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BULLETIN 250

Controlling the Epidemic of Apple Worms

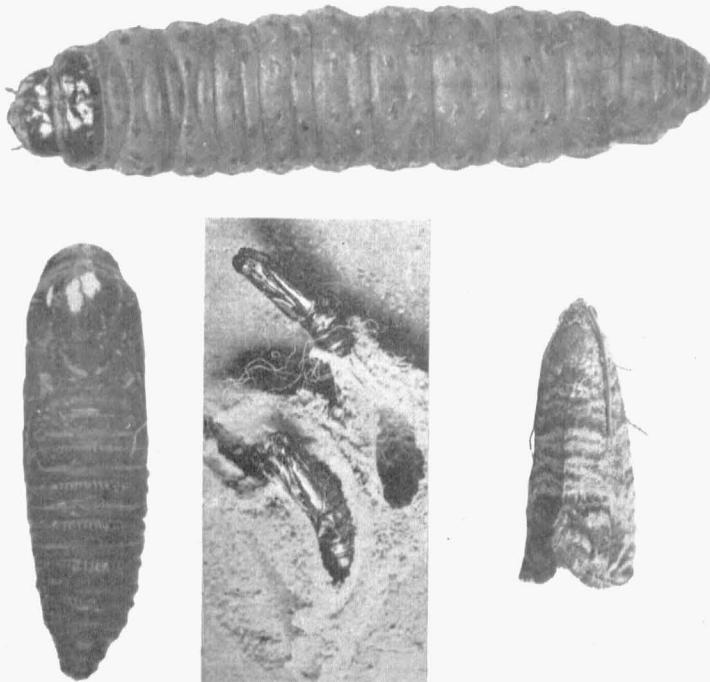


Fig. 1.—Life history of the codling moth showing the larva, pupa, pupa cases in the cocoons, and the adult moth. The larva and pupa are enlarged six diameters, the moth four, and the pupa cases three.

COLUMBIA, MISSOURI

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THIS BULLETIN AT A GLANCE

During the past two years fruit growers have not been effectively controlling the codling moth.

This has been due to several reasons, including natural conditions which have favored the pest.

The spray programs in common use have not proved sufficient.

For effective control the grower must know when the apple worms are present and entering the fruit. Breeding cage observations properly conducted will alone enable the grower to know exactly when each application should be made and how long to continue to spray for each brood of worms.

Greater efforts must be made to control the first brood of worms.

In the cover sprays for first-brood worms more arsenate of lead should be used.

Where the grower is in a position to use dust^W applications, these may prove helpful in supplementing spray applications.

From present available information, growers should not consider replacing spraying with dusting.

Later summer applications, where needed to control apple worms only, may very well be dust. It will help to reduce the amount of spray burn and spray residue at picking time.

Controlling the Epidemic of Apple Worms

L. HASEMAN AND K. C. SULLIVAN

Abstract.—This bulletin points out the fact that for the past two years the codling moth has done serious damage to the apple crop in Missouri. It explains that this unusual damage is due to favorable natural conditions, abnormal life cycle of the pest, and lack of spray coverage at times needed. Facts are cited showing the importance of greater effort to control the first brood of worms. Breeding cages are recommended to determine the time each application should be made. Emphasis is placed on the proper timing of the different applications and on the thoroughness with which they are made. An increase in the amount of arsenic is recommended in the cover sprays for the first-brood worms. There is a brief discussion of orchard dusting and the use of dust applications to supplement sprays.

During the past two years the apple worm or codling moth has been the outstanding pest with which the apple growers of Missouri have had to contend. Never before in the history of Missouri apple growing has this pest been so active and so difficult to control. Because of the present serious epidemic this bulletin has been prepared to help the growers in their efforts to keep their crops clean. The pest is on the crest of a wave of abundance and natural conditions are clearly favoring its development. In a few seasons no doubt these conditions will change but in the meantime more vigorous efforts at control are necessary.

