaux with arsenate of lead	10	2	57	52
27	65-66	Target brand quick Bordeaux with arsenate of lead	9	3	49	42
Check	67	No treatment	53	12	78	3
29	70-71	Bordeaux made with carefully slaked lime with arsenate of lead	11	3	72	59
30	72-73	Bordeaux made with carelessly slaked lime with arsenate of lead	8	1	64	44
40	94-95	Bordeaux with arsenate of lead	26	2	84	50
42	99-100	Bordeaux with iron sulfate with arsenate of lead	32	8	89	26
Check	98	No treatment	51	19	99	1

ever, as shown by the corresponding checks, was higher than in the other plats included in the group. It cannot be concluded, therefore, that iron sulfate lessened the efficiency of the arsenate of lead.

SPRAYING EXPERIMENTS IN 1910 AT CENTRALIA, MARION COUNTY

BY L. EARL FOGLESONG

OBJECTS

The objects of the experiments at Centralia in 1910 were to study: (1) the efficiency of Bordeaux and lime sulfur as fungicides; (2) the efficiency of homemade, commercial, and self-boiled lime sulfur for late spring and summer sprays; (3) the effects of adding lime-sulfur sludge to the clear solution; (4) the effects of using various proportions of lime and sulfur in making the self-boiled product; and (5) the relative values of acid, neutral, and mixed arsenates of lead.

LOCATION AND DESCRIPTION OF ORCHARD

It was planned to carry out experiments bearing on the above questions in several orchards—one each in Pike, Calhoun, Cumberland, Clay, and Marion counties. A very severe freeze, however, occurred April 23 and 24, which killed all the apples in all the orchards under consideration except the one located at Neoga, in Cumberland county. As a result the experimental work was abandoned for the season at all points except the orchard at Neoga, and one at Centralia in Marion county, which was maintained in order to study the effects of the various sprays on the foliage.

The experimental plats at Centralia were located in the orchard of G. H. Perrine and Sons. The trees used were of the Ben Davis variety, twenty-five years old.

TREATMENT

The trees were sprayed as follows:

Plat	Application	Date	Time	Treatment
1	1	March 31	Just before bloom	Commercial lime sulfur diluted 1 to 30 with arsenate of lead, 4–100
	2	April 11	Just after fall of petals	
	3	April 20		
	4	May 31		
2	1	March 31	Just before bloom	Bordeaux, 8–8–100, with arsenate of lead, 4–100, followed immediately with milk of lime, 8–100, this subsequent coat being maintained
	2	April 13	Just after fall of petals	
	3	April 20		
	4	April 25	A maintenance coat of milk of lime	
	5	May 16	A maintenance coat of milk of lime	
	6	May 31	Just before bloom	

Plat	Application	Date	Time	Treatment
3	1	March 31	Just before bloom	Bordeaux, 8–8–100, with arsenate of lead, 4–100
	2	April 13	Just after fall of petals	
	3	April 20		
	4	May 31		
4a	1	March 31	Just before bloom	Homemade lime sulfur,[1] without sludge, with arsenate of lead, 4–100
	2	April 12	Just after fall of petals	
	3	April 20		
	4	June 1		
4b	1	April 1	Just before bloom	Homemade lime sulfur,[1] with sludge added, with arsenate of lead, 4–100
	2	April 13	Just after fall of petals	
	3	April 20		
	4	June 1		
5	1	April 2	Just before bloom	Self-boiled lime sulfur, 32–32–200, with arsenate of lead, 4–100
	2	April 14	Just after fall of petals	
	3	April 22		
	4	May 30		
6	1	April 2	Just before bloom	Self-boiled lime sulfur, 16–16–100, with arsenate of lead, 4–100
	2	April 14	Just after fall of petals	
	3	April 22		
	4	May 30		
7	1	April 2	Just before bloom	Self-boiled lime sulfur, 10–10–50, with arsenate of lead, 4–100
	2	April 14	Just after fall of petals	
	3	April 27		
	4	May 30		
8	1	April 2	Just before bloom	Self-boiled lime sulfur, 8–8–50, with arsenate of lead, 4–100
	2	April 14	Just after fall of petals	
	3	April 27		
	4	May 30		
9	1	April 2	Just before bloom	Self-boiled lime sulfur, 6–6–100, with arsenate of lead, 4–50
	2	April 14	Just after fall of petals	
	3	April 27		
	4	May 30		
11	1	April 2	Just before bloom	Commercial lime sulfur diluted 1 to 30 with arsenate of lead (acid),[2] 4–100
	2	April 13	Just after fall of petals	
	3	April 28		
	4	June 1		
12	1	April 1	Just before bloom	Commercial lime sulfur diluted 1 to 30 with arsenate of lead (normal),[3] 4–100
	2	April 13	Just after fall of petals	
	3	April 28		
	4	June 1		
13	1	April 1	Just before bloom	Commercial lime sulfur diluted 1 to 30 without arsenate of lead
	2	April 13	Just after fall of petals	
	3	April 28		
	4	June 1		

[1]Prepared according to the formula recommended by J. P. Stewart, Penn. State Col. Agr. Exp. Sta. Bul. 92; 100 pounds sulfur, 50 pounds lime, 50 gallons water.

[2]Hemingway arsenate of lead.

[3]Sherwin-Williams arsenate of lead.

EFFECTS OF BORDEAUX AND LIME SULFUR

In Plat 1, commercial lime sulfur controlled apple scab well. No spray injury was observed until several weeks after the fourth application, when a very small amount became noticeable. The leaves on the trees in this plat were perceptibly smaller than those from trees treated with a spray containing a surplus quantity of lime, as were the leaves from trees sprayed with homemade lime sulfur (Plat 4), but they had excellent color, and the fruit buds formed during the season were very large and numerous.

Standard Bordeaux (8-8-100) applied to the trees in Plat 3 produced severe spray injury, but not until after the third application, when many leaves turned yellow and fell to the ground. The fruit buds on this plat were perceptibly smaller than those on Plats 1, 4, and 5, probably because of the severity of the injury to the foliage. Scab was controlled by the standard Bordeaux both in this plat and in Plat 2.

EFFECTS OF HOMEMADE, COMMERCIAL, AND SELF-BOILED LIME SULFUR

The homemade mixture of lime sulfur did not control the scab so well as the commercial, used on Plat 1. Altho the damage was small, homemade lime sulfur resulted in more foliage injury than commercial lime sulfur, and this injury came earlier in the season. The foliage, however, was very good, and the fruit buds were apparently as large and as numerous as in Plat 1.

Plat 5, where the trees were sprayed with self-boiled lime sulfur, showed very little benefit from the spray. Scab was present in almost as large quantities as on the untreated foliage of the check trees. The leaves on the trees sprayed with self-boiled lime sulfur appared to be larger than those on the other trees sprayed with lime sulfur. This spray made the tree and foliage very white, and the material stuck well. Its fungicidal value, however, proved small.

EFFECTS OF ADDING LIME-SULFUR SLUDGE TO A CLEAR SOLUTION OF LIME SULFUR

In Plat 4 one-half the trees were sprayed with homemade lime sulfur with the sludge included, and the other half without the sludge. The lime sulfur was made by G. H. Perrine and Sons at the beginning of the season and kept as a stock solution. The specific gravity of the material was determined by hydrometer test and the spray used at a dilution corresponding to the strength of the commercial material. The trees which were sprayed with the homemade mixture combined with the sludge, Plat 4b, were more plainly marked by the spray, but no difference in the vigor or color of the foliage could be detected,

either favorable or unfavorable, as a result of the presence of the sludge in the mixture.

EFFECTS OF SELF-BOILED LIME SULFUR MADE IN VARYING PROPORTIONS

All combinations gave very similar results as far as could be determined from the foliage. The amounts of scab and insect injury on the foliage in each of the plats were very similar, as were also the vigor and color of the leaves. Compared with untreated trees and with trees sprayed with Bordeaux and ordinary lime sulfur, these plats demonstrated the inefficiency of self-boiled lime sulfur as a fungicide for apple foliage.

EFFECTS OF ACID, NEUTRAL, AND MIXED ARSENATES OF LEAD

As the principal purpose of arsenate of lead is the control of insects affecting the fruit, the results of these tests in 1910 are of comparatively little value. All brands of arsenate of lead gave equally good control of insects affecting the foliage. Arsenate of lead combined with lime sulfur increased the fungicidal value of the mixture over lime sulfur alone, as indicated by the control of scab. Slight spray injury occurred in all the plats in this group but no differences in amounts or character could be observed.

SPRAYING EXPERIMENTS IN 1911 AT CENTRALIA, MARION COUNTY

BY L. EARL FOGLESONG

OBJECTS

The objects of the experiments at the Centralia orchard in 1911 were: (1) to test the efficiency of Bordeaux and lime sulfur as fungicides for the apple; (2) to determine whether or not applications of lime sulfur made while the trees are dormant have any value in controlling scab and other diseases during the succeeding growing season; (3) to compare the efficiency of light and heavy applications of Bordeaux and lime sulfur; (4) to learn the effects of adding copper sulfate to lime sulfur in order to increase the fungicidal value of the mixture; and (5) to determine the effects of maintaining a Bordeaux coating on the fruit and foliage by sealing it in with a second coating of Bordeaux or with a coating of milk of lime, the coating to be renewed with sufficient frequency during the season to protect the first application from the action of rain and air.

LOCATION AND DESCRIPTION OF ORCHARD

The plats under treatment were located in the same orchard and in the same block of trees as those of the experiments in 1910.

OUTLINE OF TREATMENTS

Sixteen plats arranged as shown in Chart 7 were sprayed as follows:

Plat	Application	Date	Time	Treatment
A	1	April 15	Just before bloom	Bordeaux arsenate of lead
	2	May 2	Just after fall of petals	Lime sulfur arsenate of lead
	3	May 16		Lime sulfur arsenate of lead
	4	June 26		Lime sulfur arsenate of lead
B	1	April 15	Just before bloom	Bordeaux arsenate of lead
	2	May 4	Just after fall of petals	Bordeaux arsenate of lead
	3	May 16		Lime sulfur arsenate of lead
	4	June 29		Lime sulfur arsenate of lead
C	1	April 15	Just before bloom	Lime sulfur arsenate of lead
	2	May 4	Just after fall of petals	Bordeaux arsenate of lead
	3	May 15		Bordeaux arsenate of lead
	4	June 27		Bordeaux arsenate of lead
D	1	April 15	Just before bloom	Lime sulfur arsenate of lead
	2	May 2	Just after fall of petals	Lime sulfur arsenate of lead
	3	May 15		Bordeaux arsenate of lead
	4	June 27		Bordeaux arsenate of lead

Plat	Application	Date	Time	Treatment
E	1	April 15	Just before bloom	Lime sulfur arsenate of lead
	2	May 2	Just after fall of petals	Lime sulfur arsenate of lead
	3	May 16		Lime sulfur arsenate of lead
	4	June 29		Lime sulfur arsenate of lead
F	1	April 15	Just before bloom	Lime sulfur arsenate of lead,
	2	May 3	Just after fall of petals	4 applications. This plat re-
	3	May 16		ceived no winter applica-
	4	June 29		tion of lime sulfur
G	1	April 15	Just before bloom	Bordeaux arsenate of lead, 4
	2	May 4	Just after fall of petals	applications. This plat had
	3	May 15		received no winter applica-
	4	June 26		tion of lime sulfur
H	1	April 15	Just before bloom	Bordeaux arsenate of lead, 4
	2	May 4	Just after fall of petals	applications. This material
	3	May 15		was applied in large quan-
	4	June 27		tities
I	1	April 15	Just before bloom	Bordeaux arsenate of lead, 4
	2	May 4	Just after fall of petals	applications. This material
	3	May 15		was applied in quantities
	4	June 29		even less than for the ordi-
				nary spraying
J	1	April 15	Just before bloom	Bordeaux arsenate of lead, 4
	2	May 4	Just after fall of petals	regular applications. Extra
	3	May 15		applications were for main-
	4	June 6	An extra application	taining the coating of Bor-
	5	June 28		deaux and were made of the
	6	July 21	An extra application	same material
	7	Aug. 12	An extra application	
K	1	April 15	Just before bloom	Bordeaux arsenate of lead, 4
	2	May 4	Just after fall of petals	regular applications. Extra
	3	May 15		applications were for main-
	4	June 6	An extra application	taining the coating of Bor-
	5	June 29		deaux and were made with
	6	July 21	An extra application	milk of lime, 8–100
	7	Aug. 12	An extra application	
L	1	April 15	Just before bloom	Bordeaux alone, 8–8–100
	2	May 2	Just after fall of petals	Arsenate of lead, 4–100
	3	May 16		Arsenate of lead, 4–100
	4	June 28		Arsenate of lead, 4–100
M	1	April 15	Just before bloom	Lime sulfur alone, 1–17
	2	May 2	Just after fall of petals	Arsenate of lead, 4–100
	3	May 16		Arsenate of lead, 4–100
	4	June 28		Arsenate of lead, 4–100
N	1	April 15	Just before bloom	Lime sulfur, 1–17, with cop
	2	May 2	Just after fall of petals	per sulfate, 4–100
	3	May 16		
	4	June 29		

Plat	Application	Date	Time	Treatment
O	1	April 15	Just before bloom	Lime sulfur, 1–17, with copper sulfate, 8–100
	2	May 2	Just after fall of petals	
	3	May 16		
	4	June 29		
P	1	April 15	Just before bloom	Lime sulfur, 1–17, with copper sulfate, 12–100
	2	May 2	Just after fall of petals	
	3	May 16		
	4	June 29		

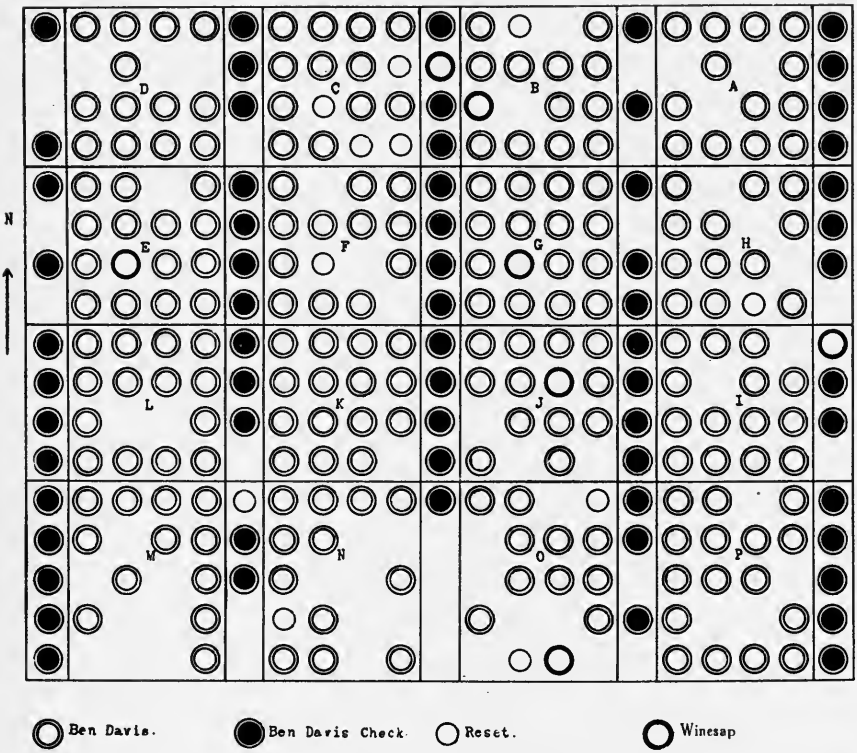

CHART 7.—PLAN OF PLATS IN ORCHARD OF G. H. PERRINE AND SONS, CENTRALIA, 1911

APPARATUS AND PREPARATION OF MATERIALS

A gasoline power spray outfit equipped with spray tower belonging to G. H. Perrine and Sons was used to make all the applications. The spray was applied at a pressure of approximately 150 pounds to the square inch. The lime sulfur used thruout these experiments was made by G. H. Perrine and Sons in a newly installed steam cooker.

It was made according to the Illinois formula: 50 pounds lime, 100 pounds sulfur, and 66 gallons water. While the trees were dormant, the spray was applied at a dilution of 1 gallon of lime sulfur to 7 gallons of water. During the summer it was applied at a dilution of 1 gallon to 17 of water. Bordeaux was made on the standard formula: 8 pounds lime, 8 pounds copper sulfate, and 100 gallons water. Arsenate of lead at the rate of 4 pounds to each 100 gallons of spray mixture was used at all applications unless otherwise noted.

CHARACTER OF RECORDS AND METHOD OF MAKING

A record of daily temperatures, rainfall, cloudiness, and wind was made. Notes were taken from time to time on the amount, vigor, and color of the foliage. All dropped apples were examined to determine the effects of the sprays in preventing injury from insects and fungi. At the close of the season the apples were picked, and four representative trees were selected from each plat and from each check row for record making. Fifty apples chosen at random from the crop of each tree were taken from the sorting table and examined for evidences of scab, sooty blotch, flyspeck, bitter rot, blotch, and other fungous diseases, and for injuries from codling moth, curculio, and other insects. The data obtained thruout the season were later tabulated for detailed study.

WEATHER CONDITIONS

The weather, tho significant in this year's data, did not cause much trouble at or during the spraying periods. The times of spraying Plats J and K were dependent on the occurrence of rains.

A cold rain which continued from April 27 to April 29 fell during the blossoming period and prevented the pollination of the large set of blossoms. The crop was, therefore, light, and because of this fact the records obtained from the fruit were less conclusive than was desired.

EFFECT ON FOLIAGE

In the general study of the foliage, spray injury was particularly noted. More or less injury was caused by all the sprays, altho the time of application was an important factor in this connection.

The lime sulfur used at the third application was unusually harmful this year,—more so than in any year since the writer has closely observed its action. Oversprayed branches were the most severely burned. The injury to the foliage, however, was soon effaced as far as the eye could discern. Badly burned leaves fell and the remaining leaves were rich in color and apparent vigor.

Bordeaux injured the foliage and russeted the fruit. The apples russeted by the lime-sulfur spray looked, and really were much less injured in the fall than in midsummer, the injury thinning out and becoming inconspicuous; but the Bordeaux-sprayed apples were in many

instances so severely injured as to be unmarketable. More foliage was lost from the Bordeaux-sprayed trees than from those sprayed with lime sulfur, and the general appearance thruout the summer was poorer.

The foliage of Plats J and K (sprayed with Bordeaux) was much poorer than that of the plats sprayed a fewer number of times with the same mixture. The repetition of the spray was detrimental under the conditions of this year. In percentage of injury and general appearance, these two plats varied but little.

The foliage on Plats L and M (sprayed with Bordeaux arsenate of lead, and lime sulfur arsenate of lead, respectively) was good average foliage at the close of the season. The amount of injury present was much less than that produced by Bordeaux alone, and slightly less than that produced by lime sulfur alone. There were several severe attacks of yellow-leaf on these plats when no other plat was so infested.

The appearance of the foliage in Plats N, O, and P was generally below the average of the other plats. The sprays resulted in considerable foliage and fruit injury and there was a dark discoloration on the bark, foliage, and fruit, due to the copper and sulfur compound, that was unsightly to one accustomed to the light appearance caused by other sprays.

A good deal of injury was caused this year by all sprays, which in order of severity ranked as follows: Bordeaux, copper sulfate and lime sulfur, lime sulfur, and arsenate of lead.

EFFECT ON FRUIT

The fruit from these plats was picked and examined in October, with the results presented in Tables 28 and 29.

Scab.—Bordeaux, lime sulfur, and the combination of lime sulfur and copper sulfate all reduced the amount of scab to a very marked degree as compared with the check plats. Even Plat M, which showed the poorest control of any sprayed plat, gave only 12 percent of scabby apples, as compared with 44 percent for the unsprayed trees. Plats A, B, G, H, J, K, and L, all of which received Bordeaux for the first application, showed an average of only 3 percent of scabby apples, whereas those plats receiving lime sulfur at the first application averaged 5.5 percent. The difference, tho small, rather consistently favored Bordeaux for the first spray. In the present season, the spray applied before the blossoms opened was clearly the important one in the control of scab. Where no fungicide was used after the blossoms fell, as in Plats L and M, the control of this disease was good. The results for these two plats favored Bordeaux as a first application more strongly than the general results for the whole series of treatments; Plat L, which received Bordeaux, showed only 7 percent of scab, as

TABLE 28.—EFFECT OF ALL THE SPRAYS ON THE PICKED APPLES, IN THE EXPERIMENTS AT CENTRALIA, 1911

Plat	Treatment	Applications	Percentage of picked apples affected by								
			Scab	Blotch	Sooty blotch	Codling moth	Curculio	Russet			Burn
								Serious	Slight	Total	
A	Bordeaux arsenate of lead	1									
	Lime sulfur arsenate of lead	2, 3, 4	1	29	8	8	7	2	78	80	1
B	Bordeaux arsenate of lead	1, 2									
	Lime sulfur arsenate of lead	3, 4	2	12	15	20	16	3	76	79	2
C	Lime sulfur arsenate of lead	1									
	Bordeaux arsenate of lead	2, 3, 4	9	11	3	10	8	4	70	74	0
D	Lime sulfur arsenate of lead	1, 2									
	Bordeaux arsenate of lead	3, 4	5	9	3	17	14	2	60	62	0
E	Lime sulfur arsenate of lead	1, 2, 3, 4	5	6	6	3	13	1	57	58	7
F	Lime sulfur arsenate of lead (no dormant spray)	1, 2, 3, 4	4	15	12	1	12	2	73	75	13
G	Bordeaux arsenate of lead (no dormant spray)	1, 2, 3, 4	4	2	5	2	11	14	82	96	0
H	Bordeaux arsenate of lead	1, 2, 3, 4	1	3	9	1	10	3	86	89	0
J	Bordeaux arsenate of lead followed by applications of Bordeaux	1, 2, 3, 4 5, 6, 7	1	1	3	2	4	9	86	95	0
K	Bordeaux arsenate of lead followed by applications of milk of lime	1, 2, 3, 4 5, 6, 7	4	3	3	6	4	8	82	90	0
L	Bordeaux alone	1									
	Arsenate of lead alone	2, 3, 4	7	32	16	5	13	3	78	81	0
M	Lime sulfur alone	1									
	Arsenate of lead alone	2, 3, 4	12	35	27	7	14	0	80	80	0
N	Lime sulfur with 4–100 copper sulfate	1, 2, 3, 4	4	15	44	6	18	3	94	97	7
O	Lime sulfur with 8–100 copper sulfate	1, 2, 3, 4	3	6	3	3	15	3	96	99	27
P	Lime sulfur with 12–100 copper sulfate	1, 2, 3, 4	2	9	2	1	2	0	86	86	16
Check	Composite check, no treatment	none	44	27	49	12	16	0	7	7	0

NOTE.—Plat I is omitted from the records owing to an error in the quantity of spray material applied.

