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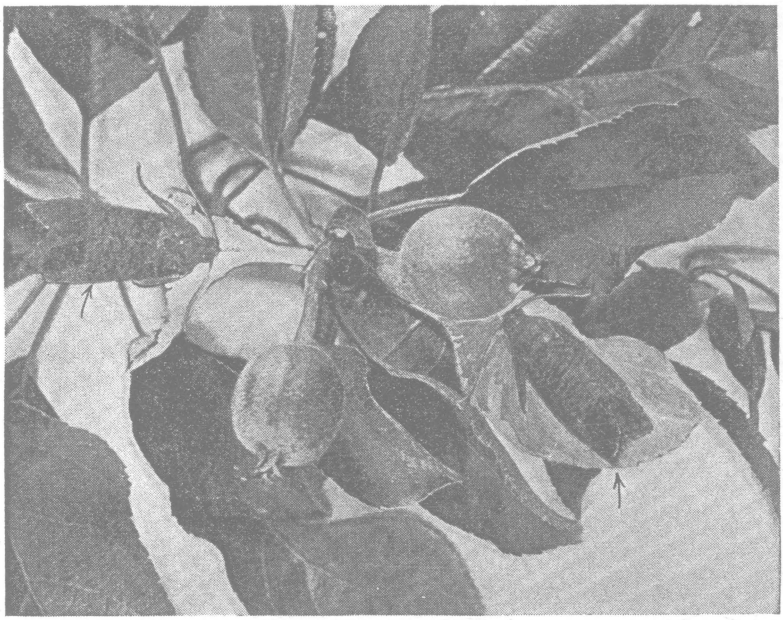
The Codling Moth
and Its Control



Stage of apple development at about the time the first codling moth eggs hatch. Moths enlarged about 3 times.

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Summary

Losses from codling moth have increased in many Ohio orchards in recent years. This is the result of (1) unusual abundance of the insect due to climatic conditions, and (2) interference with established spraying procedure by spray residue regulations. These losses have been largely limited to Lawrence County and to the area bordering the west end of Lake Erie.

There are two generations of the insect annually in Ohio, with a partial third brood of larvae occurring during some seasons in southern counties. The two generations are so long drawn out that, in orchards with heavy codling moth populations, some eggs are hatching almost daily from early June until late September.

Spraying with arsenate of lead is the best control method known. Spray applications should be made very thoroughly and an attempt made to cover all sides of the little fruits as well as the foliage. The calyx cup spray should always be applied. This is followed with from two to five cover sprays, depending upon the degree of infestation. Very few orchards need receive over three cover sprays. Timing these sprays is very important. Every effort should be made to control the first brood in order to reduce the worm population in late summer and the number of sprays required against the second brood.

Substitute materials for asenate of lead are recommended only where the worm population is relatively light and where their use will avoid a spray residue problem. These materials are all inferior to arsenate of lead in codling moth control.

To guard against spray injury and to aid in the weathering off of objectionable residue, 8 pounds of special spray lime per 100 gallons is recommended.

Banding trees with chemically treated bands is recommended in orchards where sprays have not controlled. Such bands kill from 40 to 50 per cent of the worms which leave the apples, provided the trees are properly prepared for banding.

Elimination of hibernating places in and about the orchard, removal of wormy fruits in thinning, screening, or closing of packing houses until midsummer to prevent escape of moths, and the proper disposal of cull fruit, all contribute to make a spray program successful.

Spray residue tolerances must eventually be met. Where the regular spray schedule results in only a slight amount of excess residue, wiping the fruit may clean it satisfactorily. However, wiping at best removes only about one-third of the residue present. For fruit grown under a heavy spray program and carrying much excess residue, washing in an acid bath is the only recourse.

The Codling Moth and Its Control

THE CODLING MOTH* at present constitutes the worst apple insect pest in Ohio. The problem of controlling it is not new, and the difficulties have been increasing since 1930. This is apparently due to above normal summer temperatures, coupled with subnormal rainfall and low humidity. The codling moth is very sensitive to climatic conditions, and is more successful in hatching and entering the fruit under conditions of low humidity than under high humidity. Furthermore, above-normal temperatures speed up its development and result in a more populous second generation of larvae, which enter the fruit throughout August and September. A study of Ohio weather records reveals that from 1930 to 1933 all of the summer months from June to September inclusive had above-normal mean temperatures. Over the same period the rainfall was below normal during 11 out of the 16 months.

In addition to favorable weather conditions, the codling moth problem has been aggravated because of recent official rulings against the presence of lead and arsenical residue on the fruit. This has prevented some Ohio growers from applying the necessary late cover sprays to protect the fruit against the second brood of entering worms.

Conditions in Southern Ohio.—The present situation in Ohio regarding codling moth is very unusual in that the insect is not a serious pest generally over any large section of the state. The problem has become serious in southern Ohio only in Lawrence County. There the growing season is decidedly longer than elsewhere in the state, and, during some seasons, third generation larvae are present and enter the fruit in September.

In Lawrence County, most of the orchards were set out on what was considered favorable frost-free sites, namely, on the high slopes and tops of hills. Evaporation and humidity measurements show that these orchard sites have a considerably lower moisture content throughout the summer months than have the orchards of the Ohio River valley. It is an interesting fact that in Lawrence County the codling moth problem has become much more serious in the hill orchards than in those located in the valleys. Other southern Ohio counties do not have a serious codling moth infestation.