In Missouri there are two large commercial apple growing sections. The more important of these is centered in Southwest Missouri in the Ozark region while the second section borders the Missouri and the Mississippi Rivers in the central and northern part of the state. The codling moth problem has always been and will continue to be of greater importance in the Ozark section than in Central or North [Missouri due to the fact that the Ozark section lies farther south where the growing season is longer. This has a marked influence on the yearly life cycle of the codling moth. It gives more days in which to develop, with the result that usually three full generations develop during the growing season in Southwest Missouri. Farther north along the Missouri river usually only two full generations and a partial third develop each year. As a matter of fact, the life cycle of the codling moth may vary considerably in orchards in close proximity to each other, and for this reason it is extremely difficult to recommend a definite spray schedule which will control the codling moth in all sections and under all conditions.

CAUSE OF ITS PRESENT ABUNDANCE

Every commercial apple grower is fully aware of the present increased abundance of the codling moth. This great increase of the pest may be attributed to a number of factors. The abundance of any particular insect may vary from year to year. This variation is brought about in part at least by natural conditions, such as seasonal weather changes and the abundance of natural enemies. These conditions cannot be influenced by man but their effect on a pest may be foretold in advance by careful observations. The abundance of most injurious insects runs more or less in cycles and those cycles are governed largely by seasonal weather conditions and natural enemies. It is quite probable that in a few years natural conditions will again help to reduce the codling moth to its former status. In the meantime, however, growers must increase their effort at control. This will not only help to keep the fruit cleaner each year but it will also help nature to bring the codling moth again under control. Natural conditions favorable to the pest constitute the first and most important cause of the present abundance of this pest.

During the past two years, as a second complicating factor, the life cycle of the codling moth has been very abnormal. The peaks of emergence of the adults, of both the spring and the summer broods, have been abnormal and their emergence has been drawn out over a period of several weeks with the result that it has been very difficult to keep the rapidly growing fruit sufficiently covered with poison to prevent the larvae from entering. In other words the spraying schedule which has been commonly used in the past has been insufficient to control the codling moth under present conditions. This has helped to bring about the tremendous increase of the pest.

A third factor which has helped to complicate the problem of control has been the unusual abundance of curculio stings. Along the Missouri River both the apple curculio and the plum curculio have been unusually abundant and their tiny stings have provided entry for the apple worms. By entering at these punctures they escape the poison sprayed over the surface of the fruit.

There is still another and a very important reason for the present abundance of apple worms. A grower with years of experience develops a confidence in his own methods which too often encourages haste and lack of thoroughness. Also as his trees grow larger or his bearing acreage increases he too often does not increase his spraying equipment to keep pace. In some cases he has left off perhaps one spray or he has hurried in order to get over the orchard. This has resulted in an ever increasing number of worms which have escaped him to start off the next year's crop of worms. That this is true, we must admit, when we find an oc-

casional grower who has been able in the last two years to keep his apples clean, while his neighbors have lost heavily. Such growers in the past have often appeared to be extravagant in the number of applications made and in the amount of spray solution used on each tree. We had this same difficulty with the scale a few years ago.

GROWERS MUST INCREASE AND IMPROVE THEIR SPRAY SCHEDULE

In the past many of our fruit growers have depended primarily on three sprays for the actual control of the codling moth. They are first, the calyx spray applied during the short period while the calyx cups

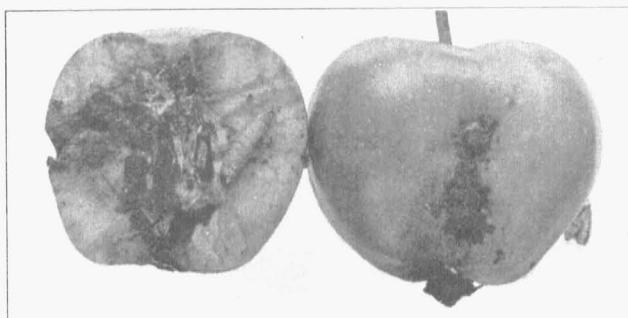


Fig. 2.—Apple showing the apple worm and the injury it has done.

are open, second, the ten-day or two-week spray applied from ten days to two weeks after the calyx spray and third, the July spray applied some time during the first half of July. The first two sprays are for the control of the first or spring brood of worms and the last one is applied for the second or summer brood. This schedule has been used for years in the State and under ordinary conditions has usually controlled the codling moth very effectively. Under present conditions, however, with the great variations in the life cycle of the pest and its greater abundance, this schedule has become entirely inadequate.

