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MIXED SPRAYS FOR APPLE SCAB AND CODLING MOTH

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MIXED SPRAYS FOR APPLE SCAB AND CODLING MOTH

The injury done to the apple by the Scab and Codling Moth throughout the Palouse country has become so serious that it is impossible longer to raise a salable crop without thorough spraying. From a yearly injury from these two causes in 1903 and 1904 of nothing for the scab and but two or three per cent for the moth, the ratios have risen step by step. In 1899 I took up the work of combatting the scab near Julietta, and the results were published in Bulletin 20 of this Station. The scab was then doing much injury in the orchard selected and was gradually working its way into the orchards of higher altitudes, as on Bear Ridge, Fix, and American Ridges, and to a slight extent about Moscow and Viola. Associated with me in this spraying experiment was Prof. Aldrich, who devoted his time to the codling moth, the result of his investigations being published in Bulletin 21. Again in 1902 Prof. Aldrich devoted his energies to this subject, taking up at this time the question of two or three broods in Idaho, and these results formed the matter for Bulletin 36. Since that time both scab and moth have grown more and more injurious, varying in damage yearly according as conditions were favorable or unfavorable, but each maximum for a period of two or three years being higher than it was before.

In 1905 the scab and moth were both so bad as to discourage many apple growers, so that some did not spray at all, while a few began to pull out their trees, especially on American Ridge.

Experiments were undertaken by the writer during the growing season of 1905, to try to demonstrate which is the best mixed spray with which to cambat these two pests, but the weather conditions were so unfavorable as to render the experiment almost a failure. The results were published in the Annual Report for 1905, and the evidence here given was enough to establish conclusively that three sprayings with Bordeaux Mixture, well made and thoroughly applied, were sufficient to prevent almost all injury to the apple from this cause. On the other hand, whether from severe cold in the

spring, from winds so heavy at various times while the apples were on the trees as in many places practically to strip the trees of fruit, and a season so dry as to cause many of the apples in this poorly cultivated orchard to wither and drop off, while those which remained had no size—whether, I say, from these causes individually or collectively, I know not, but it was found impossible to make any deductions as to *which* insecticide was best when mixed with Bordeaux.

The work was taken up again during the present year, this time in the orchards of Mr. B. C. Dowdy and O. O. Hurt, opposite one another and about a mile and a half from the center of Moscow. It was my desire to establish beyond doubt, as much as one year's spraying can establish anything:

(1), How early one must begin spraying to get best results in combatting the scab.

(2), How many sprayings are needed to accomplish this best. This was intended merely as a check upon the 1905 sprayings, for I had shown there conclusively that three sprayings will save the crop, if it will not practically wipe out the scab for the years.

(3), Which insecticides with the Bordeaux will do the work best, the Taft formula, the Kedzie formula, Paris Green, Home-made Arsenate of Lead, or Swift's Arsenate of Lead.

(4), Whether in this country, with its abundant spring and early summer rains, three thorough sprayings as advocated by Prof. Ball for Utah, will give a reasonably worm-free crop of apples in Northern Idaho.

(5), A comparison of the crop with that of Mr. Fred Veatch near Moscow, to see whether the additional benefits enjoyed by him from banding trees, from absence of nearby unsprayed and consequently infested orchards, and from one additional spraying, will pay the orchardist for the extra work entailed.

It would be my desire, in view of the previous bulletins published by this station as well as the many valuable ones by other institutions, and from the knowedge that all successful apple-growers are already acquainted with scab and codling moth, to pass over all discussion of the life histories of both pests, and devote myself entirely to the discussion of these five problems above outlined. On the other hand, the conversations I have had with many would-be growers of apples

the past two years, and the many letters received asking information of these subjects, make it necessary to take up briefly the life-histories of scab and moth before going into the main discussion.

SYNOPSIS OF LIFE HISTORY OF SCAB.

Scab on apple, as well as that on pear and potato, is due to a low form of plant-life we call a fungus. A fungus is nearly always destitute of green coloring matter called Chlorophyll. Plant food is elaborated by this chlorophyll under sunlight, warmth, and moisture. That being the case, the fungi can get their living only in two ways: First, by eating the *living* juices of either plant or animal, when they are called *parasites;* or by existing upon *dead* animal or vegetable remains, when they are called *saprophytes.* The apple-scab, wheat rust and smuts, and lumpy jaw are examples of the first, muchrooms and the common moulds of the second. The apple-scab leading a parasitic existence, it must have the growing tissues of the apple, such as its fruits, leaves, and young shoots, to live upon. But the peculiar thing about this fungus, as well as about many more, is that it spends its days, while the apple tree is in the growing condition, as a parasite, and while the tree is dormant, during the winter and early spring, it lives as a saprophyte on the dead apple leaves. This discovery, made as regards the scab only a few years ago, has a most important bearing on the subject for the apple grower. While spraying the tree and fruit was the only remedy once recommended, now that its *dual* nature is known, taking care of the dead leaves in early spring by either gathering them in piles and when dry burning, or by plowing them under, is no less important. By these means the *winter spores,* as they are called, are prevented from emerging from their cases and helping along the re-infection of the orchard the succeeding year. While this is supplementary, *spraying intelligently* must still remain the principal means of eradicating the scab by killing both winter and summer spores as they germinate. The question of how many times to spray and how early in the season to begin have naturally a very important bearing on the subject. It has usually been considered necessary to spray the first time before the buds have well opened, and by this means kill both winter and summer spores just as they begin to germinate, for let it be understood that no

spray as used today will kill the spores *before* they germinate. They are too hard-shelled and resistant. The advisability of this early spray has been questioned by several station workers, and it was my desire to get some light upon this question by avrying the times of first sprayings.

