OKLAHOMA

AGRICULTURAL EXPERIMENT STATION

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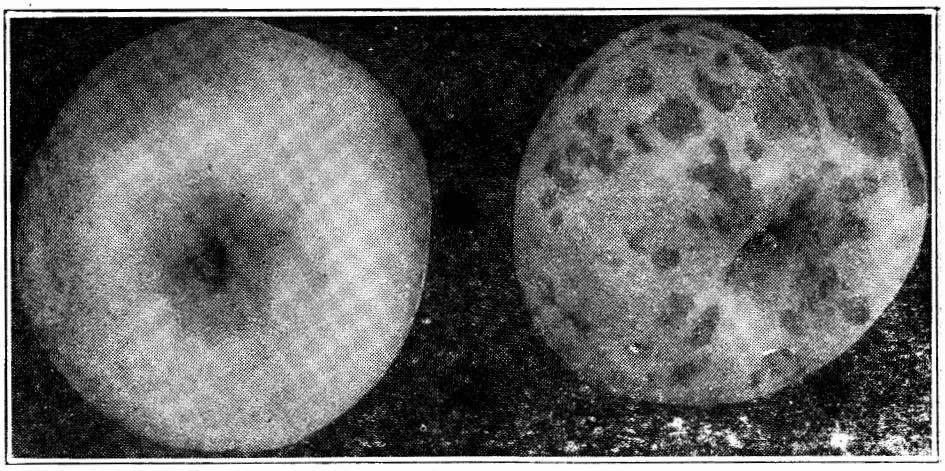
Orchard Spraying

By
MORRIS AND NICHOLSON.



SPRAYED VERSUS UNSPRAYED APPLES.

Stillwater, Oklahoma.

AGRICULTURAL EXPERIMENT STATION

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Oklahoma Experiment Station

INTRODUCTION.

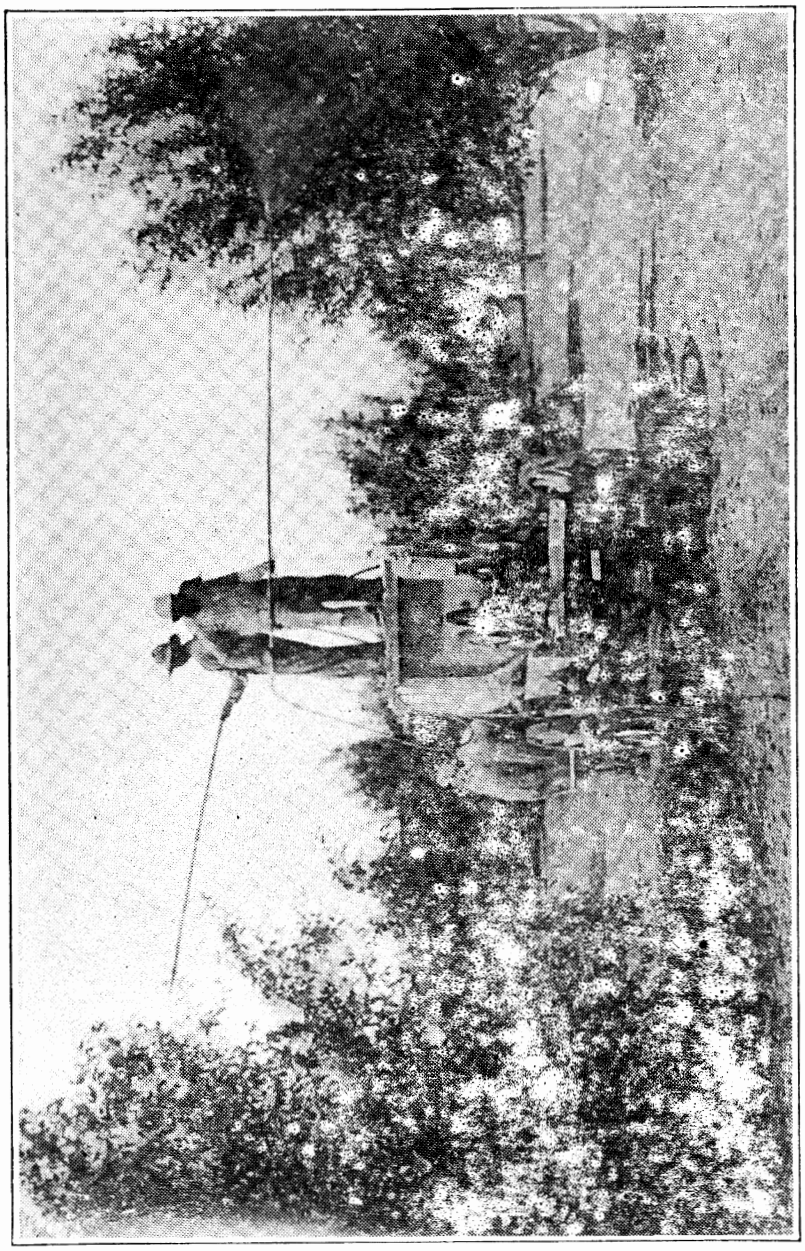
The time has come when the Oklahoma fruit grower is obliged to use some means for saving his crop from insects and diseases. These pests have continued to increase at an enormous rate in the last few years. The amount of orchard acreage has increased greatly and the losses, amounting to at least 50 per cent of the crop are greater than they ought to be, especially when there are practical methods of saving 80 per cent to 85 per cent of the crop free from these pests. In the older states where this problem was presented years ago, the losses are now reduced to a minium by a well regulated and yearly performed system of spraying.

The apple crop of Oklahoma is injured more each year by the larva of the codling moth than by any other insect. The damage done does not come so much from the destruction of the tissue as it does from the fact that the worm opens the door to the entrance of fungus spores. These latter cause destructive rots which work out from the worm burrows into the surrounding tissue. An apple once attacked by the codling moth larva can never be a first-class fruit on any market, and in fact is unsalable on the best markets. Such fruit will not endure cold storage but must be used shortly after gathering. In cold storage they soon succumb to the decay agencies. By careful estimations, based upon statistics and field observations, these insects cost the apple growers of Oklahoma $500.000 last season. This loss could have been largely saved. Where spraying is done correctly each year for a period of four or five years, the damage has been lessened from seventy-five per cent to five per cent, and even as low as one per cent.

PLAN OF EXPERIMENT.

An experiment in spraying was made on a large scale for the purpose of determining the cost of spraying, the benefits that may be derived from the work, and the practicability of the work from a financial standpoint. The orchards used in this work were divided into plats of sufficient size to give each plat a practical test. Check, or unsprayed trees were left in each plat.

The orchards selected had never been sprayed and had received very poor care and cultivation but were in no worse shape than the average farm orchard. The trees were very thick in the top and good spraying work could not be done with less than twice the effort necessary to be expended upon trees of equal size but with properly formed tops.



Power Sprayer at work in the Experiment Station Orchard

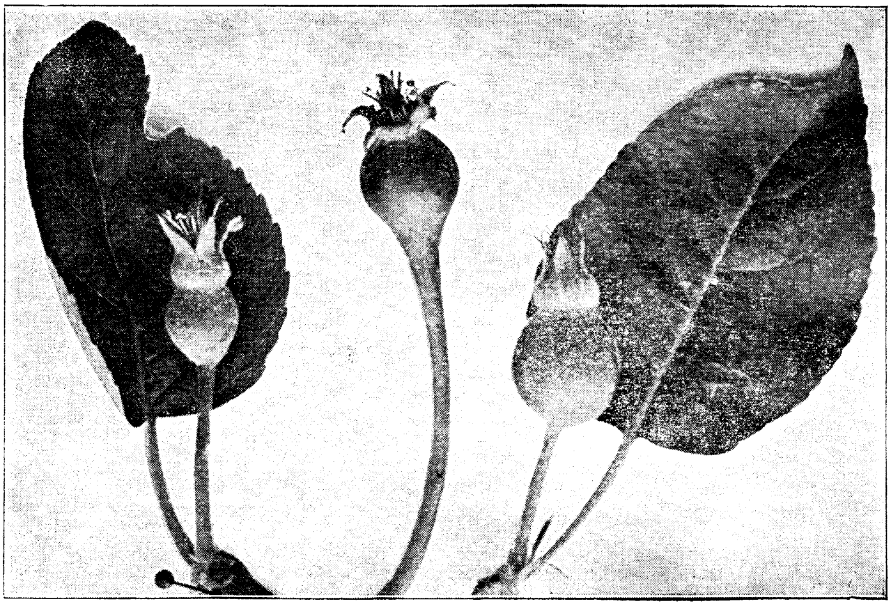
PLAN OF SPRAYING

Plat 1 was to be sprayed as soon as the blossoms fell from the trees. This plat was sprayed once only. Plat 2 was sprayed three times. The first spraying was to be done as soon as the blossoms fell from the trees. The second spraying was to be done two weeks after the first and the third two weeks after the second. Plat 3 was to be sprayed six times. The first, second, and third sprayings were to be done on the same dates as on plat 2. The forth spraying was to be done four weeks after the third, the fifth two weeks after the fourth, and the sixth two weeks after the fifth.