TABLE 29.— EFFECT OF ALL THE SPRAYS ON THE DROPPED APPLES, IN THE EXPERIMENTS AT CENTRALIA, 1911

Plat	Treatment	Applications	Percentage of dropped apples affected by								
			Scab	Blotch	Sooty blotch	Codling moth	Curculio	Russet			Burn
								Serious	Slight	Total	
A	Bordeaux arsenate of lead.....	1									
	Lime sulfur arsenate of lead.....	2, 3, 4	17	1	0	0	9	10	35	45	0
B	Bordeaux arsenate of lead.....	1, 2									
	Lime sulfur arsenate of lead.....	3, 4	17	1	0	0	12	13	43	56	0
C	Lime sulfur arsenate of lead.....	1									
	Bordeaux arsenate of lead.....	2, 3, 4	26	4	0	3	11	9	48	57	0
D	Lime sulfur arsenate of lead.....	1, 2									
	Bordeaux arsenate of lead	3, 4	18	5	1	4	18	6	37	43	0
E	Lime sulfur arsenate of lead.....	1, 2, 3, 4	13	1	1	2	12	8	34	42	1
F	Lime sulfur arsenate of lead (no dormant spray)	1, 2, 3, 4	15	3	1	4	8	17	42	59	10
G	Bordeaux arsenate of lead (no dormant spray)	1, 2, 3, 4	28	3	3	4	5	30	43	73	0
H	Bordeaux arsenate of lead.....	1, 2, 3, 4	15	1	1	1	4	30	48	78	0
J	Bordeaux arsenate of lead followed by applications of Bordeaux	1, 2, 3, 4 5, 6, 7	18	0	1	2	3	30	50	80	0
K	Bordeaux arsenate of lead followed by applications of milk of lime.....	1, 2, 3, 4 5, 6, 7	21	0	1	6	6	19	59	78	0
L	Bordeaux alone	1									
	Arsenate of lead alone	2, 3, 4	22	4	3	4	14	6	43	49	0
M	Lime sulfur alone	1									
	Arsenate of lead alone	2, 3, 4	29	9	4	4	10	12	44	56	0
N	Lime sulfur with 4–100 copper sulfate..	1, 2, 3, 4	14	3	8	6	11	38	46	84	7
O	Lime sulfur with 8–100 copper sulfate..	1, 2, 3, 4	20	1	0	3	7	26	53	79	14
P	Lime sulfur with 12–100 copper sulfate..	1, 2, 3, 4	12	1	1	0	5	10	43	53	8
Check	Composite check, no treatment.....	none	41	14	8	4	15	0	5	5	0

NOTE.—Plat I is omitted from the records owing to an error in the quantity of spray material applied.

contrasted with Plat M, which received lime sulfur and showed 12 percent of scab. It will be observed that the treatment in both plats left sufficient infection to cause serious damage in a season favorable for the development of scab. There is no evidence to show that the dormant-tree application exerted any influence in checking it.

Blotch.—Bordeaux, when used for the second and third sprayings, gave better results in the control of blotch than lime sulfur, as may be seen by comparing Plats C, G, H, J, and K, all of which received Bordeaux for the second and third applications, with Plats A and F, which received lime sulfur for the same two applications. Plat E, sprayed with lime sulfur thruout the season, showed only 6 percent of blotch, a control almost as good as the average plat where Bordeaux was used in one or more of the final sprayings, but not so good as where Bordeaux was used exclusively, as in Plats H, J, and L. Arsenate of lead alone was quite ineffective as a fungicide for blotch, Plats L and M, which received only arsenate of lead at the two final sprayings, showing more blotch than even the untreated plats. Lime sulfur with copper sulfate reduced blotch noticeably, but was no more effective than lime sulfur alone, and was considerably less effective than Bordeaux.

Sooty Blotch.—Sooty blotch was better controlled by Bordeaux, when used for the third or fourth application, than by lime sulfur. The addition of the larger quantities of copper sulfate to lime also resulted in a marked reduction in the amount of sooty blotch. Arsenate of lead, however, proved ineffective as a fungicide for this disease.

Decay.—Black rot was common on all the check plats. Except in the plats sprayed with arsenate of lead at the second and third applications, and in Plat N, where two pounds of copper sulfate were added to the regular dilution of lime sulfur, there was a lessening of the disease as a result of all the sprays. In this respect Bordeaux and lime sulfur proved about equally effective.

Codling Moth.—The infestation of codling moth in the various plats could hardly have been uniform, since Plats B and D, which were properly sprayed with arsenate of lead in combination with Bordeaux or lime sulfur, showed considerably more infection than the composite check plat, while Plats A and C, which were similarly sprayed, showed nearly as much. The infestation in the several check plats was also very uneven. Comparing treated plats with their adjoining checks, a fair degree of control is found. Comparing the average injury from codling moth on all sprayed plats, except B and D, with the composite check, it is found that the sprayed plats showed an average percentage of 4.2 injured apples and the check plats an average percentage of 12.

Curculio.—The results indicated a somewhat uneven distribution of infestation by the curculio. On the average, the sprayed plats showed less injury than the checks, and Plats A, C, J, K, and P showed

decidedly fewer injured apples than the unsprayed plats. On the other hand the other sprayed plats showed so little difference from the checks that definite conclusions cannot be based on the results.

Russet.—Bordeaux and the combination of lime sulfur and copper sulfate were responsible for more russeting of the fruit than lime sulfur or arsenate of lead. Where Bordeaux or the combination of lime sulfur and copper sulfate were used for all applications (Plats G, H, J, K, N, O, and P), more than 85 percent of all the apples were more or less russeted. Plats E and F, sprayed thruout the season with lime sulfur, showed only 66 percent of russeted apples, and the russet on this fruit was trivial in character compared with that on the apples of the other plats, only 1½ percent being severely russeted.

Burn.—This is an arbitrary term which was immediately and suggestively applied to an injury found on the trees sprayed with lime sulfur this summer. It was found most often on the south and west sides of the trees, and might have been called a sun scald but for the fact that it was found only on lime-sulfur sprayed trees. The burn followed both the third and fourth applications.

SUMMARY OF RESULTS AT CENTRALIA, 1911

1. The season's work confirms the already well-established effectiveness of Bordeaux as a fungicide for the control of scab, blotch, sooty blotch, and black rot. It indicates also that lime sulfur possesses only slightly less efficient fungicidal properties, at least in a dry season, than Bordeaux. Both fungicides caused some injury to the fruit, Bordeaux in the form of russet and lime sulfur in the form of burn. Bordeaux was more injurious to the foliage, causing some yellow-leaf and much spotting. On the whole, honors for the two sprays were even.

2. Applications of lime sulfur made while the trees were dormant failed to exercise any controlling effect over apple scab or blotch during the ensuing season.

3. No results were obtained bearing on the comparative effects of heavy and light applications of Bordeaux and lime sulfur.

4. The addition of copper sulfate to lime sulfur proved unnecessary and inadvisable, owing to the severe injury which it caused to foliage and fruit.

5. Double applications of Bordeaux and coatings of milk of lime were not more satisfactory than single applications of Bordeaux in the control of scab. Double applications of Bordeaux were more injurious to the foliage and caused more russeting of the fruit than single applications.

6. Arsenate of lead alone showed no noticeable fungicidal properties.

SPRAYING EXPERIMENTS IN 1912 AT ANNA, UNION COUNTY

BY L. EARL FOGLESONG

OBJECTS

In formulating this year's spray schedule the following questions were considered and groups of treatments were arranged with a view toward their solution: (1) the relative efficiency of Bordeaux and lime sulfur; (2) the relative efficiencies of various dilutions of lime sulfur; (3)the relative efficiencies of moderate and heavy applications of Bordeaux; (4) the relative efficiencies of various classes of arsenate of lead; (5) the fungicidal value of various arsenates of lead when added to lime sulfur; (6) the possibility of interchanging lime sulfur for Bordeaux, or vice versa; (7) the best time and number of times for spray applications; and (8) the value of copper ferrocyanide, both as a fungicide and as an insecticide.

LOCATION AND DESCRIPTION OF ORCHARD

The orchard used for these experiments is located in Union county, three miles southwest of Anna, in the unglaciated portion of southern Illinois. This orchard, which is owned by Mr. F. P. Anderson, of Anna, has been well sprayed, pruned, and cultivated. There are a large number of varieties of apples on the farm, but the experiments were made only on Jonathan and Winesap. With but few exceptions the treatment was the same for each variety.

TREATMENT

The experimental areas were divided into plats, each of which was treated in the manner described in the various tables which are presented in connection with the results which were obtained. The arrangement of these plats is shown in Charts 8 and 9.

APPARATUS AND PREPARATION OF MATERIALS

Unless otherwise stated, the Bordeaux used in these treatments was made on the formula, 8 pounds copper sulfate, 8 pounds lime, and 100 gallons water. The lime sulfur was a commercial brand testing between 32.5° and 33° Baume, or 1.2889 and 1.2946 specific gravity, and was used at the rate of 3 gallons in 100 gallons of the diluted mixture (approximately 8 pounds sulfur in 100 gallons); arsenate of lead in the paste form was added to the diluted spray mixture at the rate of 4 pounds per 100 gallons. The copper ferrocyanide

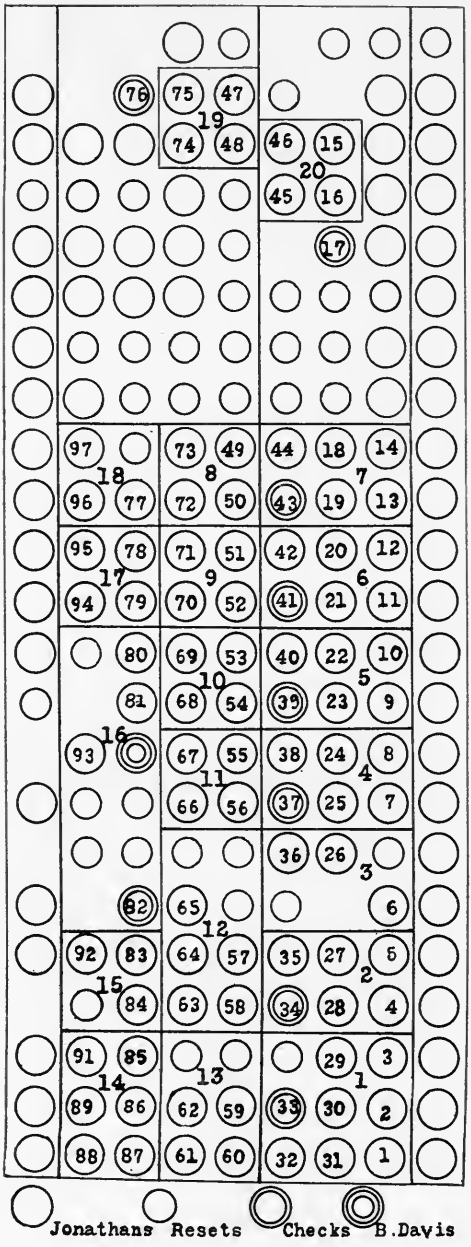

CHART 8.—PLAN OF PLATS IN JONATHAN BLOCK IN ORCHARD OF MR. F. P. ANDERSON, ANNA, 1912

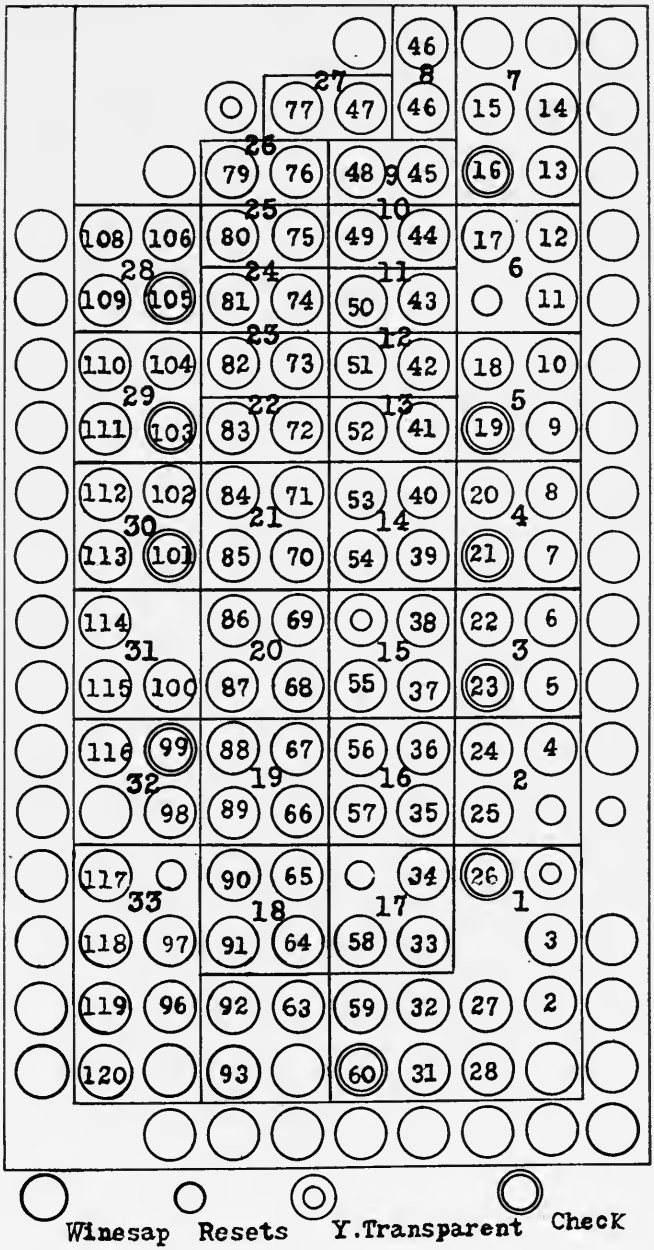

CHART 9.—PLAN OF PLATS IN WINESAP BLOCK IN ORCHARD OF MR. F. P. ANDERSON, ANNA, 1912

was made on the formula, 2 pounds potassium ferrocyanide, 2 pounds copper sulfate, and 100 gallons water. The two substances were mixed at equal and full dilutions. Each plat was sprayed three times after the dormant-tree spray; Application 1 was made when the blossoms were in the cluster-bud stage; Application 2 was made immediately after the fall of the petals; and Application 3 was made about 10 days after Application 2. The Jonathan block was sprayed with winter-strength lime sulfur (1 to 10) April 6; the Winesap block received a similar spraying, April 10, at a strength of 1 to 12, the weaker dilution being used because the buds were farther advanced at that time. Two additional summer applications were made to certain plats in the Winesap block. All applications were made with a gasoline power outfit equipped with a tower, to permit spraying the entire tree. The spray was applied at a pressure of 200 pounds per square inch, using Vermorel nozzles for the first application, Bordeaux nozzles for the second application, and Friend nozzles for all succeeding applications.

CHARACTER OF RECORDS AND METHOD OF MAKING

Foliage.—Notes were made during the early part of the season at weekly intervals, and during the latter part of the season at bi-weekly intervals, on the vigor, color, and amount of foliage. Comparisons were thus obtained of the effectiveness of the various spray mixtures used in controlling the insect pests and fungous diseases which attack the foliage of the apple. Direct effects of the spray mixtures themselves upon the foliage were also observed. They were in the form of injuries to the leaves, and included a brown spotting and the yellowing of part of the foliage as a result of certain applications. Altho these effects alone were not sufficient to base conclusions upon, they were, nevertheless, important in the compilation and study of results from the spraying treatments.

Fruit.—Two hundred of the dropped apples from each tree were examined to secure records of their injuries. Where the number of "dropped apples" was less than 200, all the fallen fruit was examined. The records on the picked fruit were made in the following manner: The apples from all of the trees except those discarded because of deviation from the standard type within the block, diseased and undersized trees, trees which failed to bloom, trees of odd varieties, or trees which for other reasons were not typical of those within the plat, were counted, graded, and weighed. The samples examined, which included 200 apples each, were collected at random from the whole crop produced by each tree, in the same manner and under the direction of the same man, in an attempt to secure a uniform comparison thruout the plats. A workman chosen for his reliability and good sense picked from each tree the required number of apples. His

ladder was placed at least four times for each tree, once in each quarter of the tree. The apples were picked without regard to size, blemishes, or other quality, in order to secure samples that fairly represented the crop.

WEATHER CONDITIONS

The weather at the time of the dormant spraying was cloudy, and a very light rain followed the application made to the Jonathan block. At the time of the first summer spraying (the cluster-bud spraying) the weather was windy and cloudy with more or less rain. Plats 1 and 2 had to be resprayed, as it was believed that more or less spray material was washed off by rains which occurred soon after its application. At the time of the second application the weather was again cloudy, but no rainfall occurred to prevent the completion of the regularly scheduled work. Ideal weather prevailed at the time of the third application; there was a bright sun, very little wind, and no rainfall. Rain interfered with both the later summer applications; it was necessary, however, to make them as nearly at the correct time as could be done under the circumstances, respraying the plats where the spray appeared to be washed off by rains which followed the operation. The latter part of the summer was dry.

EFFECT ON FOLIAGE FOR ALL TREATMENTS

The observations on the effects of the different sprays on the foliage are summarized as follows: Where lime sulfur alone, lime sulfur arsenate of lead, copper ferrocyanide alone, and copper ferrocyanide arsenate of lead were used for the first application, no spray injury resulted. Bordeaux arsenate of lead, at the time of the first application, appeared to cause a small amount of burning of the foliage, the injury being confined to the tips of the expanding leaves. In the case of the second application, some injury to the foliage resulted from the application of lime sulfur alone, and also from lime sulfur arsenate of lead. None appeared to follow the application of Bordeaux arsenate of lead or copper ferrocyanide after the second application.

The spray was applied without any immediate injury to the foliage from any of the spraying materials used. Two weeks, however, after the third application, the trees sprayed with Bordeaux began to show noticeable foliage injury, particularly in the Jonathan block. Two severe epidemics of yellow-leaf occurred on the trees where Bordeaux was used. Each outbreak followed a period of rainy or cloudy weather in the Jonathan. It is estimated that 25 percent of all the Bordeaux-sprayed foliage in the Jonathan block turned yellow and fell to the ground in the course of these two epidemics. The attacks of yellow-leaf, were, however, much more severe in the Jonathan block than in the Winesap block. Injury began to appear on the leaves of the trees

TABLE 30.—EFFECTS OF BORDEAUX AND LIME SULFUR IN COMBINATION WITH ARSENATE OF LEAD IN THE JONATHAN BLOCK, IN THE EXPERIMENTS AT ANNA, 1912

Plat	Treatment	Dates of applications			Percentage of dropped apples affected by			Percentage of picked apples affected by						
										Codling moth				
		1st spray	2d spray	3d spray	Scab	Codling moth	Curculio	Scab	Sooty blotch	Calyx	Side	Total	Curculio	Severe russet
2	Bordeaux arsenate of lead.....	1/15	5/8	5/20	6	42	20	3	1	18	27	45	24	61
3	Lime sulfur arsenate of lead	1/15	5/8	5/18	6	38	23	3	7	5	24	29	18	0
Check	No treatment				30	47	30	37	37	24	23	47	37	0
5	Bordeaux arsenate of lead.....	1/15	5/8	5/20	4	30	19	4	1	13	25	38	25	51
6	Lime sulfur arsenate of lead.....	1/15	5/8	5/18	8	45	22	9	2	9	37	46	25	0

sprayed with copper ferrocyanide alone, and also on those sprayed with copper ferrocyanide arsenate of lead, at the same time that the Bordeaux injury began to show after the third application, that is, about two weeks after the time of spraying.

EFFECTS OF BORDEAUX AND LIME SULFUR

Table 30 presents the data recorded on the Jonathan plats sprayed with corresponding applications of Bordeaux and lime sulfur. The effects of these treatments were as follows:

Scab.—The variety Jonathan is not very subject to scab; consequently, it does not furnish as good comparative spray data as may be secured, for example, from Winesap, Ben Davis, or Mammoth Black Twig. From the data in Table 30, we may conclude that the two sprays in question are of practically equal fungicidal value. The results slightly favor Bordeaux, tho the difference is easily within the range of experimental error.

Sooty Blotch.—Bordeaux controlled this disease more effectively than lime sulfur, possibly on account of its superior adhesiveness.

Codling Moth.—Lime sulfur arsenate of lead gave results slightly superior to Bordeaux arsenate of lead in the control of the first brood of codling moth, as indicated by the relative numbers of picked apples which had been entered by the insects. Taking the dropped apples into account, however, the differences are scarcely consistent.

Curculio.—Very little difference in the comparative control of curculio was shown by the two sprays. Both reduced the injury from this insect on picked apples by amounts varying from 12 to 19 percent.

Russet.—Lime sulfur caused very little russet, whereas Bordeaux caused a large amount, some of which was very serious in character.

Table 31 presents the data derived from the comparative tests of Bordeaux and lime sulfur on the Winesap plats. It also shows the effects of the various applications applied singly and in all combinations. The effects of the treatments were as follows:

Color.—The color of the lime-sulfur sprayed apples was brighter and clearer than that of the Bordeaux-sprayed apples.

Scab.—The Winesap is very susceptible to this fungus. The data for the unsprayed trees show that the percentage of injury due to this disease was very high, a total of 83 percent of the picked apples being more or less seriously affected. Both fungicides varied somewhat in their efficiency in combating scab, but, in general, as may be gathered by a study of Table 31, Bordeaux exercised a somewhat superior control.

Sooty Blotch.—This disease was more effectively controlled by Bordeaux, partially, perhaps, because of its superior adhesiveness.

Codling Moth.—As in the Jonathan block, lime sulfur arsenate of lead was apparently more efficient in controlling the first brood of codling moth than Bordeaux arsenate of lead.

TABLE 31.—EFFECTS OF BORDEAUX AND LIME SULFUR IN COMBINATION WITH ARSENATE OF LEAD IN THE WINESAP BLOCK, IN THE EXPERIMENTS AT ANNA, 1912

Plat	Treatment	Dates of Applications					Percentage of dropped apples affected by			Percentage of picked apples affected by						
		1st spray	2d spray	3d spray	4th spray	5th spray	Scab	Codling moth	Curculio	Scab	Sooty blotch	Codling moth			Curculio	Severe russet
												Calyx	Side	Total		
8	Lime sulfur arsenate of lead	1/20					41	55	30	63	64	11	7	18	36	0
27	Bordeaux arsenate of lead	1/18					45	42	31	69	62	19	5	24	46	0
9	Lime sulfur arsenate of lead		5/7				80	38	34	87	54	7	4	11	36	0
26	Bordeaux arsenate of lead		5/8				53	39	35	63	24	13	4	17	47	0
10	Lime sulfur arsenate of lead			5/20			81	40	21	90	32	9	5	14	35	0
25	Bordeaux arsenate of lead			5/23			88	41	32	93	19	16	3	19	43	0
11	Lime sulfur arsenate of lead	1/20	5/7				59	36	22	67	52	6	4	10	32	0
24	Bordeaux arsenate of lead	1/18	5/8				26	40	22	21	10	11	3	14	30	1
12	Lime sulfur arsenate of lead	1/20		5/20			52	33	29	55	26	6	3	9	32	0
23	Bordeaux arsenate of lead	1/18		5/23			17	35	20	25	5	8	2	10	23	0
13	Lime sulfur arsenate of lead		5/7	5/20			58	26	24	61	23	4	2	6	34	0
22	Bordeaux arsenate of lead		5/8	5/23			58	31	25	63	2	7	2	9	28	2
14	Lime sulfur arsenate of lead	1/20	5/7	5/20			24	24	31	17	29	2	1	3	32	0
21	Bordeaux arsenate of lead	1/18	5/8	5/23			15	26	20	11	1	5	1	6	29	3
15	Lime sulfur arsenate of lead	1/20	5/7	5/20	6/29		27	21	26	21	13	1	1	2	33	0
20	Bordeaux arsenate of lead	1/18	5/8	5/23	6/29		20	20	18	12	0	2	0	2	20	2
16	Lime sulfur arsenate of lead	1/20	5/7	5/20	6/29	7/19	45	20	24	31	8	1	3	4	27	0
19	Bordeaux arsenate of lead	1/20	5/7	5/20	6/29	7/20	36	15	19	25	0	1	1	2	18	1
Check	No treatment						73	42	34	83	60	19	11	30	37	0

TABLE 32.—EFFECTS OF USING LIME SULFUR FOR SOME APPLICATIONS AND BORDEAUX FOR OTHER APPLICATIONS IN THE SAME SEASON'S OPERATIONS IN THE JONATHAN BLOCK, IN THE EXPERIMENTS AT ANNA, 1912

Plat	Treatment	Dates of applications			Percentage of dropped apples affected by			Percentage of picked apples affected by						
										Codling moth				
		1st spray	2d spray	3d spray	Scab	Codling moth	Curculio	Scab	Sooty blotch	Calyx	Side	Total	Curculio	Severe russet
2	Bordeaux arsenate of lead	4/15	5/5	5/20	6	42	20	3	1	18	27	45	24	61
4	Bordeaux arsenate of lead	4/16	5/5											
	Lime sulfur arsenate of lead			5/18	4	21	20	4	2	9	19	28	18	35
7	Lime sulfur arsenate of lead	4/15	5/6											
	Bordeaux arsenate of lead			5/20	3	23	14	3	0	5	19	24	19	5
8	Lime sulfur arsenate of lead	4/15												
	Bordeaux arsenate of lead		5/5	5/18	2	35	16	2	0	14	25	39	23	60
9	Lime sulfur arsenate of lead	4/15		5/18										
	Bordeaux arsenate of lead		5/5		3	37	16	3	2	12	26	38	22	46
10	Bordeaux arsenate of lead	4/16		5/20										
	Lime sulfur arsenate of lead		5/6		3	25	20	2	1	7	24	31	24	5
11	Bordeaux arsenate of lead	4/16												
	Lime sulfur arsenate of lead		5/6	5/18	2	36	20	1	3	5	18	23	15	1
3	Lime sulfur arsenate of lead	4/15	5/6	5/18	6	38	23	3	7	5	24	29	18	0
Check	No treatment				30	47	30	37	37	24	23	47	37	0

Russet.—Bordeaux caused much more russeting of the fruit than lime sulfur. Russeting tends to retard the growth of the apple and in some cases renders it unsalable, but, in the case of the Winesap variety, there is a tendency, as the apple grows, for this injury to be outgrown. The second application, which is the one immediately following the fall of the petals, caused the bulk of this injury, tho some additional russeting followed the third application.