SYNOPSIS OF LIFE HISTORY OF CODLING MOTH

There are three stages in the life history of the codling moth:

(1). The larva or worm.
(2). The pupa.
(3). The Moth, or mature insect.

The insect always passes the winter in the larval condition, as a worm. It spins about itself in the fall a web called cocoon, to protect itself from the cold, rain, other insects and birds. It endeavors to find, and almost always succeeds in finding, some dry place to pass the winter, such as old fences, boards, scaly bark of trees, or even large clods. At varying times in the spring, according to the season or whether it has a warm or cool hiding place, this worm changes into that peculiar brown object called the pupa, and from this stage into the moth. Here is the first and most important point for the apple-grower, who intends to fight the moth successfully, to understand. You must know just *when* the moth appears in order to do intelligent work. Therefore prepare yourself a *breeding cage and* confine some of the worms in it, that you may *know* with certainty when the moth comes out. One of the simplest cages is a wide mouthed fruit jar, and in place of a lid tie some light wire gauze about the mouth securely so that neither worm nor moth can get out. Place the jar in the orchard in a cool dry place. About the time of apple blossoming refer to your jar daily. As soon as the first moth comes out you should begin your spraying, whether, *all* the petals, or "blossoms," have fallen or not. It is rare that a moth emerges from its pupa-case before most of the petals have fallen; often it does not take place till a week or two after this time. To show how this varies from year to year, let me instance from other bulletins and from my own work. In Utah in 1903 the first moths appeared, according to Ball, about the first of June. In 1899, according to Aldrich, the first moth

appeared about June 16th, probably two weeks later than usual, while the blossoms did not fall till June 14-17. This year the first moth appeared in my cage May 18, while the apples were in full blossom about May 14th. This was due to the unusually warm dry spring which forced out both moths and flowers a couple of weeks earlier than usual. To be in time to catch the first worms, which might have come out before those in my cage did, I had to spray before most of the petals had fallen. The transformations of the worm take about 50 days and may be shown graphically as follows:

1. Winter worms change to moths about when petals are falling. First spraying.

2. Moths mate and lay eggs in a day or two.

3. Eggs hatch almost always in about eight or ten days, while petals close in about ten days—*"first brood of worms."*

Many advise a second spraying at this time, to get the poison into the calyxcups before the last of them close, and to catch the last of the young worms of the first brood before they enter the apple. No spray can affect the worm when once he has entered the fruit unharmed or unpoisoned.

4. Worm remains in apple about 18 or 20 days.

5. He then comes out by enlarging the tunnel he made on entering or by eating out a new tunnel, and lets himself down from the apple to the ground by a silken thread, or crawls down the trunk of the tree, seeking a hiding place in which to pupate.

6. Having found such a hiding place, he wraps himself up as did the winter worm, gradually changes to a pupa, and comes out as a moth in about 20 days. Simpson found this time varied from 11 to 49 days in Southern Idaho.

7. The eggs are again laid, and they again hatch in about 8 or 10 days. As this forms the time for the *third spraying,* or the second, if we have omitted the last one mentioned, we must again have recourse to the breeding cage. In fact it is much more essential that we should know the exact time this set of moths appears than the first, as we are more or less limited in the first spraying by the date of full flowering. So, as soon as the worms come out of the apples, which can be told by the *bands* on your trees, (and you should use bands), catch some, place them in your cage, watch when the first moth appears, add 8 or 10 days for hatching of young worms, and you

will know when this *second brood* of worms is ready to enter the apples. Your spray should be on the apples soon after the emergence of the *first* moth in order to catch early as well as late worms of this brood.

8. The young worms again eat their way into the apples, and remain inside the fruit for another 20 days or so. The first brood enters the apple mainly by the *calyx end,* hence the necessity of having the poison well down in the calyx cup and ready for them. The second brood enters the apple anywhere, but usually not by the calyx. When the mature worm emerges from the apple again, he does not, about Moscow, change again this season into the moth, but seeks a hiding place spins about him his cocoon, and there spends the winter. Rarely they remain in the apple when stored.

EXPERIMENTS CONDUCTED IN 1906.

Work was begun at the orchards of Mr. Dowdy and Mr. Hurt, April 17th. My first spraying was for the purpose of establishing the fact *when* should the first application for scab be applied to get the best results. Five hundred and ninety trees were selected in a single body in the younger orchard of Mr. Dowdy. These trees are about 8 years old and consist of 198 Ganos, 84 Ben Davis and 308 Rome Beauties. In Mr. Dowdy's older orchard 140 trees were selected of various ages from young to old trees and of differing varieties. It was my purpose to spray with Bordeaux *alternate* rows in both of these orchards at this date, and the *whole* orchard at the time of the first and second sprayings for codling moth with Bordeaux plus the different insecticides, and by comparing the trees sprayed three times with those sprayed twice at the end of the scab season find out whether enough difference could be observed in the suppression of the scab to *pay* the apple-grower for using the early spray.

APPARATUS USED.