DATES OF SPRAYING.

Plat 1 was sprayed April 9th to 11th. Plats 2 and 3 were sprayed the first time April 13 to 15 and the second time on May 15th. This spraying was about two week slate owing to the fact that between April 15th and May 11th it rained on eleven days during which time 7.4 inches of water fell leaving the land so wet that the work could not be done.

The first and second sprayings on all plats were very unsatisfactory owing to lack of power in the pumps For this work a hand pump was used but sufficient pressure on the nozzles for good work could be maintained only with great labor. The wind blew very hard on the date of the second spraying and prevented satisfactory work being done.



Calyx-cavities Closing. Almost too late to Spray.
(N. Y. Bull. 142.)

Plats 2 and 3 were sprayed the third time on June 12th and 13th. This was about two weeks later than it was planned. Rain fell on twelve days between May 19th and June 12th. The land was too wet to work on, nearly all of this time. Good spraying was done.

Plat 3 was sprayed the fourth time on July 23rd and 24th. And the fifth on August 8th and 9th. The work was well done.

Paris green and lead arsenate were both used on each plat but no advantage was noted in favor of either material except that the lead arsenate would remain suspended in solution for a longer period than would the Paris green. Paris green was used in the proportion of 1-3 pound to 50 gallons of water and lead arsenate in the proportion of 2 to 6 pounds per 50 gallons, depending upon the per cent of arsenic contained. This would be at the rate of about 1-3 pound arsenic to 50 gallons of water. Bordeaux mixture, made by using 3 pounds of copper sulfate and 4 pounds of lime to 50 gallons of water, was used in each spraying.

The first two sprayings were done with a hand pump and a pressure between 30 and 40 pounds was maintained on the nozzles. The other spraying was done with a gasoline engine power pump that maintained a pressure of 125 pounds on the nozzle.

TABLE SHOWING THE EFFECT OF SPRAYING IN THE DIFFERENT PLATS.

Plat number.	Number of times sprayed	Percent of fruit free from worms	Percent of fruit free from disease
1	1	71.6	25
1 check	Not sprayed	60	25
2	3	79	93
2 check	Not sprayed	64	66
3	5	93.4	91.7
3 check	Not sprayed	64	60

The above table is based on the actual count of the fruit that matured on the tree and that was hand picked in early fall. Over 60 per cent of the fruit on the unsprayed trees was free from worms at the time of gathering but this does not show the proportion of windfall from the sprayed and unsprayed trees. If we take the fruit set July 1st as a basis of the crop borne, the unsprayed trees lost on an average 60 per cent of their crop between July 1st and Sept. 15th. The sprayed trees in plat 2 lost less than 15 per cent and the sprayed trees in plat 3 lost less than 10 per cent. About

90 per cent of the windfall fruit, in each of the three plats, was wormy. The gain by spraying was not all in the per cent of fruit free from worms and disease but a large increase in the amount of fruit carried to maturity. Windfall fruit is not all due to insectsand diseases. The character and amount of cultivation given the orchard has also a very important influence over the amount of windfalls. Spraying and cultivation are both necessary to the maturing of a crop of good fruit in Oklahoma.

The above cut shows all the fruit from a sprayed tree. The apples in the small pile are wormy and those in the large pile are free from worms.

NOTES ON SPRAYING

KIND OF PUMP

The kind and size of pump required for spraying depends upon the size of the orchard. The barrel pump may be used very successfully on orchards containing not over 500 fruit trees. For orchards above that size, power sprayers should be used. The average farm orchard of one or two hundred trees can be sprayed very successfully with a good barrel pump but nothing smaller should be purchased for over ten trees. The spray pump must be strong and compact in form and the pump should not stand more than eighteen inches above the barrel, the forms in which nearly all of the pump is inside the barrel are generally to be preferred. All working

parts of the pump that come in contact with the spray liquids should be made of brass. The pump should have power rather than capacity. It must be able to throw the liquid with great force in order to form a good spray.

The common mistake made is to buy a small pump at first, with the expectation of buying a better one later. Spraying seldom pays under such circumstances because good work cannot be done with a small, weak pump. The best plan is to get a good strong pump and give it a fair trial of not less than two years and if it does not give good results, the pump can then be sold or put to some other use.

THE NOZZLE.

There are two general types of nozzles in common use. The vermorel nozzle throws a funnel-shaped spray which is made by the liquid passing, with a very rapid rotating motion, through a small opening in the cap of the nozzle. This nozzle makes a very fine spray and is the form preferred by the majority of orchardists who are successful in spraying work. There are many modified forms of this nozzle but they all depend on the same principle for the formation of the spray. This nozzle clogs easily with solid particles of lime or other material that may pass through the pump. The bordeaux nozzle throws a solid straight stream of liquid against a flat surface and in this way breaks the liquid into a fine fan-shaped spray. This is a very good nozzle but is not as good as the vermorel type for general spraying work.

The pump must maintain a good pressure of liquid on the nozzle in order to do good spraying. Twenty pounds on the nozzle will not break the liquid into a fine spray but will throw it in large drops which collect on the foliage and fruit, these large drops do not cover the entire surface of the fruit and leaves unless a large quantity of liquid is used and then the liquid collects and runs off. If a pressure of one hundred pounds or more is maintained on the nozzle, the liquid will be thrown on the foliage and fruit in the form of a very fine mist. When the liquid is thrown on the plant in this form, more of it will be retained on the plant, the surface will be better covered, and less liquid and time will be used in the operation than when less pressure is maintained on the nozzle. Very good spraying can be done with a pressure of fifty to sixty pounds on the nozzle but one hundred pounds is much better and one hundred and twenty-five is still better. A pressure of forty to fifty pounds may be maintained by an ordinary pump with hard labor.

SOLUTIONS.

Bordeaux mixture is used as the fungicide in nearly all spraying done to protect plants from disease, and some form of arsenic is used to protect plants from insects. These two materials are mixed and used as one complete spraying solution and when properly prepared and applied, will prevent the attacks of all diseases and insects that can be controlled by spraying, except those insects that suck the sap of the plants. This mixture may be made in a very concentrated or in a very dilute form, The most common Bordeaux mixture is made as follows:

Copper sulfate (Blue vitriol)	4 lbs.
Fresh lime	4 "
Water	50 gallons.

Dissolve 4 pounds of copper sulfate by placing the material in a cloth sack and suspending it in a barrel or tub of water. In this way, 25 pounds can be dissolved in a barrel of water in twelve hours. Do not put this in tin or iron vessels as it will dissolve them. Before mixing, dilute this to about 20 gallons. Slack 4 pounds of fresh lime and add about 20 gallons of water. Stir the lime and water thoroughly and strain before mixing. Pour these two solutions into a barrel or tank at the same time and stir vigorously while mixing. This may be diluted to 50 gallons. If Paris green is the poison used, it should be added to the Bordeaux mixture at the rate of 1-3 pound to 50 gallons of mixture for apples, pears and potatoes. If this solution is to be used on peaches and plums, it should be more dilute. Bordeaux mixture for peaches and plums should be made in about the following proportions:

Copper sulfate	2 lbs.
Fresh lime	2 "
Paris green	1-4 "
Water	50 gallons.

Arsenate of lead is used a great deal instead of Paris green. It costs more than does Paris green but it is not adulterated to the same extent and in many cases it has given better results in spraying work. Arsenate of lead varies in the per cent of arsenic contained and the directions on the packages should be followed in preparing it for spraying work.