During the past season in Central Missouri the adult moths from the over-wintering larvae began to emerge during the period of the petal fall, they continued to emerge for a month, and the period of maximum emergence took place two weeks later than is ordinarily the case. In order thoroughly to control the pest under such conditions a spray should have been applied every ten days through May and most of June. This great variation in the spring brood resulted in a similar variation in the

July or summer brood with the result that one spray in July was again entirely inadequate. Unfortunately spray materials are costly and it also takes a great deal of time and labor to apply a spray thoroughly and one of the objects of this publication is to make certain suggestions and to point out certain practices which will tend to lessen the cost of effectively controlling the codling moth under present conditions.

Also it must be remembered, in spraying for the codling moth, that the newly hatched larva is so small that it can scarcely be seen without magnification. When it enters the apple it makes a hole smaller than the head of a pin. Therefore, unless the spray is so applied as to cover

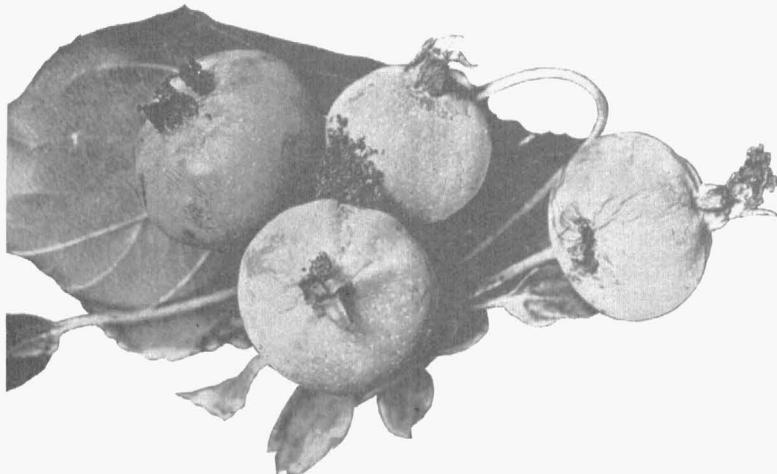


Fig. 3.—Apples showing the typical signs of first-brood apple worm work.

thoroughly every part of the surface of the apples, many of the larvae are able to get into the fruit regardless of the number of sprays applied. If a piece of work is worth doing at all it is worth doing right. The most important factor in controlling the codling moth with spray material is to do a thorough job of spraying at the right time. Unless the work is done thoroughly it is impossible to control the pest.

IMPORTANCE OF BREEDING CAGE RECORDS

The spray schedule which has been used in the past by many growers has failed to control the codling moth, primarily because the sprays were not applied often enough and at the right time. In order to control the codling moth in any particular orchard under present conditions the date of application of the sprays must be based on the emergence

dates of the adult moths. A spray applied a week too early or a week too late will not give adequate control. Most growers have been in the habit of depending on a regular schedule including only a few applications and these made regardless of conditions governing the life cycle of the insect. Such a schedule will not control the codling moth under present conditions.

In order to obtain the best results in the most economical manner the spraying schedule must be based on the life cycle of the insect. Every orchardist should run a breeding cage and keep records on the life cycle of the codling moth. The importance of knowing when the moths are on wing, and when the worms are entering the fruit cannot be overestimated. The work of keeping records on the yearly cycle of the codling moth is not difficult and it takes very little time. The results obtained will be worth many times the labor involved. The only equipment necessary is a few burlap bands and a breeding cage.

MANIPULATING BANDS AND BREEDING CAGE

In order accurately to run the yearly cycle of the codling moth a number of trees should be banded about the first of August. Use strips of burlap about eight to ten inches wide and fasten these about the trunks of the trees just below the first branch. They may be held in place either with a stout string or with tacks. The bands should be put on during the early part of August in order to serve as a shelter beneath which the larvae of the summer or fall broods spin cocoons in which to pass the winter.