EFFECTS OF USING LIME SULFUR FOR SOME APPLICATIONS AND BORDEAUX FOR OTHER APPLICATIONS IN THE SAME SEASON'S OPERATIONS

Table 32 presents the data recorded on the Jonathan plats where lime sulfur was used for some applications and Bordeaux for other applications in the same season's operations. No corresponding experiments were made on Winesap trees. The results were as follows:

Scab.—The two fungicides were about equally efficient in the control of scab.

Sooty Blotch.—On the plats where Bordeaux was used for the third application there was less sooty blotch than where lime sulfur was used.

Codling Moth.—Lime sulfur arsenate of lead was slightly superior to Bordeaux arsenate of lead in the control of the first brood of codling moth.

Curculio.—The data show no marked differences in the control of curculio by the standard sprays.

Russeting and Foliage Injury.—Lime sulfur caused much less russeting as well as much less foliage injury. The second application appeared to cause most of the russeting of the fruit; but foliage injury seemed to have been produced in about equal amounts by both the second and third applications. In combination sprays, where the second application was lime sulfur and the third Bordeaux, or vice versa, there was a characteristic russeting comparable with that which appeared where copper-sulfate solution was mixed with lime sulfur. This russeting appeared in the form of a black speckling or dotting.

EFFECTS OF DIFFERENT DILUTIONS OF LIME SULFUR

Table 33 presents the data recorded on the Winesap plats where different dilutions of lime sulfur were used. No corresponding experiments were conducted in the Jonathan block.

Owing to the small variations between the different plats, the effects are not described under separate headings. The following facts are, however, brought out by a study of Table 33: first, the absence of russeting where lime sulfur was used; second, the control of first-brood codling moth; third, the small amount of sooty blotch present on any of the apples in the sprayed plats compared with the un-

TABLE 33.—EFFECTS OF DIFFERENT DILUTIONS OF LIME SULFUR IN THE WINESAP BLOCK, IN THE EXPERIMENTS AT ANNA, 1912

Plat	Treatment	Dates of Applications					Percentage of dropped apples affected by			Percentage of picked apples affected by						
		1st spray	2d spray	3d spray	4th spray	5th spray	Scab	Codling moth	Curculio	Scab	Sooty blotch	Codling moth			Curculio	Severe russet
												Calyx	Side	Total		
2	Lime sulfur, 1–33, arsenate of lead	1/20	5/7	5/22	6/29	7/20	41	19	17	44	7	1	0	1	29	0
	Lime sulfur, 1–43, arsenate of lead															
3	Lime sulfur, 1–33, arsenate of lead	1/20	5/7	5/22	6/29	7/20	37	9	18	29	5	1	1	2	27	0
	Lime sulfur, 1–63, arsenate of lead															
4	Lime sulfur, 1–33, arsenate of lead	1/20	5/7	5/22	6/29	7/20	41	10	22	42	9	2	2	4	24	0
	Lime sulfur, 1–53, arsenate of lead															
5	Lime sulfur, 1–33, arsenate of lead	1/20	5/7	5/22	6/29	7/20	35	21	20	27	7	2	4	6	32	0
	Lime sulfur, 1–43, arsenate of lead															
	Lime sulfur, 1–53, arsenate of lead															
6	Lime sulfur, 1–33, arsenate of lead	1/20	5/7	5/22	6/29	7/20	39	18	21	28	8	2	1	3	23	0
	Lime sulfur, 1–43, arsenate of lead															
16	Lime sulfur, 1–33, arsenate of lead	1/20	5/7	5/22	6/29	7/19	45	20	24	31	8	1	3	4	27	0
Check	No treatment						73	42	34	83	60	19	11	30	37	0

TABLE 34.—EFFECTS OF MODERATE AND HEAVY APPLICATIONS OF BORDEAUX IN THE JONATHAN BLOCK, IN THE EXPERIMENTS AT ANNA, 1912

Plat	Treatment	Dates of applications			Percentage of dropped apples affected by			Percentage of picked apples affected by						
		1st spray	2d spray	3d spray	Scab	Codling moth	Curculio	Scab	Sooty blotch	Codling moth			Curculio	Severe russet
										Calyx	Side	Total		
1	Bordeaux arsenate of lead, moderate	4/15	5/5	5/20	13	43	30	6	0	17	27	44	28	20
13	Bordeaux arsenate of lead, heavy	4/16	5/5	5/20	3	47	19	3	0	16	26	42	11	36
Check	No treatment				30	47	30	37	37	24	23	47	37	0

sprayed trees. The degree of dilution, within the ranges given in the table, made no appreciable difference in the results obtained when used for late summer applications.

Effects of Moderate and Heavy Applications of Bordeaux

Table 34 presents the data recorded on the Jonathan plats where moderate and heavy applications of Bordeaux were used. These experiments were not duplicated in the Winesap plats. The results were as follows:

Scab.—An effective control of scab resulted from both moderate and heavy applications of Bordeaux.

Sooty Blotch.—Both moderate and heavy applications of Bordeaux proved to be extremely efficient in preventing injury from this fungus.

Codling Moth.—In the control of codling moth heavy applications gave no better control than moderate applications.

Curculio.—A somewhat striking difference is to be observed in the relative control of this insect exercised by the two applications in favor of the heavier application. In the picked apples, 11 percent of all the fruit was injured by curculio where the heavy application was made, whereas in the moderately sprayed plat, 28 percent of all the fruit was affected. In the case of the dropped apples 19 percent of the heavily sprayed fruit was attacked by curculio, whereas 30 percent of all the fruit on the trees given the moderate application was injured.

Russet.—The heavy application of Bordeaux resulted in the production of a somewhat larger number of russeted apples, and in much more severe russeting on the individual apples affected. The apples on the heavily sprayed trees were, on the average, a trifle smaller than those on the lightly sprayed trees.

Effects of Mixed, Neutral, and Acid Arsenates of Lead in Combination with Lime Sulfur

Tables 35 and 36 present the data recorded on the Jonathan and Winesap plats where mixed, neutral, and acid arsenates of lead were used in combination with lime sulfur. The results were as follows:

Scab.—Table 36 appears to show a small but consistent lessening of the amount of scab where the acid arsenate of lead was added to lime sulfur. In general the neutral and mixed arsenates of lead did not add to the effectiveness of the lime sulfur, with which they were mixed, in the control of scab. The acid arsenate of lead was decidedly superior.

Sooty Blotch.—The addition of all kinds of arsenate of lead to lime sulfur gave a spray superior to lime sulfur alone in the control of sooty blotch. Altho the differences between the various kinds were

TABLE 35.—EFFECTS OF MIXED, NEUTRAL, AND ACID ARSENATES OF LEAD USED IN COMBINATION WITH LIME SULFUR IN THE JONATHAN BLOCK, IN THE EXPERIMENTS AT ANNA, 1912

Plat	Treatment	Dates of applications			Percentage of dropped apples affected by			Percentage of picked apples affected by						
										Codling moth				
		1st spray	2d spray	3d spray	Scab	Codling moth	Curculio	Scab	Sooty blotch	Calyx	Side	Total	Curculio	Severe russet
3	Mixed arsenate of lead with lime sulfur	4/15	5/6	5/18	6	38	23	3	7	5	24	29	18	0
16	Neutral arsenate of lead with lime sulfur	4/18	5/6	5/18	2	29	16	2	13	3	16	19	19	0
17	Acid arsenate of lead with lime sulfur	4/18	5/6	5/18	3	40	17	3	3	6	23	29	21	0
18	Lime sulfur alone	4/18	5/6	5/18	4	58	11	2	21	30	21	51	20	0
Check	No treatment				30	47	30	37	37	24	23	47	37	0

TABLE 36.—EFFECTS OF MIXED, NEUTRAL, AND ACID ARSENATES OF LEAD IN COMBINATION WITH LIME SULFUR IN THE WINESAP BLOCK, IN THE EXPERIMENTS AT ANNA, 1912

Plat	Treatment	Dates of applications			Percentage of dropped apples affected by			Percentage of picked apples affected by						
										Codling moth				
		1st spray	2d spray	3d spray	Scab	Codling moth	Curculio	Scab	Sooty blotch	Calyx	Side	Total	Curculio	Severe russet
14	Mixed arsenate of lead with lime sulfur	4/20	5/7	5/22	24	24	31	17	29	2	1	3	32	0
28	Neutral arsenate of lead with lime sulfur	4/20	5/8	5/22	32	29	25	34	40	9	5	14	34	0
30	Acid arsenate of lead with lime sulfur	4/20	5/9	5/22	13	28	37	6	31	7	4	11	50	0
29	Lime sulfur alone	4/20	5/9	5/22	24	49	28	26	65	24	6	30	46	0
Check	No treatment				73	42	34	83	60	19	11	30	37	0

not large there is a fairly consistent difference favoring first, the mixed arsenate of lead; second, the acid arsenate of lead; and finally, the neutral form.

Codling Moth.—No consistent differences appeared in the relative control which the various kinds of arsenate of lead exercised over the codling moth. All brands showed a high degree of effectiveness when compared with the plats sprayed with lime sulfur alone, and with the checks, which received no spray whatever.

Curculio.—The differences in the control of this insect as shown by the treatments in the various plats are inconsistent. In the Jonathan plats all sprays appeared to lessen the amount of injury from curculio to a considerable extent, even lime sulfur alone showing a better degree of control. In the Winesap block, however, the data from which are presented in Table 36, there was a larger amount of injury from curculio on the trees in the lime-sulfur plat than on the trees in the unsprayed plat, indicating an irregular infestation thruout the block. No definite conclusion can, therefore, be made as to the relative efficiency of the different sprays in controlling this insect.

Russet.—There was no severe russet on either the Jonathan or the Winesap apples. This may be attributed to the fact that no Bordeaux was used in the experiment.

Effects of Mixed, Neutral, and Acid Arsenates of Lead in Combination with Bordeaux

Tables 37 and 38 present the data recorded on the Jonathan and Winesap plats where mixed, neutral, and acid arsenates of lead were used in combination with Bordeaux. The results were as follows:

Scab.—There was no apparent difference in the control of scab which could be attributed to the use of the arsenates of lead.

Codling Moth.—In the Jonathan block, the neutral arsenate of lead gave superior control, but in the Winesap block, very little difference in the respective values of the type is shown.

Curculio.—The three classes of arsenate of lead gave fairly equal control of this insect, except in Plat 15 in the Jonathan block, where neutral arsenate of lead was used.

Russet.—The amount of russet, which was very large in all cases in the Jonathan block, did not vary consistently with any one class of arsenate of lead.

Effects of Copper Ferrocyanide With and Without Arsenate of Lead

Tables 39 and 40 present the data recorded on the Jonathan and Winesap plats where copper ferrocyanide was used separately and in combination with arsenate of lead. Data from plats treated with Bor-

TABLE 37.—EFFECTS OF MIXED, NEUTRAL, AND ACID ARSENATES OF LEAD IN COMBINATION WITH BORDEAUX, IN THE JONATHAN BLOCK, IN THE EXPERIMENTS AT ANNA, 1912

Plat	Treatment	Dates of applications			Percentage of dropped apples affected by			Percentage of picked apples affected by						
										Codling moth				
		1st spray	2d spray	3d spray	Scab	Codling moth	Curculio	Scab	Sooty blotch	Calyx	Side	Total	Curculio	Severe russet
2	Mixed arsenate of lead with Bordeaux	4/15	5/8	5/20	6	42	20	3	1	18	27	45	24	61
15	Neutral arsenate of lead with Bordeaux	4/16	5/8	5/20	2	31	28	1	0	8	21	29	42	54
14	Acid arsenate of lead with Bordeaux	4/16	5/8	5/20	3	52	30	1	1	18	24	42	27	54
Check	No treatment				30	47	30	37	37	24	23	47	37	0

TABLE 38.—EFFECTS OF MIXED, NEUTRAL, AND ACID ARSENATES OF LEAD IN COMBINATION WITH BORDEAUX, IN THE WINESAP BLOCK, IN THE EXPERIMENTS AT ANNA, 1912

Plat	Treatment	Dates of applications			Percentage of dropped apples affected by			Percentage of picked apples affected by						
										Codling moth				
		1st spray	2d spray	3d spray	Scab	Codling moth	Curculio	Scab	Sooty blotch	Calyx	Side	Total	Curculio	Severe russet
21	Mixed arsenate of lead with Bordeaux	4/18	5/8	5/23	15	26	20	11	1	5	1	6	29	3
32	Neutral arsenate of lead with Bordeaux	4/21	5/8	5/23	27	32	23	16	6	7	4	11	23	5
31	Acid arsenate of lead with Bordeaux	4/21	5/8	5/23	23	34	27	14	3	7	5	12	26	3
Check	No treatment				73	42	34	83	60	19	11	30	37	0

TABLE 39.—EFFECTS OF COPPER FERROCYANIDE USED SEPARATELY AND IN COMBINATION WITH ARSENATE OF LEAD IN THE JONATHAN BLOCK, IN THE EXPERIMENTS AT ANNA, 1912

Plat	Treatment	Dates of applications			Percentage of dropped apples affected by			Percentage of picked apples affected by							
										Codling moth					
		1st spray	2d spray	3d spray	Scab	Codling moth	Curculio	Scab	Sooty blotch	Calyx	Side	Total	Curculio	Severe russet
19	Copper ferrocyanide and arsenate of lead	4/18	5/6	5/13	7	22	25	8	27	5	18	23	32	11
20	Copper ferrocyanide alone	4/18	5/6	5/13	9	45	46	15	50	21	19	40	59	1
Check	No treatment				30	47	30	37	37	24	23	47	37	0
2	Bordeaux arsenate of lead	4/15	5/5	5/20	6	42	20	3	1	18	27	45	24	61
3	Lime sulfur arsenate of lead	4/15	5/6	5/18	6	38	23	3	7	5	24	29	18	0

TABLE 40.—EFFECTS OF COPPER FERROCYANIDE USED SEPARATELY AND IN COMBINATION WITH ARSENATE OF LEAD IN THE WINESAP BLOCK, IN THE EXPERIMENTS AT ANNA, 1912

Plat	Treatment	Dates of applications			Percentage of dropped apples affected by			Percentage of picked apples affected by							
										Codling moth					
		1st spray	2d spray	3d spray	Scab	Codling moth	Curculio	Scab	Sooty blotch	Calyx	Side	Total	Curculio	Severe russet
1	Copper ferrocyanide alone	4/20	5/9	5/22	78	58	33	87	71	27	15	42	47	0
33	Copper ferrocyanide with arsenate of lead	4/20	5/9	5/22	46	28	31	47	56	8	4	12	33	0
14	Lime sulfur arsenate of lead	4/20	5/7	5/20	24	24	31	17	29	2	1	3	32	0
21	Bordeaux arsenate of lead	4/18	5/8	5/23	15	26	20	11	1	5	1	6	29	3
Check	No treatment				73	42	34	83	60	19	11	30	37	0

deaux arsenate of lead and lime sulfur arsenate of lead were included in these tables for comparison. The results were as follows:

Scab.—Copper-ferrocyanide sprays were less efficient in preventing injury from scab than Bordeaux and lime-sulfur sprays. The addition of arsenate of lead to copper ferrocyanide appeared to increase the fungicidal value of the spray. In the Winesap block the trees sprayed with copper ferrocyanide alone were as severely attacked by scab as the unsprayed trees.

Sooty Blotch.—As in the case of scab, the copper-ferrocyanide sprays proved less efficient in the control of sooty blotch than either Bordeaux or lime sulfur. The addition of arsenate of lead, however, to copper ferrocyanide considerably increased the fungicidal value of the spray.

Codling Moth.—In both the Jonathan and Winesap blocks the copper-ferrocyanide sprays were not effective in controlling this insect. The addition of arsenate of lead to the spray reduced the damage from codling moth appreciably, especially in the Jonathan block.

Russet.—There was a noticeable amount of russet on the plats sprayed with copper ferrocyanide and arsenate of lead in the Jonathan block. The russet was less severe than on the apples which had been sprayed with Bordeaux, but was much more severe than on the apples sprayed with lime sulfur. Copper ferrocyanide caused less injury in the form of russet on the Winesap apples than on the Jonathans. The addition of arsenate of lead to copper ferrocyanide increased the amount of russeting on the Jonathan apples.

SPRAYING EXPERIMENTS IN 1911 AT GRIGGSVILLE, PIKE COUNTY

BY ALFRED J. GUNDERSON, FIRST ASSISTANT IN POMOLOGY

OBJECTS

In the spraying work at the Griggsville station during 1911, experiments were conducted to determine the following points: (1) the relative value of lime sulfur and Bordeaux as summer sprays; (2) the value of winter applications of lime sulfur; (3) the relative effect of light and heavy applications of Bordeaux; (4) the means of reducing injury following the use of Bordeaux; (5) the value of interchanging lime sulfur and Bordeaux as summer sprays; (6) the value of arsenate of lead as a fungicide when used alone for controlling codling moth; and (7) the value of spray made by adding copper sulfate to lime sulfur.

LOCATION AND DESCRIPTION OF ORCHARD

The orchard used for these experiments belonged to Mr. G. Warton and was located one mile south of Griggsville. About one hundred and sixty fifteen-year-old trees were used, which, with the exception of a few trees of odd varieties, consisted of Ben Davis. They were planted about thirty feet apart each way.

The general vigor of the trees was good, considering that they had never received any care. No spraying had been done in the orchard; consequently it had never produced a profitable crop. The orchard offered ideal conditions for carrying on the experiment.

OUTLINE OF TREATMENTS

In laying out these experiments, the orchard was divided into sixteen plats of eight to eleven trees each, and a check or unsprayed row was left thru the entire length of the orchard. These plats were grouped and sprayed as nearly under the same conditions as possible, especial care being taken that the plats in a given group should be strictly comparable.

The plats in the orchard were sprayed as follows:

Plat	Application	Date	Treatment
A	1	April 20	Heavy spraying with lime sulfur arsenate of lead
	2	May 9	" " " " " " " "
	3	May 22	" " " " " " " "
B	1	April 20	Heavy spraying with lime sulfur arsenate of lead
	2	May 9	" " " " " " " "
	3	May 22	" " " " " " " "

Plat	Application	Date	Treatment
C	1	April 20	Heavy spraying with Bordeaux arsenate of lead
	2	May 9	" " " " " " "
	3	May 22	" " " " " " "
D	1	April 20	Heavy spraying with Bordeaux arsenate of lead
	2	May 9	" " " " " " "
	3	May 22	" " " " " " "
E	1	April 20	Light spraying with Bordeaux arsenate of lead
	2	May 9	" " " " " " "
	3	May 22	" " " " " " "
F	1	April 20	Heavy spraying with Bordeaux arsenate of lead
	2	May 10	" " " " " " "
	3	May 23	" " " " " " "
	4	June 1	" " " " " " "
	5	June 12	" " " " " " "
	6	July 25	" " " " " " "
G	1	April 20	Heavy spraying with Bordeaux arsenate of lead
	2	May 10	" " " " " " "
	3	May 23	" " " " " " "
	4	June 1	" " " " " " "
	5	June 12	" " " " " " "
	6	July 25	" " " " " " "
			Each application was followed by a 4–50 solution of lime.
H	1	April 21	Heavy spraying with Bordeaux arsenate of lead
	2	May 11	" " " lime sulfur " " "
	3	May 23	" " " " " " " "
I	1	April 21	Heavy spraying with Bordeaux arsenate of lead
	2	May 11	" " " " " " "
	3	May 23	" " " lime sulfur " " "
J	1	April 21	Heavy spraying with lime sulfur arsenate of lead
	2	May 11	" " " Bordeaux " " "
	3	May 23	" " " " " " "
K	1	April 21	Heavy spraying with lime sulfur arsenate of lead
	2	May 11	" " " " " " " "
	3	May 23	" " " Bordeaux " " "
L	1	April 21	Heavy spraying with Bordeaux arsenate of lead
	2	May 10	" " " arsenate of lead
	3	May 24	" " " " "
M	1	April 21	Heavy spraying with lime sulfur arsenate of lead
	2	May 10	" " " arsenate of lead
	3	May 24	" " " arsenate of lead
N	1	April 21	Heavy spraying with lime sulfur arsenate of lead plus 4 pounds copper sulfate to 100 gallons
	2	May 12	" " " " " " " "
	3	May 24	" " " " " " " "
O	1	April 21	Heavy spraying with lime sulfur arsenate of lead plus 8 pounds copper sulfate to 100 gallons
	2	May 12	" " " " " " " "
	3	May 24	" " " " " " " "
P	1	April 21	Heavy spraying with lime sulfur arsenate of lead plus 12 pounds copper sulfate to 100 gallons
	2	May 12	" " " " " " " "
	3	May 24	" " " " " " " "
Check	none		No treatment

NOTE.—All plats except B and C received a winter application of lime sulfur, April 10-14.