Bordeaux mixture, Paris green, and arsenate of lead settle to the bottom of the tank very rapidly and unless the mixture is vigorously stirred, the valuable material will be pumped out before one-third of the liquid is used. Constant and vigorous agitation is necessary to prevent settling. The agitators that are attached to the bottom of the common barrel spray pumps are of little or no

value. They do not stir the liquid enough to prevent settling. A long paddle made of a piece of board can be used to good advantage and will do the work better than the agitators attached to the pumps.

TIME OF SPRAYING.

The dates that the spraying should be done can be given only approximately and are based on the growth and development of the trees, fruit, diseases and insects. The early summer apples can be protected by three sprayings. The first application should be given as soon as the blossoms fall. It is important that this spraying be done before the calyx leaves of the apples close. The second spraying should be done about ten days later and the third spraying should be done about two weeks after the second.

The fall and winter varieties should be sprayed as many as five times and seven times may often be required to adequately protect the fruit from insects and diseases. The first three sprayings should be given the same as directed for the early summer apples and the fourth spraying should be done about six weeks after the third. The fifth, sixth and seventh sprayings, when given should follow each other in intervals of about two weeks. The number of sprayings required will vary some according to the location of the orchard and character of the season. Five sprayings gave very satisfactory results on Ben Davis, Winesap, Jonathan, and Missouri Pippin apples in the summer of 1907 and one spraying gave fair results on early summer apples. The spring of 1907, however, was exceptional in that it was cold, wet and late and the insects did not begin active work as early as common. The result of several years' work indicates that seven sprayings will more often be found desirable than five and it will not be safe to depend upon protecting the fruit with less than six.

THOROUGHNESS.

Spraying must be well done if it is to be of any value. Slipshod work will not pay. The liquid must be applied from every direction so that all parts of the foliage and all the fruit will be wet. If the top of the tree is very dense, the nozzle should be held in the center and the spray thrown in every direction. The work cannot be done in a high wind. The side of the plant next to the wind will be washed and the side opposite will show little sign of the spray. Spraying is a preventive and not a remedy. The damage done by a disease or an insect can be repaired only by the plant itself. The spraying must be done early and the protection made complete before the disease and insects appear. The insects that work inside of the fruit cannot be reached or affected by spraying the plants

after they have made their way into the fruit. Foliage insects, however can be reached by spraying at any time. Three fundamental rules to be followed in spraying are: Spray on time; be thorough in the work, use the correct material. If these three rules are followed, satifactory results will be obtained in nearly every case.

COST OF SPRAYING

The cost of spraying bearing apple trees varies from three to twenty cents for every tree sprayed. The spaying mixture composed of Bordeaux and Paris green, or arsenate of lead, will cost one to three cents per gallon. The amount of material required to spray a bearing apple tree varies from one to five gallons. Three or four gallons of spraying mixture will cover a well-formed tree that has a spread of top of fifteen feet. The amount used depends somewhat upon the pressure maintained upon the nozzle while doing the work.

The size and thickness of the top of the tree govern the amount of liquid required to cover the foliage and fruit thoroughly. Trees with open tops can be covered with less material and in less time than trees of equal size with dense tops. The open topped trees show less disease on the fruit and foliage than do the thick-topped trees, but there are other conditions that cannot be discussed here, that seem to indicate that the thick-topped trees are more productive than the open-topped ones.

The time required to do the spraying depends upon the convenience and location of the mixing tank or barrel and upon the ability of the pump to supply a heavy pressure on the nozzle. About half of the time spent in spraying an orchard is used in making up the spraying mixture and filling the spraying tank. This part of the work can be greatly facilitated by arranging the mixing tank or barrel and water supply convenient for the work and near the orchard.

HOW LONG WILL ONE SPRAYING PROTECT?

The length of time that the spraying material will remain on the fruit and foliage and be effective in protecting from insects and diseases depends upon the rate of growth of the fruit and foliage and upon the weather. The dry material on the fruit protects only the amount of surface covered. As the fruit and foliage grow, new surface is exposed and these new surfaces should be covered with fresh spraying material. The Bordeaux mixture and the arsenic poisons will remain on some of the foliage for months after the last spraying but the rains will wash off enough to expose the tissue to disease and insect attacks. If rain falls soon after the spraying has been done, the work should be repeated at once.

Bordeaux mixture will frequently injure the fruit and foliage, this injury appearing in the form of rusty spots. This injury is most common in cases in which rain has fallen immediately after the trees were sprayed. It has proved to be a serious trouble in Oklahoma.

LEARN HOW.

Spraying is not a task that requires skilled labor but experience, careful and thoughtful work are of value in securing results. The ability to swing the spray nozzle about through the top of the tree and cover all the plant with the spraying liquid in the shortest time and least waste of liquid is developed only by practice. The trees will show the effective work when the liquid dries, those that show the result of poor work should be sprayed again.

THE RESULTS ARE ACCUMULATIVE.

The results obtained from the first year's spraying are frequently unsatisfactory. The second and third years work will give much better returns. The insects and diseases will be reduced in quantity each year and spraying will the first year protect 20 per cent of the fruit will in three or four years protect 50 per cent to 75 per cent of the fruit. Spraying is an expensive and laborious process that should not be undertaken unless the orchard is given reasonable care and cutiivation. Spraying is the last addition to the different processes of orchard cultivation. It is more expensive than cultivation but fully as necessary if good results are to be obtained and it is not worth the doing unless the other necessary processes of good cultivation are followed out.

O. M. Morris,
Horticulturist.

THE CODLING MOTH.

LIFE HISTORY OF THE CODLING MOTH.

For the purpose of determining the complete life history of this insect, apple trees were screened with wire cages and the insects in them were subjects for study and observation for one complete year.

The data obtained by the use of these cages were confirmed and supplement by broader field observations.

THE INSECT IN THE FALL.

During the latter part of summer and early fall, the codling moth prepares for winter. It does this by spinning a cocoon in which it rests as a larva until the following spring. As early as September 3rd, worms were found entering the cocoons in which they would remain until spring. On September 26 nearly all the insects found were in the larval stage and were located under pieces of loose bark on the trees, in crevices, and even under clods of dirt on the ground around the trees. Rubbish on the ground was found to give excellent quarters in which to hide. Most of these larvae were fully grown, measuring from one-half to three-forths of an inch in length and of a pinkish flesh color The insect is easily distinguished while in this stage by its association with the apple, and by its brown head and pink colored body. During the fall, no moths, or pupal cases were found.

THE INSECT IN THE WINTER.

As a rule the larvae remained unchanged in their silken cocoons through the winter A few pupal cases, however, were found, the number not exceeding two per cent of all the insects. The few that had changed from the larval form to the pupal stage were the more fully developed individuals when fall came on, and were able to take advantage of the warm days of winter to transform. No moths were discovered at this time. In other words, the temperature was not high enough to induce the few pupal cases to deliver fully developed moths.

It can be safely stated, therefore, that the codling moth spends the winter in and around the tree in the larval or worm stage. Destruction of loose bark and rubbish, which serve as resting places for the insects, will lessen the chances of them remaining near the tree. Often decayed fruit is allowed to remain on the ground and this gives an excellent opportunity for the worms in them to complete their larval development, and even to use the old dried apple as a shelter in which to pass the winter months.

THE INSECT IN THE SPRING.

During the latter part of February and through March the larvae pass into the pupal stage. No moths were found, although some insects had passed into the pupal stage during the winter.

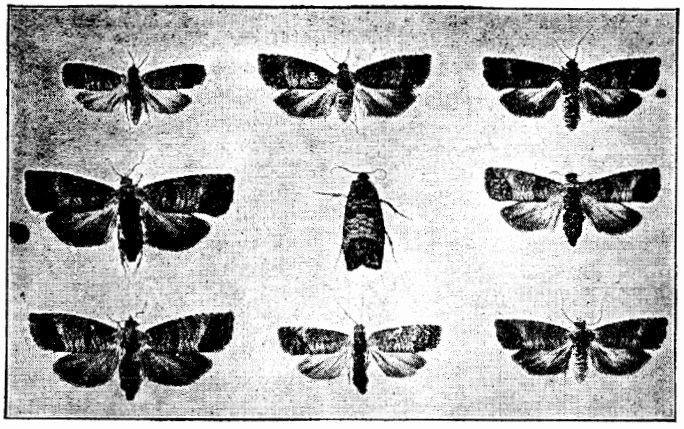
THE INSECT IN THE SUMMER.

At blooming time (April 8-12) and for four weeks thereafter the moths were present, busily depositing eggs upon the leaves and young fruit.

DESCRIPTION OF THE INSECT.