Many of the larvae, on maturing, leave the fruit and crawl down to the trunk of the tree in search of a well-protected place in which to construct their cocoons. Ordinarily the cocoons are constructed beneath bits of bark, and if a burlap band is placed around the trunk, large numbers of the larvae will take advantage of the added protection which it affords.

The bands should not be disturbed until the middle of the following April or about the time the cluster bud spray is applied. At that time the bands should be carefully removed and the cocoons containing the over-wintering larvae collected and placed in the breeding cage. In case bands are not put on trees in August one can collect the cocoons from beneath bits of bark on the tree trunks.

Most any sort of a container which can be tightly closed and in which the moths can be observed from the outside may be used as a breeding cage. A wooden box from twelve to eighteen inches square and six to eight inches deep with a glass or very fine screen wire top will make a very satisfactory breeding cage. One hundred cocoons if possible should be collected and placed in the cage since more reliable data can be obtain-

ed from a large number of individuals than from a small number. The cage containing the larvae should be placed out of doors, as nearly as possible under the same conditions as those which prevail in the orchard. Careful observations should be made daily, especially as soon as the first adult moths begin to emerge.

Under normal conditions the first emergence may be expected at about the time the petals are falling. The main emergence may then continue for a couple of weeks or even for a month, as in case of last year. This can be determined by the breeding cage observations.

If the weather is warm egg laying will begin within three days after the adults emerge and the eggs will hatch in six to ten days and it is highly important to have a good coverage of poison on to greet the first larvae that hatch.

By carefully watching the breeding cage day by day the grower will be able to determine how long the moths are continuing to emerge and therefore the number of spray applications necessary to keep the young fruits protected from the first brood of worms. If the breeding cage is properly handled, one may expect worms to begin entering the fruit in from ten days to two weeks after the first moths appear in the cage and worms will continue to enter the fruit until after the last moths in the cage have died. Naturally the heaviest entrance of worms into the fruit will follow immediately after the peak or maximum emergence of moths. With this in mind it is an easy matter to decide how many applications following the calyx spray will be necessary and when they should be made. If one counts the cocoons he places in the cage and then every few days after the moths begin to emerge if he counts the moths and destroys them he will know when the peak of moth emergence has passed, and can, therefore, plan his spray program accordingly. A breeding cage, carefully used, is the only means the grower has of knowing definitely just what the codling moth is doing in his orchard. By means of it he can wisely determine that part of his spray schedule following the calyx spray. His cluster-bud and calyx sprays must be applied when the buds and blossoms are in the proper stages of development, as discussed later, but his later sprays should be applied when the breeding cage shows that they are needed.

After the spring-brood moths have all emerged, clean out the breeding cage and later when apples begin to show signs of worm injury collect one or two hundred of these and place them in the breeding cage where later the worms will mature and the moths of the summer brood will emerge. If the burlap bands are kept on the tree trunks one can collect the cocoons from beneath the bands during late June. Normally second-brood moths will begin to emerge early in July. One should care-

fully follow the emergence of the second brood moths the same as he did in case of the first brood moths and determine when the July spray or sprays should be made. If the moths of this brood emerge for a long time, two applications in July may be necessary. In the southern part of the State, where a third brood develops, the breeding cage may again be used though the overlapping of broods at that time makes it difficult to get accurate breeding cage records. The writers plan to broadcast information on the dates of moth emergence this summer to help those who do not run breeding cages and to supplement the records of those who do use breeding cages.

YEARLY CYCLE OF THE CODLING MOTH

From what has already been said regarding the breeding cage records and from the grower's present knowledge of the pest he will understand that the codling moth lays eggs which hatch into the apple worms. These feed in the fruit until full-fed, when they leave the fruit and select protected places where they spin their cocoons. In these the worms change to the small, brown, spindle-shaped pupae from which later emerge the moths. The pest lives through the winter in the full-fed worm stage in a cocoon. Normally these worms pupate about the time apples bloom, and the moths emerge following the dropping of the blossoms. Where the pest is