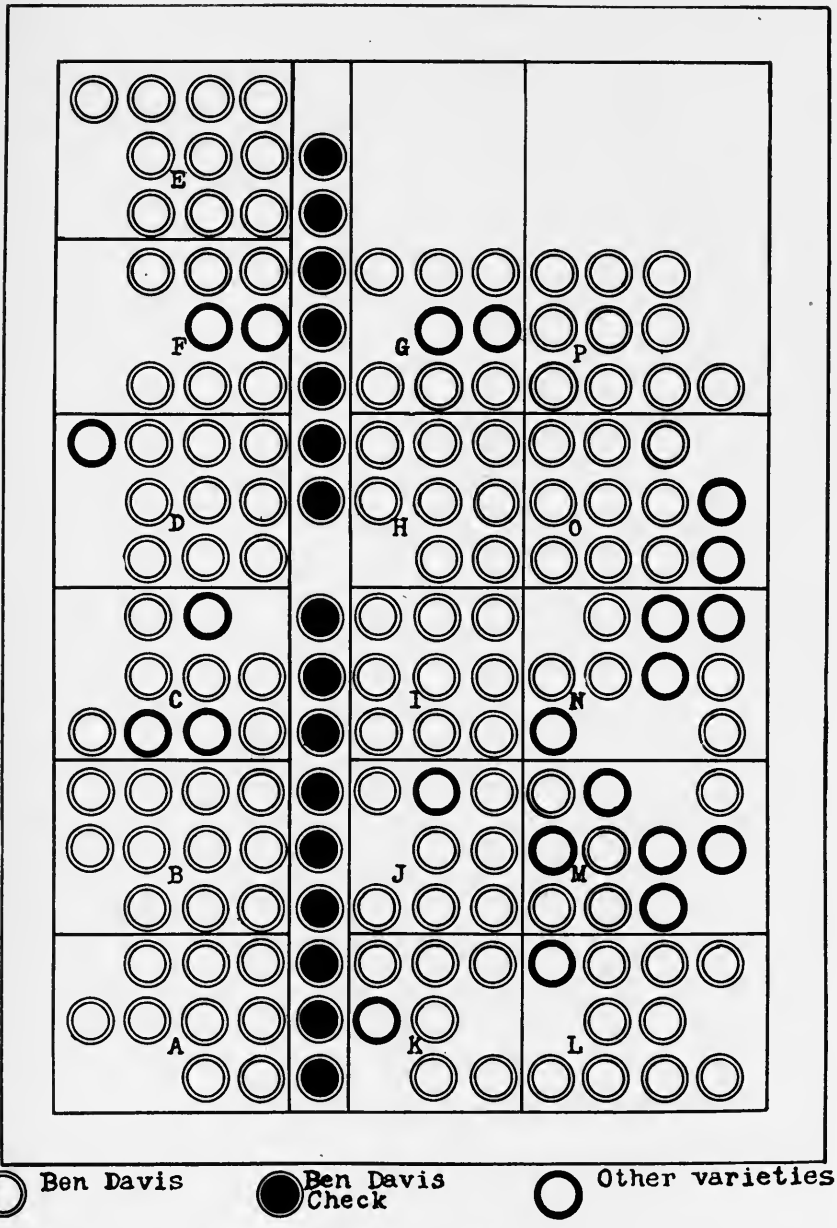

CHART 10.—PLAN OF PLATS IN ORCHARD OF MR. G. WARTON, GRIGGSVILLE, 1911

APPARATUS AND PREPARATION OF MATERIALS

In all cases where Bordeaux was used it was made according to the standard formula: 8 pounds of copper sulfate and 8 pounds of lime to 100 gallons of water. The lime sulfur was made according to the Illinois formula: 50 pounds of lime and 100 pounds of sulfur boiled together in 66 gallons of water until all the sulfur was in solution. For winter strength, lime sulfur was used at the rate of 1 gallon in 7 gallons of water (approximately 20 pounds of sulfur in 100 gallons); for summer strength, it was used at the rate of 1 gallon in 18 gallons of water (approximately 8 pounds of sulfur in 100 gallons). Grasselli arsenate of lead paste was used at the rate of 4 pounds to 100 gallons of spray. All plats except B and C received a winter application of lime sulfur. Each plat also received three summer sprays. Application No. 1 was made in the cluster-bud or pink stage; No. 2 was made at the dropping of the petals; and No. 3 was made about two weeks later. In addition to the three summer sprays above referred to, Plats F and G received three extra summer sprays.

The winter spray of lime sulfur was applied with a 200-gallon Gould hand outfit, at about 150 pounds pressure. The summer sprays were applied with a 50-gallon Gould barrel oufit, at about 150 pounds pressure. In all the spraying, double Vermorel nozzles were used. All plats, except where noted otherwise, were sprayed heavily; every part of the tree received a thoro application.

CHARACTER OF RECORDS AND METHOD OF MAKING

During the season, records were kept of all items of importance. These records included the appearance of the foliage thruout the season in regard to fungi, insects, spray, and vigor. Dropped apples were collected, counted, and examined for various injuries. At picking time two representative trees from each sprayed plat and two from the unsprayed plats were chosen and used in obtaining the data. Two hundred apples were selected from different parts of each tree and examined carefully. The results from the two trees in each plat were averaged together, this average being taken to represent the value of the treatment. Records from the unsprayed trees were made in the same manner. All the apples from each tree in each plat and from each tree in the check row were counted, weighed, and sorted in No. 1's, No. 2's, and culls.

The No. 1 Ben Davis were not less than 2½ inches in diameter, were free from scab, with only a slight amount of insect or other injuries, and of good shape and color. No. 2 apples were 2¼ inches in diameter, occasionally with slight scab, and with not over 20 percent of the apples injured to a slight extent by insects and other causes;

they were of good shape and color. Apples below these qualifications were classed as culls.

WEATHER CONDITIONS

The weather from the latter part of April until September was exceptionally hot and dry. The trees were in bloom May 1, and the still, sultry days and nights at that time presented ideal conditions for setting of the fruit. All the trees set a good crop and were heavily loaded at picking time.

Under the dry conditions of the spring and summer, very little scab developed even on the unsprayed orchards in the vicinity. September and October, however, were unusually wet, and during that time sooty blotch developed in great abundance and caused severe damage, especially to unsprayed fruit. At the end of the season, the foliage on the unsprayed trees in the experimental orchard was almost as healthy in appearance as the foliage on the sprayed trees.

VALUE OF A DORMANT-TREE APPLICATION OF LIME SULFUR, AND RELATIVE VALUE OF LIME SULFUR AND BORDEAUX AS SUMMER SPRAYS

Spraying with lime sulfur while the trees are dormant is the standard treatment for San Jose scale. Many growers, however, apply this spray whether an orchard has scale or not, believing that trees sprayed with lime sulfur while dormant suffer less from scab during the following season than those which are not so sprayed.

To determine the value of a dormant-tree application of lime sulfur, and also to learn the relative value of lime sulfur and Bordeaux as summer sprays, four plats were treated as follows:

Plat A: Lime sulfur arsenate of lead, 1st, 2d, and 3d applications (with dormant-tree application of lime sulfur).

Plat B: Lime sulfur arsenate of lead, 1st, 2d, and 3d applications (without dormant-tree application of lime sulfur).

Plat C: Bordeaux arsenate of lead, 1st, 2d, and 3d applications (without dormant-tree application of lime sulfur).

Plat D: Bordeaux arsenate of lead, 1st, 2d, and 3d applications (with dormant-tree application of lime sulfur).

EFFECT ON FOLIAGE

The foliage of Plats A, B, C, and D was practically free from scab during the entire season. A slight amount of scab appeared on the unsprayed trees about May 20, but at no time during the summer was the infection serious; in fact, it was negligible. No apparent difference could be noted between the foliage of Plat A, which received a dormant-tree application of lime sulfur, and Plat B, which did not, for both plats appeared equally vigorous and free from scab. The same was true of Plats C and D, and indicated that under the conditions in this orchard a dormant-tree application of lime sulfur was useless.

Plats A and B, which received three summer applications of lime sulfur, and Plats C and D, which were sprayed three times with Bordeaux, suffered little from scab. Early in the summer a very slight amount of lime-sulfur injury appeared on the foliage of Plats A and B. No appreciable amount of Bordeaux injury was noticed on the foliage of Plats C and D until the latter part of September, when this spray caused the trees to lose a considerable number of leaves. On the whole, Plats A and B, which were sprayed with lime sulfur, had denser and more vigorous-looking foliage and retained it longer than Plats C and D, which were sprayed with Bordeaux.

EFFECT ON FRUIT

The apples from these plats were picked, sorted, and examined October 20, and the results are presented in Table 41.

This table shows that the dormant-tree application of lime sulfur had no effect on apple scab, for it is evident that the amount of scab on Plat A was practically the same as on Plat B, and this is also true for Plats C and D.

The results also show that Bordeaux was slightly superior to lime sulfur in the control of apple scab, but the difference is so slight that the two may fairly be considered to have been equal in effectiveness. The unsprayed row shows only 12.37 percent slight scab, which is a small amount of infection for unsprayed apples. This may be explained by the fact that the spring and summer were exceedingly dry and offered conditions unfavorable to scab development.

There was a difference, however, between the amounts of flyspeck and sooty blotch on Plats A and B and Plats C and D. Plats A and B, sprayed with lime sulfur, showed 19.75 and 22.25 percent flyspeck and 23.5 and 19.25 percent sooty blotch, respectively, as compared with Plats C and D, sprayed with Bordeaux, which showed but .25 and 4 percent flyspeck, and .5 and 4 percent sooty blotch. The unsprayed row, however, showed 63.87 percent flyspeck and 52 percent sooty blotch. It is probable that a difference in adhesiveness in favor of Bordeaux over lime sulfur explains this difference in control.

The amount of codling moth on sprayed plats and on the check row was small. The amount of curculio injury was greater for the lime-sulfur plats than for the Bordeaux plats.

A very important difference between the effects of these sprays upon the fruit is shown in the russet columns. Plat C, sprayed with Bordeaux, had .5 percent serious and 41.75 percent slight russet, and Plat D, sprayed with Bordeaux, had 37.25 percent slight russet. Plats A and B, sprayed with lime sulfur, gave, on the other hand, only 2.25 and 4 percent slight russet, respectively. Plats A and B also showed but a negligible amount of lime-sulfur burn.

TABLE 41.—EFFECTS OF BORDEAUX AND LIME SULFUR IN COMBINATION WITH ARSENATE OF LEAD AS SUMMER SPRAYS WITH AND WITHOUT WINTER APPLICATIONS OF LIME SULFUR, IN THE EXPERIMENTS AT GRIGGSVILLE, 1911

Plat	Treatment	Applications	Total no. picked apples	Total bu. picked apples	Percentage grades			Percentage of picked apples affected by								
								Scab						Russet		
					No. 1	No. 2	Culls	Serious	Slight	Flyspeck	Sooty blotch	Codling moth	Curculio	Serious	Slight	Burn
A	Lime sulfur arsenate of lead with winter application	1, 2, 3	6323	33.5	79	18	3	0	1.00	19.75	23.50	1.00	40.50	.0	2.25	1.25
B	Lime sulfur arsenate of lead without winter application	1, 2, 3	5768	27.8	69	28	3	0	2.75	22.25	19.25	1.50	37.75	.0	4.00	1.75
C	Bordeaux arsenate of lead without winter application	1, 2, 3	7107	35.0	71	26	3	0	.25	.25	.50	2.25	20.00	.5	41.75	.00
D	Bordeaux arsenate of lead with winter application	1, 2, 3	5406	29.6	74	24	2	0	.50	4.00	4.00	1.25	29.75	.0	37.25	.00
Check	No treatment	none	11862	61.7	65	31	4	0	12.37	63.87	52.00	3.87	53.50	.0	.00	.00

TABLE 42.—EFFECTS OF LIGHT AND HEAVY APPLICATIONS OF BORDEAUX IN COMBINATION WITH ARSENATE OF LEAD, IN THE EXPERIMENTS AT GRIGGSVILLE, 1911

Plat	Treatment	Applications	Total no. picked apples	Total bu. picked apples	Percentage grades			Percentage of picked apples affected by							
								Scab						Russet	
					No. 1	No. 2	Culls	Serious	Slight	Flyspeck	Sooty blotch	Codling moth	Curculio	Serious	Slight
D	Bordeaux arsenate of lead (heavy)	1, 2, 3	5406	29.6	74	24	2	0	.50	4.00	4.00	1.25	29.75	0	37.25
E	Bordeaux arsenate of lead (light)	1, 2, 3	6964	38.8	72	24	4	0	.50	26.50	18.75	5.75	43.00	0	18.75
Check	No treatment	none	11862	61.7	65	31	4	0	12.37	63.87	52.00	3.87	53.50	0	.00

Plats A and B had 79 and 69 percent No. 1's, 18 and 28 percent No. 2's, and 3 and 3 percent culls, respectively. Plats C and D gave 71 and 74 percent No. 1's, 26 and 24 percent No. 2's, and 3 and 2 percent culls, respectively. The unsprayed row had 65 percent No. 1's, 31 percent No. 2's, and 4 percent culls, which was very exceptional for unsprayed apples. Flyspeck, sooty blotch, and curculio were instrumental in reducing the percentage of No. 1 apples on Plats A and B, while curculio and russet caused the reduction on Plats C and D.

There was a marked difference between the lime-sulfur and Bordeaux apples. Those sprayed with lime sulfur were larger, smoother, and had better color and a more waxy finish than those sprayed with Bordeaux.

LIGHT VERSUS HEAVY APPLICATIONS OF BORDEAUX

There has been some question as to whether or not the amount of Bordeaux injury is proportional to the quantity of spray applied. To determine the relative effect of light and heavy applications of Bordeaux, two plats were treated as follows:

Plat D: Bordeaux arsenate of lead (heavy).
Plat E: Bordeaux arsenate of lead (light).

EFFECT ON FOLIAGE

Both light and heavy applications controlled scab on the foliage effectively. The appearance of the foliage of Plats D and E was very similar until the latter part of September, when Bordeaux injury began to appear on Plat D. This injury reduced the amount of foliage materially. Plat E, however, suffered no appreciable amount of injury. This difference indicates that the amount of Bordeaux injury to foliage was more or less proportional to the quantity of spray applied.

EFFECT ON FRUIT

The apples from these plats were picked, sorted, and examined October 20 to 23; the results are presented in Table 42.

Table 42 shows that heavy and light applications of Bordeaux were equally effective in the control of scab, .5 percent slight scab appearing on both plats. Plat E, given the light application, however, showed 26.5 percent flyspeck and 18.75 percent sooty blotch as compared to 4 percent flyspeck and 4 percent sooty blotch on Plat D, which was given the heavy application. Plat D showed only 1.25 percent affected by codling moth and 29.75 percent by curculio, as compared with Plat E with 5.75 percent codling-moth and 43 percent curculio injury. It is evident from this that better control of flyspeck, sooty blotch, codling moth, and curculio was obtained where Bordeaux arsenate of lead was applied heavily.

There was, however, less russet on Plat E, which received light applications of Bordeaux, than on Plat D, which was sprayed heavily. Plat E showed 18.75 percent slight russet as compared with Plat D with 37.25 percent slight russet.

Each plat had very nearly the same percentage of No. 1's, No. 2's, and culls.

The apples from Plat E, which was sprayed lightly with Bordeaux, had better color than those from Plat D, which received heavy applications of Bordeaux.

ATTEMPTS TO REDUCE BORDEAUX INJURY

It has been suggested that by keeping fruit and foliage continually coated with the spray, Bordeaux injury might be reduced. Previous experiments have shown that a solution of milk of lime applied soon after the Bordeaux application became dry reduced injury to foliage.[1] In order to determine the practical application of these methods, the following experiment was conducted:

Plat D: Bordeaux arsenate of lead (heavy), 1st, 2d, and 3d applications.

Plat F: Bordeaux arsenate of lead (heavy), 1st, 2d, and 3d applications, followed by three additional applications.

Plat G: Bordeaux arsenate of lead (heavy), 1st, 2d, and 3d applications, followed by three additional applications of 4–50 lime solution.

EFFECT ON FOLIAGE

Scab was effectively controlled on the foliage of Plats D, F, and G. No Bordeaux injury to foliage occurred until late in September. The amount of injury at that time was about equal on all three plats. The foliage of all plats dropped prematurely, as compared with plats not sprayed with Bordeaux. The foliage of Plat F, which was kept well coated with Bordeaux until late in the summer, was no better nor freer from Bordeaux injury than Plat D, which received the three regular applications only. The foliage on Plat G, which was sprayed the same number of times as Plat F, and where each Bordeaux application was followed by one of milk of lime, was no better than the foliage of Plat F, which did not receive the milk of lime, nor was it any better than Plat D, which received the three regular applications only.

EFFECT ON FRUIT

The apples from Plats D, F, and G were picked, sorted, and examined October 20 to 21, and the results are presented in Table 43.

These results show that scab was completely controlled on Plats F and G, which received respectively six applications of Bordeaux with and without applications of milk of lime following. Plat D, which received the three regular applications only, showed but .5 percent slight scab. Flyspeck and sooty blotch were effectively controlled

[1] C. S. Crandall, Ill. Agr. Exp. Sta. Bul. 135, p. 280 (1909).

on Plat D, and were absolutely controlled on Plats F and G. Codling-moth injury to all plats was very slight. All sprays reduced the amount of curculio injury materially.

A very interesting difference between the effects of these sprays upon the fruit is shown in the russet column. Plat D, which received three regular applications of Bordeaux, shows 37.25 percent slight russet; Plat F, sprayed six times with Bordeaux, shows 35.25 percent slight russet. In other words, spraying so as to maintain a coating of Bordeaux was of no value in reducing injury to the fruit. Plat G, sprayed the same number of times with Bordeaux as Plat F, but treated with an application of milk of lime after each Bordeaux spray, shows 56.25 percent slight russet. It would appear from these records that the increased amount of russet on Plat G, as compared with that on Plat F, was due to the lime applications,—a rather unlooked-for result. Bordeaux injury to fruit may be the result of too high pressure. It is possible that the small particles of lime in Bordeaux or in milk of lime may, under certain pressures and conditions, injure the cuticle of apples by permitting the entrance of soluble copper to the cells of the skin of the apple, thus causing russet. The increase in the amount of russet on Plat G, as compared with Plat F, may have been due to the applications of milk of lime following the Bordeaux sprays. Plat G, however, produced a higher percentage of No. 1 apples than did Plats D and F.

The fruits from all plats lacked color and finish. Tho the russet on the apples was slight, it was, nevertheless, very noticeable and gave the fruit a rough finish.

VALUE OF INTERCHANGING LIME SULFUR AND BORDEAUX AS SUMMER SPRAYS

It has generally been thought that Bordeaux russeting accompanies sprays applied soon after the setting of the fruit. It has been suggested, therefore, that lime sulfur might be substituted for Bordeaux at this critical time. With the hope that a method might be determined which would do away with russeting of the fruit and injury to foliage, and which would at the same time control fungous diseases, plats were treated as follows:

Plat A: Lime sulfur arsenate of lead, 1st, 2d, and 3d applications.

Plat D: Bordeaux arsenate of lead, 1st, 2d, and 3d applications.

Plat H: Bordeaux arsenate of lead, 1st application; lime sulfur arsenate of lead, 2d and 3d applications.

Plat I: Bordeaux arsenate of lead, 1st and 2d applications; lime sulfur arsenate of lead, 3d application.

Plat J: Lime sulfur arsenate of lead, 1st application; Bordeaux arsenate of lead, 2d and 3d applications.

Plat K: Lime sulfur arsenate of lead, 1st and 2d applications; Bordeaux arsenate of lead, 3d application.

TABLE 43.—EFFECTS OF APPLYING MILK OF LIME IMMEDIATELY AFTER APPLYING BORDEAUX, IN THE EXPERIMENTS AT GRIGGSVILLE, 1911

Plat	Treatment	Applications	Total no. picked apples	Total bu. picked apples	Percentage grades			Percentage of picked apples affected by							
								Scab		Flyspeck	Sooty blotch	Codling moth	Curculio	Russet	
					No. 1	No. 2	Culls	Serious	Slight					Serious	Slight
D	Bordeaux arsenate of lead (heavy).....	1, 2, 3	5406	29.6	74	24	2	0	.50	4.00	4.0	1.25	29.75	.00	37.25
F	Bordeaux arsenate of lead (heavy).....	1, 2, 3 4, 5, 6	4976	24.0	71	26	3	0	.00	.00	.0	3.50	21.00	.25	35.25
G	Bordeaux arsenate of lead (heavy) followed by milk of lime 4–50.....	1, 2, 3 4, 5, 6	5945	26.8	82	16	2	0	.00	.00	.0	.25	21.00	.25	56.25
Check	No treatment	none	11862	61.7	65	31	4	0	12.37	63.87	52.0	3.87	53.50	.00	.00

TABLE 44.—EFFECTS OF USING LIME SULFUR FOR SOME APPLICATIONS AND BORDEAUX FOR OTHER APPLICATIONS IN THE EXPERIMENTS AT GRIGGSVILLE, 1911

Plat	Treatment	Applications	Total no. picked apples	Total bu. picked apples	Percentage grades			Percentage of picked apples affected by								
								Scab		Flyspeck	Sooty blotch	Codling moth	Curculio	Russet		Burn
					No. 1	No. 2	Culls	Serious	Slight					Serious	Slight	
A	Lime sulfur arsenate of lead.....	1, 2, 3	6323	33.5	79	18	3	0	1.00	19.75	23.50	1.00	40.50	0	2.25	1.25
D	Bordeaux arsenate of lead	1, 2, 3	5406	29.6	74	24	2	0	.50	4.00	4.00	1.25	29.75	0	37.25	.00
H	Bordeaux arsenate of lead	1														
	Lime sulfur arsenate of lead.....	2, 3	5173	29.5	83	13	4	0	1.25	20.00	25.75	1.25	39.25	0	17.00	.75
I	Bordeaux arsenate of lead	1, 2														
	Lime sulfur arsenate of lead.....	3	6718	36.0	77	18	5	0	.00	9.00	14.00	2.25	38.50	0	49.50	.00
J	Lime sulfur arsenate of lead.....	1														
	Bordeaux arsenate of lead	2, 3	7001	29.0	65	30	5	0	.50	8.00	18.50	3.25	30.75	0	39.50	.00
K	Lime sulfur arsenate of lead.....	1, 2														
	Bordeaux arsenate of lead	3	4111	21.6	68	28	4	0	.25	13.25	14.00	4.75	39.25	0	9.50	1.00
Check	No treatment	none	11862	61.7	65	31	4	0	12.37	63.87	52.00	3.87	53.50	0	.00	.00

EFFECT ON FOLIAGE

During the entire season practically no scab appeared on the foliage of Plats H, I, J, and K. The foliage of all these plats was equally vigorous thruout the entire season, with the exception of a slight amount of Bordeaux injury which appeared on Plats J and K toward the end of the season.

EFFECT ON FRUIT

The apples from these plats were picked, sorted, and examined October 20, 25, and 26, and the results are presented in Table 44.

All sprays controlled scab almost completely, but flyspeck and sooty blotch were not so satisfactorily prevented. Plat H had 20 percent flyspeck and 25.75 percent sooty blotch; Plat I had 9 percent flyspeck and 14 percent sooty blotch; Plat J, 8 percent flyspeck and 18.5 percent sooty blotch; and Plat K, 13.25 percent flyspeck and 14 percent sooty blotch. These results, therefore, indicate that where Bordeaux was used a greater number of times than lime sulfur, the amount of flyspeck and sooty-blotch infection was less. Codling-moth injury was very slight on all these plats, even on the unsprayed row. Curculio injury was reduced to some extent on all sprayed trees as compared with the unsprayed trees.

Plat H, which received Bordeaux for the first spray and lime sulfur for the second and third, showed 17 percent slight russet. By subtracting from this amount 2.25 percent, which was the amount of slight russet shown on Plat A, sprayed three times with lime sulfur, it is found that Bordeaux at the first application caused 14.75 percent slight russet. As may be noted, no russet appeared on the unsprayed row. Plat I, sprayed with Bordeaux for the first and second applications and with lime sulfur for the third, showed 49.5 percent slight russet. Since 14.75 percent slight russet has been attributed to the first application of Bordeaux, this amount deducted from 49.5 percent slight russet leaves 34.75 percent slight russet due to the second Bordeaux and the third lime-sulfur sprays. Sprays 1, 2, and 3 together caused only 2.25 percent injury when lime sulfur was used thruout. Therefore, at least 32.5 percent of the russet may be attributed to the second application of Bordeaux. Plat J showed 39.5 percent slight russet. It has just been stated that 32.5 percent slight russet came from the second application of Bordeaux. By subtracting this amount from 39.5 percent, the amount of slight russet shown on Plat J, it is found that the third application of Bordeaux caused only 7 percent slight russet. Plat K, which received lime sulfur for the first and second applications and Bordeaux for the third, showed 9.5 percent slight russet, 2.25 percent of which was caused by lime sulfur, the balance 7 percent having been caused by Bordeaux. To sum up the discussion on russet, these results show that the greatest amount of russeting

from Bordeaux occurred at the second application, and that a small amount came from both the cluster-bud spray and the spray applied two weeks after the fall of the petals. A negligible amount of lime-sulfur burn occurred on Plats H and K.