THE MOTH

The fore wings of the moths are of a brownish gray color, with numerous cross lines of gray which give them a watered-silk appearance. Near the tip of each wing is a brown spot. The expanse of



Pictures of Codling-moth Showing its variations.
(After Slingerland.)

wing is about three-fourths of an inch across, but while at rest the wings are folded down making the insect appear quite small. The length does not exceed one-half inch. The peculiar watered-silk appearance with the brown spot at the tip of the wings, which when folded make the spots appear as one at the end of the wings, are distinguishing features that make the miller easily recognized. During the day, the moths rest on hidden parts of the tree and can only

be seen when they are carefully sought for, or the tree is disturbed. When disturbed they will flit to a new shelter almost too rapidly for the eye to follow.

THE EGG.

The eggs are deposited by the females according to C. B. Simpson (1) (Bul. 41 Div. of Ent. 1903) in the late afternoon or early evening. As to the number of eggs deposited by each female, the writer obtained no definite data. Several females were dissected and the eggs in all stages of development counted. Never more than thirty to thirty-five were found and in some cases only eight or ten. The average number generally given for this insect is fifty.

WHERE ARE THE EGGS DEPOSITED?

The females from the brood that had passed the winter in the orchard deposited largely upon the leaves. On April 20th, several trees were selected and a section taken on each tree and the entire area of each section searched for the eggs of this moth.

The following are the results expressed in percentages Under side of leaf, 48 per cent; upper side of leaf, 28 per cent; on stems and side of fruit 9 per cent; in calyx of fruit, 17 per cent.

On August 15th, the leaves and fruit of several trees were examined again for the eggs of the second brood of moths and not one egg was found upon the leaves. All were found upon the sides of the apples and on the adjacent stems.

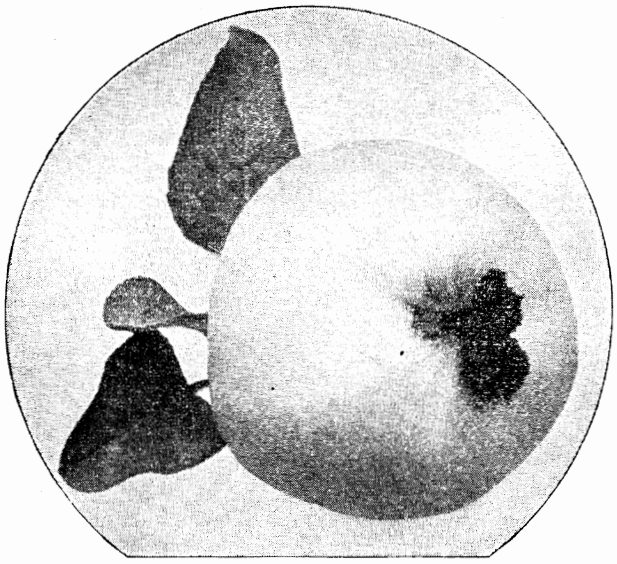
PERIOD OF INCUBATION

Moths were kept in the laboratory for the purpose of inducing them to deposit eggs, but each effort resulted in failure. The data relative to the period of incubation was obtained by gathering fruit and leaves with eggs attached and allowing them to hatch. This requires from three to five days, but does not indicate the whole time from deposition to hatching. By adding a few days for the time elapsed prior to gathering the eggs, we can estimate that the whole period is about one week. This agrees with the time given by Slingerland (2) Cornell Bul. No. 142.

THE WORMS.

The worm when it is first hatched is less than 1-16 of an inch long with black head and shiny dark spots. Newly hatched worms were observed to leave the spot where hatched and apparantly seek for their natural food. After finding an apple the insect sought farther for a favorable place to enter the fruit. A rough spot, or where two apples touched, or the calyx end offered inducements to the worms and they generally began to feed upon the skin in this

region for the purpose of affecting an entrance. A small portion of the skin was actually devoured according to our observation. Another young worm in the laboratory was found feeding upon the leaves of the apple. This may have been due to a failure to find fruit, but it does indicate the possibilities of the insect which means much to the success of spraying. If the insect will feed upon foliage even to a limited amount before it enters the fruit, the chance for its getting poison through spraying is greatly increased. Its habit of feeding upon the skin of the apple, and especially the portion of the apple in the calyx cup, makes it imperative that the spray should reach these portions. Spraying must be done therefore before the calyx cup closes so as to allow the poison to reach the interior of it



A wormy apple showing the familiar mass of brown particles thrown out at the blossom-end by the young worm. (N. Y. Bull. No. 142)

No records were made as to the action of the worm when it had once gained access to the apple. Its work there is better understood by the results rather than by the actual operation as all can testify.

The following field notes indicate the usual point of attack when the young worm enters the fruit.

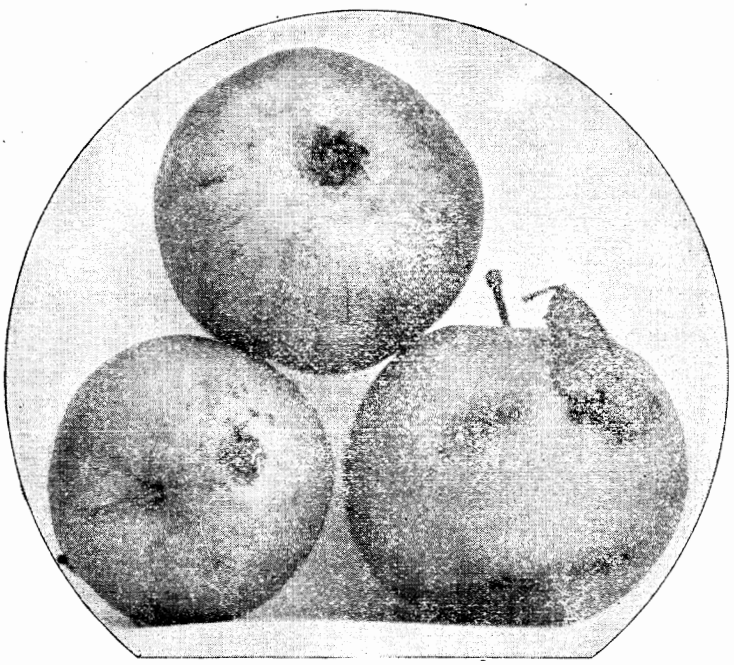
"June 8, 1907. Fallen fruit in orchard infested with worms, 1 per cent. Infected fruit entered by worm from calyx or blossom end, 71 per cent."

"June 25, 1907. Examined 24 apples, 16 had been entered at the calyx end and 8 from the side."

"Aug. 3, 1907. Examined 36 apples, 23 had entered from the side and 13 had entered at the calyx end.

"Aug. 9. 1907. Examined 70 apples, 52 had entered at side, 17 had entered at calyx, 1 had entered near stem

These notes would indicate that earlier in the season while the apples are small, the worms enter the greater per cent at the calyx end. During the attack of the later broods the greater part are entered at the sides.



Wormy spots made by a second brood of apple-worms. (After Slingerland)

After the worms leave the fruit they were never observed to feed, but immediately sought a shelter in which to spin a cocoon. If a worm left an apple which was still hanging on the tree, it would lower itself by means of a silken thread to the ground or limb below. Once on the ground or on the limb, it sought shelter, and especially a dry place. None were observed going to damp earth or into green growth like grass or weeds.

LENGTH OF TIME WORMS REMAIN IN FRUIT

The larvae remain in the apple until full grown, when they leave the fruit and seek a shelter in which to spin a cocoon and pass into the pupal, or resting stage. The time required to reach full larval development in the apple has been given by Slingerland, Cornell Bul. 142, as from twenty to thirty days. According to the following table, the length of time was shortened to as few as seven days. Temperature has considerable effect upon the time and these observations were made during the hottest part of the summer.

Table showing the length of time in fruit.

Date Entered	Date Left	Time in Fruit
July 13	July 26	13 days
July 17	July 27	10 "
July 17	July 29	12 "
July 17	July 31	14 "
July 20	July 27	7 "
July 20	July 31	11 "

LENGTH OF TIME WORMS REMAIN IN COCOON

Cocoons of the codling-moth as they are found attached to the tree.

(After Slingerland.)