Our outfit consisted of a large Bean pump mounted on a truck near a low cylindrical spray-tank which holds 100 gallons of liquid. A 50-foot hose was used with bamboo extension rod and one nozzle. The nozzles used varied with season and time of spraying. For this spraying, as the main object

is to cover the tree with spray, using no more force than is necessary to accomplish the object, a double Vermorel was used. This gives a fine mist and covers a tree very quickly.

TO MAKE BORDEAUX.

The Bordeaux used was the 4-4 formula and was prepared as follows: Thoroughly dissolved 24 pounds of bluestone in 12 gallons of hot water. Slacked in another half barrel 24 pounds of lime, first adding warm water gradually to hasten action, and finally adding cold water enough while slacking was going on to bring the whole to 12 gallons. Thus each gallon of water contained 2 pounds of bluestone and 2 pounds of lime respectively. The benefit of making "stock solutions" is a great saving of time. It would pay a person to have larger vessels than we employed, viz. half barrels, if he can buy or make them. They can be used from year to year, if stored at the end of the spraying season. To prepare th 4-4 formula, or 4 pounds of lime and bluestone each to the 50 gallon barrel, as our tank held 100 gallons of liquid, a hose was attached to the water tank and about 25 gallons of water run into it. From a bucket 4 gallons of the lime liquid was poured in, straining carefully, and then while one of us poured in 4 gallons of bluestone from a *wooden* bucket, the other stirred the mixture vigorously with a hoe. *Good* Bordeaux can never be made by pouring together the 4 gallons of each without diluting. If the lime is well dissolved, or slacked, and the bluestone water poured in gently while vigorous stirring is done with the hoe, a sky-blue, well mixed compound is the result, which does not separate out and settle rapidly, but remains in solution, if stirred occasionally while spraying, until the whole tankful is exhausted.

Two days were devoted to this first spraying, and in that time 370 trees were covered, large and small, while 500 gallons of Bordeaux were used, or 1 2-5 gallons to the tree. The Bordeaux cost us, disregarding labor of making and putting on, about one cent per tree. Counting team and man at $3.50 and extra help at $1.50, it would make the cost of first spraying 3 7-10 cents per tree. If the trees had all been large, the cost would have been much more.

SECOND SPRAYING.

Began the second spraying May 14th.

The period of full bloom was about May 10th, but the past month had been so unusually warm and dry that I feared some of the earliest moths might have been out some time, and, as I wished to get ahead of the entire brood, I began spraying while more than half the petals were still on. The first moth appeared in the breeding cage May 18th, much earlier than usual. I had as an additional reason my former observations that the *first* blossoms most frequently make the *best* apples. The only additional equipment to my former spraying, besides the insecticides, consisted of a short length of pipe three inches long, bent to one side at a rounding angle of about 30 or 40 degrees, fitting onto the extension rod, and having the nozzle at the other end. This I consider a very important adjunct to the first spraying for the moth, for by its means, and turning the rod in our hands, the spray may be *forced into the calyx-cup,* no matter at what angle the flowers stand to the axis of the tree. Even the Bordeaux nozzle, which I recommend for this spraying, will not send the spray in properly without its use, while no other nozzle with which I am acquainted will do it at all. If the trees are not very large the spray can be applied from the ground perfectly, but if too tall to reach the topmost flowers one must stand upon some elevation placed on the wagon. My experience tallies with that of Prof. Ball of the Utah Station that the secret of good success in spraying lies in the use of some such contrivance as this, by means of which as above stated, the liquid carrying the insecticide, may be forced into the calyx-cup, no matter at what angle the flowers may point as regards tree-axis. I think it is the experience of most workers with the moth that the majority of the first brood of worms enter the apple by the calyx-end and if the poison is not forced through the little cone of stamens, it will not be in the place where most of the young worms take their first meal.

The insecticides used with the Bordeaux were as follows:

1. Taft Formula. Boiled together in a porcelain-lined vessel for about three quarters of an hour.

White Arsenic	1 lb.
Lime, unslacked	2 lbs.
Water	1 gallon

I added about 1 1-3 quarts to each 100-gallon tank. One

pint to the barrel is often recommended. Used a pound or two of slacked lime in addition to secure against burning.

2. Kedzie Formula. Boil until dissolved in same vessel as last (ordinarily about 15 minutes).

White Arsenic	1 lb.
Sal Soda	4 lbs.
Water	1 gallon

I again used 1 1-3 quarts to tank. One pint to the barrel is generally recommended. As soon as insecticide is placed in tank, if Bordeaux is not used, 2 to 4 pounds of freshly slacked lime must be added to prevent burning. I even added a couple of pounds to the Bordeaux, though there was already present probably sufficient lime to prevent burning, either by the arsenic or by the copper sulphate (bluestone).

3. Paris Green. Added one-half pound of this to the 100-gallon tank of Bordeaux. Always stir up the poison in about 1 quart of water till thoroughly mixed before pouring into tank, stirring the material in the tank thoroughly also as the Paris Green is added. This arsenical settles only too readily at best.

4. Arsenate of Lead. Dissolve separately in buckets,

Arsenate of Soda	10 ozs.
Acetate of Lead	22 ozs.

Then mix while stirring and
pour into Water or Bordeaux 100 gallons.

I dissolved 40 ounces of arsenate of soda and 88 ounces of acetate of lead in one gallon of water each, then add 1-4 of each. Both substances dissolved more readily in warm water, but should not be united until nearly cool.