Conditions in Western Lakeshore and Eastern Counties.—Next to Lawrence County the most severe infestations are found in orchards located near the west end of Lake Erie, where the land is level, but where drouth conditions have prevailed for several years. In this area many of the orchards have old trees with rough bark which offer excellent hiding places for the overwintering larvae. No codling moth problem has developed in the eastern half of the state, where the insect has been well controlled with but one cover spray applied against each of the two broods.

Three Sprays Effective in Most Orchards.—While the insect has increased greatly in abundance in some orchards, the fact still remains that nearly 80 per cent of Ohio orchardists are controlling codling moth satisfactorily with the calyx application followed by one cover spray against each of the first and second brood of larvae. This program leaves the fruit poorly protected with spray covering from the middle of August until harvest time, but it has controlled worms and prevented an arsenical residue problem.

* *Carpocapsa pomonella Linn.*

Following the 1933 federal ruling against the presence of lead residue, many growers substituted calcium arsenate for lead arsenate in the midsummer or July spray against the second brood. In some orchards where the calcium arsenate was substituted, the spraying program failed to control the worms satisfactorily. Not only did more of the fruits show worm entrances, but the "stings" marking the unsuccessful attempts of worms to enter, were consistently deeper on fruits where the calcium arsenate cover sprays were applied than on fruit sprayed with lead arsenate.

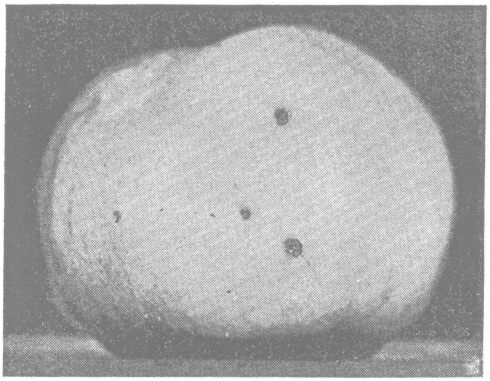

Fig. 1.—Codling moth "stings" caused by larvae which ate through the skin but were killed by spray.

In some orchards where two applications of 2 per cent summer oil alone were applied instead of arsenate of lead in the midsummer spray, the worm injury was very severe. Not all of the increase of codling moth infestation can be attributed to arsenate of lead substitutes, for we have observed a marked increase of "stung" and wormy apples where lead arsenate was used throughout the season.

When codling moth has built up a heavy population in an orchard it is not controlled easily. In such orchards growers are at present compelled to increase the number of lead arsenate cover sprays, and be prepared to remove the spray residue from the harvested fruit.

Food Plants and Varietal Resistance

The codling moth infests apples and pears. Apples are the preferred food, though serious injury may come to pears in locations where the insect is troublesome. In other localities, pears may be grown successfully without any sprays being applied for this insect.

The codling moth injures certain varieties of apples more than others. McIntosh, Chenango, and Cortland are very difficult varieties to keep clean of worm injury where the insect is abundant. This is apparently due to the tender thin skin of these varieties. On the other hand, Stark, York Imperial, and crab apples are the least susceptible to injury. Other commercial varieties show little difference in their susceptibility to codling moth injury.

Native wild hosts consist of wild crab and certain members of the hawthorn group. Wild host plants are of little importance as centers of dispersal or carryover of codling moth infestations.

Life History

The codling moth overwinters in the larval stage in tightly constructed cocoons located principally under the loose bark of the tree trunks and larger limbs. Other hibernating places are (a) in packing houses where cull apples were stored or sorted, (b) in stored crates or baskets which contained cull

fruit, and (c) in sheltered places in the orchard, such as piles of wood, brush, posts, or fallen limbs under the trees. Very few larvae are found in the grass or mulch under trees. None are found in or on the bare soil.

The First Brood.—The larvae change to the pupal stage within the overwintering cocoons, and the first moths emerge soon after petal-fall. Moths emerge principally during the morning hours and within two or three days begin laying eggs, provided the evening temperature is favorable. They are active only when the temperature is above 62°F. At this temperature very few eggs are laid. As the temperature approaches 68° many eggs are deposited, while above 68° egg laying takes place rapidly.

The eggs hatch in about 10 days to 2 weeks and the newly hatched larvae wander over the leaf, making their way to the fruit (see Fig. 2). It is probable that only a small percentage of them are able to reach the little apples. If the eggs are laid on the fruits, the newly hatched larvae may wander over the surface of the apple from 30 minutes to 3 hours before burying themselves beneath the skin of the apple.

If successful in entering, they remain inside the apple about 3 weeks, and may leave the fruit before it drops, or fall to the ground with the infested apple. In either case they usually make their way to the tree trunk, or other hiding place, where they spin a dense cocoon around their bodies and change to pupae. In the absence of rough bark, they may wander up or down the tree for a considerable distance before locating a hiding place.