The length of time the worm remains in the cocoon, as a worm, depends entirely upon the season of the year. In the fall or late summer, the worm will remain unchanged until the following spring. But should it be late spring or early summer, the worm will transform in three to five days to a brown pupa. This latter is the resting stage and is the time when the insect transforms from a worm to a dusky miller or moth. The time required for these changes is again regulated by temperature. It may be as short as ten days or as long as three weeks. On July 6th, a fully developed worm was placed in the laboratory in a warm part of the room and on July 16th it had completely transformed to a moth.

Table to show length of time worm remains in cocoon

Date Entered Cocoon	Date Issued as Moth	Time
July 6	July 17	11 days
July 24	Aug. 1	8 "
July 24	July 31	7 "
July 29	Aug. 7	9 "
July 29	Aug. 7	9 "
July 25	Aug. 6	12 "
July 29	Aug. 8	10 "
Aug. 9	Aug. 22	13 "
Aug. 9	Aug. 22	13 "
Aug. 12	Aug. 25	13 "

NUMBER OF BROODS IN OKLAHOMA.

The question of the number of broods is of prime importance in that the process of control by spraying turns upon this knowledge. It is essential that the number and time of appearing of the broods be known definitely. The data at hand answers this question only partially. The results indicate only two broods which greatly overlap each other, but subsequent investigations may reveal a third. At least this year the greatest destruction to the apple crop came from the second brood, and spraying operations directed at this brood resulted in saving as high as eighty-nine per cent of the apples of the sprayed orchard.

All individuals of a brood will not appear at the same date. Some moths are late in emerging in the spring, their eggs are laid later, and the young worms may be retarded in their development, so that for several weeks, the codling moth may be found in all stages. But from the time the first worm appears in the spring to the time that the last one, coming from the egg of a moth that has passed the winter as a larva, passed into the pupal stage we are dealing only with the first brood. It is true that some of the earlier individuals will have developed and produced moths belonging to the second brood, before the last individual of the first has completed its development, but we are still obliged to extend over the calendar the above named time and designate it as the period of the first brood. The second brood will begin to appear before the first has passed, but it, like the first, must extend to the time that the last tardy individual has passed into the resting stage. There may be a few precocious individuals that produce a third generation, but certainly the data at hand do not attribute any appreciable numbers to this brood.

LENGTH OF LIFE OF THE MOTH.

The length of time that a female has in which to deposit her eggs can only be a few days at most. Washburn claims that the life is from ten to fifteen days. Simpson says one lived for seventeen days in a cage. The writer failed to get moths to feed in confinement, which perhaps accounts for the short period that they lived in the cages. The following observations were made:

Date Emerged	Date Died	Days
Aug. 1	Aug. 5	4 days
July 31	Aug, 5	5 "
Aug. 7	Aug. 10	3 "
Aug. 7	Aug. 12	5 "
Aug. 6	Aug. 10	4 "
Aug. 8	Aug. 13	5 "

The following field notes indicate the time of the broods for the season of 1907:

April 20—Eggs of Codling Moth numerous over trees.
May 15—Small worms in few apples. Spring cold.
June 6—Larva found only in apples. None had left fruit.
June 8—Ten per cent of larvae left fruit.
June 12—Twenty-five per cent of larvae left fruit.
June 18 Fifty per cent of larvae left fruit.
June 25 Many worms left apples. Those remaining nearly developed.
July 2 Adult moths found.
July 3-5 Worms found in apples in cage.
July 8 An apple found where one worm just left and a small one entering on other side.
July 8 Ten cocoons found.
July 9 Large numbers of small larvae just entering apples.
Aug. 3 Worms in large per cent of apples.
Aug. 6 Many empty cocoons. Many apples where worms just entered.
Aug. 14 Many apples where worms just left.
Aug. 19 Few small worms. Large per cent leaving fruit.
Sept. 3 Large number of larvae in cocoons.
Sept. 3 Some apples have small worms. Few pupae.
Sept. 7 Large number of larvae in cocoons. Few pupae.
Sept. 26 Many larveae in cocoons.

These notes show the presence of two large broods and possibly a few individuals of the third generation. The third generation is insignificant and will probably be destroyed on account of its lateness. The larva will not be able to develop before cold weather and consequently will be destroyed.

The first brood was found in the worm stage, from May 15th to July 2nd. Some of the individuals of this brood came out of the fruit as early as June 8th and will be the individuals that will be represented by the partial third brood. The second brood began to work upon the fruit, as a brood about July 8th and continued in the fruit until September 1st. After September 3rd the third brood appeared as small worms entering a few late apples but they were only few in number. The greater part of the second brood began to enter winter quarters at the above date (September 3rd) and on September 7th, many of them were in the coccoon stage.

To corroborate the observations made in the field, several dozen trees were selected in June and ten apples that had not been attacked by worms were tagged and watched closely to see when the

first one would be entered by a codling mothe larva. The following results were obtained:

Trees tagged in June.					
June 26	4	trees	July 17	21	trees
July 2	4	"	" 25	10	"
" 9	10	"	Aug. 1	11	"
" 14	7	"	" 9	10	"

When the fruit on a tree was infested that tree was left out of the observations.

This would indicate that during the whole period from June 26th to August 9th, larvae were hatched and were entering the fruit. In other words the second brood was made up of individuals of varying ages. The greater part of the brood, however, fell between July 9th and 25th.

In order to ascertain the presence of codling moth adults of the third brood, a trap lantern was placed in the orchard nightly from September 3rd to October 15th. Each night's catch was examined and the codling moths identified.

Sept.	3	6	(2 of this catch contained eggs)		
"	4	8	Sept.	11	3
"	5	8	"	12	5
"	6	27	"	14	7
"	7	39	"	15	2
"	8	11	"	17	9
"	9	0	"	18	0
"	10	0	"	19	0

None were captured from this on to October 15th. This would indicate two things (1) that moths of a third brood were present in small numbers, (2) Codling moths are attracted to lights. This latter statement is disbelieved by many entomologists but the above results indicate that they were attracted nearly as strongly as other moths. On the night of September 7th, the following insects were captured:

56	Pterostichus scalptus*	1	small water scavenger beetle
1	Apple twig girdler	3	Black swimmers
16	Tiger beetles*	3	Ichneumon flies*
1194	Pterostichus erythropus*	10	Stink bugs
4	Praying mantes*	131	Tortricids
1	Dragon fly	250	Leaf hoppers
1	Lace wing*	17	Small carabid beetles*
7	Diabrotica sarar	677	Pyralide moths
1	Lady beetle*	20	Noctuid moths
14	Tarnished plant bugs	97	Geometrid moths
2	Cotton leaf bugs	2	Epicauta vittata
1	Plum curcule	18	Emonidae
1	Click beetle	39	Codling moths

Those with stars after them are beneficial insects.

DO TRAP LIGHTS PAY AS INSECT DESTROYERS?

Two thousand five hundred and seventy-seven insects were caught and out of that number one thousand two hundred and ninety-two were beneficial insects, while a large number of the others were not harmful enough to be economically considered. It is evident that lights are not valuable as destroyers of harmful insects, for the beneficial forms destroyed would soon kill many times the number of destructive insects captured by the light.

DURING WHAT STAGE MUST THE INSECT BE FOUGHT?

The efforts of the fruit grower should be directed against the worm before it enters the fruit and spraying is the most efficient method which will destroy the larvae that feed upon the surface of leaf or fruit before entering the apple. This application should be made, therefore, at a time when the worms hatch from the eggs. Since the broods overlap and young worms may be found at almost any time, the spraying solution should be present on the tree continuously from the beginning of the first brood up to the time the apples are nearly developed. This may necessitate repeated sprayings during rainy weather. Certainly it means that the calendar cannct be used as a guide for the time of spraying. It can be used to indicate when, of all times, poison should be present; namely, at the dates when the big broods are at their maximum, which are from April 20th to June 1st and from July 1st to August 1st.

OTHER INSECTS IN THE ORCHARD.

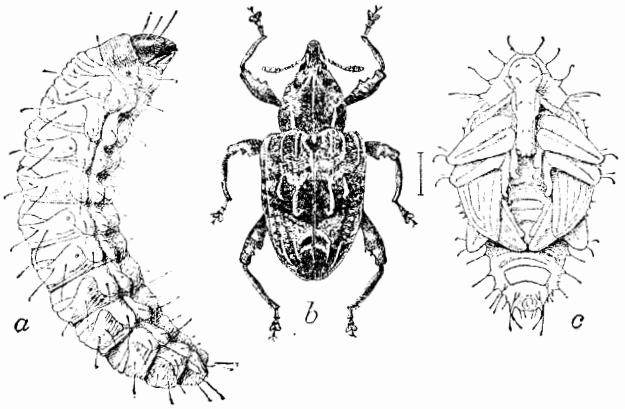
The orchard offers inducements for other insects aside from the codling moth and a word relative to some of these minor pests may not be out of place here.