Plats H and A produced the highest percentages of No. 1 apples. The fruit from Plat H had the best color, altho the apples from all of these plats had good color and fair finish.

ARSENATE OF LEAD ALONE AS A FUNGICIDE

To determine the fungicidal value of arsenate of lead alone when used primarily as a spray for codling moth, plats were sprayed as follows:

Plat L: Bordeaux arsenate of lead, 1st application; arsenate of lead, 2d and 3d applications.

Plat M: Lime sulfur arsenate of lead, 1st application; arsenate of lead, 2d and 3d applications.

EFFECT ON FOLIAGE

No appreciable amount of scab appeared on the foliage of Plats L and M. The foliage was very vigorous during the entire season, and practically no foliage injury resulted from the use of the sprays.

EFFECT ON FRUIT

The apples from these plats were picked, sorted, and examined October 20 and 25, and the results are presented in Table 45.

These results show that the sprayings given Plats L and M were effective in controlling scab. Plat L had 14 percent flyspeck and 24.5 percent sooty blotch as compared with Plat M with 21 percent flyspeck and 35 percent sooty blotch. It is evident that arsenate of lead applied at the second and third applications had little effect on these diseases. The results seem to show that lime sulfur arsenate of lead and Bordeaux arsenate of lead applied at the first spraying reduced the amount of flyspeck and sooty-blotch infection, but that arsenate of lead alone applied at the second and third applications had little or no fungicidal value.

Codling-moth and curculio infestation was reduced on both plats. Plat L showed 10.5 percent slight russet, and Plat M only 1.25 percent slight russet. It is evident, in the case of Plat L, that the russet was caused by the Bordeaux, which was used at the first application.

The fruit from both Plats L and M had excellent color and finish, exceeding in this respect the apples from any of the other plats in the orchard. It was evident that the arsenate of lead stimulated color. Plat M had 84 percent No. 1's and Plat L, 77 percent of the same grade.

TABLE 45.—EFFECTS OF ARSENATE OF LEAD WITH A FUNGICIDE BEFORE THE BLOOM AND WITHOUT A FUNGICIDE AFTER THE BLOOM, IN THE EXPERIMENTS AT GRIGGSVILLE, 1911

Plat	Treatment	Applications	Total no. picked apples	Total bu. picked apples	Percentage grades			Percentage of picked apples affected by								
								Scab		Flyspeck	Sooty blotch	Codling moth	Curculio	Russet		Burn
					No. 1	No. 2	Culls	Serious	Slight					Serious	Slight	
L	Bordeaux arsenate of lead	1														
	Arsenate of lead alone	2, 3	5760	34.4	77	22	1	0	.00	14.00	24.5	.50	39.00	0	10.50	0
M	Lime sulfur arsenate of lead	1														
	Arsenate of lead alone	2, 3	5519	32.7	84	14	2	0	1.25	21.00	35.0	2.25	35.25	0	1.25	0
Check	No treatment	none	11862	61.7	65	31	4	0	12.37	63.87	52.0	3.87	53.50	0	.00	0

TABLE 46.—EFFECTS OF VARYING QUANTITIES OF COPPER SULFATE WITH LIME SULFUR ARSENATE OF LEAD, IN THE EXPERIMENTS AT GRIGGSVILLE, 1911

Plat	Treatment	Applications	Total no. picked apples	Total bu. picked apples	Percentage grades			Percentage of picked apples affected by								
								Scab		Flyspeck	Sooty blotch	Codling moth	Curculio	Russet		Burn
					No. 1	No. 2	Culls	Serious	Slight					Serious	Slight	
N	Lime sulfur arsenate of lead with 4–100 copper sulfate	1, 2, 3	4652	31.3	80	18	2	0	.00	9.50	8.75	6.75	37.50	0	21.50	.00
O	Lime sulfur arsenate of lead with 8–100 copper sulfate	1, 2, 3	6021	32	73	23	4	0	.00	16.25	20.50	4.25	45.75	0	37.25	.75
P	Lime sulfur arsenate of lead with 12–100 copper sulfate	1, 2, 3	3329	21.8	83	13	4	0	.00	2.75	8.50	1.50	41.75	0	53.00	1.00
A	Lime sulfur arsenate of lead	1, 2, 3	6323	33.5	79	18	3	0	1.00	19.75	23.50	1.00	40.50	0	2.25	1.25
Check	No treatment	none	11862	61.7	65	31	4	0	12.37	63.87	52.00	3.87	53.50	0	.00	.00

ADDING COPPER SULFATE TO LIME SULFUR

To determine the value of adding copper sulfate to lime sulfur, plats were sprayed as follows:

Plat N: Lime sulfur arsenate of lead + 4 pounds of copper sulfate to 100 gallons
Plat O: " " " " + 8 " " " " " " "
Plat P: " " " " +12 " " " " " " "
Plat A: " " " "

EFFECT ON FOLIAGE

When copper sulfate was added to the dilute lime sulfur, the resulting mixture appeared dark brown in color. After drying on the foliage and fruit, it appeared black. The spray was remarkably adhesive, showing noticeably on both fruit and foliage at picking time.

The foliage of Plats N, O, and P was practically free from scab during the entire season. No foliage injury resulted from the use of the sprays. The foliage was by far the best of any in the orchard. It appeared more dense and possessed a darker green color than any other.

EFFECT ON FRUIT

The apples from these plats were picked, sorted, and examined October 24; the results are presented in Table 46.

These results show that all the sprays on Plats N, O, and P controlled scab perfectly. Plat P showed 2.75 percent flyspeck and 8.5 percent sooty blotch, as compared with Plat O with 16.25 percent flyspeck and 20.5 percent sooty blotch, and Plat N with 9.5 percent flyspeck and 8.75 percent sooty blotch. Curculio injury was slightly reduced on all plats. Codling-moth injury was small on the sprayed and unsprayed plats.

The amount of russet on these plats increased with the amount of copper sulfate in one hundred gallons of the sprays. Plat N, with 4 pounds of copper sulfate to 100 gallons, had 21.5 percent slight russet; Plat O, with 8 pounds of copper sulfate to 100 gallons, 37.25 percent slight russet; and Plat P, with 12 pounds of copper sulfate to 100 gallons, 53 percent slight russet. These results show that the amount of russet increased with the amount of copper sulfate in the sprays. This russet differed from ordinary Bordeaux russet, appearing in the form of small dark specks. The amount of lime-sulfur burn on Plats O and P was negligible.

Plat P had 83 percent of No. 1 apples, Plat N, 80 percent, and Plat O, 73 percent. The fruit from all three plats had good color but was a little rough in finish.

SUMMARY OF RESULTS AT GRIGGSVILLE, 1911

1. Conditions at the Griggsville station during 1911 were unfavorable for the development of scab. Unsprayed orchards in this vicinity were practically free from this fungus.

2. Under these conditions, a winter application of lime sulfur was of no value in the control of scab and had no beneficial effect on the trees.

3. Homemade lime sulfur, containing 8 pounds of sulfur in 100 gallons of spray along with 4 pounds of arsenate of lead, proved equal to Bordeaux arsenate of lead, 8-8-4-100, in controlling scab. Bordeaux, however, gave better results than lime sulfur in the control of fly-speck and sooty blotch.

4. Three applications of Bordeaux arsenate of lead caused injury to foliage and russeted the fruit, while lime sulfur arsenate of lead caused practically no russet and no foliage injury.

5. Trees sprayed with lime sulfur arsenate of lead had better foliage and the fruit possessed higher color and finish than those sprayed with Bordeaux arsenate of lead.

6. A light application of Bordeaux caused less foliage injury and russeting of the fruit than a heavy application.

7. Maintaining a coating on fruit and foliage caused no reduction in the amount of injury to either. Applying an 8-100 milk-of-lime to trees sprayed with Bordeaux, as soon as the Bordeaux was dry, did not reduce the amount of injury to foliage, while it did increase the amount of russet on the fruit.

8. Russeting of the fruit resulted from each of the three applications of Bordeaux. Most of the russeting, however, occurred at the second application, which was made immediately after the fall of the petals.

9. Arsenate of lead alone had practically no fungicidal value.

10. Lime-sulfur solutions, to which were added 4, 8, and 12 pounds of copper sulfate to 100 gallons, controlled scab perfectly, and gave a very dense green foliage. The sprays caused considerable russeting of the fruit, the severity varying with the amount of copper sulfate in each.

11. The best colored and best finished apples were produced on the plats which were sprayed with arsenate of lead alone at the second and third applications, indicating that arsenate of lead has a stimulating effect on color.

SPRAYING EXPERIMENTS IN 1912 AT GRIGGSVILLE, PIKE COUNTY

BY ALFRED J. GUNDERSON

OBJECTS

In the spraying work at the Griggsville station during 1912, experiments were conducted to determine the following points: (1) the relative value of lime sulfur and Bordeaux; (2) the value of interchanging lime sulfur and Bordeaux as summer sprays; (3) the fungicidal and insecticidal value of various strengths of copper ferrocyanide; (4) the effect of the addition of arsenate of lead to lime sulfur; and (5) the relative values of various strengths of lime sulfur.

LOCATION AND DESCRIPTION OF ORCHARD

For these experiments the orchard used belonged to Mr. F. Turnbull, located three and one-half miles southeast of Griggsville. Two hundred and six fourteen-year-old trees were chosen, which, with the exception of a few trees of odd varieties, were Ben Davis. The trees were planted thirty-two feet apart each way.

The general vigor of the trees was good, for in previous years they had received some cultivation and pruning. No spraying, however, had ever been done in the orchard; consequently the trees had never produced anything but bulk and cider apples. The fact that the trees had never received any spray assured an infection of scab and insects and offered good conditions for carrying on these experiments.

TREATMENT

The plats in the orchard were treated as shown in the accompanying schedule:

Plat	Application	Treatment
A	1: April 27	Lime sulfur arsenate of lead
	2: May 10	Bordeaux " " "
	3: May 29	" " " "
B	1: April 27	Lime sulfur arsenate of lead
	2: May 9	" " " " "
	3: May 29	Bordeaux " " "
C	1: April 27	Lime sulfur arsenate of lead
	2: May 10	Bordeaux " " "
	3: May 29	Lime sulfur " " "
D	1: April 27	Lime sulfur arsenate of lead
	2: May 9	" " " " "
	3: May 29	" " " " "
E	1: April 27	Bordeaux arsenate of lead
	2: May 9	Lime sulfur " " "
	3: May 29	Bordeaux " " "
F	1: April 27	Bordeaux arsenate of lead
	2: May 10	" " " "
	3: May 29	" " " "

Plat	Application	Treatment
G	1: April 27	Bordeaux arsenate of lead
	2: May 10	Lime sulfur " " "
	3: May 29	" " " " "
H	1: April 27	Bordeaux arsenate of lead
	2: May 10	" " " "
	3: May 29	Lime sulfur " " "
I	1: April 30	Copper ferrocyanide arsenate of lead, 1–1–4–100
	2: May 12	" " " " " 1–1–4–100
	3: May 31	" " " " " 1–1–4–100
J	1: April 30	Copper ferrocyanide arsenate of lead, 1½–1½–4–100
	2: May 12	" " " " " 1½–1½–4–100
	3: May 31	" " " " " 1½–1½–4–100
K	1: April 30	Copper ferrocyanide arsenate of lead, 2–2–4–100
	2: May 12	" " " " " 2–2–4–100
	3: May 31	" " " " " 2–2–4–100
L	1: April 30	Copper ferrocyanide alone, 1–1–100
	2: May 11	" " " 1–1–100
	3: May 31	" " " 1–1–100
M	1: April 30	Copper ferrocyanide alone, 1½–1½–100
	2: May 11	" " " 1½–1½–100
	3: May 31	" " " 1½–1½–100
N	1: April 30	Copper ferrocyanide alone, 2–2–100
	2: May 11	" " " 2–2–100
	3: May 31	" " " 2–2–100
O	1: April 27	Lime sulfur alone
	2: May 10	" " "
	3: May 31	" " "
P	1: April 27	Arsenate of lead alone, 4–100
	2: May 10	" " " " 4–100
	3: May 31	" " " " 4–100
Q	1: April 30	Lime sulfur (1 in 36) arsenate of lead
	2: May 9	" " 1 " 36 " " "
	3: May 31	" " 1 " 36 " " "
R	1: April 30	Lime sulfur (1 in 24) arsenate of lead
	2: May 9	" " 1 " 24 " " "
	3: May 31	" " 1 " 24 " " "
S	1: April 30	Lime sulfur (1 in 14) arsenate of lead
	2: May 9	" " 1 " 14 " " "
	3: May 31	" " 1 " 14 " " "
Check	none	No treatment

In laying out these experiments the trees were divided into twenty-one plats of eight or nine trees each, and a check or unsprayed row was left thru the entire length of the orchard. These plats were grouped, and each group was sprayed as nearly under the same conditions as possible, so that the plats in each group should be strictly comparable.

APPARATUS AND PREPARATION OF MATERIALS

In all cases where Bordeaux was used in these treatments it was made according to the standard formula: 8 pounds copper sulfate and 8 pounds lime to 100 gallons of water. The lime sulfur was made according to the Illinois formula: 50 pounds lime and 100 pounds sulfur, boiled together in 66 gallons of water until all the sulfur was

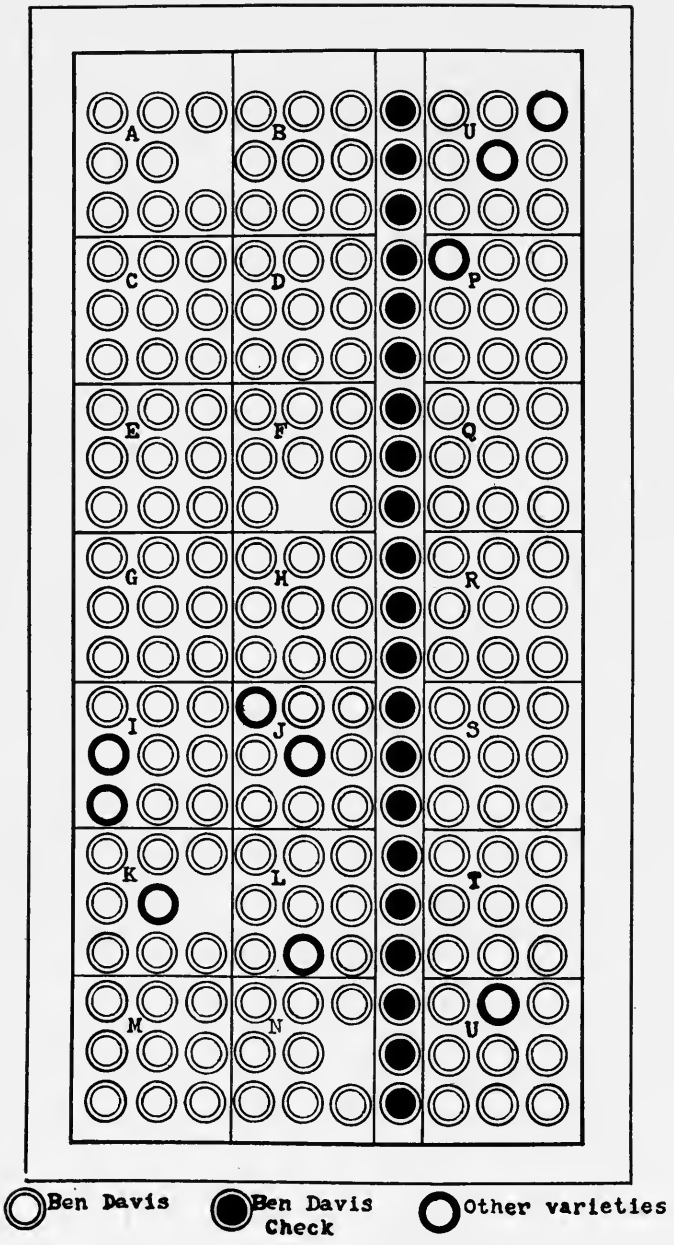

CHART 11.—PLAN OF PLATS IN ORCHARD OF MR. F. TURNBULL, GRIGGSVILLE, 1912

in solution. Unless otherwise stated this was used at the rate of 1 gallon in 18 gallons of water (approximately 8 pounds of sulfur in 100 gallons). Copper ferrocyanide was made from equal amounts of copper sulfate and potassium ferrocyanide, diluted in equal parts of water, and then run together; Grasselli arsenate of lead paste was used at the rate of 4 pounds to 100 gallons of spray.

SPRAY DATES

All sprays were applied with a Friend power spray outfit at 150 to 175 pounds pressure. Double Vermorel nozzles were used. Three applications were made: the first in the cluster-bud stage; the second at the dropping of the petals; and the third about three weeks later.

CHARACTER OF RECORDS AND METHOD OF MAKING

During the season records were kept including the appearance of the foliage thruout the season in regard to fungi, insects, spray injury, and vigor. Dropped apples were counted and examined for various injuries. At picking time four representative trees from each sprayed plat and seven from the unsprayed row were selected and as many of the apples as the sorting table would conveniently hold were taken from all parts of each tree; from these, 200 representative apples were selected and examined carefully. The results from the four trees in each plat were averaged, and the average taken to indicate the value of the treatment. The fruit from the seven unsprayed trees was recorded in like manner. All the apples from each tree in each plat, and from each tree in the check row, were counted, weighed, and graded according to the standard adopted by the Illinois State Horticultural Society.[1]

WEATHER CONDITIONS

The weather during the late spring and early summer was very wet and rather cool. However, at no time after the trees started their growth did the temperature drop below 40 degrees. The trees were in full bloom May 4, and a heavy rain occurred during that night.

RELATIVE VALUE OF LIME SULFUR AND BORDEAUX

As a further test of the relative value of lime sulfur and Bordeaux in this section of the state, plats were again sprayed with these materials as shown in Table 47.

EFFECT ON FOLIAGE

About May 15 the slightly elevated green spots of apple scab began to appear on the foliage of the unsprayed trees. On examining the foliage on Plats D and F, practically no scab was found; this

[1]See footnote, page 60.

was true for the rest of the season, indicating that lime sulfur and Bordeaux were equally effective in their control. This was not true, however, in regard to leaf spot (*Sphaeropsis malorum*), which was more in evidence on the foliage of the trees sprayed with Bordeaux than on the trees sprayed with lime sulfur. The unsprayed trees showed a great deal of leaf spot due to this fungus. A little Bordeaux injury appeared on the foliage in the form of small brown spots about four days after the second application. The trees sprayed with Bordeaux suffered from an epidemic of yellow-leaf June 25, and a second outbreak occurred August 10, reducing the amount of foliage materially. Thruout a considerable part of the season these trees were easily recognized by the scanty development of their leaves. The trees sprayed with lime sulfur, on the other hand, retained a dense, deep green foliage, and showed practically no spray injury at any time during the season.

EFFECT ON FRUIT

The apples from these plats were picked, sorted, and examined on October 14 and 15, with the results presented in Table 47.

Scab.—The data presented show that Bordeaux was slightly superior to lime sulfur in the control of apple scab, but the difference, .15 percent serious and 4.25 percent slight scab, is so slight that the two may be considered to have been equal in efficiency. The unsprayed row showed 68.36 percent serious and 21 percent slight scab, indicating that both Bordeaux and lime sulfur were very effective in the control of this disease. Flyspeck and sooty blotch appeared on the fruit of the unsprayed trees late in September, but the attack, as the records indicate, was not very serious in character. All diseases were well controlled by both lime sulfur and Bordeaux, the latter giving slightly better results.

Codling Moth and Curculio.—The arsenate of lead in both sprays effectively prevented damage from codling moth. The amount of injury done by the plum curculio was reduced from a total of 72.14 percent on the unsprayed trees to 12.12 percent on the lime-sulfur plat and 9.24 percent on the Bordeaux plat. Nearly all of the curculio injury recorded from these sprayed plats was in the form of healed-over egg punctures made by the spring generation of curculio, while most of the injury on the unsprayed trees was caused by the feeding punctures of the new brood.

Russet.—A very important difference between the effects of these sprays upon the fruit is shown in the russet columns. There was 23.4 percent serious and 53.5 percent slight russet on the trees sprayed with Bordeaux, as compared with 1 percent and 12.75 percent injury on the trees sprayed with lime sulfur. Reference to the amount of russet on the unsprayed trees will show that 4.07 percent serious and 11.2 percent slight russet may have been caused by something other

TABLE 47.—EFFECTS OF LIME SULFUR AND BORDEAUX IN COMBINATION WITH ARSENATE OF LEAD, IN THE EXPERIMENTS AT GRIGGSVILLE, 1912

Plat	Treatment	Applications	Total no. picked apples	Total bu. picked apples	Percentage grades			Percentage of picked apples affected by											
								Scab		Fly-speck		Sooty blotch		Codling moth		Curculio		Russet	
					No. 1	No. 2	Culls	Serious	Slight	Serious	Slight	Serious	Slight	Calyx	Side	Serious	Slight	Serious	Slight
D	Lime sulfur arsenate of lead	1, 2, 3	7831	53.0	69	27	4	2.40	7.12	.12	.0	.00	3.87	.00	.12	1.25	10.87	1.00	12.75
F	Bordeaux arsenate of lead	1, 2, 3	2310	14.7	56	33	11	2.25	2.87	.00	.0	.00	.00	.00	.00	2.12	7.12	23.40	53.50
Check	No treatment	none	6448	34.9	5	44	51	68.36	21.00	.14	6.0	2.71	21.07	3.43	1.00	53.57	18.57	4.07	11.20

than the sprays. As these amounts were present on the unsprayed trees, the indications are that the russet on the plat sprayed with lime sulfur was not caused by the spray. By the same reasoning, however, it would appear that 19.33 percent of the serious russet and 42.3 percent of the slight russet, in Plat F, can be attributed to Bordeaux.

On examining these results for the percentage of the different grades of fruits, we note that the lime-sulfur plat had 69 percent No. 1's, 27 percent No. 2's, and 4 percent culls, as compared with the Bordeaux plat with 56, 33, and 11 percent, respectively, of the same grades. The differences were due to Bordeaux russet. There was a marked contrast between the lime-sulfur and the Bordeaux-sprayed apples. Those sprayed with lime sulfur were large and smooth, with a waxy finish and very high color, while those sprayed with Bordeaux were smaller, often badly russeted and distorted, poorly colored, and lacking in finish.

VALUE OF INTERCHANGING LIME SULFUR AND BORDEAUX AS SUMMER SPRAYS

The results just discussed show Bordeaux and lime sulfur to be almost equally efficient as sprays for scab, flyspeck, and sooty blotch, but they indicate that Bordeaux is objectionable because of its injurious effect on the fruit and foliage. Results in previous years indicated that russeting accompanies Bordeaux sprays applied soon after the setting of the fruit. It has been suggested, therefore, that lime sulfur might be substituted for Bordeaux at this critical time, retaining Bordeaux for other sprays. In order to determine the effects of such a substitution, plats were treated as shown in Table 48.

EFFECT ON FOLIAGE

All the sprays controlled apple scab effectively on the foliage. There were, however, differences in the appearance of the foliage as regards spray injury. A few days after the second application, Bordeaux injury made its appearance on Plats A, C, and H. The cool wet weather at this time may have been a factor in causing the injury. The foliage of Plats B, E, and G was in good condition. On June 25, about three weeks after the third application, Bordeaux injury in the form of yellow leaves appeared on Plats A, B, and E, and on August 10 a second outbreak appeared. This so greatly reduced the amount of foliage on Plat E that the trees resembled those sprayed at all applications with Bordeaux. Plat E did not recover from this attack and retained only a scanty supply of leaves for the rest of the season. Plat A was affected in much the same manner. Plats B, C, G, and H recovered from the injury and took on a good foliage for the remainder of the season. It was evident that the fewer the sprays of Bordeaux the plats received, the less was the resulting foliage injury.