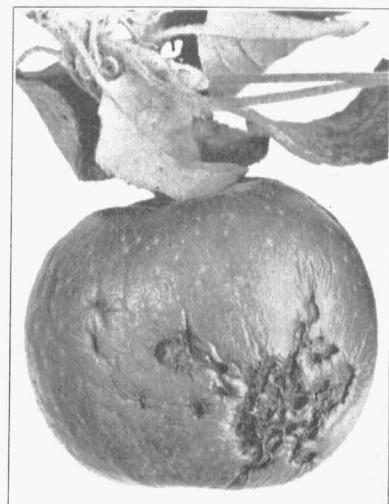


Fig. 4.—Apple severely injured by apple curculio. This shows typical feeding punctures of the apple curculio.

double-brooded as in the northern part of the State, the second brood of moths emerges during July. Farther south, where three or more broods appear, later broods of moths emerge during late summer or in early fall before the apple crop is picked. Each succeeding brood is of course the offspring of the brood just preceding it. Consequently, where spraying is not effective in controlling the first brood, the later broods become more and more dangerous because of the greatly increased number of the pests.

IMPORTANCE OF CONTROLLING THE SPRING BROOD

Every effort should be made to control the spring brood of apple worms. If the spring brood is thoroughly controlled much less damage

will be done by the summer or later broods. Each adult female lays from 30 to 100 eggs. For every worm that escapes a dose of poison in the spring there will be a great many worms that will have to be poisoned in July. Apply the calyx spray thoroughly and carefully. Then follow it with coverage sprays to prevent first-brood worms from entering. The number of coverage sprays must be determined from the records of moth emergence. Keep in mind that when the young apples are growing rapidly as in the early part of the season they soon grow out from under the coat of spray. While worms continue to emerge in great numbers and the apples are growing, a spray application should be made every two weeks, at least, and preferably every ten days. It is up to the grower to control more effectively the first brood so that fewer applications will be needed later when they complicate the question of spray residue on picked apples.

Where the apple and plum curculios are abundant they will begin to sting the fruit as a rule within two weeks after the blossoms fall or within a week or ten days after the calyx spray is applied. Where these curculios are abundant one should follow the calyx spray with a curculio spray in a week or at most ten days. As soon as the crescent or circular stings begin to appear, spray and use twice the amount of arsenate of lead, or two pounds to 50 gallons of spray solution.

SPRAY SCHEDULE BASED ON MOTH EMERGENCE RECORDS

As stated earlier it is not possible under present conditions to set down a hard and fast spray schedule for the codling moth. It is not our intention to urge the use of more spray applications than are actually needed and, that is why we urge apple growers to maintain breeding cages and to follow breeding cage records. It is evident to all, however, that we must produce cleaner crops of fruit in the future. The following suggested spray schedule, if linked with careful emergence records, should enable growers to control the codling moth. The first two sprays are of course not directed at this particular pest.

Dormant Spray.—To be applied only when San Jose scale is present. Use 6 gallons of lime-sulphur solution in 42 gallons of water, or a spray of 2 per cent lubricating oil emulsion, or a commercial miscible oil as directed.

Cluster-bud Spray.—To be applied just before the blossoms open but after the individual flower buds of the cluster begin separating. It is directed largely at apple scab. Use 1½ gallons of lime-sulphur solution and 1 pound of dry arsenate of lead in 50 gallons of spray solution.

Calyx Spray.—To be applied after most of the blossoms are off but before the calyx ends of the young fruits close. It is directed largely at those apple worms which later try to enter at the calyx end of the fruit,

and at apple scab. Use 1 or not more than $1\frac{1}{2}$ pounds of dry arsenate of lead and $1\frac{1}{2}$ gallons of lime-sulphur solution in 50 gallons of spray solution. This should be applied very thoroughly.



Fig. 5.—Apple blossoms in the cluster or pink stage ready for the cluster bud spray.

Cover Sprays.—These should follow the curculio spray where it is applied, otherwise they should follow the calyx spray at a time to be determined from the moth emergence records. They are directed especially at the apple worm and blotch. Use $1\frac{1}{2}$ or 2 pounds of arsenate of lead in 50 gallons of spray solution and either lime-sulphur or where

apple blotch is serious use 3-4-50 bordeaux mixture as the fungicide. These coverage sprays should be applied at intervals of ten days to two weeks until emergence records show that the danger from first-brood worms is past.