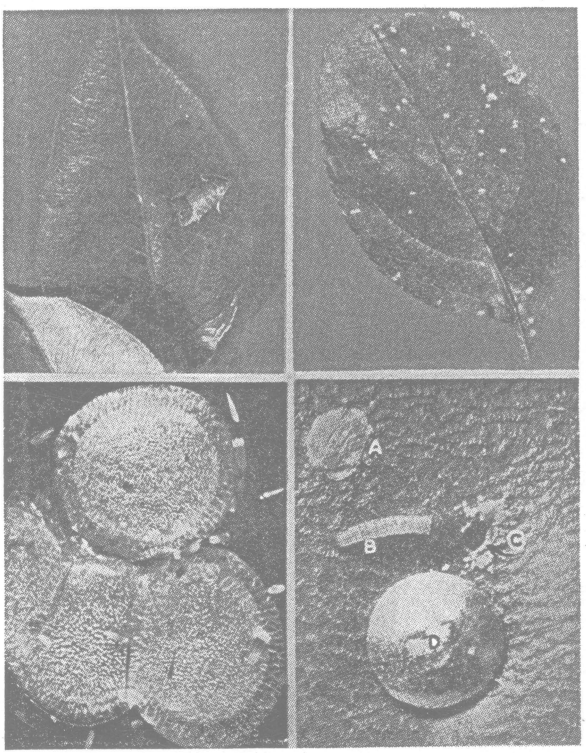

Fig. 2.—*Upper left*—Moth at rest on leaf. (*Original*)
Upper right—Eggs laid on leaf. (*After U.S.D.A.*)
Lower left—Eggs enlarged. ((*Original*)
Lower right—A—Eggshell; B—newly hatched larvae; C—entrance holes; D—head of pin. (*After U.S.D.A.*)

The Second Brood.—After remaining in the cocoon for about three weeks, the moths of the summer generation emerge and lay eggs to produce a new crop of worms. If the late worms are numerous, apples may be ruined in August and September. Since emergence of moths from the overwintering cocoons is prolonged over a period of 5 or 6 weeks, the

earliest hatching worms of the second generation may be entering the fruit before the last deposited eggs of the first generation have hatched. Thus, under heavy codling moth infestation, newly hatched larvae may be entering the fruits every day during the summer months, with no cessation of operations between the two broods. However, records of emergence secured from screen cages and bait pan catches show that there are definite peaks of moth emergence and moth activity. The spray program effective under light or moderate infestation aims to time the two cover sprays to coincide with the beginning of hatching of the two broods.

A few of the first generation larvae, and all of those of the second brood which escape being poisoned by the sprays, leave the apples during the period from August to October and remain in their cocoons until the following June or July. Thus, these larvae spend from 8 to 10 months in their cocoons located in the hibernating places.

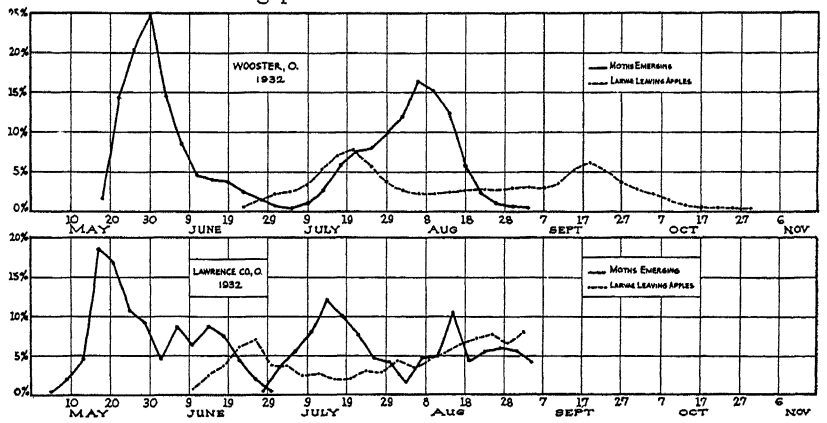

Fig. 3.—*Solid line*—Daily record of emergence of moths from cocoons collected from tree trunks and kept in screen cage under tree.

Broken line—Daily record of full grown larvae going under tree bands after leaving apples.

The following data summarize the life history of the insect:

	First Brood	*Second Brood*
Time between earliest moth emergence and laying of first eggs	2– 8 days	1– 3 days
Incubation period of eggs	9–13 days	5– 7 days
Length of life of moth	10–30 days	5– 15 days
Duration of egg laying by each moth	16–20 days	10– 18 days
Number of eggs laid by each female moth	25–75	40–130
Larvae feeding in apples	18–24 days	16– 21 days
Time spent in cocoon	14–21 days	8– 10 months

Flight and Dispersal of Adult Codling Moths.—Adult codling moths fly only at night and remain hidden during the day. They become active soon after sundown, being most active during the evening twilight period. It is during this time that most of the eggs are laid. Moth flight can be observed by standing so that the tops of the trees are between the eye and the western horizon and watching the nervous, jerky flitting of the moths. They dart in and out of the same tree or to adjacent trees, but do not fly far in

seeking a place to lay eggs. Over 50 per cent of the marked moths liberated in an orchard were caught in bait pans less than 200 feet from point of liberation. Over 90 per cent were caught within 500 feet of liberation point. They do not fly in a strong wind or during rainy or cool nights. Flight and egg-laying stop when complete darkness arrives, but are resumed just before daylight unless the temperature is too low.