EFFECT ON FRUIT

The apples from these plats were picked, sorted, and examined October 14 to 16. The data as presented in Table 48 show that the treatments given Plats E, G, and H were the most effective in controlling scab, Plats A, B, and C having the greatest amount. The former three, as may be noted, were sprayed the first time with Bordeaux, and the latter three with lime sulfur. All the plats in this series were sprayed first on April 27, and on the next day four inches of cold-beating rain fell. It is probable that less of the Bordeaux was washed off than of the lime sulfur, the former being more adhesive, and that the superior efficiency of Bordeaux in controlling scab may have been due to its greater adhesiveness.

A small amount of flyspeck or sooty blotch was found on Plats A, B, and C. On all plats codling-moth and curculio injury were reduced materially.

The largest important differences occur in the amount of russet found on the different plats. It is a question as to how long after the petals have fallen applications of Bordeaux will cause russet.[1] An examination of the results for Plat G, where Bordeaux was used only at the first or cluster-bud spray, shows 17.87 percent serious russet and 37.12 percent slight russet. Plat C, where Bordeaux was used only at the time of the second application, immediately after the bloom, showed 3.89 percent serious russet and 34.9 percent slight. Plat B, where Bordeaux was used for only the third application, three weeks after the fall of the bloom, showed 4.7 percent serious russet and 44.3 slight. It is to be observed, however, that on the unsprayed row 4.07 percent serious russet appeared and 11.2 percent slight. The true effects of the sprays are determined, therefore, by subtracting the amounts of russet on the unsprayed trees from those on the sprayed trees. In doing this for Plat G, it was found that Bordeaux applied at the cluster-bud stage actually caused 13.8 percent serious russet and 25.92 percent slight; that Plat C, sprayed with Bordeaux immediately after the bloom, showed 23.7 slight russet; and that Plat B, sprayed with Bordeaux three weeks after the bloom, showed 33.1 percent slight russet. From these results it may be concluded that where Bordeaux was applied just before the bloom, just after the fall of the petals, or within three weeks after their fall, russet was the most important factor in reducing the percentage of No. 1 apples. The more seldom Bordeaux was used and the more often lime sulfur was used, the better the color, finish, and smoothness of the fruit.

FUNGICIDAL AND INSECTICIDAL VALUE OF VARIOUS STRENGTHS OF COPPER FERROCYANIDE

To test the fungicidal and insecticidal value of copper ferrocyanide at different strengths, plats were treated as shown in Table 49.

[1] U. P. Hedrick, N. Y. (Geneva) Agr. Exp. Sta. Bul. 287, p. 163.

TABLE 48.—EFFECTS OF BORDEAUX FOR SOME APPLICATIONS AND LIME SULFUR FOR OTHER APPLICATIONS, IN THE EXPERIMENTS AT GRIGGSVILLE, 1912

Plat	Treatment	Applications	Total no. picked apples	Total bu. picked apples	Percentage grades			Percentage of picked apples affected by											
								Scab		Fly-speck		Sooty blotch		Codling moth		Curculio		Russet	
					No. 1	No. 2	Culls	Serious	Slight	Serious	Slight	Serious	Slight	Calyx	Side	Serious	Slight	Serious	Slight
A	Lime sulfur arsenate of lead	1																	
	Bordeaux arsenate of lead	2, 3	5687	38.2	59	33	8	6.50	8.00	.00	.0	.00	.25	.25	.12	3.30	11.50	6.87	50.50
B	Lime sulfur arsenate of lead	1, 2																	
	Bordeaux arsenate of lead	3	4632	30.7	65	29	6	2.66	5.83	.00	.0	.66	6.33	.00	.00	3.33	15.00	4.70	44.30
C	Lime sulfur arsenate of lead	1, 3																	
	Bordeaux arsenate of lead	2	6153	41.1	59	31	10	8.60	8.40	.12	.0	.00	1.40	.00	.00	2.40	16.40	3.89	34.90
D	Lime sulfur arsenate of lead	1, 2, 3	7831	53.0	69	27	4	2.40	7.12	.12	.0	.00	3.87	.00	.12	1.25	10.87	1.00	12.75
E	Bordeaux arsenate of lead	1, 3																	
	Lime sulfur arsenate of lead	2	5429	37.5	72	23	5	.87	4.25	.00	.0	.00	.00	.00	.00	1.12	6.75	11.00	43.00
F	Bordeaux arsenate of lead	1, 2, 3	2310	14.7	56	33	11	2.25	2.87	.00	.0	.00	.00	.00	.00	2.12	7.12	23.40	53.50
G	Bordeaux arsenate of lead	1																	
	Lime sulfur arsenate of lead	2, 3	3423	26.8	70	23	7	.63	1.25	.00	.0	.00	.00	.00	.00	1.00	8.60	17.87	37.12
H	Bordeaux arsenate of lead	1, 2																	
	Lime sulfur arsenate of lead	3	3820	30.5	66	26	8	.75	1.00	.00	.0	.00	.00	.00	.12	2.90	11.62	20.87	46.10
Check	No treatment	none	6448	34.9	5	44	51	68.36	21.00	.14	6.0	2.71	21.07	3.43	1.00	53.57	18.57	4.07	11.20

NOTE.—Plats D and F are included in the table for convenient reference only.

EFFECT ON FOLIAGE

Apple scab appeared on the foliage of all the sprayed plats about the time it appeared on the unsprayed row, and caused severe damage thruout the season. On Plats I, J, and K, which were sprayed with copper ferrocyanide arsenate of lead, the amounts of scab, leaf spot, and insect work on the foliage were not as severe as on Plats L, M, and N, where the arsenate of lead was omitted. This indicates that the arsenate of lead not only possessed insecticidal but also some fungicidal value. There was a striking difference between the retention of the foliage of Plats I and L, due seemingly to the use or omission of arsenate of lead. From these results it appeared that arsenate of lead possessed considerable value, directly or indirectly, as a fungicide. Toward the end of the season, Plats L, M, and N were completely defoliated, and could not be distinguished from the unsprayed trees. Copper ferrocyanide alone, in the three strengths tested and under the conditions which prevailed in the experimental work at Griggsville in 1912, had practically no value as a fungicide or insecticide on apple foliage. This spray lacked adhesiveness and was easily washed off by rains. The addition of arsenate of lead may have increased its adhesiveness, a possibility that may explain to some extent the better control of fungi in Plats I, J, and K. Some foliage injury in the form of brown spots appeared on all plats about June 25. This injury was visible during the remainder of the season.

EFFECT ON FRUIT

The apples from these plats were picked, sorted, and examined October 16 to 18. From the results presented in Table 49 we learn that copper ferrocyanide when used alone at these three strengths has very little value, if any, as a spray for scab. These sprays, however, considerably reduced flyspeck and sooty blotch, altho they had no effect on codling moth and but little on curculio. In Plats I, J, and K, where arsenate of lead was used, it will be noted that the sprays reduced scab, flyspeck, and sooty blotch considerably. This reduction was probably due in some manner to the arsenate of lead. The arsenate of lead of the sprays also controlled codling moth and, to some extent, curculio. The percentage of No. 1 fruit on Plats L, M, and N, where no arsenate of lead was used, hardly more than equaled that on the unsprayed row, while for Plats I, J, and K, where arsenate of lead was used in combination with copper ferrocyanide, the percentage of No. 1 fruit was strikingly higher. The percentage of No. 2's and culls was less where arsenate of lead was used. The fruit from Plats L, M, and N resembled that from the unsprayed row, for it was small, scabby, badly damaged by insects, and lacked color. The apples began dropping prematurely, as did the foliage, because of serious fungous and insect injuries. The fruit from Plats I, J, and K took on an

TABLE 49.—EFFECTS OF VARIOUS DILUTIONS OF COPPER FERROCYANIDE WITH AND WITHOUT ARSENATE OF LEAD, IN THE EXPERIMENTS AT GRIGGSVILLE, 1912

Plat	Treatment	Applications	Total no. picked apples	Total bu. picked apples	Percentage grades			Percentage of picked apples affected by											
								Scab		Flyspeck		Sooty blotch		Codling moth		Curculio		Russet	
					No. 1	No. 2	Culls	Serious	Slight	Serious	Slight	Serious	Slight	Calyx	Side	Serious	Slight	Serious	Slight
I	Copper ferrocyanide arsenate of lead (1–1–4–100)	1, 2, 3	7466	43.4	27	54	19	37.10	23.3	.00	.00	.12	1.60	.00	.00	2.10	7.00	2.10	6.50
L	Copper ferrocyanide without arsenate of lead (1–1–100)...	1, 2, 3	4140	24.0	8	60	32	51.50	23.0	.12	2.00	.75	15.12	3.12	1.25	27.00	17.30	3.50	7.00
J	Copper ferrocyanide arsenate of lead (1½–1½–4–100) ...	1, 2, 3	7303	44.5	30	52	18	32.50	23.5	.00	.00	.00	.62	.00	.00	1.80	8.80	2.00	3.40
M	Copper ferrocyanide without arsenate of lead (1½–1½–100)	1, 2, 3	3903	24.6	6	63	31	45.00	29.0	.00	1.75	.12	11.60	2.40	.60	47.00	18.00	2.60	4.90
K	Copper ferrocyanide arsenate of lead (2–2–4–100)	1, 2, 3	7190	43.6	27	55	18	44.00	17.5	.00	.00	.12	2.00	.00	.00	3.10	9.25	.90	3.25
N	Copper ferrocyanide without arsenate of lead (2–2–100)...	1, 2, 3	3490	21.7	4	64	32	57.00	24.0	.00	1.00	.25	11.90	10.80	2.10	40.30	18.50	3.00	9.50
Check	No treatment	none	6448	34.9	5	44	51	68.36	21.0	.14	6.00	2.71	21.07	3.43	1.00	53.57	18.57	4.07	11.20

excellent color, tho it was small and scabby. The arsenate of lead had a stimulating effect on color.

It must be concluded, therefore, that under the conditions which prevailed in the Griggsville experiments in 1912, copper ferrocyanide, as a summer spray, was practically useless.

EFFECT OF THE ADDITION OF ARSENATE OF LEAD TO LIME SULFUR

The addition of arsenate of lead to lime-sulfur solution causes a chemical reaction which changes the composition of a small amount of each.[1] It is also known that the addition of arsenate of lead to lime sulfur affects the fungicidal value of that spray.[1] To determine the effect of the addition of arsenate of lead to lime sulfur under the conditions existing in this part of the state, three plats were treated as shown in Table 50.

EFFECT ON FOLIAGE

On the foliage of Plat O, which was sprayed with lime sulfur alone, there was a slight infection of scab, but on the foliage of Plat P, sprayed with arsenate of lead alone, there was considerable infection, tho less severe than on the check row. The foliage of Plat D, sprayed with lime sulfur arsenate of lead, showed practically no scab. There was some leaf spot on Plats O and P, but Plat D showed almost no infection with this fungus. The addition of arsenate of lead to lime sulfur apparently increased the fungicidal value of that spray.

There was some insect work on the foliage of Plat O due to the absence of arsenate of lead, and the leaves were not so deeply colored as those on the trees of Plats P or D. Plat P showed a little foliage injury in the form of brown edges and tips, but the amount was almost negligible.

EFFECT ON FRUIT

The apples from these plats were picked, sorted, and examined October 11 to 12. The results as presented in Table 50 show that lime sulfur when used alone controlled scab very effectively on the fruit. Of the apples sprayed with arsenate of lead alone, 37.5 percent were infected with serious scab, and 31.5 percent with slight scab. Arsenate of lead, however, increased the fungicidal value of lime sulfur, for in comparing the results for scab on Plat O, sprayed with lime sulfur alone, and Plat D, sprayed with lime sulfur and arsenate of lead, we note a small difference in favor of the latter plat. There was a little more flyspeck and sooty blotch on Plat O than on Plat P, owing possibly to the fact that Plat O was located in a slightly lower part of the orchard.

Arsenate of lead controlled codling moth perfectly, while lime sulfur had no effect upon it. In curculio injury a decided reduction may be noted in all sprayed plats as compared with the check row.

[1] E. Wallace, N. Y. (Cornell) Agr. Exp. Sta. Bul. 289, p. 146.

TABLE 50.—EFFECTS OF LIME SULFUR AND ARSENATE OF LEAD USED SEPARATELY AND IN COMBINATION, IN THE EXPERIMENTS AT GRIGGSVILLE, 1912

Plat	Treatment	Applications	Total no. picked apples	Total bu. picked apples	Percentage grades			Percentage of picked apples affected by											
								Scab		Fly-speck		Sooty blotch		Codling moth		Curculio		Russet	
					No. 1	No. 2	Culls	Serious	Slight	Serious	Slight	Serious	Slight	Calyx	Side	Serious	Slight	Serious	Slight
O	Lime sulfur alone.....	1, 2, 3	7718	57.7	59	32	9	4.00	11.75	.00	2.0	.00	8.25	6.00	.90	16.50	23.00	1.50	8.40
P	Arsenate of lead alone...	1, 2, 3	6478	41.2	25	62	13	37.50	31.50	.00	.0	.00	.12	.00	.00	9.75	14.25	.50	5.10
D	Lime sulfur arsenate of lead	1, 2, 3	7831	53.0	69	27	4	2.40	7.12	.12	.0	.00	3.87	.00	.12	1.25	10.87	1.00	12.75
Check	No treatment	none	6448	34.9	5	44	51	68.36	21.00	.14	6.0	2.71	21.07	3.43	1.00	53.57	18.57	4.07	11.20

TABLE 51.—EFFECTS OF VARIOUS DILUTIONS OF LIME SULFUR, IN THE EXPERIMENTS AT GRIGGSVILLE, 1912

Plat	Treatment	Applications	Total no. picked apples	Total bu. picked apples	Percentage grades			Percentage of picked apples affected by											
								Scab		Fly-speck		Sooty blotch		Codling moth		Curculio		Russet	
					No. 1	No. 2	Culls	Serious	Slight	Serious	Slight	Serious	Slight	Calyx	Side	Serious	Slight	Serious	Slight
Q	Lime sulfur arsenate of lead, 4 pounds sulfur to 100 gallons	1, 2, 3	6631	43.4	75	20	5	1.40	9.90	.00	.0	.00	.00	.00	.12	.62	7.26	1.10	12.75
R	Lime sulfur arsenate of lead, 6 pounds sulfur to 100 gallons	1, 2, 3	9805	63.5	72	22	6	2.60	7.40	.00	.0	.00	.50	.00	.00	1.40	11.00	1.10	9.30
D	Lime sulfur arsenate of lead, 8 pounds sulfur to 100 gallons	1, 2, 3	7831	53.0	69	27	4	2.40	7.12	.12	.0	.00	3.87	.00	.12	1.25	10.87	1.00	12.75
S	Lime sulfur arsenate of lead, 10 pounds sulfur to 100 gallons	1, 2, 3	5288	38.8	86	12	2	.12	1.00	.00	.0	.00	.00	.00	.00	.90	8.40	2.75	13.90
Check	No treatment	none	6448	34.9	5	44	51	68.36	21.00	.14	6.0	2.71	21.07	3.43	1.00	53.57	18.57	4.07	11.20

The reduced amount of injury on Plat P was due to the arsenate of lead. Just why the amount of curculio injury on Plat O was reduced in comparison to what appeared on the unsprayed row would be difficult to explain, and yet it is important. Apparently the lime sulfur acted as a repellent.

Scab reduced the percentage of No. 1 apples in Plat P, sprayed with arsenate of lead alone, in comparison with Plat O, where lime sulfur alone was used. The fruit from Plat P had a better color and smoother finish than that from Plat O. Arsenate of lead again showed a stimulating effect on color and finish.

RELATIVE VALUES OF VARIOUS STRENGTHS OF LIME SULFUR

In the preceding experiments in which lime sulfur was used, the amount of sulfur in solution was approximately 8 pounds to each 100 gallons of spray. To determine the efficiency of various strengths of homemade lime sulfur, four plats were treated as shown in Table 51.

EFFECT ON FOLIAGE

All the sprays held both scab and leaf spot in check; there was practically no scab during the entire season on all four plats. The foliage was similar in appearance,—very dense, and dark green in color. The different sprays had a decidedly stimulating effect on the size and smoothness of the leaves, and caused almost no injury. The foliage of the sprayed plats remained on the trees until after November 7, while that of the unsprayed row was completely gone by October 10. The retention of this dense green foliage so late in the season seemed to increase the size and vigor of the fruit buds, as the difference in size between the buds on these plats and those on the plats which suffered considerable foliage injury from spray was very apparent.

EFFECT ON FRUIT

The apples from these plats were picked, sorted, and examined October 9 to 11. The results as presented in Table 51 show that the spray given Plat S controlled scab on the fruit almost perfectly, there being but .12 percent severe scab and 1 percent slight scab. Plats Q, R, and D show about the same percentages of scab, only slightly more than Plat S. Flyspeck was controlled on all plats except Plat D, where the injury was negligible. All sprays controlled sooty blotch with the exception of those used on Plats D and R, where the infection was very slight. Codling-moth control was almost perfect on all plats. Injury from curculio was reduced materially by all the sprays. All plats produced a high percentage of No. 1 fruit, Plat S the highest.

The fruit from all these plats took on a very high color and a smooth waxy finish and was of good size. The apples on Plat S seemed to have a deeper and better distributed color than those on the other

plats. On all plats the stimulating effects of lime sulfur and arsenate of lead on the color and smoothness of the fruit was further demonstrated. These plats were the best of any in the orchard on account of the freedom of the fruit from fungi and insects, the large size, high color, and smoothness of the fruit, and the heavy, dense green foliage.

SUMMARY OF RESULTS AT GRIGGSVILLE, 1912

1. Homemade lime sulfur containing 8 pounds of sulfur and 4 pounds of arsenate of lead to 100 gallons proved equal to Bordeaux arsenate of lead, 8-8-4-100, as a spray for apple scab, and the two sprays were practically equal in their control of flyspeck and sooty blotch.

2. Three applications of Bordeaux arsenate of lead caused severe injury to foliage and badly russeted the fruit, while lime sulfur arsenate of lead did not injure the foliage seriously nor russet the fruit.

3. Lime sulfur arsenate of lead had an invigorating effect on the foliage and a stimulating effect on the color and size of the fruit, besides giving it a very waxy finish.

4. Some russeting of the fruit resulted from each of the three applications of Bordeaux.

5. Bordeaux injury to fruit and foliage developed under cool, wet conditions.

6. The severe foliage injury caused by Bordeaux had a detrimental effect on the development of the next-year's fruit buds. The buds on lime-sulfur trees were large, plump, and well developed, while the buds on the trees sprayed with Bordeaux were smaller and apparently not so well developed.

7. Copper ferrocyanide proved practically useless as a fungicide or insecticide.

8. Lime sulfur arsenate of lead was slightly more effective in controlling scab, flyspeck, and sooty blotch than lime sulfur alone. The arsenate of lead may have increased the adhesiveness of the lime sulfur.

9. Fruit sprayed with arsenate of lead alone had a higher color than that sprayed with lime sulfur alone, indicating that arsenate of lead stimulates color.

10. Arsenate of lead alone had some fungicidal value and caused but a negligible amount of foliage injury.

11. Various strengths of homemade lime sulfur containing 4, 6, 8, and 10 pounds of sulfur together with 4 pounds of arsenate of lead to 100 gallons, controlled scab, flyspeck, and sooty blotch effectively, and gave excellent foliage and highly colored, large, smooth fruit. The 10-pound strength (10-100) was the most efficient, controlling scab almost perfectly; less than 2 percent of the fruit was infected with scab; and the color of the fruit was deeper and better distributed.

GENERAL SUMMARY

By B. S. PICKETT

In this summary the writer has attempted to answer the questions presented in the introduction (pages 50 and 51), to point out certain facts which are not specifically mentioned in the questions referred to, and to make recommendations for the general spraying of apple orchards in Illinois. Where the material would permit, results from the various experiments are tabulated for convenient reference. The data answering several of the questions, however, could not be tabulated advantageously, and such results are presented in the form of brief summaries or statements from the annual reports of the individual experiments.

SUMMARY OF DATA

1. *What is the general effectiveness of applications of standard spray mixtures, including Bordeaux, lime sulfur, and arsenate of lead in the control of fungi and insects on the apple?*

No fact stands out more distinctly in a study of the data presented in the reports included in this bulletin than the general effectiveness of spraying over no spraying. Even under the most unfavorable circumstances, some degree of benefit has resulted from the application of all of the standard sprays in every series of experiments and in every year of the experimentation. Year after year the sprayed plats have been conspicuous by their more healthy and vigorous foliage and by the freedom of their fruit from insects and diseases. Of necessity the benefits from spraying have varied more or less from season to season. In 1911 both diseases and insects were conspicuous by their comparative absence. Even unsprayed orchards produced considerable fruit of good quality. Under such conditions the best possible effects of sprays are not fully demonstrated. Nevertheless, even in 1911, spraying proved its superiority over failure to spray in every case experimented upon.

Tables 52 and 53 present the general results of four years' experimentation in an attempt to answer the above question. Every result thruout the reports previously presented which bears directly upon this subject has been included in these tabulations.

It will be seen from Table 52 that the smallest control exercised over apple scab as a result of spraying at least three times with Bordeaux or Bordeaux in combination with arsenate of lead amounts to 67 percent, and that the largest control amounts to 98 percent. In six experiments out of ten, 90 percent or over of all the scab which might have appeared in the sprayed plats was prevented as a result of spraying with Bordeaux or Bordeaux in combination with arsenate of lead.

TABLE 52.—GENERAL EFFECTS OF THE STANDARD FUNGICIDES, BORDEAUX AND LIME SULFUR

Fungicide	Year	Place	Experimenter	Table	Percentage of fruit saved from scab by spray	Percentage scab controlled as compared with checks
Bordeaux	'09	Griggsville	L.E.F.	26	47 to 56	75 to 90
Bordeaux	'11	Neoga	O.S.W.	6	51 to 61	67 to 80
Bordeaux	'11	Neoga	O.S.W.	7	67	79
Bordeaux	'11	Centralia	L.E.F.	28	37 to 43	84 to 98
Bordeaux	'11	Griggsville	A.J.G.	41	12	98
Bordeaux	'12	Neoga	O.S.W.	14	72 to 87	73 to 88
Bordeaux	'12	Flora	W.A.R.	21	14	93
Bordeaux	'12	Anna	L.E.F.	30	33 to 34	87 to 90
Bordeaux	'12	Anna	L.E.F.	31	57 to 71	70 to 87
Bordeaux	'12	Griggsville	A.J.G.	47	66	97
Lime sulfur	'09	Griggsville	L.E.F.	24	17 to 56	19 to 60
Lime sulfur	'10	Neoga	O.S.W.	1	6 to 85	6 to 85
Lime sulfur	'11	Neoga	O.S.W.	6	25 to 48	33 to 63
Lime sulfur	'11	Neoga	O.S.W.	7	55	65
Lime sulfur	'11	Centralia	L.E.F.	28	39 to 40	89 to 91
Lime sulfur	'11	Griggsville	A.J.G.	41	11	91
Lime sulfur	'11	Griggsville	A.J.G.	46	11 to 12	91 to 100
Lime sulfur	'12	Neoga	O.S.W.	14	72 to 84	72 to 84
Lime sulfur	'12	Neoga	O.S.W.	17	41 to 52	45 to 57
Lime sulfur	'12	Flora	W.A.R.	21	15	100
Lime sulfur	'12	Anna	L.E.F.	30	26 to 34	70 to 92
Lime sulfur	'12	Anna	L.E.F.	31	51 to 65	62 to 80
Lime sulfur	'12	Anna	L.E.F.	33	39 to 56	47 to 67
Lime sulfur	'12	Griggsville	A.J.G.	47	70	80
Lime sulfur	'12	Griggsville	A.J.G.	51	78 to 88	88 to 99

Lime sulfur exercised varying degrees of control, running from as low as 6 percent to as high as 100 percent. In two experiments out of fifteen, 100 percent control was obtained. In six experiments out of fifteen, lime sulfur exercised a control running above 90 percent. In five cases this fungicide prevented less than 50 percent of the possible damage from apple scab. In no single case, however, did it fail to exercise some control over this fungus, and in those experiments where the poorest control was obtained, certain plats showed an effectiveness varying from 57 to 85 percent.