Curculio Spray.—This should be used only where curculios are serious and should follow the calyx spray in a week or ten days. It is directed largely at the apple and plum curculios and early hatching apple worms. Use 2 pounds of arsenate of lead and $1\frac{1}{2}$ gallons lime-sulphur to 50 gallons of spray solution.

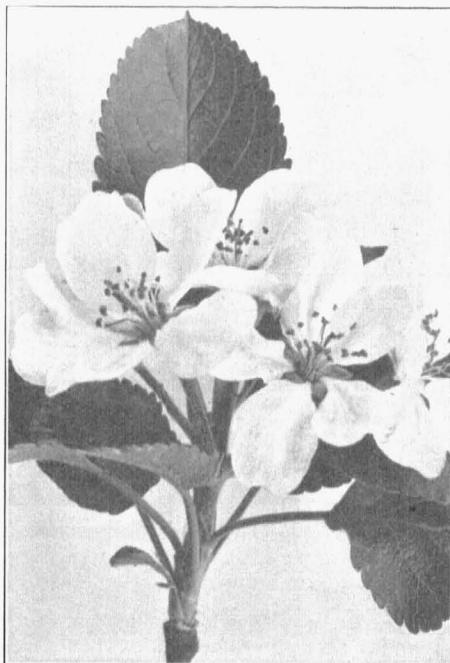


Fig. 6.—Apple blossoms. Do not spray when apple blossoms are in this stage as it will injure the set of fruit and will poison bees which are needed in the proper pollination of the blossoms.

July Spray.—This application is directed largely at the second brood of apple worms, other insects, and diseases. Under normal conditions it is made during the first ten days of July in the southern part of the State, from July 7 to 15 in the central, and from July 10 to 20 in the northern part of the State. However, the date to apply it can be determined definitely from the emergence records. As soon as the moths appear in numbers in the cage the application should be made. Use one pound of arsenate of lead and one gallon of lime-sulphur in 50 gallons of spray solution, or 3-4-50 bordeaux mixture as the fungicide, if apple blotch is serious.

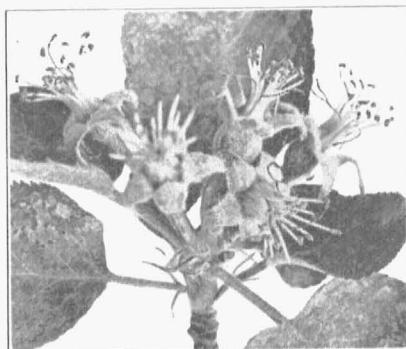


Fig. 7.—Apples in proper stage for receiving the calyx spray. Note the open calyx ends of each small fruit.



Fig. 8.—Apples too far advanced for the calyx spray. Apples of this size are ready for the curculio or first coverage spray.

Later Applications.—In case the breeding cage records show that moths of the second or July brood continue to emerge in considerable numbers for more than two weeks a second July application with the same spray solution should follow the first in about two weeks.

In the northern half of the State there is usually only a sprinkle of worms of the third brood so that later spray applications are not recommended, though a dust application in August may be used if worms are abundant. In the southern half of the State worms in considerable numbers may hatch almost continuously from August until apples are picked. Under such conditions an application or two during August may be needed and here dust applications, as discussed later, would be preferable.

DUSTING

For the past two years the College has been investigating orchard dusting under Missouri conditions. During the past year a number of commercial growers have been testing dusting and the College has access to their results. We are not prepared to make any final recommendations on dusting at this time. However, under the present difficulties with worms and with spray residue on the picked apples, we feel that there are some points regarding our dusting investigations which should be discussed here in connection with codling moth control work. We will briefly point out the advantages and disadvantages of dusting as they have been demonstrated in our experiments to date.

Dust applications have given as good control of apple worms and curculios as have liquid applications.

Due to the absence of apple scab and blotch in the experimental orchard we have been unable to compare the results of the dust and liquid applications on the control of diseases.

Labor and materials considered, dusting and spraying cost practically the same, with a slight difference in favor of spraying.

When limited for time, dusting has an advantage over spraying.

The spray sticks better, but in later applications this is a disadvantage because of the spray residue.