Counts of worm infested fruit on rows of well sprayed trees joining an unsprayed orchard indicate that infestation reaches base level for the sprayed orchard within approximately five rows of the border. It would seem, therefore, that moths originating from adjoining unsprayed apple trees affect principally the nearby trees, and that extra first brood sprays applied to these trees would serve as an effective buffer and protect the remainder of the orchard.

Natural Control

Natural agencies that contribute to the control of the codling moth are: (a) weather, (b) birds, (c) parasites, (d) disease, and (e) complete failure of crop. Winter temperatures lower than 12°F. below zero are known to kill many of the overwintering larvae that are exposed above snow line. Northeastern Ohio counties have such below-zero temperatures during many winters, and no doubt this aids in keeping down the insect in those orchards.

Birds are very important as destroyers of hibernating codling moth larvae in Ohio. The principal birds which feed upon the larvae are: downy woodpecker, sapsucker, nuthatch, and chickadee. These birds are very effective in locating the hibernating larvae under loose bark, and their telltale work is evidenced by the holes they have drilled in the bark to reach their victims. In searching tree trunks for overwintering codling moth larvae during April, more than 85 per cent of overwintering codling moth cocoons may be found empty because of the activity of birds (see Fig. 4).

Insect parasites destroy only a small percentage of larvae. These are of several species and parasitize both the larvae and eggs of their host. Though the codling moth has long been established in America, insect parasites do not effect a high degree of control.

Diseases of the larvae are responsible for reduction of varying numbers of the insects. Cocoons are often found occupied with dead or mummied bodies of the larvae that have been killed by a fungous disease. Little is known about this disease.

Finally, anything approaching complete failure of the fruit crop is a very effective check against the insect, and will serve to reduce a heavy infestation to the point where it may take two or three years for the insect to again become serious. During the year following a failure of the apple crop, codling moth is not difficult to control.

Spraying As a Control

Spraying with arsenate of lead still constitutes the most efficient and economical method of controlling codling moth. The number of sprays necessary depends upon the worm population. Failure to make sufficient applications, or the use of substitute materials, is attended with great risk where the worm infestation is heavy. To be successful, the sprays must be: (a) correctly timed, (b) thoroughly applied, and (c) repeated as necessary to maintain adequate coverage.

Calyx-cup Spray.—Although the calyx-cup spray must be made 3 or 4 weeks before any codling moth eggs hatch, it is a very important codling moth spray and should never be omitted. Few, if any, moths have emerged from their cocoons at petal fall time. The control secured by this spray is through the application of arsenate of lead in the calyx cup and the covering of the calyx lobes, or sepals. Later these close up (see Fig. 5), and the spray material will be held within the calyx end of the apple. Thus, the calyx-cup spray, if properly applied, kills codling moth larvae which try to enter the calyx end of the fruit at any time during the summer.

Cover Sprays.—The number of cover sprays needed will depend upon the season and the worm population in the orchard. Growers who previously have grown clean fruit with two cover sprays, should apply additional ones only in case codling moth injuries have recently increased. The insect always gives sufficient warning before taking a heavy toll. The additional cover sprays, when necessary, should be applied to keep the expanding fruit surface covered with poison so that late hatching larvae will not be able to enter.

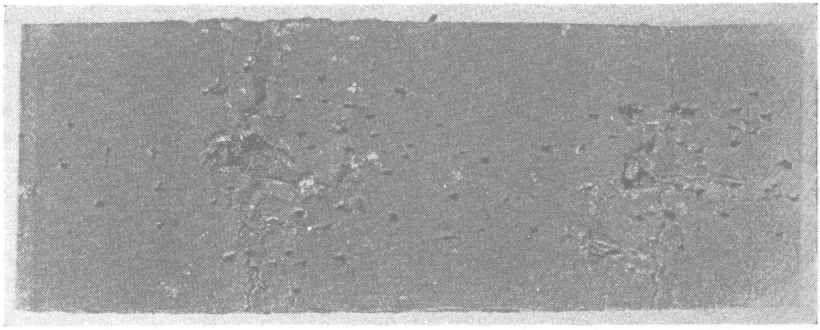

Fig. 4.—The holes were made in a tree band by birds searching for the codling moth larvae.

In very few Ohio orchards is it necessary to apply more than three cover sprays to protect against codling moth.

The proper number and timing of cover sprays against the first brood of worms are very important if we are to control the second brood. They eliminate second brood blemishes. Second brood cover sprays do not wholly prevent "stings," but frequently convert what would have been a worm entrance into a worm sting.

Timing the Cover Sprays.—The first cover spray against each of the two broods is timed by the entomologists and the information relayed through the Ohio Spray Service.

When evening temperatures are above 62°F., hatching of first brood codling moth eggs can be expected to commence 11 to 14 days after the emergence of the first moths. Since weather conditions largely govern the time of moth emergence and egg-laying, the first hatching may be as early as 2 weeks, or as late as 4 weeks after petal fall. This depends upon the temperature during May and early June. High temperatures promote egg-laying and shorten the incubation period. Likewise low temperatures retard egg-laying and incubation.

Timing the *first cover* spray correctly is very important. It would be disastrous to apply it too late during early hatching seasons, or to apply it too early in seasons when hatching is delayed.