5. Swift's Arsenate of lead.

Arsenate of Lead	6 lbs.
Water or Bordeaux	100 gallons

Dissolve the lead compound in about 1 gallon of warm water. This paste takes a long time to dissolve in cold water even with much stirring. Then pour into tank of water or Bordeaux, stirring mixture with the hoe.

A survey was first made of the two orchards to be sprayed. Whether from the excessively cold weather in March or from

the lack of sufficient rainfall during the seasons of 1905 and 1906, nearly all of the Rome Beauties and Ben Davis in the young orchard and the old orchard of Mr. Dowdy had borne no apples, or from one to six apples on isolated trees; while at Mr. Hurt's, opposite, his Limbertwigs, Ganos and Rome Beauties had but few blossoms. The work on Mr. Dowdy's Rome Beauties, Ben Davis and the trees in his old orchard were therefore abandoned and a plat of about 70 8-year-old and abundantly blooming Ben Davis was taken up in its stead. At this time no scab was apparent in either of the orchards. The division of trees for spraying was as follows: An equal number of each kind of apple trees were selected for each spray. This gave approximately:

DOWDY ORCHARD.

Ganos 198, or for each of 5 sprays about 40.

Ben Davis 75, or for each of 5 sprays about 15.

HURT ORCHARD.

Jonathan 43, or for each of 5 sprays about 9.

Rome Beauty 60, or for each of five sprays about 12.

Limbertwig 50, or for each of 5 sprays about 10.

All of these trees were sprayed most thoroughly at this date, and as the Jonathans were gigantic and only about 18 feet apart, three times as much spray was consumed in spraying these as would be the case on smaller trees and further apart.

There were, after the changes in plan above detailed, 416 trees in the whole experiment, and 14 tankfuls of the sprays were used. This makes about 3-2-5 gallons of spray to each tree. This ratio is higher than we should expect in ordinary spraying, for the Jonathans of Mr. Hurt were so large and close together that it took nearly 100 gallons of spray for each nine trees.

COST OF SECOND SPRAYING.

The time consumed in putting on these 14 tanks of spray was, as nearly as I could estimate, 3 1-2 days. The parts of six days were taken in the work, but as we were constantly being interrupted by light rains accompanied by severe wind the actual hours spent in spraying can not be given with exactness.

This would mean for labor at $5.00 for two men and team 4.2 cents per tree.

COST OF SPRAY PER TREE.

Taft's—300 Gallons.

1 lb. Arsenic	$ .10
2 lbs. Lime	.02
	$ .12
300 gals. Bordeaux	2.40
Spray for 83 trees	$2.52
Cost per tree	3.1 cts.
Labor	4.2 cts.
Total per tree	7.3 cts.

Kedzie's—300 Gallons.

1 lb. Arsenic	$ .10
4 lbs. Sal Soda	.08
8 lbs. Lime	.08
	$ .26
300 gals. Bordeaux	2.40
Spray for 83 trees	$2.66
Cost per tree	3.2 cts.
Labor	4.2 cts.
Total per tree	7.4 cts.

Paris Green.

1½ lbs. Paris Green	$ .45
300 gals. Bordeaux	2.40
Spray for 83 trees	$2.85
Cost per tree	3.4 cts.
Labor	4.2 cts.
Total per tree	7.6 cts.

Swift's Arsenate of Lead.

18 lbs Arsenate of Lead	$2.88
300 gals. Bordeaux	2.40
Spray for 83 trees	$5.28
Cost per tree	6.4 cts.
Labor	4.2 cts.
Total per tree	10.6 cts.

Home-Made Arsenate of Lead.

40 ozs. Arsenate of Soda	$ .62½
88 ozs. Acetate of Lead	.97½
	$1.60
300 gals. Bordeaux	2.40
Spray for 83 trees	$4.00
Cost per tree	4.8 cts.
Labor	4.2 cts.
Total per tree	9.0 cts.

A much higher price had to be given for many of the spraying materials than last year. The fire in San Francisco had much to do with this. Let us hope this increased expense may not be continuous.

THIRD SPRAYING.

Began third spraying June 18th. On inspecting the orchard to see the results of our former sprayings, I met with several disappointments.

In the first place many of the trees sprayed the last time had now no fruit upon them at all. This was particularly the case with the northern and more elevated portion of the Ganos, which had from few to not a single apple upon many of the trees, while those in the south half were heavily loaded with fruit. Hurt's Limber Twigs and Rome Beauties were also almost devoid of fruit. So all the Ganos destitute of fruit and

all of the Rome Beauties and Limbertwigs, regardless of few apples or not, were dropped from the experiment. Whether this loss of fruit was due to the March freeze or to subsequent frosts added to dry weather, I know not.

In the second place, while no scab could be found on the sprayed trees, very little could be found on the checks and unsprayed portions of the orchards. In fact, the dry spring had so interferred with its development that it was hardly in evidence throughout the season—a decided contrast to its ravages during the seasons of 1894 and 1895.

INJURY THROUGH SPRAY

(Due to Inclement Weather?)