In windy weather dusting is impracticable, but under the same conditions thorough spraying can also be done only with difficulty.

For even coverage, under favorable conditions, dusting gives as good or better results than spraying.

Where water is scarce and the land hilly dusting has the advantage.

Dusting causes no spray burn or russetting of the fruit.

The above points would seem to favor dusting but the grower must keep in mind the fact that until we find a dry fungicide which controls diseases as well or better than the liquid applications, dusting can not entirely replace spraying. At present, therefore, under Missouri conditions dust applications can with safety be considered only as supplements to liquid sprays. As such we believe they will help both in the control of the apple worm and in solving our present spray residue problem. This, of course, will be true more especially where the orchardist has sufficient interest to justify the purchase of two types of equipment.

Some growers, whose equipment is not sufficient to enable them to properly spray their orchard within the limit of time, are planning to spray and dust alternately. This should work very well if the liquid spray applications are made when the control of the fruit diseases can be

best effected. Where such a plan is followed the cluster-bud and calyx applications should be liquid sprays. The curculio applications, or, in its absence, the first coverage spray, could be a dust application. The second coverage spray after the calyx spray should then be a liquid application. In case fruit diseases are not a problem the one or two July applications would very well be dust applications. Also in the southern part of the State, where later applications are given, the dust may work well unless a disease problem has developed.



Fig. 9.—Power duster in operation.

Where dust applications are made we would advise the use of a mixture including 90 pounds of fine dusting sulphur and 10 pounds of arsenate of lead, and for average large bearing trees about 3 pounds per tree per application. Dusting should be done when there is no wind and where possible night dusting when the dew is on is desirable, though not absolutely necessary. Where the grower is in a position to use dust applications to supplement spray applications we are of the opinion that he will get as good results in the control of apple worms and fruit diseases as where all applications are liquid sprays, and he will have less spray residue to contend with at picking time. Whether one sprays or dusts or combines the two, his results will largely depend on his timing of the applications and on the thoroughness with which he applies them. The breeding cage records should enable him properly to time his sprays.

ORCHARD SANITATION AND MECHANICAL CONTROL

This publication, presented at this critical period in codling moth control, would not be complete without a word regarding those orchard practices which may be used as supplements to the spraying program for controlling the pest. Under normal conditions some of these suggestions would not be advisable but under present conditions we believe that in many orchards at least they will prove both practical and desirable.

(1) In the first place, many of the culls at picking time and windfalls throughout the season contain worms. If these can be gathered and disposed of so as to destroy these worms, fewer moths will appear in the orchard the following season.

(2) Likewise packing sheds, apple pens, baskets, boxes, barrels and other containers in which cull or infested apples are kept for a time, will later be found to contain apple worms in their winter cocoons. These containers should be treated or left in tight storage until the following July so that the moths which may emerge from them will not be able to get back to the orchard. These sources of trouble are important and should be looked after even when the epidemic of this pest may not be so serious.

(3) Many of the worms, perhaps we might say most of the worms, on leaving the fruit during the summer and fall before it is picked, find protection beneath bits of bark on the tree trunks where they spin their cocoons. These later transform to the moth stage. This is the most important source of moths later and should be looked after. During the past fall, winter and spring a number of our growers have been scraping their tree trunks and collecting and burning the loose bark and the apple worms in their cocoons. This is slow and expensive but they feel that by doing this they will destroy enough worms to justify the expense. Other growers applied bands to their tree trunks to trap the over-wintering worms where they should be destroyed by hand or with a wire brush before the moths emerge in May. These bands may be used during the coming summer to trap the summer broods of worms. If used the bands should be examined and all worms destroyed every two weeks from the first of June to the first of October. Where the apple worms are especially abundant in orchards last year the growers should expect good returns for their efforts along these lines, though under normal conditions scraping and banding tree trunks are not generally considered practical treatments.

The whole question of the protection of the apple crop from insects and diseases is just now receiving greater attention than at any other

time since commercial fruit growing was first undertaken in this country and the next few years will probably bring great changes in the whole program. However, under present conditions we believe that the program presented in this bulletin, if properly followed, will result in a more effective control of the codling moth under Missouri conditions.



Fig. 10.—Power sprayer in operation