The spray service has attempted to time these sprays for the principal orchard sections. This is done through: (a) emergence cages kept under observation at representative orchards in each fruit section, and (b) correlating the daily moth emergence with evening temperatures. The time when hatching is expected to commence is announced through letters relayed by the county agents and also by radio.

After the first cover spray is applied, the necessity of applying additional cover sprays against the first brood of worms depends upon the codling moth population in the orchard. If the infestation is light, no additional sprays against the first brood are necessary. Where the insect is a serious problem,

Fig. 5.—*Left*—Right time for calyx-cup spray.
Right—Calyx lobes closing. Almost too late for calyx-cup spray.

one, and in extreme cases, two additional first brood cover sprays should be make to keep the expanding fruit coated with poison. The timing of additional sprays, if necessary, can best be done by the grower.

The cover spray against the *second brood* of larvae is timed by banding trees to catch first brood worms that spin their cocoons under the bands. These bands are then transferred to screen cages where the moths are trapped as they emerge. When the first moths of the summer brood appear, the midsummer spray should start within 7 or 8 days. This time is announced to the growers through letters relayed by the county agents.

Thoroughness of Coverage

Every fruit on the tree that is not covered, or only partially covered with spray, is unprotected against entering codling moth larvae. The above statement applies to every spray application. Each grower should make a study of his method of applying sprays so that he may assure himself of thorough coverage.

At the time of the calyx-cup spray, the main idea is to fill every calyx with the spray solution. If this is done, practically no worm entrances through

the calyx will follow. In the cover sprays it is very important to thoroughly cover the young fruits and the leaves surrounding them. The most difficult part of the tree to cover is the top, and special attention should be given to it. The best methods of doing this will depend somewhat upon the size of the trees and the manner in which they have been pruned. Trees up to 20 or even 25 years of age, if not unusually high, may be sprayed from the ground, using either a spray gun or a cluster rod or "broom." This also gives the operator the opportunity of getting inside the tree for "under spraying," which is frequently necessary in the case of heavy infestations.

With larger trees, one man should spray from the top of the sprayer or from a tower. A second man should walk, doing the "under spraying," and cover the lower part of the tree. It is sometimes considered that the inside of the tree may be sufficiently covered by throwing the spray through the openings in the branches across to the opposite side. However, practical testing of this theory shows that it is not a dependable method of obtaining thorough, uniform coverage.

The amounts of spray necessary for good coverage may be figured in terms of gallons necessary for each year of the tree's age. For example, apple trees from 5 to 10 years of age will require about ½ gallon of spray for each year. In other words, a tree 10 years old would need 5 gallons of spray per application. Trees over 10 years of age will need slightly increased amounts up to ¾ gallon for each year's age. Thus, a tree 28 years old may need 21 gallons per application for good coverage.

A good system of application insures the spraying of each tree in exactly the same manner, and, if conscientiously followed, will result in uniform coverage.

Spreaders.—Extensive data taken in many experiments show that very little is gained in coverage or in codling moth control by the use of casein spreaders in sprays on apple. The use of spreaders results in the spray coat being more evenly distributed and the spray residue less visible. They are reported to make a given amount of spray cover more trees, but this is usually offset by the additional cost of the spreader and the increased run-off of the spray.

Oil spreaders, such as mineral oil, fish oil, and vegetable oils, complicate the spray residue problem, and for this reason are not generally recommended for use in Ohio. Growers who consider that their situation demands the use of oils as spreaders and stickers may obtain general information regarding them from either the University Extension Service or the Ohio Agricultural Experiment Station.

Value of Lime

Injury by the spray materials may appear on both the fruit and foliage. Most types of spray injury, and especially those from arsenicals, may be greatly reduced by adding lime to the spray mixture. Excess lime is slightly unfavorable to the efficiency of the spray, both as a fungicide and as a control for codling moth, but greater safety and better finish of fruit justify its use. Freshly hydrated lime, free from grit and of such fineness that 99 per cent will pass through a 300-mesh sieve, should be used.

In the past, high calcium lime has been recommended, but recent field experience shows that both high calcium and high magnesium lime are satisfactory. Lime purchased in the spring will be satisfactory for use that season, but should not be used the following season for spraying.

Spray Residue

The spray residue situation may be briefly stated as follows:

1. All fruit offered for sale carrying more than .01 grain of arsenic trioxide (As_2O_3) per pound is subject to seizure by federal and state food and drug officials, who can force the removal of the arsenic trioxide exceeding the specified amount, or destroy the fruit.
2. All fruit carrying more than the announced tolerance of lead is subject to the same conditions as above. For 1934 this tolerance will be .019 grain per pound of fruit.

Due to the fact that Ohio fruit growers have used lime freely in their sprays and have avoided oils as stickers for lead arsenate, the residue problem is not nearly so severe in this state as elsewhere. Tests and analyses have consistently shown that lead arsenate, when used with lime, can be applied in all sprays against the first brood of worms without danger of excessive residue of either lead or arsenate. Before the lead tolerance went into effect, lead arsenate could also be used in the midsummer spray without exceeding the tolerance. Now, however, lead arsenate, even with excess lime, cannot be used in midsummer without serious risk that the lead will exceed the tolerance.