In the third place and this was the greatest disappontment of all, the Bordeaux of the second spraying had injured many of the apples by russetting and distorting them. This injury I think entirely due to the very windy, wet weather that lasted throughout our second spraying. I know that many will disagree with me in this, attributing the injury to frost when the apples were young, or to defective lime used in the Bordeaux. That is neither one nor the other can, I think, be shown by the following facts. Checks were left in every set of apples we sprayed. These checked or unsprayed trees showed at picking, *perfectly smooth fruit,* except for worms, while neighboring trees, only 16 feet away and on the same elevation, showed much injury. This was noticeable especially in the Jonathans, Ganos, and Ben Davis. That it was not due primarily to the lime is evidenced by the fact that the orchard of the firm of Spotswood and Veatch, about which I shall have more to say further on, was not injured by the spraying in the least, though he used the same lime. My own orchard and that of Mr. Forney, only a few miles away, sprayed at the same time that I was engaged in my experiment, also suffered much. I can only account for Mr. Veatch's suffering *no* injury in his orchard this year to the fact that, though he began his spraying just about as I left off, viz, May 20th, he was stopped after two days by rain and did not begin again till the rains were all over. His trees by this time had entirely dropped their petals. Whether his immunity was due to the fruit being older and more resistant, or to the pleasant sunny weather, during which the spray would dry soon after being placed on tree and fruit,

thus holding the copper salt in place better, I know not. This problem I intend to take up next year, and if possible solve.

Some may hold that Bordeaux plus Arsenate of Lead may account for the injury, and I have heard this idea advanced, but when I say the injury was just the same with the Taft and Kedzie formulas, with Paris Green, with my own Arsenate of Lead, and with Swift's; when I further call to mind that Mr. Veatch suffered *no* injury though he has used Arsenate of Lead in his Bordeaux mixture for two years, this idea or reason falls flat.

I therefore decided to drop out from the third spraying all of the Ganos which had no fruit, as well as all of Hurt's Limber-twigs and most of his Rome Beauties, since no scab could be seen on either of the last named and the apples were too scanty to make picking profitable. I limited my sprayings from this time on to the Ganos bearing fruit, the Ben Davis, the Jonathans, and a few Roman Beauties. We sprayed part of the morning of the 18th of June, but were again stopped by rain. The weather of June 19th and 20th was pleasant, and we finished our third spraying the evening of the last day. In all two and one-fourth days were consumed in spraying about 320 trees, while about nine tank-fulls, or 900 gallons of spray, were used. The Bordeaux was again used with the insecticides, in spite of the fact that little Scab was to be seen, but because it has been our experience that late rains with warm weather would be sure to bring on a severe attack of the disease unless the Bordeaux were on the tree to counteract it. The cost of this spraying averaged per tree for labor and spray about 7 4-5 cents, while the average of second spraying was about 8 2-5 cents per tree. Since the cost of both labor and spray was the same, it shows that the increased cost of second spraying can be attributed to constant interruptions due to inclement weather. If the trees had all been as large as were many of them the cost per spraying would have been 10 or 12 cents per tree, when only two men and one line of hose is employed.

Even yet no wormy apples could be seen, and since we had been forced to search for half a day to find enough winter worms to put in our breeding cage, it was supposed that their scarcity, added to our thorough sprayings, had killed most of the first brood. As the first moths had emerged in the cage

May 18th, the first brood would be ready to enter the apples about May 28th, and, adding 50 days for the time elapsing between broods, the second brood would be entering the apples about July 17th. No wormy apples being *seen* by June 20th, we determined to omit the spraying the first or second week in July, and apply the fourth spray about August 1st. Right here was, I think, our great mistake, but as we intended to give only three sprayings, we deemed August the better month.

CONDITION AT THINNING TIME.

When Mr. Dowdy thinned his apples July 26th-27th, a record was made of the checked trees and of those immediately adjoining them. The most noticeable results were to be found in the Ben Davis. Of these, one checked tree yielded 827 culls, of which 395 were wormy, or 47 per cent! The two trees directly east and west of these, and only 16 feet away, showed the effect of spraying. From the east tree 142 culls were picked, and of these only eight were wormy, or 6 per cent. The west tree yielded 290 culls, of which 29 were wormy, or 10 per cent. As the other sprayed trees showed even less wormy apples, according as the distance from the checked trees increased, it is fair to presume that the difference was due to the killing by the second and third sprays. The average of the two trees east and west of the checked tree would be 8 per cent wormy, while the check gave 47 per cent. Hence about five-sixths of the worms of the first brood were killed by these first two sprayings, or 83 per cent. As these trees were only 16 feet from the check, as before stated, it is also safe to suppose that a greater per cent of the first brood were killed throughout the orchard. Heavy rains followed our third spraying, and it is likely that when the second brood came on about July 17th, they found the sides of the apples at least almost devoid of poison, and most of this brood choose the sides in preference to the calyx end. This supposition is reinforced by the records in the orchard of Spotswood and Veatch, which will be given later.

FOURTH SPRAYING

By August 1st, all of the stragglers of the first brood had left the apple, while of the second brood many had entered the apples some time before and many young worms were *still*

entering them. I instantly saw that we were too late to catch any but the later worms of the second brood, but determined to make the application to this end. I omitted the Bordeaux at this time, but of the arsenicals the same sprays were used on the same plats, with this exception. I selected several trees out of each plat and these we did not spray. By this means I could determine what proportion of the second brood I could still kill by spraying. Two and one-quarter days were again spent in making this application. As the extra lime of the Bordeaux was lacking, and as some of the lime in the barrel had partially air-slacked, I used about 5 pounds extra of the lime to eack tank of spray with the Paris Green, the Taft and the Kedzie formulas.