In the twenty-nine experiments included in Table 53, arsenate of lead did not fail to exercise some degree of control over codling moth and curculio in some one or more of the plats included in each of the experiments. In four cases, however, certain sprayed plats in the experiment showed more injury than the check plats. It will be observed, however, that in every one of these four cases the total infestation of codling moth was very small, the largest loss due to failure of the spray to control the insect amounting to 3 percent of the entire crop. Under the circumstances in which these slightly inconsistent results appear, the inconsistency must be attributed to unequal infection rather than to ineffectiveness of the spray.

TABLE 53.—GENERAL EFFECT OF THE STANDARD INSECTICIDE, ARSENATE OF LEAD, ALONE OR IN COMBINATION WITH VARIOUS FUNGICIDES

Year	Place	Experimenter	Table	Percentage of fruit saved from codling moth	Percentage of control of codling moth compared with check	Percentage of fruit saved from curculio	Percentage of control of curculio compared with checks
'09	Griggsville	L.E.F.	23	5 to 12	100	21 to 35	21 to 43
'09	Griggsville	L.E.F.	25	14	82	No control	
'09	Griggsville	L.E.F.	26	17 to 19	85 to 95	25 to 30	27 to 32
'09	Griggsville	L.E.F.	27	4 to 18	33 to 95	10 to 50	10 to 64
'10	Neoga	O.S.W.	1	20 to 28	71 to 100	62 to 85	62 to 85
'10	Neoga	O.S.W.	4	10 to 26	36 to 93	32 to 80	32 to 80
'10	Neoga	O.S.W.	5	14 to 25	50 to 89	46 to 81	46 to 81
'11	Neoga	O.S.W.	10	−2 to 1	−33 to 17	−1 to 6	−17 to 100
'11	Neoga	O.S.W.	11	5 to 16	31 to 100	−4 to 12	−27 to 80
'11	Centralia	L.E.F.	28	7.8	65	0 to 14	0 to 88
'11	Griggsville	A.J.G.	41	2 to 3	42 to 74	13 to 34	24 to 61
'11	Griggsville	A.J.G.	42	−2 to 3	−50 to 75	11 to 24	20 to 44
'11	Griggsville	A.J.G.	43	0 to 3.5	0 to 90	24 to 33	44 to 61
'11	Griggsville	A.J.G.	44	−1 to 3	−25 to 75	14 to 24	26 to 44
'11	Griggsville	A.J.G.	45	2 to 3	50 to 75	15 to 18	28 to 34
'11	Griggsville	A.J.G.	46	−3 to 3	−75 to 75		
'12	Anna	L.E.F.	30	1 to 18	2 to 36	12 to 19	32 to 51
'12	Anna	L.E.F.	31	24 to 28	86 to 93	4 to 19	11 to 51
'12	Anna	L.E.F.	35	16 to 32	34 to 63	17 to 19	46 to 51
'12	Anna	L.E.F.	36	16 to 27	53 to 90	−13 to 5	−35 to 16
'12	Anna	L.E.F.	37	2 to 18	4 to 38	−5 to 13	−14 to 35
'12	Anna	L.E.F.	38	18 to 24	60 to 80	8 to 14	22 to 38
'12	Anna	L.E.F.	39	2 to 24	4 to 51	5 to 19	14 to 51
'12	Anna	L.E.F.	40	18 to 27	60 to 90	4 to 8	8 to 16
'12	Griggsville	A.J.G.	47	3.43	100	60 to 63	83 to 88
'12	Griggsville	A.J.G.	48	3.2 to 3.4	93 to 100	53 to 64	74 to 89
'12	Griggsville	A.J.G.	49	3.43	100	60 to 63	83 to 88
'12	Griggsville	A.J.G.	50	3.43	100	48 to 60	67 to 83
'12	Griggsville	A.J.G.	51	3.43	100	60 to 64	83 to 89

The general effectiveness of the spray will be seen when it is noted that in fifteen experiments of the twenty-nine tabulated, 90 percent or better control of the codling moth was obtained in some of the plats included.

Curculio was less thoroly controlled by arsenate of lead than was codling moth. Nevertheless in only six of the experiments were there any plats which failed to show some degree of prevention of injury by reason of the application of the spray. Eleven experiments out of the twenty-nine included some plats in which 80 percent or more of the injury was prevented by the application of the spray.

2. *What are the relative values of Bordeaux and lime sulfur as sprays for the apple?*

Table 54 presents a summary of the comparative values of Bordeaux and lime sulfur in the various experiments during 1909-12.

TABLE 54.—COMPARATIVE EFFECTIVENESS OF BORDEAUX AND LIME SULFUR AS SUMMER SPRAYS FOR APPLES

Year	Place	Experimenter	Page	Lime sulfur compared with Bordeaux	As regards
'09	Griggsville	L.E.F.	121–124	Inferior	Scab on fruit
'10	Neoga	O.S.W.	61–62	Inferior	Scab on foliage
			62	Superior	Vigor and abundance of foliage
'10	Centralia	L.E.F.	128	Equal	Scab on foliage
			128	Superior	Spray injury to foliage
'11	Neoga	O.S.W.	75–87	Inferior	Scab on fruit
			75–77	Inferior	Color of fruit
			74	Inferior	Spray injury to foliage
'11	Centralia	L.E.F.	138	Superior	Russeting of fruit
			133–134, 138	Superior	Vigor and abundance of foliage, spray injury to foliage
			134–137	Inferior	Scab, blotch, and sooty blotch on fruit
'11	Griggsville	A.J.G.	161–162	Equal	Scab on fruit
			161–162	Inferior	Flyspeck and sooty blotch on fruit
			161–163	Superior	Russeting, color, and finish of fruit
			160–161	Equal	Scab on foliage
			160–161	Superior	Vigor and abundance of foliage
'12	Neoga	O.S.W.	94	Inferior	Scab on fruit
			94	Inferior	Amount of surface colored
			94	Superior	Finish of fruit
			94	Equal	Yield of No. 1 apples
			92	Inferior	Scab on foliage
'12	Flora	W.A.R.	111	Equal	Scab on fruit
			116	Superior	Spray injury to foliage
			117	Superior	Russeting of fruit
			111	Inferior	Blotch on fruit
			108	Equal	Scab on foliage
			108–111	Superior	Injury to foliage
'12	Anna	L.E.F.	145	Inferior	Scab and sooty blotch on Jonathan apples
			145	Inferior	Scab and sooty blotch on Winesap apples
			145	Superior	Russet of Jonathan apples
			148	Superior	Russet of Winesap apples
			143	Superior	Injury to foliage
'12	Griggsville	A.J.G	176	Inferior	Scab, sooty blotch, and flyspeck of fruit
			176–178	Superior	Russet on fruit
			178	Superior	Color, size, finish, and grading of fruit
			175	Equal	Scab on foliage
			176	Superior	Leaf spot

From the above tabulation it will be seen that Bordeaux has in most of the experiments proved superior to lime sulfur as a fungicide.

In six different experiments Bordeaux proved superior to lime sulfur in the control of scab on the fruit; in two experiments the fungicides were equal in this respect. Lime sulfur, however, was not superior in any case. In two experiments Bordeaux proved superior to lime sulfur in the control of scab on the foliage. In four experiments the control of scab on the foliage was equal. Lime sulfur was in no case superior to Bordeaux in the control of scab on the foliage. In six experiments Bordeaux was superior to lime sulfur in the control of blotch, sooty blotch, and flyspeck fungi. In no case was lime sulfur superior or equal to Bordeaux in the control of these diseases. In only one experiment is lime sulfur reported as showing a control superior to Bordeaux on a fungous disease of the foliage. In the experiments at Griggsville in 1912, leaf spot *(Sphaeropsis malorum)* was more in evidence on the trees sprayed with Bordeaux than on the trees sprayed with lime sulfur.

Lime sulfur, however, proved superior to Bordeaux in the majority of the experiments in respect to spray injury to the foliage and fruit. In nearly all cases the foliage on the trees sprayed with lime sulfur was more vigorous than the foliage on the Bordeaux-sprayed trees, and in most cases the lime-sulfur-sprayed fruit was of superior finish and color.

In seven experiments out of nine, lime sulfur proved superior to Bordeaux in its effect on the vigor and abundance of foliage or in its effect on spray injury. In 1911 in the Neoga experiments, lime sulfur proved inferior to Bordeaux in relation to spray injury to the foliage, and in 1912 at the same place, the vigor and abundance of foliage on the lime-sulfur and Bordeaux-sprayed plats were equal. In five experiments lime sulfur was superior to Bordeaux as regards russeting of the fruit. With the exception of the experiments at Neoga in 1911 and 1912, lime-sulfur-sprayed fruit was more brightly colored and more attractive in appearance than Bordeaux-sprayed fruit. In reporting on the experiments at Neoga in 1911 and 1912, O. S. Watkins, in charge of these experiments, calls attention to the fact that while lime-sulfur-sprayed apples had a higher finish and brighter color than Bordeaux-sprayed apples, the color was not distributed over so much of their surface as in the Bordeaux-sprayed apples. He concludes that the Bordeaux-sprayed apples had more color as a whole than the lime-sulfur-sprayed apples, tho this color was not so attractive, especially as the apples hung on the trees. The general conclusion, however, which must be derived from a summary of all the results, is that the lime-sulfur-sprayed apples were enough more attractive than the Bordeaux-sprayed apples to give them a higher commercial value on the market. With two exceptions lime-sulfur-sprayed apples graded a larger proportion of No. 1 fruit than Bordeaux-sprayed apples, and in one of the exceptional cases the grading

of the two was equal. In the experiment at Neoga in 1911 lime-sulfur-sprayed apples graded lower than Bordeaux-sprayed apples.

The results of the comparisons of Bordeaux and lime sulfur indicate, therefore, a greater efficiency for Bordeaux as a fungicide but, combined with its excellent fungicidal properties, serious tendencies to injure fruit and foliage as a result of its application. Lime sulfur, on the other hand, exercised a fair degree of control of fungi and caused little damage to fruit or foliage. The comparative value of the two sprays varied somewhat from year to year. In 1911 lime sulfur caused considerable injury to fruit as a result of lime-sulfur burn, and was slightly less efficient as a fungicide than Bordeaux. In 1912 lime sulfur proved to be the most desirable spray in every series of experiments except those performed at Neoga, where it was to all intents and purposes equal to Bordeaux.

It must be concluded from these observations that Bordeaux and lime sulfur, properly used, are both excellent sprays for the apple. Where fungous diseases are known to be serious, as in orchards which have long been neglected, the orchardist should use the stronger fungicide, viz., Bordeaux. Bordeaux is also advised for the cluster-bud spray, since it is a more powerful fungicide and seldom at this stage seriously injures either fruit or foliage. In orchards previously cared for the authors agree in advising the use of lime sulfur for the spray which follows the fall of the petals, and for the third summer spray, which follows from a week to ten days after the fall of the petals.

3. *Can Bordeaux injury be lessened or prevented by frequent sprayings with the same spray or by maintaining over the Bordeaux a coating of lime thruout the season?*

Experiments were made to test this point at Neoga in 1910 and 1911, and at Centralia and Griggsville in 1911. The results of the experiments at Neoga in 1910 (page 71) indicated that "injuries to foliage and fruit following the use of Bordeaux were lessened by following the applications of Bordeaux as soon as dry with 8/100 milk of lime." It was further noted that "applications of milk of lime had a stimulating effect upon the foliage." The results at Neoga in 1911 (page 87) indicated that "injuries to foliage and fruit following the use of Bordeaux were lessened (1) by following the applications of Bordeaux as soon as dry with 8/100 milk of lime, and (2) by using the drench spray of Bordeaux."

At Centralia in 1911 (Table 28, page 135) Plats J and K, where the regular applications of Bordeaux were followed immediately by second or sealing-in applications of Bordeaux and milk of lime respectively, showed no better control of scab and no less injury to the fruit than some of the plats which were not sprayed with the follow-up applications. Foliage injury was more severe in Plats J and K than in the other plats.

The experiments at Griggsville in 1911 indicated (pages 164-165) that second applications of Bordeaux following immediately after the three regular applications did not affect in any way the amount of russet on the fruit. Applications of milk of lime even appeared to increase rather than reduce the amount of russeting. Bordeaux injury did not appear on the foliage until late in September. Plats receiving the follow-up sprays were as severely affected as those which received only the regular applications. The foliage on all the Bordeaux-sprayed plats fell slightly prematurely and at the same time.

As none of the secondary sprays gave extremely marked results, even tho they showed some beneficial effects in certain of the experiments, it is concluded that secondary applications of neither Bordeaux nor milk of lime can be recommended other than in an experimental way.

4. *Is it possible to interchange Bordeaux and lime sulfur, in a spray schedule, to advantage, using Bordeaux for one or more applications and lime sulfur for the remaining applications?*

The results of these experiments in general indicate that Bordeaux is a more powerful fungicide than lime sulfur but that it frequently causes such serious damage to fruit and foliage that its use is not always satisfactory. Theoretically, therefore, it seemed possible that Bordeaux might be used for the spray before the bloom, when there was little possibility of injuring the small, still unfertilized apples, and when the foliage was so little unfolded as to expose very little surface to its action, as in most seasons this spray is the most effective one in combating apple scab. This spray might then be followed by lime sulfur or Bordeaux, as circumstances might indicate, for later applications, thus avoiding the leaf injury and fruit russeting which accompany the later, particularly the second, applications of Bordeaux. Experiments were accordingly planned to compare all possible combinations of Bordeaux and lime sulfur for the first three applications, and were carried out at Centralia and Griggsville in 1911, and at Neoga, Flora, and Griggsville in 1912.

The experiments at Centralia in 1911 showed that in the control of scab "The differences" between the sprayed plats, "tho small, consistently favored Bordeaux for the first spray." L. E. Foglesong, in charge of these experiments, reports, "In the season of 1911, the first spray (applied before the blossoms opened) was clearly the important one in the control of scab." (Page 134.)

At Griggsville in 1911 (Table 44, page 166), Plat H, which received Bordeaux for the first application and lime sulfur for the second and third applications, gave the largest proportion of No. 1 apples. Plats sprayed more frequently and later with Bordeaux showed a better control of sooty blotch and flyspeck, but the fruit on these plats was much more russeted than on Plat H.

The Neoga experiments of 1912 indicated (page 103) that "the most satisfactory treatment consisted of Bordeaux arsenate of lead for the first application, and lime sulfur arsenate of lead for the second and third applications."

At Flora in 1912 the use of lime sulfur for the first three applications gave better results than any of the combination sprays, but Bordeaux for the first application with lime sulfur for the second and third ranks second in desirability. The relative amounts of injury to the fruit caused by Bordeaux at the various applications is presented in Table 22, page 114, and shows that comparatively little was due to the first application.

The Griggsville experiments in 1912, like those at Flora, favored spraying for the first three applications with lime sulfur alone, but with unsatisfactory results from Bordeaux at the first application with lime sulfur for later applications, Table 48, page 180.

A. J. Gunderson, in charge of the experiments at Griggsville, reports (page 179) as follows, "The more seldom Bordeaux was used and the more often lime sulfur was used, the better the color, finish, and smoothness of the fruit." Fruit receiving Bordeaux was more severely russeted than fruit sprayed with lime sulfur, more russet occurring at the first application than from the later sprays in these experiments. Foliage injury occurred in all Bordeaux-sprayed plats. Plats sprayed but once with Bordeaux made a good recovery, but plats sprayed more than once failed to recover during the remainder of the season.

The general conclusions from these experiments are that the use of Bordeaux for the spray before the blossoms open is generally advisable and that lime sulfur should be used for the second and third summer sprays.

5. *What is the most effective and at the same time the most economical dilution of lime sulfur as a fungicide spray?*

In various experiments lime sulfur has been used at dilutions running from 3½ pounds of sulfur in 100 gallons of spray mixture (1 gallon commercial concentrated lime sulfur testing 33° Baume in 80 gallons of spray mixture) to 13½ pounds of sulfur in 100 gallons of spray mixture (1 gallon commercial concentrated lime sulfur, testing 33° Baume, in 20 gallons of spray mixture). As will be seen from Table 55, the results were somewhat variable. Taking into consideration, however, not only the plats designed particularly to answer this question, but also all results from plats sprayed with lime sulfur, it has been found that lime-sulfur sprays containing from 6 to 8 pounds of sulfur in each 100 gallons of spray mixture give eminently satisfactory results. Sprays of these strengths are obtained by using 1 gallon of commercial concentrated lime sulfur in from 33 to 40 gallons of water, or 1 gallon of homemade lime sulfur prepared according to the Illinois formula in 18 to 24 gallons of water.

TABLE 55.—EFFECTS OF VARYING DILUTIONS OF LIME SULFUR FOR SUMMER SPRAYS

Dilutions of lime sulfur used	Place	Year	Experimenter	Page	Compared with lime sulfur, 1 gal. to 40 of water (com.)	As regards
1 to 50 (com.)	Neoga	'11	O.S.W.	81	Superior	Scab
1 to 20					Inferior	Scab
1 to 80 (com.)	Neoga	'12	O.S.W.	100	Inferior	Scab
1 to 60 (com.)					Inferior	Scab
1 to 20 (com.)					Inferior	Scab
1 to 36 (Ill. form.)	Griggsville	'12	A.J.G.	184	Superior	Scab
1 to 18					Inferior	Scab
1 to 18					Superior	Scab
1 to 14					Superior	Scab
1–33, 1–63 (com.) 1–53	Anna	'12	L.E.F.	149	Equal	All results

6. *Is homemade concentrated lime sulfur, prepared according to to the formula: 100 pounds sulfur, 50 pounds lime, 50 gallons water, as efficient as the ordinary commercial concentrated lime sulfur?*

Experiments were conducted to test this point in 1910 at Neoga and Centralia, with results, as will be seen from Table 56, slightly favoring the commercial article. In 1911 and 1912 the formula above mentioned was abandoned in favor of the Illinois formula, 100 pounds sulfur, 50 pounds lime, 66 gallons water.

TABLE 56.—EFFECTS OF HOMEMADE CONCENTRATED LIME SULFUR

Year	Place	Experimenter	Page	Homemade concentrated lime sulfur compared with		For control of
				Bordeaux	Commercial concentrated	
'10	Neoga	O.S.W.	61–64	Inferior	Equal	Scab on foliage
					Slightly superior	Scab on fruit
				Inferior	Equal	Foliage injury
'10	Centralia	L.E.F.	128	Superior	Inferior	Foliage injury
				Inferior	Inferior	Scab

7. *What is the fungicidal value of self-boiled lime sulfur, and how does it compare with lime sulfur made in the usual manner?*

Self-boiled lime sulfur was experimented with at Griggsville in 1909 and at Neoga in 1910. Table 57 presented herewith shows at a glance that this spray proved inferior to lime sulfur made in the usual way, and also inferior to Bordeaux where self-boiled lime sulfur

and Bordeaux were compared. Reference to the reports of experiments for the years 1909 and 1910 shows that the experimenters found self-boiled lime sulfur practically worthless as a fungicide for both the fruit and foliage of the apple. It appeared, however, from the reports of both series of experiments, that the self-boiled lime sulfur exerted some stimulating or beneficial effects on the health and vigor of the foliage not in any way connected with its possible properties as a fungicide. The foliage in the plats sprayed with self-boiled lime sulfur was noteworthy for its abundance, dark green color, and generally luxuriant appearance. Its worthlessness in the control of apple scab precludes the possibility of its being used as a successful spray for the apple.

TABLE 57.—EFFECTS OF SELF-BOILED LIME SULFUR

Year	Place	Experimenter	Page	Self-boiled lime sulfur compared with		For control of
				Bordeaux	Lime sulfur	
'09	Griggsville	L.E.F.	121		Inferior	Scab on fruit
			122		Inferior	Scab on foliage
'10	Neoga	O.S.W.	61–62	Inferior	Inferior	Scab on foliage
			62–63		Inferior	Scab on fruit

8. *Will the addition of copper sulfate to lime sulfur increase the fungicidal value of the spray?*

In an effort to increase the fungicidal properties of lime sulfur, copper-sulfate solution was added to this spray and tested in 1911 at Neoga, Centralia, and Griggsville, and in 1912 at Flora. The experiments at Neoga (page 87) showed that "lime sulfur arsenate of lead in combination with copper sulfate gave an efficient spray and caused no injury to either fruit or foliage." The experiments at Centralia (pages 134 and 137), showed that the addition of copper sulfate in considerable quantities (8 pounds in 100 gallons) resulted in a marked reduction in the amount of sooty blotch, but that it was not more efficient than lime sulfur alone in the control of other diseases. Moreover, it resulted in more severe russeting of the fruit than lime sulfur alone in the experiments at Griggsville, reported on page 170. The addition of copper sulfate failed to produce any marked increase in the fungicidal properties of the spray, and it resulted in more russeting of the fruit, the amount of russeting increasing with the amount of copper sulfate added.

At Flora in 1912 copper sulfate was added to lime sulfur only for the application of spray made before the bloom. The application was no more efficacious than that of lime sulfur alone in the control of scab,

and it resulted in an unusually severe russeting of the fruit (page 116).

It is concluded, therefore, that the addition of copper sulfate to lime sulfur does not add to its usefulness as a spray. In three of the experiments reported on, it resulted in more or less severe injury to the fruit.

9. *Is an application of lime sulfur made at the strength used for San Jose scale, applied while the trees are dormant, of any value as a preventive of apple scab?*

Experiments were made bearing upon this point at Centralia and Griggsville in 1911, and at Neoga in 1912. The results of the experiments at Centralia (page 137) indicate that "there is no evidence to show that the dormant-tree application exerted any influence in checking the development of scab." Experiments at Griggsville bore out those at Centralia. On page 161 it is stated that Table 41 shows that "the dormant-tree application of lime sulfur had no effect on apple scab." The experiments on this point at Neoga in 1912, reported in Table 13, page 91, indicate that a winter application is of doubtful benefit. The average infection of scab in the winter-sprayed plats amounted to 22 percent as compared with an average infection of 25 percent on those which did not receive the winter application.

In all of the experiments reported, the winter applications were followed later by the regular summer sprays. The authors are, therefore, of the opinion that it is possible, in spite of the results presented, that winter applications might have exercised some degree of control over scab which could not be detected in comparison with other plats, owing to the fact that they received all the sprays that were absolutely necessary for the control of this disease. To test this point it would be necessary to give only a winter application which should not later be followed by the regular summer sprays. As the regular summer sprays could not, of course, be abandoned, the results of the experiment bearing on this point lead to the inevitable conclusion that the dormant-tree spray with lime sulfur is unnecessary for the control of the apple scab.

10. *What is the most effective poison which can be combined advantageously with standard fungicides for the control of chewing insects, particularly the codling moth and the plum curculio?*

Paris green and arsenate of lead were the only insecticides experimented with. These were compared in plats at Griggsville in 1909, and the results are tabulated in Table 26, page 124. Paris green proved less effective than arsenate of lead and caused considerable foliage injury. When used separately, as in Group 1 of the Griggsville experiments in 1909, Paris green and arsenate of lead gave practically equal control of codling moth, tho arsenate of lead proved superior in preventing injury from curculio. Paris green caused very serious foliage injury in Plats 8 and 10, and considerable injury in Plat 9.

As these results confirmed previous experiments and more or less universal experience, further tests with Paris green were considered unnecessary and experiments with this insecticide were accordingly abandoned.