PLUM CURCULIO.

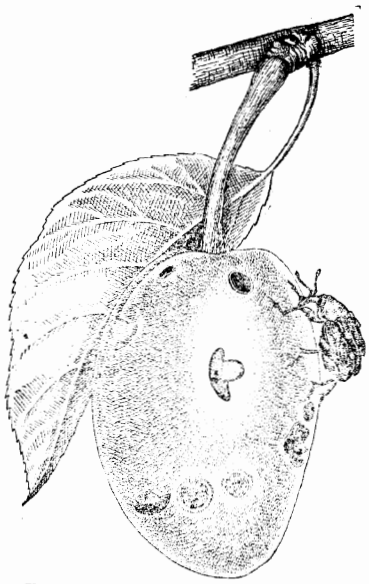
This is the insect that does the notable damage to the p apricots, cherries and peaches in Oklahoma. The small, white, footless grubs found in these fruits are the larval forms of this humped-back, long-billed insect. The adult, a dark colored insect with humps on its back, spends the winter among rubbish near the orchard. About blooming time they appear and feed upon the blossoms and tender foliage until the fruit is set. When the fruit is large enough to receive an egg, the female cuts a crescent shaped slit in the skin, deposits an egg under the same, and closes the puncture by gluing down the flap. These crescent cuts are very characteristic of the work of this insect. The eggs soon hatch into the small grubs which make their way into the flesh of the fruit.

The worm leaves the fruit and passes into the soil to pupate, the whole cycle requiring from five to seven weeks.

The methods of controling the ravages of this pest have recently changed in some localities. The old method of jarring the trees in the early morning to capture the insect (see cut) has been replaced in some localities by spraying with arsenical solutions. The tenderness of the foliage of the stone fruits requires a weaker solution than that used on the apple and pear. Arsenate of lead can be used at the rate of two pounds to fifty gallons of water, and Paris green at the rate of one pound to one hundred and fifty to two hundred gallons of water. These proportions are recommended by the Bureau of Entomology in Circular No. 73. The fact that the beetles feed upon foliage during blooming time and just prior to the forming of the fruit, makes the spraying method effective. A good plan would be to spray with the Arsenic and Bordeaux for the purpose of destroying the fungus diseases as well as the insects. The sprayings should be done just as the buds are opening, and again when the petals have fallen. This may be repeated as often as the trees ap-



The plum curculio (a) larva, (b) adult, (c) pupa. Greatly enlarged.(From Chittenden) U. S. D. A.



Plum curculio: Adult female on plum, showing the circular feeding punctures and the crescentic egg-laying punctures. Enlarged. (Cir. 73 Bureau of Entomology) U. S. D. A.

pear to need spraying, until the fruit is nearly full sized. The essential thing is to be sure that the leaves are well supplied with the poison at all times.

Good cultivation and the destruction of all fallen fruit lessen the number of curculios considerably. The cultivation breaks up the pupal chambers and destroys the immature beetles. The destroying of all fallen fruit gets rid of many larvae still contained in the fruit.

CANKER WORMS.

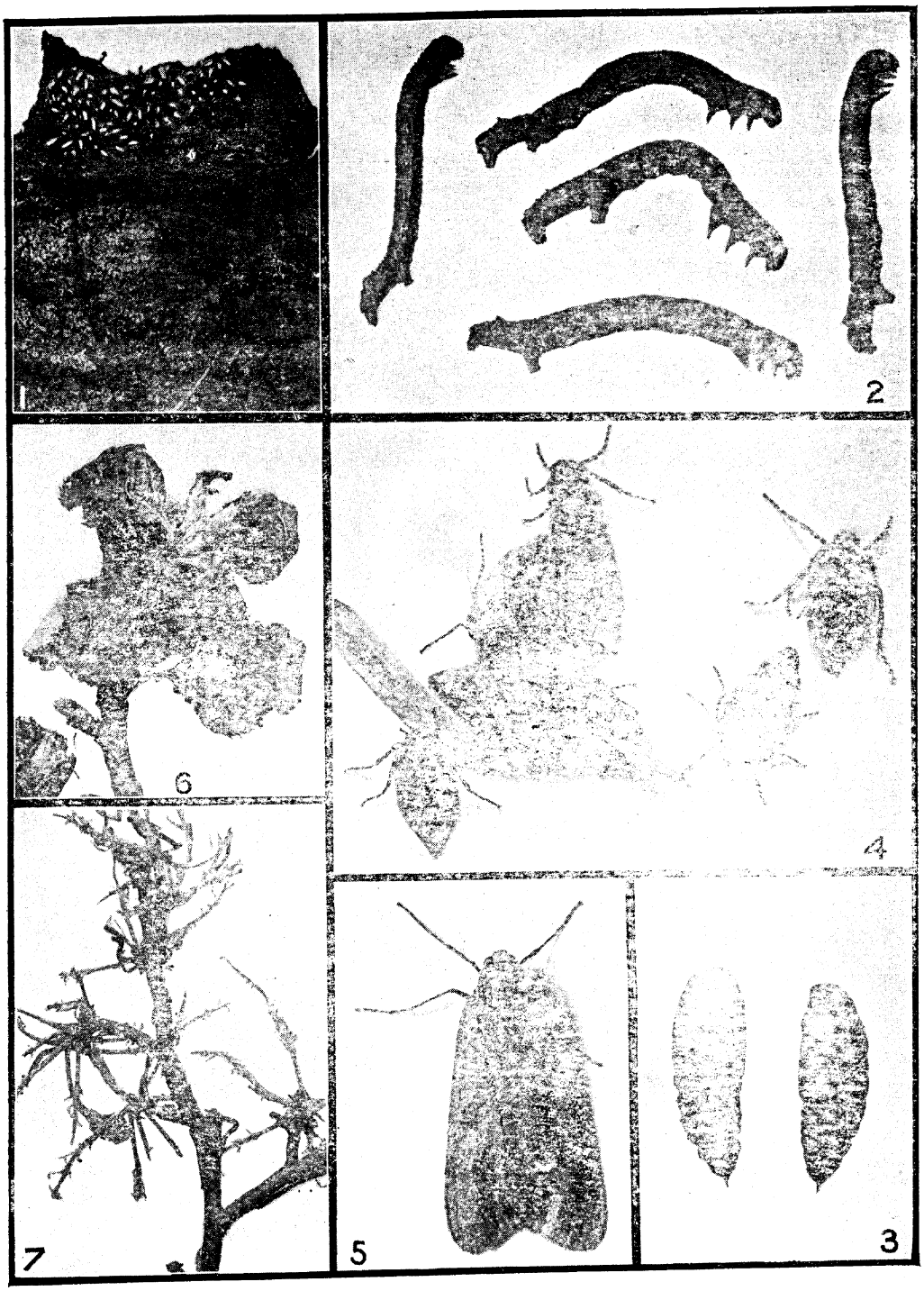
This insect does the damage to the apple by destroying the foliage. There is but one brood a year in Oklahoma and the damage is done bythe larvae during the spring and early summer. After the worms have reached maturity they pass into the soil to pupate. Here they remain until the following winter when, on mild days, they will emerge as moths, and will climb up into trees to hide away until time to deposit eggs. Cut opposite shows the fully developed worms, the wingless female and winged male all enlarged about two times. The females deposit the eggs under pieces of bark and in crevices on the tree trunk. Figure 1 shows these greatly enlarged.

The amount of damage done by this insect is not great in Oklahoma, and little concern need be taken regarding it. The treatment for codling moth is wholly adequate for the control of the canker worm. Especially is this true if the orchard receives a thorough mid summer cultivation to break up the pupal cases of this insect, which are in the upper two inches of soil.

Since the canker worms are held in check by spraying for codling moth, many other lesser insects that devour the apple foliage are likewise destroyed by the sprays.

A FEW FUNGUS DISEASES OF THE APPLE.

These apple diseases may be held in check largely by the application of Bordeaux mixture at the time the arsemates are applied



STAGES AND WORK OF SPRING CANKER-WORM.