Substitute Materials for Arsenate of Lead

The situation regarding lead residue has brought forth renewed interest in substitute spray materials. To be sure of meeting the present residue requirement, spraying with arsenate of lead should stop in southern Ohio about June 20 and in northern Ohio about July 4. If arsenate of lead is used after these dates, the fruit in most years must be washed, or run the risk of carrying an excess of lead residue. Therefore the large number of growers who are not equipped to wash their fruit will desire to use some material other than arsenate of lead against the second brood.

Several substitute materials are available, although it should be definitely understood that they are not as satisfactory as arsenate of lead.

Calcium Arsenate.—Experimental tests and the extensive use of this material by growers in 1933 have shown definitely that calcium arsenate is not as efficient as lead arsenate for worm control. While calcium arsenate did not injure foliage in Ohio in 1933, injury has occurred in previous seasons. In order to insure safety, excess lime should be used. If calcium arsenate is used as a substitute for arsenate of lead, the following formula is suggested in sections of the state where bordeaux mixture is not required for bitter-rot control:

Calcium arsenate	2	pounds
Dry lime-sulfur	4	pounds
or		
Liquid lime-sulfur	1½	gallons
Spray lime	10	pounds
Water to make	100	gallons

If used with 1-3-50 bordeaux, add 4 pounds of lime per 100 gallons. If used with 2-6-50 bordeaux, no lime is needed. Though safe with the above fungicides, calcium arsenate caused severe dropping of foliage when used with both flotation sulfur and Cop-O-Sil in experimental tests during 1933.

Manganese Arsenate.—In Ohio tests, this material has been more effective as a worm control than calcium arsenate. The formula suggested is the same as that given for calcium arsenate. As in the case of calcium arsenate, excess lime must be used with it to guarantee safety. Manganese arsenate also caused foliage dropping when used with flotation sulfur.

Summer Oils.—Summer oils and oil combinations have been used extensively in some western states. Oils cannot be combined with lime-sulfur, which limits their use in Ohio. Field experiments extending over several seasons have shown that summer oils, when used alone, cannot be depended upon to control codling moth in late summer. Combinations of oil with some other materials have shown fair control, and these are discussed in the following paragraphs.

Oil-oleic Acid.—In recent seasons, the Indiana Agricultural Experiment Station has developed the use of oleic acid in combination with mineral oil. Two gallons of summer oil (Verdol) plus 1.6 pints of oleic acid per 100 gallons, is the recommended strength. The oleic acid is added to the oil before the latter is poured into the spray tank. Tests made in Ohio during 1933 showed that the effectiveness of the oil was increased by the addition of the oleic acid, and the mixture proved to be safe on foliage.

Oil-Nicotine.—According to present knowledge, it appears that summer oil, to which nicotine sulfate has been added, is the best of the oil combinations for codling moth control. It is not quite as effective as arsenate of lead. One gallon of summer oil, to which is added ¾ pint of nicotine sulfate, for each 100 gallons of spray, is the strength suggested. In the case of lighter infestations, ½ pint of nicotine sulfate may be used for each 100 gallons.

The cost of summer oil mixtures is a serious objection to their use. Moreover, the problem of a suitable fungicide to use with the oils is as yet unsolved. Since they are contact sprays and are directed against the eggs and newly hatched larvae, more applications may be necessary than where arsenate of lead is used. Too many applications of oil, or a single application of too great concentration, may cause injury. Oil sprays interfere with leaf metabolism, and under conditions such as heavy crop load, drouth, or general poor health of the tree, there may result severe injury to the foliage and to the development of the fruit buds. Injury to the foliage usually appears as marginal or blotch burn of varying size, followed later by the dropping of the leaf.

Where extra arsenate of lead sprays have been used against the first brood, the use of summer oil combinations against the second brood may require washing of the fruit to remove the residue.

Fluorine Compounds.—In discussing the fluorines as substitutes for arsenate of lead it must be remembered that their use in midsummer may not avoid a residue problem. The Federal Pure Food and Drug Administration has established a tolerance for fluorine. The fluorines, such as natural cryolite and barium fluosilicate, are almost as effective against codling moth in midsummer as is arsenate of lead, provided oils are used with them as stickers. In

the early part of the growing season, due presumably to cooler weather when fluorine is not active, these materials are not efficient in worm control.

Fluorine compounds cannot be used with lime-sulfur or bordeaux mixture, but can be mixed with flotation sulfur. Serious injury to the fruit of Jonathan has occurred in Illinois following repeated applications of fluorine compounds.

Removal of Residue

Wiping.—Several excellent wiping machines for cleaning and polishing apples are now on the market. Some of the manufacturers of these machines make claims that they can be used in the removal of spray residue. Studies of the possibility of residue removal by wiping have been made by the United States Department of Agriculture, state agricultural institutions, and commercial companies. From these results it appears that wiping at best will remove no more than one-third of the residue present, and that after the wiping rags become dirty and impregnated with residue, very little is removed. In most cases it is necessary to reduce the residue more than one-third, therefore, wiping offers little promise in solving a serious residue problem.

Washing.—For Ohio growers who are having difficulty in controlling the codling moth, and at the same time are unable to keep spray residue within the limits, a complete spray schedule of arsenate of lead, followed by washing, is recommended. Fruit may be washed more readily immediately after picking. Spray residue clings tenaciously to stored apples, due to the waxy coating that is formed on the fruit during storage. The difficulties of residue removal are also increased where oils are used as stickers. In such combinations, it is frequently necessary to heat the washing solution in order to remove the residue.