When experiments with copper ferrocyanide were commenced, it was thought that this spray might possess some poisoning qualities which would make it useful as an insecticide. It was not, of course, used in combination with Bordeaux or lime sulfur, as the spray was designed as a fungicide. It may be noted, however, that copper ferrocyanide failed to show any decided qualities as a poison spray.

11. *Does arsenate of lead when used alone possess any fungicidal value?*

Experiments bearing upon this point are reported from Neoga in both 1911 and 1912, and from Griggsville in 1911. The first of these experiments in 1911 at Neoga appeared to show that arsenate of lead when used alone did exercise some fungicidal action, but was responsible for considerable foliage injury (page 87). The experiments of 1912, however, lead to the following conclusion (page 103): "Arsenate of lead alone possesses practically no fungicidal value and should never be used except in combination with a fungicide." The Griggsville experiments for 1911 reported on page 171 confirm these results (arsenate of lead had practically no fungicidal value).

12. *Does arsenate of lead when added to Bordeaux or lime sulfur increase their fungicidal value?*

Experiments at Neoga in 1911 and 1912 showed (pages 87 and 103) that a mixture of lime sulfur and arsenate of lead was more efficient in preventing apple scab than lime sulfur used alone. In fact, in 1912 O. S. Watkins reports: "Lime sulfur arsenate of lead is a very much more efficient fungicide than lime sulfur alone."

The experiments at Anna in 1912 (page 150) indicated that "the neutral and mixed arsenates of lead did not add to the effectiveness of lime sulfur in the control of scab." Acid arsenate of lead added to lime sulfur appeared to improve the fungicidal value of the spray for the control of this disease. The addition of all kinds of arsenate of lead to lime sulfur gave a spray superior to lime sulfur alone for the control of sooty blotch.

At Griggsville in 1912 (page 186) "lime sulfur arsenate of lead was slightly more effective in controlling scab, flyspeck, and sooty blotch than lime sulfur alone."

Thruout the experiments in general, the addition of arsenate of lead to Bordeaux added nothing to its fungicidal value.

It is concluded, therefore, that the addition of arsenate of lead to lime sulfur increases its fungicidal value, while the addition of arsenate of lead to Bordeaux does not improve the fungicidal value of the resulting spray.

13. *Are there differences between various brands of arsenate of lead which would make one brand more useful than another, either alone, or in combination with the standard fungicides?*

Various brands of arsenate of lead have been used alone or in combination with standard fungicides at Neoga and Centralia in 1910, at Neoga in 1911, and at Anna in 1912.

The experiments at Neoga in 1910 (page 71) indicated that "for use with lime-sulfur solution, neutral or ortho arsenate of lead gave better results than arsenates of lead containing higher percentages of arsenic oxid." No results were obtainable at Centralia in 1910.

In 1911 the experiments at Neoga showed rather insignificant differences between the various brands of arsenate of lead, but O. S. Watkins, in charge of these experiments, states that "altho the results recorded in the different columns do not show wide variation between the different plats, they are in accord with those obtained in 1910, which showed that, in combination with lime-sulfur solution, the neutral arsenate of lead produced a spray which was more efficient and safer to use than those arsenates of lead higher in arsenic oxid."

At Anna in 1912 (pages 150 and 152) acid arsenate of lead used with lime sulfur showed a small but consistent lessening in the amount of scab and sooty blotch over mixed and neutral brands. All brands effectively controlled codling moth, but inconsistent differences appeared in the control of curculio. The various classes of arsenate of lead when used in combination with Bordeaux showed no important differences in the control of diseases, insects, or injuries to the fruit.

It was found that arsenates of lead were more efficient used in combination with the fungicides than alone, and that they caused less foliage injury.

14. *Of what value are certain new sprays both as fungicides and as insecticides?*

Among the new sprays experimented with were copper ferrocyanide, Cucasa, and Sulfocide. Of these, Sulfocide proved unsatisfactory, as, when used in combination with Paris green, it severely injured the foliage (report of spraying experiments at Neoga, in 1911, O. S. Watkins, page 87). Cucasa proved almost as efficient as Bordeaux, caused no russeting of the fruit, but was somewhat injurious to foliage (page 87). Not being more efficient than Bordeaux, this spray was also abandoned.

Copper ferrocyanide made by combining copper sulfate and potassium cyanide seemed to possess advantages, both from the theoretical and practical standpoint, that made it seem advisable to test this spray somewhat more thoroly. Experiments were accordingly conducted with copper ferrocyanide at Neoga in 1911, and at Anna, Flora, and Griggsville in 1912. Table 58 presents a summary of results from the use of this spray.

TABLE 58.—EFFECTS OF COPPER FERROCYANIDE COMPARED WITH BORDEAUX AND LIME SULFUR

Year	Place	Experimenter	Page	Copper ferrocyanide compared with		With reference to
				Bordeaux	Lime sulfur	
'11	Neoga	O.S.W.	85	Superior	Superior	Vigor of foliage
			85–87	Inferior	Not compared	Scab on fruit
			86	Superior	Not compared	Grading
'12	Flora	W.A.R.	110	Superior	Superior	Foliage injury, abundance
			111	Equal	Equal	Scab on fruit
			111–113	Inferior	Inferior	Blotch, sooty blotch, and flyspeck on fruit
			113–116	Superior	Inferior	Russet on fruit
'12	Anna	L.E.F.	155	Inferior	Inferior	Scab, sooty blotch, and flyspeck on fruit
			155	Superior	Inferior	Russet on fruit
'12	Griggsville	A.J.G.	181	Inferior	Inferior	Scab and leaf spot on foliage
			181	Inferior	Inferior	Health and vigor of foliage
			181–183	Inferior	Inferior	Scab, sooty blotch, and flyspeck on fruit
			181–183	Inferior	Inferior	Grading

In 1911 copper ferrocyanide proved superior to Bordeaux and lime sulfur with regard to the vigor of the foliage, and superior to Bordeaux with regard to the grading of the fruit. It was inferior to Bordeaux in the control of scab on the fruit. At Flora in 1912 it again proved superior to both Bordeaux and lime sulfur with regard to vigor and abundance of foliage, and it also caused less foliage injury. It was equal to Bordeaux and lime sulfur in the control of scab on the fruit, but inferior in the control of blotch, sooty blotch, and flyspeck. It caused less russet than Bordeaux, but more than lime sulfur. In the experiments at Anna it proved inferior in the control of scab, sooty blotch, and flyspeck to both Bordeaux and lime sulfur. It caused less russeting of the fruit than Bordeaux, but more than lime sulfur. The most discouraging results from this spray are reported from Griggsville, where it was tried on several plats and at various strengths, both in combination with an insecticide and separately. In this entire series of experiments copper ferrocyanide appeared to be worthless.

It is believed by the authors of this bulletin that this spray is worthy of further investigation, but the results thus far obtained do not warrant recommending copper ferrocyanide other than in an experimental way.

15. *How often and at what times should summer sprays be applied?*

Experiments bearing directly on these points were performed at Griggsville in 1909, at Neoga and Griggsville in 1911, and at Neoga and Anna in 1912.

The results at Griggsville in 1909 emphasized the importance of the spray applied immediately after the fall of the petals. The spray applied at this time reduced codling-moth injury from 17 percent on the unsprayed plat to 3 percent on the sprayed plat; it reduced scab from 89 percent on the check to 49 percent on the sprayed plat. Altho there was less injury from codling moth in the plat sprayed once before the bloom than in the check plat, the difference could scarcely be due to the effect of the spray, and this spray apparently reduced scab from 89 to 85 percent only. (See Table 25, page 123.)

In 1911, at Neoga, plats were sprayed three, four, and five times. The fourth application of homemade lime sulfur reduced scab from 51 to 44 percent, and the fifth application further reduced it to 31 percent. Commercial lime sulfur reduced scab from 39 to 28 percent at the fourth application, but no further reduction appeared to follow the fifth application. The fourth application of Bordeaux did not seem to reduce scab, but a fifth application reduced scab from 25 to 15 percent (Table 6, page 76). The irregular character of these results is probably traceable to the different sticking qualities of the fungicides. Bordeaux from the early sprays remained on the trees long enough to make a fourth application unnecessary. The fifth application, however, was made at a time when the coating of Bordeaux was disappearing and in time to lessen damage from a comparatively late attack of scab.

The experiments at Griggsville in 1911 (Table 43, page 166) gave the following results: The addition of three extra summer sprays (six in all) resulted in a slightly better control of curculio, but did not increase the production of No. 1 apples to any considerable extent. Scab, sooty blotch, and flyspeck were almost perfectly controlled by the first three sprays: it appeared, therefore, that the additional applications were unnecessary in 1911.

The Neoga experiments in 1912 (Table 14, page 93) indicated, "The use of more than three applications seemed unnecessary in 1912, as the variation between the percentages of No. 1 apples in the different plats is neither regular enough nor varied enough to permit drawing definite conclusions."

In the experiments at Anna in 1912 (Table 31, page 146) the first application reduced codling moth slightly, the check plat showing 30 percent and the sprayed plats 18 and 24 percent respectively for lime sulfur arsenate of lead and Bordeaux arsenate of lead. Curculio were unaffected by the first application. Scab was reduced from 83 to 63 and 69 percent respectively in the lime-sulfur and Bordeaux-sprayed plats. The second application resulted in the reduction of codling-moth injury from 18 to 11 percent in the lime sulfur arsenate of lead plat, and from 24 to 17 percent in the Bordeaux arsenate of lead plat. Curculio were again unaffected by this spray. Scab was not affected by lime sulfur at this application, but Bordeaux showed a reduction from 83 to 63 percent. The third application alone was slightly less effective in controlling the codling moth than the second, and slightly more effective than the first. Its effects on curculio and scab were negligible.

The omission of the first spray proved serious in the control of scab, and the omission of the second spray was equally unfavorable in the case of the codling moth. In this series of experiments the omission of the third spray where Bordeaux was used for the first and second sprays did not prove serious, but the omission of the third application where lime sulfur was used for the first two sprays was found inadvisable.

The addition of a fourth spray reduced injury from codling moth, curculio, and sooty blotch, but did not affect scab. Five applications further reduced curculio injury but did not affect codling moth, apple scab, or sooty blotch.

In general, it was found that the first three summer sprays were the most useful in improving the general grade and quality of the fruit by controlling the majority of the insects and fungi; that none of these sprays could be omitted safely; and that the addition of the fourth and fifth sprays assisted in controlling late-brood codling moth and injury from curculio.

16. *What are the relative advantages and disadvantages of applying large and small quantities of Bordeaux?*

Experiments bearing upon this question were performed both at Griggsville in 1911 and at Anna in 1912. The first of these (pages 163 and 164) indicated that light and heavy sprayings were equally effective in the control of apple scab; that heavy applications controlled sooty blotch and flyspeck fungi and codling moth and curculio more efficiently than the light applications. Fruit receiving the heavy applications, however, was poorer in color and more severely russeted than fruit receiving the light applications. These latter differences about counterbalanced the former advantages, the grading from the two being practically equal.

In the experiments at Anna in 1912 (page 150), heavy applications of Bordeaux arsenate of lead were more efficient as a protection against curculio and scab than lighter applications, equally efficient in the control of sooty blotch, and equally inefficient in the control of codling moth, but they resulted in more russeting of the fruit than the light applications.

On the whole, these experiments indicate that a thin but complete coating of the fruit and foliage with Bordeaux arsenate of lead is more desirable than a heavy coat, except in cases where special protection from curculio is necessary.

INCIDENTAL OBSERVATIONS

Included under this heading are various observations which cannot readily be tabulated, and which were incidental to the principal lines of inquiry. They are put together under this heading for convenient reference.

1. Owing to the danger of russeting the fruit as a result of applications of Bordeaux, it is a more or less common practice to omit the fungicide from the spray following the fall of the petals, as this spray is applied more particularly for the control of codling moth. It has, however, been found inadvisable to omit the fungicide, as an infection of scab is very likely to occur at this time.

2. In several experiments lime sulfur appeared to attract codling moth and to repel curculio. The former effect was more marked than the latter, but both facts were observed with a considerable degree of consistency thruout the progress of the experiments.

3. Various quantities of arsenate of lead were used in an attempt to find the most efficient killing spray. Four pounds of paste arsenate of lead in 100 gallons of spray mixture was found efficient and economical.

4. Adding the sludge, which remained after the preparation of concentrated lime sulfur, to the spray mixture did not improve or impair the efficiency of the spray.

Recommendations

As a result of the spraying experiments detailed in this bulletin, and also from other experience and recommendations, the authors recommend that apple trees be sprayed at the times and in the manner indicated below.

1. *Dormant-tree spray.*—This spray is used particularly for the control of San Jose scale. It is applied in the fall after the leaves drop or in the spring before the buds open, preferably at the latter time. Where San Jose scale is present or is known to infest a certain locality, this spray is a necessity, and it is advised as a matter of precaution in all orchards thruout the state.

The dormant-tree spray should be either commercial or homemade lime sulfur. The commercial lime sulfur testing 33° Baume should be used at the rate of 11 gallons of commercial lime sulfur to 89 gallons of water, or 11 gallons of commercial lime sulfur in 100 gallons of the spray. This is equivalent to 1 gallon of commercial lime sulfur to 8 gallons water. The homemade lime sulfur, made according to the Illinois formula, described on page 54, is used at the rate of 20 gallons of stock solution homemade lime sulfur to 80 gallons of water, or 20 gallons of homemade lime sulfur in 100 gallons of spray.

2. *First summer application.*—This spray is used particularly for the control of apple scab. As a secondary object, however, it is used to kill the various leaf-eating insects which appear early in the season, including bud moth, tent caterpillar, and canker worm. These insects, tho not always present in large numbers, are likely to cause serious damage and must be guarded against.

The first summer application is made after the cluster buds open, as soon as the individual flower buds spread apart, but before the flower buds themselves open. In large commercial orchards it will be found necessary to begin spraying before all the individual flower buds have spread apart, in order to complete spraying before the first blossoms open. Spraying may be continued at this time until the petals have commenced to separate, but should be discontinued as soon as the stamens and pistils of the flowers are exposed.

Bordeaux, prepared according to the formula, 8 pounds copper sulfate, 8 pounds freshly slaked lump lime, and 100 gallons of water, with 4 pounds arsenate of lead added as an insecticide, is the best spray for use at this time. The preparation of this spray is described on page 54.

3. *Second summer application.*—This spray is used particularly for the control of the codling moth, but is of almost equal importance as a preventive of apple scab. Incidentally, it is advantageous as a protection against various leaf-eating insects.

It is applied immediately after the fall of the petals, while the lobes of the calyx are still distended. The greater number of the first brood

of the codling moth enter the apple thru the calyx end. By spraying the trees while the calyx cups are still open, poison will be placed on the base of the lobes and stamens and sometimes within the cup itself, where the larvae of the codling moth are reasonably sure to get it when entering the apple. At this stage the small apples point upward or outward, and the calyxes are easily coated with poison.

For this application lime sulfur arsenate of lead, using 2½ gallons of commercial concentrated lime sulfur, or 5 gallons of homemade lime sulfur (Illinois formula, page 54) in 100 gallons of spray, is recommended.

4. *Third summer application.*—This is used as an additional precaution against apple scab and codling moth. It is also a safeguard against leaf-eating insects, and to some extent against certain fungous diseases which appear later in the season, including blotch, sooty blotch, flyspeck, and leaf spot (*Sphaeropsis malorum*).

This spray should be made about ten days after the second summer application. In large orchards the second spray would in all probability not be completed at one end of the orchard until it was time to commence the third summer application at the other. The best spray for this application appears to be lime sulfur arsenate of lead.

5. *Fourth summer application.*—This spray is applied as a safeguard against apple blotch and codling moth. It is applied two to three weeks after the third summer spray. Bordeaux arsenate of lead should be used in hot dry weather; lime sulfur arsenate of lead should be used in cool weather.

6. *Fifth summer application.*—This spray is particularly for the control of the second brood of codling moth, and incidentally for the prevention of curculio injury, blotch, sooty blotch, flyspeck, and leaf spot.

It is made approximately ten weeks after the bloom, or at times varying from the last week in June in the extreme southern part of Illinois to August 1 in the northern part of the state.

For this spray arsenate of lead and lime should be used. Where fungous injury is anticipated, Bordeaux arsenate of lead may be substituted.

7. *Extra sprays.*—Extra sprays are chiefly used as safeguards against bitter rot. Where this disease is anticipated, spraying should begin the last week in June, and should be followed at intervals of ten days until four applications have been made. Bordeaux is the proper fungicide to use for this disease. It is prepared in the same manner as for the first summer application. If no preventive measures have been taken against bitter rot, and the disease appears suddenly and unexpectedly, spraying should be commenced without a moment's delay as soon as the presence of the disease is discovered.

PLATE 1.—GRIGGSVILLE EXPERIMENTS, 1912, SHOWING SEVERE RUSSET CAUSED BY BORDEAUX

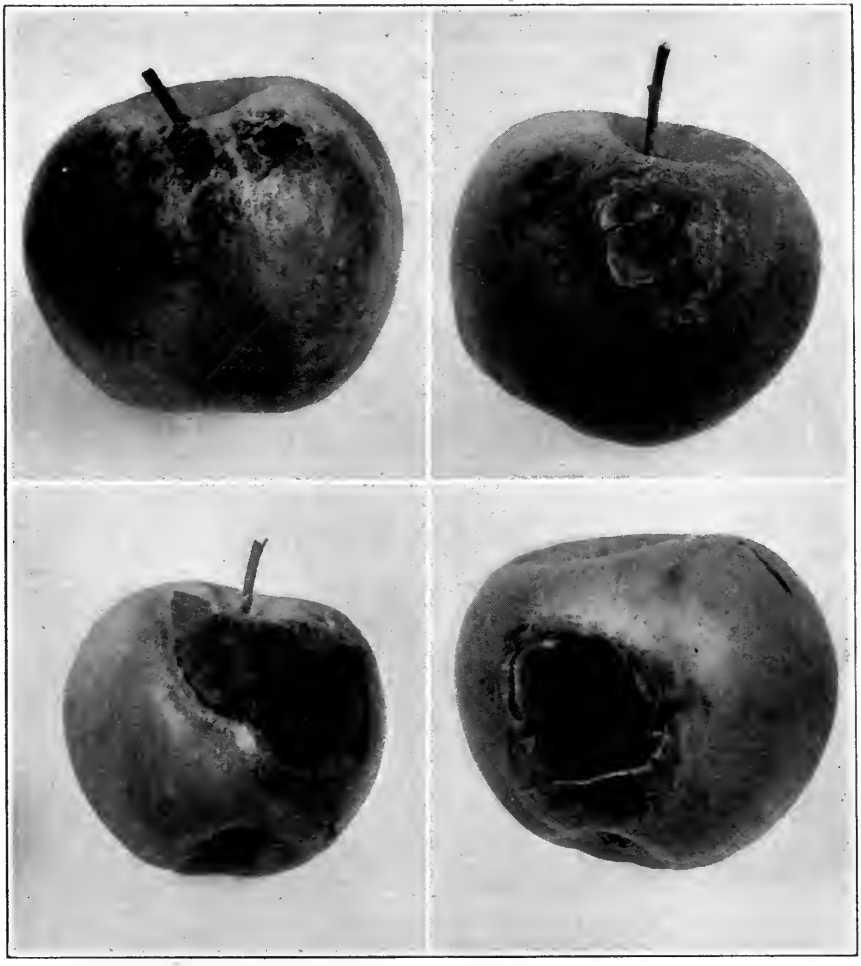

PLATE 2.—BURN DUE TO SPRAYING WITH LIME SULFUR DURING VERY HOT WEATHER

PLATE 3.—UNSPRAYED TREES, OCTOBER 2, 1912; ADJOINING TREES SHOWN IN PLATE 4

PLATE 4.—SPRAYED TREES, OCTOBER 2, 1912; ADJOINING TREES SHOWN IN PLATE 3
THE PICTURES IN PLATES 3 AND 4 WERE TAKEN FROM THE SAME SPOT

A B

PLATE 5.—GRIGGSVILLE EXPERIMENTS, 1912
A. TREE SPRAYED WITH BORDEAUX
B. TREE SPRAYED WITH LIME SULFUR

A B

PLATE 6.—GRIGGSVILLE EXPERIMENTS, 1912
A. APPLES SPRAYED WITH BORDEAUX
B. APPLES SPRAYED WITH LIME SULFUR

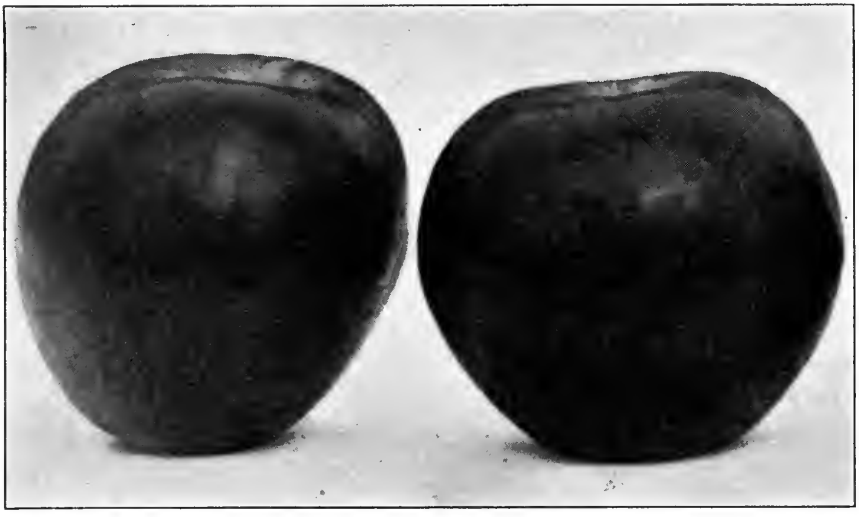

PLATE 7a.—GRIGGSVILLE EXPERIMENTS, 1912
APPLES SPRAYED WITH LIME SULFUR

PLATE 7b.—GRIGGSVILLE EXPERIMENTS, 1912
APPLES SPRAYED WITH BORDEAUX

PLATE 8.—BLOSSOM BUDS READY FOR APPLICATION OF FIRST SPRAY

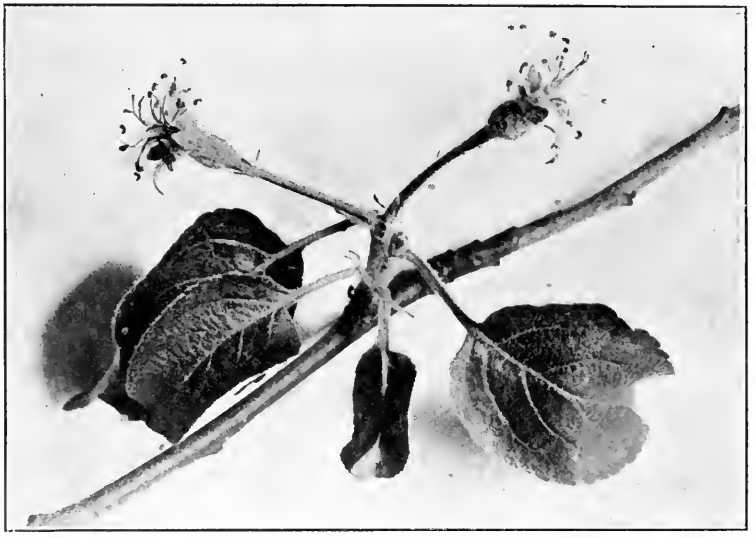

PLATE 9.—THE PROPER CONDITION AND TIME FOR THE SECOND SUMMER SPRAY; THE CALYX CUPS ARE STILL OPEN AND THE FRUITS POINT UPWARD AND OUTWARD

PLATE 10.—THE PROPER CONDITION AND TIME FOR THE THIRD SUMMER SPRAY