RESULTS AT TIME OF PICKING.

On October 18th, we began picking the apples. The season had been so dry and warm, and so many apples had been left on the Ben Davis trees of Dowdy and the Jonathans of Hurt, that they were very small, the latter being in the main of no use save for cider. These very conditions of warmth and dryness, while giving us very little scab, had produced more worms than this country had ever known before. In many unsprayed orchards hardly a single apple was raised free from worms.

Our method of procedure was as follows:

1. We would pick off all the apples from the checked trees and count them separately, separating the good from the wormy.

2. We then picked all the apples from neighboring sprayed trees and counted them.

3. Picked the apples from many trees, gradually increasing our distance from the checks in both directions.

4. Picked many trees close together, but sprayed with different sprays, to see which was the best spray.

5. Compared trees sprayed twice with arsenicals with those sprayed three times.

6. Made observations to determine whether the worms of second brood choose a rough in preference to a smooth place by which to enter the apple.

1 *CHECKED TREES.* Of Hurt's Jonathans the check gave, on tree and on ground, 971 apples, 608 of which were wormy, of 67 per cent. Of Dowdy's Ben Davis, one tree gave 289 apples with 282 wormy, another gave 63apples of which all were wormy, the third had no apples at time of picking, if it had had any at any time. These checks therefore averaged 99 per cent wormy.

In the Ganos the checked trees had but few apples.

The first had 19 apples, of which 17 were wormy, or 89 per ct.
The second had 28 apples, of which 25 were wormy, or 89 per ct.
The third had 41 apples of which 35 were wormy, or 85 per ct.
The fourth had 4 apples, of which all were wormy, or 100 per ct.
Average for these checks ..... 91 per ct.
Average of all checks ..... 86 per ct.

2. *SPRAYED TREES IN BOTH ORCHARDS.* To find a good average, seven trees of the Jonathans, sixteen of the Ben Davis, and sixty-five of the Ganos were picked, the wormy apples separated from the sound, and each counted. As these trees were selected near, as well as varying distances from, the checked trees, the averages should be representative.

The Jonathans gave 21.6 per cent wormy.
The Ganos gave 44.3 per cent wormy.
The Ben Davis gave 42 per cent wormy.
Average of the three kinds, 36 per cent, approximately.

When we consider that the third spraying with arsenicals was omitted in July, since I believed most of the first brood killed, at what proved to have been perhaps the crucial period, that no bands were used on the trees at all, and that these orchards are surrounded on several sides by orchards which are either not sprayed at all or in a haphazard way, the results are not so bad when compared with our checked trees.

3. One of the main reasons which led me to undertake this spraying was to determine which of the five arsenicals used with the Bordeaux would give best results. From the care with which I applied these sprays, for I held the rod all the time, as well as from the number of trees whose fruit was counted for worms in each experiment, I think the results con-

clusive, unless we expect the arsenate of lead. With this there is no doubt when we prepare the home-made lead arsenate after the approved and common method. Next year, however, I contemplate adding other ingredients with this mixture to see whether it will not then give as good results as Swift's.

I. Taft's Formula. 11 trees counted for worms gave in Ganos, 65.7 per cent.

Kedzie Formula. 11 trees counted for worms gave in Ganos, 51 per cent.

Paris Green. 14 trees counted for worms gave in Ganos, 47 per cent.

Prepared Lead Arsenate. 13 trees counted for worms gave in Ganos, 36 per cent.

Swift's Arsenate of Lead. 13 trees counted for worms gave in Ganos, 20 per cent.

II. Taft's Formula. 7 trees counted for worms gave in Ben Davis, 49 per cent.

Kedzie Formula. 4 trees counted for worms gave in Ben Davis, 48 per cent.

Paris Green. 4 trees counted for worms gave in Ben Davis, 38 per cent.

Prepared Lead Arsenate. 2 trees counted for worms gave in Ben Davis, 50 per cent.

(The high per cent. of worms is probably due to these trees standing near barn, chicken house, etc.)

Swift's Arsenate of Lead. 2 trees counted for worms gave in Ben Davis, 25 per cent.

III. Taft's Formula. 1 tree counted for worms gave in Jonathans, 33 per cent.

Kedzie Formula. 1 tree counted for worms gave in Jonathans, 26 per cent.

Paris Green. 1 tree counted for worms gave in Jonathans, 23 per cent.

Prepared Arsenate of Lead. 2 trees counted for worms gave in Jonathans, 18 per cent.

Swift's Arsenate of Lead. 2 trees counted for worms gave in Jonathans, 7.9 per cent.

The average of these three plats would be:

Taft's Formula.....47 per cent. wormy apples

Kedzie's Formula .....41 per cent. wormy apples
Paris Green .....36 per cent. wormy apples
Prep. Ars, of Lead.....35 per cent. wormy apples
Swift's Ars. Lead.....17 per cent. wormy apples

Thus in every plat the arsenates of lead gave best results, while as used the last gave results which uniformly far surpassed the others.

4. Value of third spraying with arsenicals at the time I applied it. As a large part of the second brood had entered the apples when I applied this spraying on August 1-3, the ouly way I could tell whether it did any good was to leave several trees in each plat unsprayed and compare these with those sprayed three times.