Both lead and arsenate may be removed to a point below the established tolerances by washing either in a solution of sodium silicate or hydrochloric acid. Sodium silicate is a representative of the alkaline washes that have been developed in the Pacific northwest. These alkaline solvents are not suited for use in Ohio, where lead is the chief residue to be removed. Hydrochloric acid, used at either 2 or 3 per cent commercial strength, is preferred for washing Ohio fruit.

The efficiency of the hydrochloric acid bath is increased by heating. However, a temperature of 110°F. should not be exceeded on account of possible injury to the fruit. Certain so-called degumming agents may also be added to the acid bath to aid in lead removal. The use of a heated solution or degumming agent is necessary where oil and lead sprays have been applied alternately, or in combination. After washing, no matter what washing solution was used, the fruit must be rinsed in water to remove the solvent.

Washing machines of several types, costs, and capacities have been developed. They range all the way from home-made outfits that can be built on the farm, to very complicated machines that only a modern factory is capable of producing. Different machines possess different rates of efficiency, and at the present time it appears that the flotation washers do not rate quite as high in residue removal as do other types.

Detailed information about types of washing equipment and methods to use in the removal of spray residue on apples are given in United States Department of Agriculture Farmers' Bulletin No. 1687.

Supplementary Control Measures

Self-working Bands.—In orchards where the spray program has not controlled codling moth, growers have found chemically treated tree bands a valuable aid in reducing the worm population. These bands consist of strips of single faced corrugated paper, cut either 2 inches or 4 inches wide, and which have been dipped in a solution of beta-naphthol dissolved in oil. This results in the paper taking up much of the chemical which is toxic to insect larvae, but does not harm the tree when properly used.

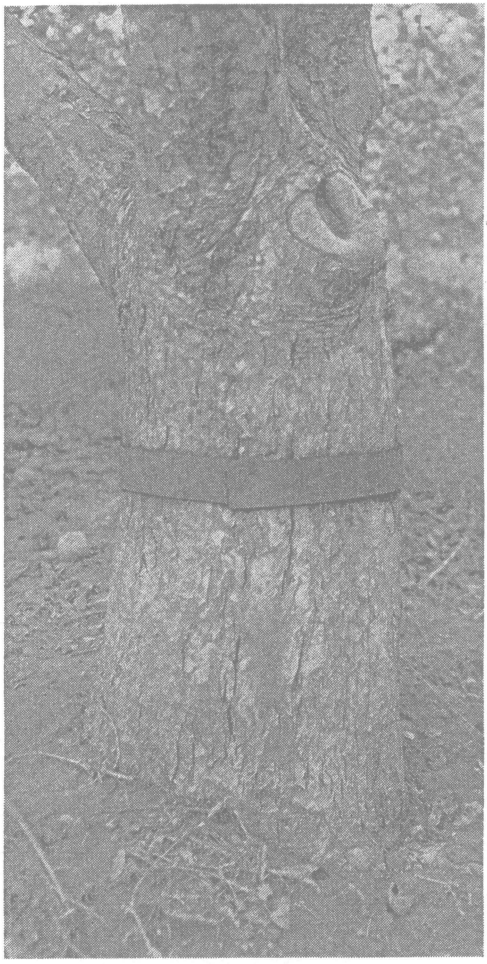

Fig. 6.—Chemically treated band on tree trunk. This kills the larvae which go under it to transform.

Young trees with smooth bark should not be banded with them. When old trees are banded, the trunk and lower limbs are scraped to remove all loose bark. This scraping should extend up about 10 feet. A special tool for scraping, such as a box scraper, or even a short handled hoe, is desirable.

The chemically treated band is then wound tightly around the tree trunk and fastened with large headed roofing nails or special wire staples (see Fig. 6). Care must be taken to fit the band into the depressions of the trunk.

The bands should be applied just before the larvae of the first brood leave the apples. It is these worms that must be killed before they transform to second-brood moths. The bands should be in place in southern Ohio by June 1, in central Ohio by June 8, and in northern Ohio by June 20. Since the bands, when applied, slowly lose their toxicity, they should not be made up or placed on the trees long before the above dates.

When the larvae, after leaving the apple, search for a place to spin their cocoons, they find the paper band and spin up in the corrugations and in the grooves of the paper held tightly against the tree (see Fig. 7). If the bands are properly made, the worms will be killed during June or July within a few days after they go under them. By autumn the bands have lost much of

their toxicity and do not kill all of the larvae. These, however, are affected by the chemical and change to an unnatural red color. Such worms usually die during hibernation. The bands are serviceable only for one season, and should be taken off the trees early in December and burned.

Under heavy codling moth population, and on large trees, each band may catch 100 to 400 worms by late fall (see Fig. 7). Where the insects have been well controlled by sprays, catches of 20 to 30 worms per band per season are normal. The chief purpose of the band is to kill the worms of the first brood which would transform to moths in July or August. These early worms are not so numerous, but they are the ancestors of the August and September brood, which too frequently injure the crop. It is estimated that on a well scraped tree the bands catch from 40 to 50 per cent of the worms which leave the apples. Their use should make it much easier to control with sprays, though the bands do not make it possible to eliminate any sprays. They are recommended only in orchards where the spray program has failed to control the codling moth.