Fig. 1.—Egg mass. Fig 2.—Larvæ, Fig. 3.—Pupæ. Fig. 4.—Female moth. Fig. 5.—Male moths. Fig. 6 & 7.—Work of canker worms on apple leaves.

for the codling moth.

The serious apple diseases are accumulative and gradually increase, until the profitableness of an orchard becomes doubtful, and eventually reaches the condition where it is a loss to its owner. No greater progress has been made in anything in the last decade than that made in spraying for plant diseases. There are very few diseases that will not respond to the attack of the spray pump. This machine has come to be a recognized necessity for the operation of the successful orchard. The spraying operation takes its place along side the cultivator and pruning hook. The time has come when the fruit grower recognizes that it is just as essential to fight the little fungus plants that attack and destroy his crops as it is to fight the larger plants or weeds, that dispute with him for the possession of his soil.

The orchards of the Experiment Station and those used for the spraying experiments are attacked each year by at least five diseases. Some of these do very little damage to the fruit aside from rendering it unsightly, while others destroy a large per cent of the fruit of uncared-for trees. All these diseases are caused by a small fungus plant that grows on or in the tissue, destroying it as it advances.

The diseases observed in the order of their destructiveness are as follows: bitter rot, scab, rust, blotch, and fly speck fungus.

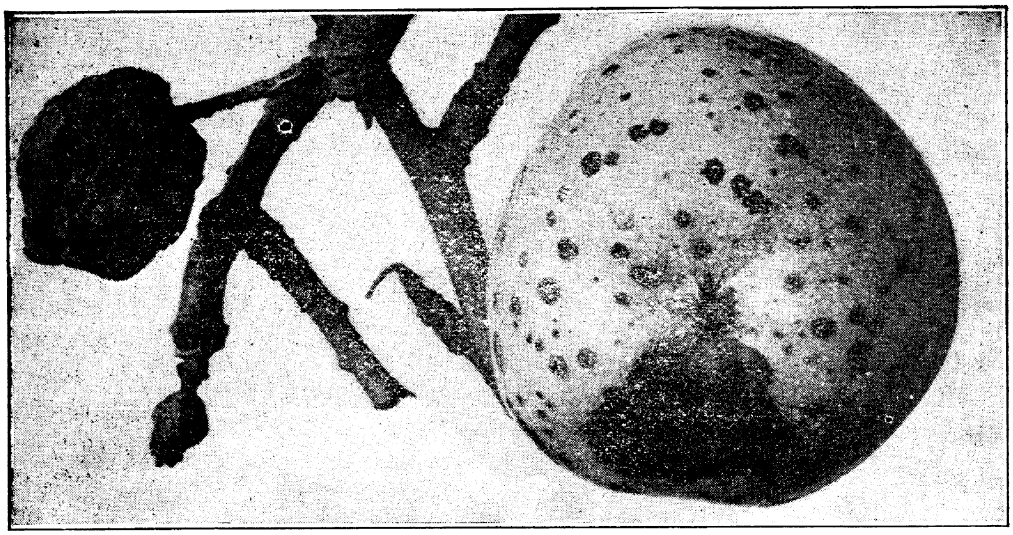
BITTER ROT.

In one orchard west of Stillwater, seventy-five per cent of the fruit was destroyed or rendered unfit for market by bitter rot.

These fungi produce fruiting bodies which are invisible, but in them produced thousands of small structures called spores. The spores are comparable to seeds and are able to rest over winter and begin growth the following spring when warm moist conditions return The remains of diseased apples left on the ground or hanging on the trees become sources from which the spores spread to inoculate the orchard the following season. The gathering and destroying of worthless fruit has great value in lessening the spread of fruit diseases.

This disease is easily recognized by the fact that the dark brown spots soon become depressed and minute black pimples soon cover these spots. These latter structures are the fruiting bodies and produce innumerable small spores.

Frequently the fruit will become entirely affected, dry up, and remain on the tree as a mummy fruit, serving as a source of infection for several months.



An apple affected with bitter-rot and a mummified fruit of the preceeding y ar's crop. (Farmer's Bull. No. 283 U. S. D. A.)

This disease is illustrated above. This year's apple has become infected while the mummified fruit of last year is still present.

Table showing amount of bitter rot in sprayed and unsprayed trees.

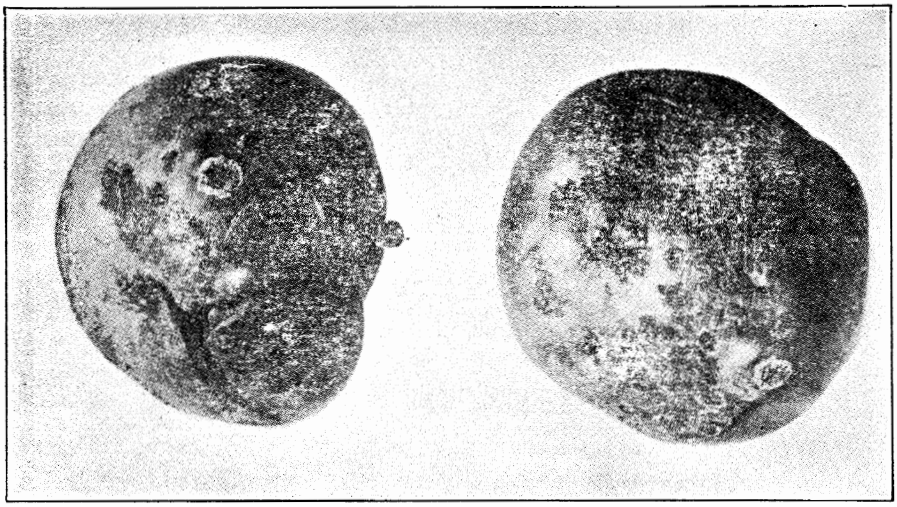
	Per cent attacked by Bitter Rot
Unsprayed trees	75 per cent
Sprayed	2 per cent 3 " " 6 " " 12 " "

This disease is not confined to the fruit but attacks the twigs and branches. Here it produces a dark shrunken canker, much cracked and wrinkled. These cankers produce spores which are as potent in producing the bitter rot in fruit as they are in producing the cankers on the twigs.

APPLE SCAB.

This disease is more general than Bitter Rot, but the actual destruction of fruit is not so great. Scabby apples are not salable on the best markets, but frequently a poor grade of fruit can be sold so that scabby fruit does not become a total loss.

The appearance of the disease is so common that a description is hardly necessary. The rough irregular areas, ranging from small spots to areas one-half inch or more in diameter, becoming dark when old, are well known to every apple grower. The disease is often found on the leaves, appearing on both sides as brownish blister-like patches. This disease on the leaves causes them to shed prematurely, leaving the tree almost bare with the exception of the scabby fruit that still adheres.



Apples badly affected with scab. (Farmers Bull. No. 283 U. S. D. A.)

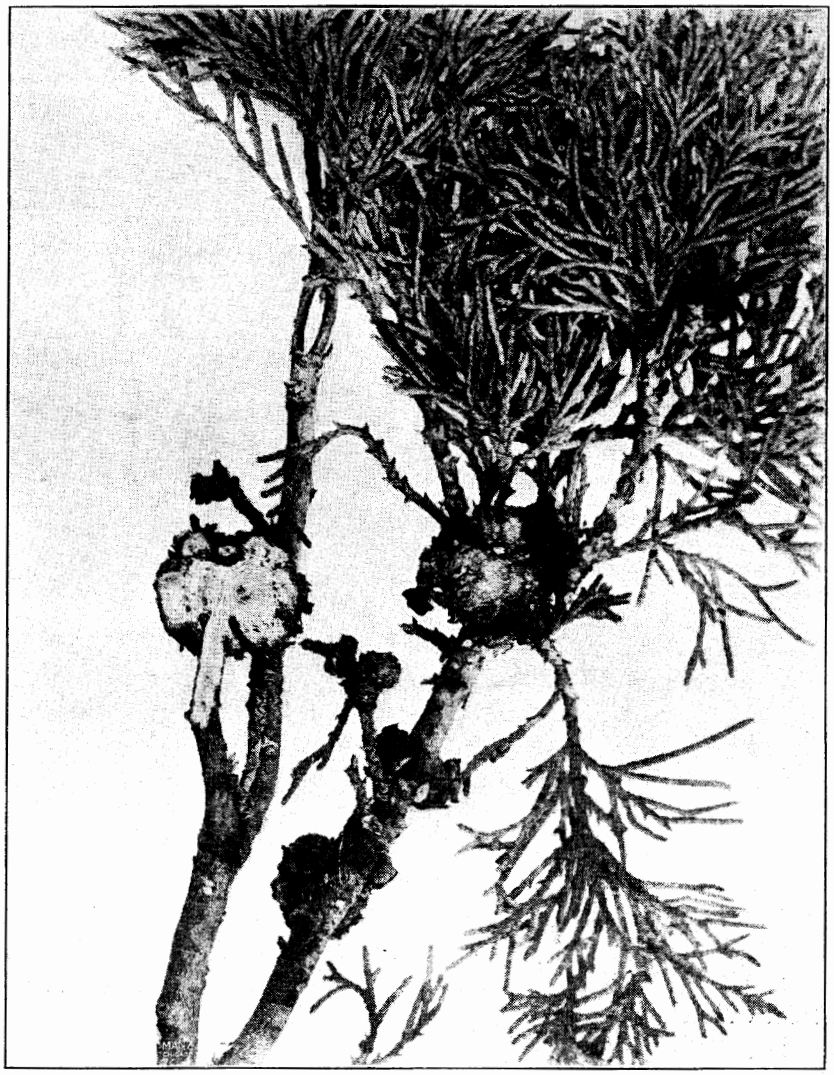
On the frontispiece may be seen an apple badly affected with this disease. The fruit frequently cracks near these diseased areas. Spores are borne in the patches and pass from tree to tree, thus scattering the disease. The winter stage is probably passed in the leaves on the ground. All remains of diseased fruit or foliage should be destroyed.