4 Gano trees sprayed with arsenicals three times, 39 per cent wormy.

4 Gano trees as near these as possible sprayed twice, 50 per cent. wormy.

5 Ben Davis trees sprayed with arsenicals three times, 43 per cent. wormy.

5 Ben Davis trees as near these as possible sprayed twice, 53 per cent. wormy.

Average sprayed twice, 51.5 per cent; sprayed three times, 41 per cent wormy.

Saved by third spraying with arsenicals, 10.5 per cent. apples.

5. Do the worms seek a rough place by which to enter the apples? It has been the general supposition that the worms which enter the sides of the apples seek a *rough* spot on the apple to enable them to use their feet and backs to help them in. It is supposed that the fact that most worms of this brood, if possible, find a place where two apples come together, where an apple rests upon a limb, or even where a leaf rests upon an apple, proves that they need something to help them *brace* themselves as they bore into the hard, smooth surface. I think this a mistake. I think the reason why the worm selects such a place is due to the fact that he wants to *hide* from his natural enemies. Many of the apples on almost every tree had been roughened and distorted by spray, as above noticed. Now since the apples had been well thinned it would be fair to pre-

sume that most of the worms would have selected these rough, cracked spots through which to enter the apple, if the idea that such a place helps them is correct. So I carefully counted on several trees, not only the numbers of wormy apples and sound, but also amongst these wormy ones how many had been bitten or entered on a perfectly smooth spot, and how many on a rough. In counting, I considered "rough" any spot that showed the slightese irrigularity or roughness in coat, whether due to spray or not.

	Worms entering rough place	Worms entering smooth place
Tree. 70 Ben Davis	50	62
Tree. 18 Gano	17	14
Tree. 56 Ben Davis	39	44

Not one of these apples entered on a perfectly smooth spot but had many moderately or very rough places by which the worm could have entered had he chosen to take the time to look for it. From these trees, and from many more on which the apples were counted but not set down in my note book, I am led to conclude that *haste* is the ruling passion in the young worm and not a desire to find a place where his work may be made easier.

AUXILIARY EXPERIMENTS AT THE ORCHARD OF SPOTSWOOD AND VEATCH

It was thought well to compare my experiments in the orchards of Messrs. Dowdy and Hurt with another orchard in this neighborhood, whose situation, surrounding conditions, and number of sprayings given it, would differ from the two I had selected. These differences can best be understood if expressed diagramatically:

Orchards selected by me.

1. Trees not banded.
2. Unsprayed orchards near.
3. Sprayed with arsenicals 3 times.
4. No fertilizers applied.

Spotswood and Veatch orchard.

1. Trees all banded for worms.
2. No unsprayed orchards near.

3. Sprayed with arsenicals 4 times.

4. Fertilizers on parts of orchard.

These headings will perhaps need explanation:

1. *BANDING.* Every good orchardist recognizes the value of banding bearing trees, and by this means add to the killing effected by the sprays. Heavy strips of cloth should be prepared 8 inches to a foot wide, and long enough to reach more than around the tree. By having these bands extra long, they can be used many years and still reach around the tree as it grows, provided they are removed and stored when not in use. To put them in place, nail a long finishing nail half way into a tree a foot or two above the ground. Cut the head off with a wire cutter or pliers, and attach one end of the cloth, having first made a fold in it so that it will present three edges instead of two. Then bring the folded band around the tree and attach the other end to the same nail, pulling tightly, but not too tightly, or the worms can not crawl under it. Any material can be used for this purpose, such as old sacks, but a good material, such as fleece-lined cotton cloth, will last longer, is more easily taken off, examined, and stored for the winter, and will catch more worms as offering a warmer and drier hiding place. Mr. Veatch, and many other good apple growers agree with him, uses more than one band on each large tree, but it has not, to my knowledge, been demonstrated yet whether the increased number of worms caught will pay for the increased time and money consumed in providing and examining several times a season so many additional bands. That they will catch *more* worms than the single band there is no doubt. To show what a help the band is I will here quote Mr. Veatch's band-record for the year.

These bands must be examined every ten days to accomplish much good, for you must remember that from the time the worm goes under the band till he or she emerges a full grown moth is only about 20 days. Now did all worms seek their hiding places on the same day, we should be safe in waiting 18 or 19 days, but this, as has before been shown, is not at all the case, some preceeding others by more than a week.

BAND RECORDS FOR 1906.

Time of Examination	Ben Davis 1300	Rome Beauty 400	Jonathan 300	Gano 400
First Ex. July 18	2800 worms	265 worms	80 worms	230 worms
Second " July 28	1350 "	176 "	76 "	132 "
Third " August 8	1224 "	58 "	20 "	31 "
Fourth " August 18	947 "	29 "	12 "	23 "
Fifth " August 28	276 "	18 "	6 "	9 "
Sixth " Sept. 7	843 "	170 "	85 "	42 "
Seventh " Sept. 18	1083 "	285 "	71 "	115 "

Some interesting conclusion can be deduced from these figures. It will be noted that the ratio between worms caught and number of trees in the Ben Davis is much higher than with any other apple. Though my experiments showed that the Rome Beauty and especially the Jonathan are not so subject to the worm as are the Ben Davis and Gano, that will not account for the disparity existing here. As the wormiest trees amongst the Ben Davis were well up the hill and not where one would expect, down the hill nearer the only other orchard and nearer the packing houses, he is convinced, as am I, that it is solely to be accounted for by *poor spraying* during the second and third applications.