Rolls of self working bands can be purchased ready made, or can be dipped at home in a solution of oil and beta-naphthol. They can be dipped

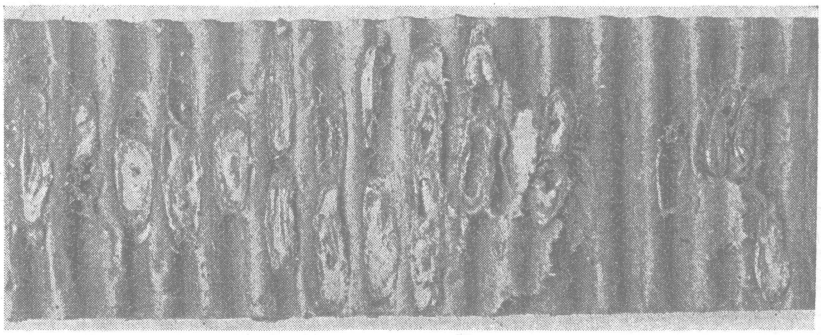

Fig. 7.—Cocoons under corrugated paper band.

either in a cold or hot solution as desired. The beta-naphthol goes into solution at 260°F. Gas or gasoline under pressure are recommended as the best source of heat for safety and ease of temperature regulation. Without such a source of heat the grower should buy his bands ready prepared, or dip them in a commercially prepared solution of oil and beta-naphthol. Additional information about making self working bands will be furnished on request.

Orchard and Packing House Sanitation.—Orchard sanitation methods of value in reducing codling moth losses include: (a) elimination of hibernating places such as piles of wood, cut trees, or other debris on the ground, and (b) the prompt disposal of wormy apples. While a sod mulch or cover crop is not utilized as a cocooning place, a mulch consisting of cornstalks or coarse weeds will shelter many transforming larvae.

Thinning operations afford an opportunity to remove from the orchard apples containing first brood larvae. Prompt gathering of worm-infested dropped apples and burying them or otherwise disposing of the same, prevents these worms from adding to the overwintering population.

Packing house sanitation is very important in orchards where the codling moth is a serious problem. The larvae leave the apples in the packing house

or storage rooms and crawl beneath nail ties, in cracks and crevices and in the joints of the storage crates. In one packing house in Lawrence County over 18,000 adult codling moths were killed during the spring emergence period. These moths, if allowed to escape, would cause worm-infested fruit within several tree rows of the packing house.

The present codling moth spray schedule is based upon time of emergence of moths in the orchard. Those which issue under the dry conditions prevailing in packing houses emerge a week or ten days later than those appearing in the orchard. This makes it necessary to apply extra sprays. Packing houses and rooms where picking crates are stored, should be tightly screene or otherwise kept closed until all of the moths have emerged and died.

Codling Moth Spray Schedule

Name of Spray		*Materials to Use*	*Explanations*
CALYX-CUP SPRAY		Dry lime-sulfur..... 4–5 lbs. *or* Liquid lime-sulfur . .. 1½ gals. *or* Wettable sulfur *and* Arsenate of lead . . 3 lbs. Hydrated lime.. . . . 8 lbs. Water to make . . .100 gals.	To fill calices of little fruits with poison This spray is effective throughout the entire season
Ten Days to Two Weeks (Special spray for scab and curculio)		Same as Calyx-cup Spray	Necessary only where apple scab spots appear on leaves or where curculio is a problem. Too early for much benefit in codling moth control
FIRST COVER SPRAY for codling moth (3 to 4 weeks after petal-fall)	First Brood Sprays	Same as Calyx-cup Spray	When first brood worms begin hatching Watch for spray service notice
Second Cover Spray for First Brood (2 weeks after first cover)	First Brood Sprays	Same as Calyx-cup Spray	Necessary only where the worm injury has been increasing and where apple maggot is a problem Near peak of hatching
Third Cover Spray for First Brood (2 weeks after second cover)	First Brood Sprays	Arsenate of lead..... 3 lbs. Hydrated lime . ..... 8 lbs. Water to make .... 100 gals.	Necessary only in *severely* infested orchards in order to keep the growing fruit covered
MIDSUMMER SPRAY* (9 to 10 weeks after petal-fall)	Second Brood Sprays	Same as Calyx-cup except use 2 lbs. of arsenate of lead. Substitute 2-6-50 Bordeaux mixture for lime-sulfur and lime where bitter-rot is prevalent.	When second brood is beginning to hatch Watch for spray service notice
Extra Cover Spray against Second Brood* (2 weeks after midsummer spray)	Second Brood Sprays	Arsenate of lead. .... 2 lbs. Hydrated lime ... ... 8 lbs. Water to make ... 100 gals.	Necessary only in *extreme* cases

The three sprays printed in heavy type are effective against codling moth under most Ohio conditions. Where four are needed, apply second cover spray for first brood. Badly infested orchards should receive the full schedule.

* The use of arsenate of lead in these sprays will make the lead residue exceed the tolerance permitted. (Growers not equipped to wash fruit should consider substitute materials; see page 11).