Table showing amount of scab on sprayed and unsprayed trees:

	Per cent Scabby		Per cent Scabby
Unsprayed	16 per cent	Sprayed	3 per cent 1 " " 5 " " 1 " "

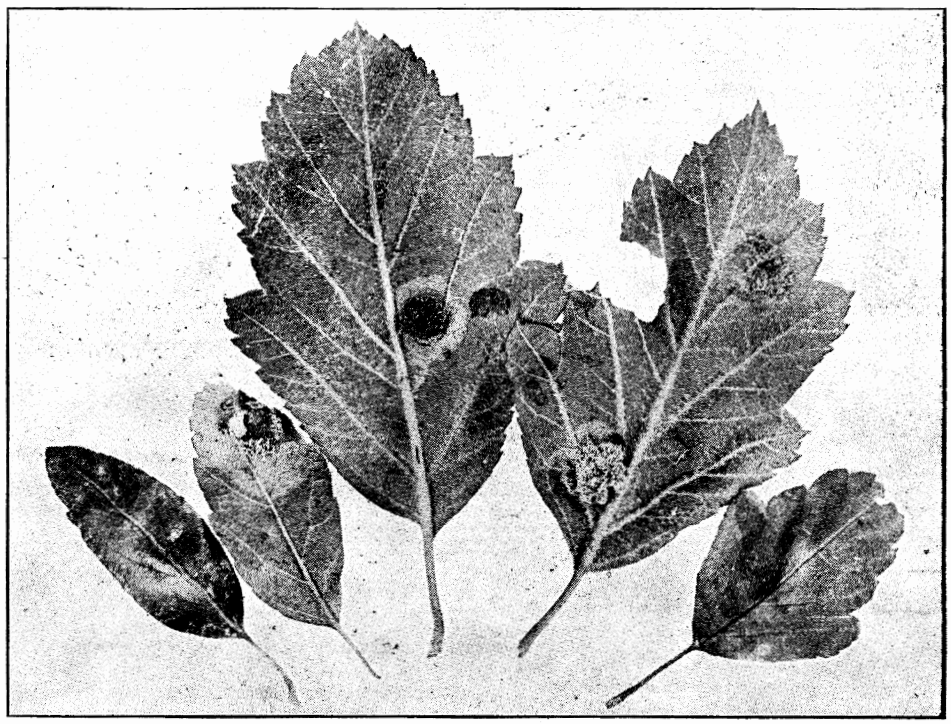
APPLE RUST.

This disease is found only in the neighborhood of cedars. The disease may appear upon the fruit or leaves of the apple, producing in each case a bright yellow spot. The leaves become so spotted at times that the whole tree appears yellow. When this happens the leaves are generally shed prematurely. The damage comes from the attack upon the fruit, and by starvation due to loss of foliage.



Perennial Cedar Apple fungus on Red Cedar. (Iowa Bull. No. 84.)

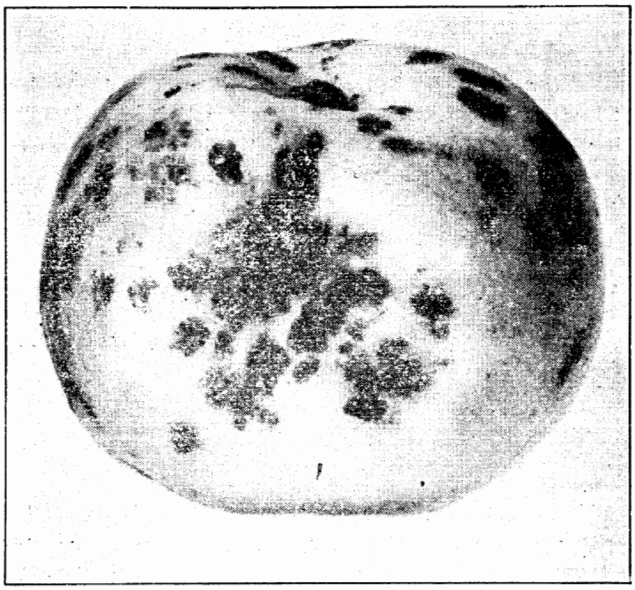
At the end of the summer the spores produced on the leaves and fruit pass to the cedar and produce there a peculiar outgrowth known as the cedar apple. This structure becomes the fruiting body of the winter spores of the apple rust, and it is from these in the spring that the apple trees are reinfested. The winter must be spent on the cedar, hence if these trees are not near, the rust will not be present in the apples. The following cuts show the rust on the apple leaves, and the so-called cedar apple.



Apple rust on wild Crab. (*Iowa Bull. No.84.*)

APPLE BLOTCH (See figure)

This disease has not done much damage herethfore in the Station orchard, but its presence indicates the need of control. The disease appears on the fruit as a blotch, at first brown and later nearly black. Little black pimples appear over this area which produce spores. The disease disfigures the fruit so it becomes unmarketable except for evaporation or cider.



A Maiden Blush apple affected with apple blotch.
(Farmers Bull. No 283 U. S. D. A.)

FLY SPECK DISEASE.

This disease is of little importance aside from its defacing the fruit. The small dotted areas on the surface of the fruit are familiar to all growers. Frequently apples will become so badly infested that the whole surface becomes one mass of these small specks.

Table showing amount of Fly Speck on sprayed and unsprayed fruit.

	Per cent of Fly Speck		Per cent Fly Speck
Unsprayed Fruit	15 per cent	Sprayed	1 per cent 0 " " 0 " " 0 " "

There are a few other leaf spot diseases that attack the foliage and render it useless for the work it has to perform; namely, the manufacturing of food for the tree. All of these, together with the above described diseases, can be held well in check, and even destroyed by a perfect system of spraying. Copper sulfate or Bordeaux mixture has been proven to be effectual in its treatment of

them. The above tables show the value of spraying for one season, and when this is followed by systematic spraying for a series of years, the results will be even more pronounced. The care of the orchard, in the way of cultivation and pruning, greatly supplements the work of the spraying machine, and the two must go hand in hand to bring the best results.

J. F. Nicholson.
Botanist and Entomologist.

SUMMARY.

The fruit and foliage of the apple tree can be protected from the attacks of insects and fungus diseases by spraying. Bordeaux mixture is the best known and most efficient spray mixture used to protect plants from fungus diseases and materials used to poison insects can be used with this solution. Paris green and lead arsenate are used as the poison and are very satisfactory for the purpose.

The cost of material and apparatus for spraying will average about ten cents per application per tree with a spread of top of twenty feet. Buy the spraying material in wholesale quantities.

It is advisable to use a general purpose nixture like Bordeaux mixture and Paris green and keep the plants and fruit well protected and avoid the necessity of giving special applications for protection against special troubles.

Spraying is a special part of orchard cultivation and is necessary for the production of good fruit. Soil tillage is the most important part of orchard cultivation and should never be neglected.