Another point that one can gain from these records is that the "hight tides" of worms existed about July 18th and somewhere between September 18th and picking time in October, when the bands were last examined. Going back 20 days would give us June 28th and August 29th, when most of worms were entering the apples, and when *theoretically* two important sprayings should be given. To the careful observer, however, it will appear that these worms *began* to increase somewhere between August 28th and September 7th, showing beyond a doubt that 20 days before this a thorough spraying should be given, or about August 10th, when the first worms of the second brood were entering the apples. As my first moths came out May 18th, allowing 10 or 12 days for mating, laying of eggs and hatching, would start the first worms into the apples May 28th or 30th. Adding 50 days for period forward to young worm again, would show that the second brood at my experiment would be entering the apples about July 17-19.

The appearance of the young worms of the second brood at Mr. Dowdy's must have been several days ahead of those at Mr. Veatch's, even allowing several days for the two broods to overlap. This shows that it is important for every apple-grower to keep breeding-cage records not only of when the first brood of moths appears, but especially when the second comes out.

SPRAYING RECORDS.

The dates when Mr. Veatch sprayed and the materials used are as follows:

First spraying was applied beginning April 18th. Bordeaux.

Second spraying was applied beginning May 20th. Bordeaux, plus Swift's Arsenate of Lead.

Third spraying was applied beginning June 16th. Bordeaux plus Swift's Arsenate of Lead.

Fourth spraying was applied beginning July 14th. Swift's Arsenate of Lead.

Fifth spraying was applied beginning August 2nd. Swift's Arsenate of Lead.

WORMY APPLES AT PICKING:

Ben Davis	20 percent
Rome Beauty	5 percent
Gano	1 percent
Jonathan	1 percent

FERTILIZING RECORDS.

Our former horticulturist, Prof. L. B. Judson, asked permission of Mr. Veatch to apply certain fertilizers to parts of his orchard, to which Mr. Veatch naturally readily consented. His orchard is of nine-year old trees, of the varieties previously stated. The rows of apples run east and west; the different fertilizers were therefore applied north and south. About fifty trees each of Rome Beauties, Jonathans and Ganos, or 150 altogether, were included in each tract to be fertilized.

Three plats were laid out, and between each two plats unfertilized rows were left as checks or controls.

PLAT I.

Bone-Meal	400 lbs.
Superphosphate	400 lbs.
Muriate of Potash	400 lbs.

PLAT II.

Bone-Meal	600 lbs.
Muriate of Potash	400 lbs.

PLAT III.

Sulphate of Iron	200 lbs.

It was hardly to be expected that much could be accomplished by these fertilizers the first year, but Mr. Veatch assures me that at time of picking in October a noticeable difference could be observed between the apples of the first two plats and those of the intervening checked rows. They appeared of better size and color, though no exact data as to weights and coloration were kept. In Plat III Mr. Veatch wished to establish whether the addition of iron in a form available for use by the tree would give a *higher color* to the apples. In this respect also he thought he could see improvement over the lower and adjacent untreated trees. A closer watch will be kept upon these plats next year.

SUMMARY OF EXPERIMENTS FOR 1905-1906.

1. Three thorough sprayings with Bordeaux mixture will, in ordinary years, completely keep in check the scab. We do not yet known by our own experience whether the first spraying as ordinarily given, just as buds are bursting ,had better be delayed, and come in later in the season. Probably late, wet summers will require a fourth spraying.

2. In view of the fact that the Bordeaux applied to the tree just as it is going out of flower, if rainy, windy weather occur at this time, almost invariably hurts the fruit, russetting and even greatly distorting it, it is our opinion that if any spraying with the Bordeaux is to be omitted, it must be *this one,* and consequently the early spraying can not be omitted. As almost no injury ensued from applying our Bordeaux at flowering season in 1905 because the weather was beautiful, we

assume that the injury is due to inclement weather, but another season is needed to demonstrate this.

3. Of all the insecticides used this season Swift's Arsenate of Lead gave best results, followed by home-made Arsenate of Lead, in every case. This does not agree althogether with other experiments conducted by our Station in former years, as well as by others.

4. Three sprayings with arsenicals are not enough to suppress the moth when unsprayed orchards are near and bands are not used.

5. Four sprayings are enough to get good results, as Mr. Veatch has shown this year, when no *unsprayed* orchards are near, and when banding is resorted to.

6. Just how many sprayings are necessary when one has careless neighbors who do not spray thoroughly if at all must of necessity be five or more.

7. Bands are a great aid in the destruction of the codling moth.

8. Apple trees should never be planted closer than 24 or 25 feet in our country where no irrigation is practiced. If planted closer than this (a greater distance would probably be better.) they will certainly be starved for water during summers and falls following winters and springs of little rain-fall as well as for food.

9. Constant cultivation throughout the latter part of spring and all of the summer is necessary to keep up the size of fruit during dry seasons.

10. The orchard-land should contain humus. It is a mistake to think that worn out wheat or other grain fields can raise good orchards.

11. Commercial fertilizers will probably have to be applied to many of our orchards where enough manure can not be had for this purpose. We have seen that even good soil, as in Mr. Veatch's orchard, will respond to commercial fertilizers. Whether enough to pay orchardists for the expense entailed must yet be proved.