Bulletin 268 July, 1921

The Agricultural Experiment Station

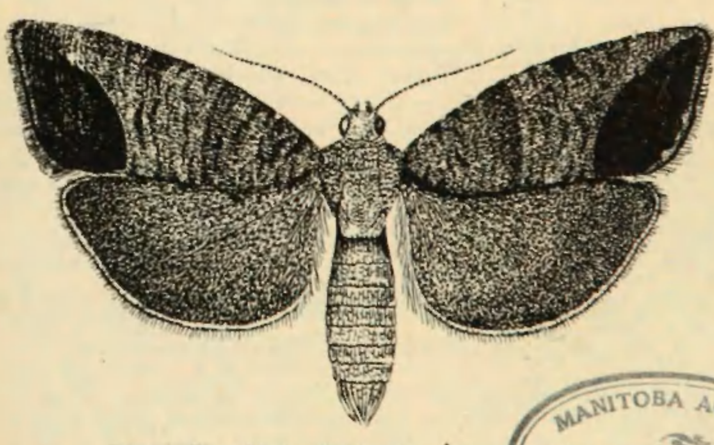
OF THE

Colorado Agricultural College

CODLING MOTH CONTROL

FOR CERTAIN SECTIONS OF COLORADO

By GEO. M. LIST and
J. H. NEWTON



The Codling Moth—*Carpocapsa pomonella, Linn.*

PUBLISHED BY THE EXPERIMENT STATION
FORT COLLINS, COLORADO
1921

The Colorado Agricultural College

FORT COLLINS, COLORADO

THE STATE BOARD OF AGRICULTURE

		Term Expires
HON. H. D. PARKER	Greeley,	1923
MRS. AGNES L. RIDDLE	Denver,	1923
HON. J. C. BELL	Montrose,	1925
HON. E. M. AMMONS	Denver,	1925
HON. W. I. GIFFORD	Durango,	1927
HON. J. B. RYAN	Rocky Ford,	1927
HON. A. A. EDWARDS, President of the Board	Fort Collins,	1929
HON. J. S. CALKINS	Westminster,	1929

GOVERNOR OLIVER H. SHOUP
PRESIDENT CHAS. A. LORY } *Ex-Officio*

L. M. TAYLOR, Secretary — G. A. WEBB, Treasurer

EXECUTIVE COMMITTEE

A. A. EDWARDS, Chairman

E. M. AMMONS — H. D. PARKER

OFFICERS OF THE EXPERIMENT STATION

CHAS. A. LORY, M.S., LL.D., D.Sc.	President
C. P. GILLETTE, M.S., D.Sc.	Director
LD CRAIN, B.M.E., M.M.E.	Vice-Director
L. M. TAYLOR	Secretary
ANNA T. BAKER	Executive Clerk

STATION STAFF

Agricultural Division

C. P. GILLETTE, M.S., D.Sc., Director	Entomologist
W. P. HEADDEN, A.M., Ph.D., D.Sc.	Chemist
G. H. GLOVER, M.S., D.V.M.	Veterinarian
W. G. SACKETT, Ph. D.	Bacteriologist
ALVIN KEZER, A.M.	Agronomist
G. E. MORTON, B.S.A., M.S.	Animal Husbandman
E. P. SANDSTEN, M.S., Ph.D.	Horticulturist
B. O. LONGYEAR, B.S.	Assistant in Forestry
I. E. NEWSOM, B.S., D.V.S.	Veterinary Pathologist
A. K. PEITERSEN, B.S., M.S., Ph.D.	Botanist
RALPH L. CROSMAN, B.S.	Editor
R. E. TRIMBLE, B.S.	Assistant in Irrigation Investigations
EARL DOUGLASS, M.S.	Assistant in Chemistry
P. K. BLINN, B.S., Rocky Ford	Alfalfa Investigations
MIRIAM A. PALMER, M.A.	Delineator
J. W. ADAMS, B.S., Cheyenne Wells	Assistant in Agronomy, Dry Farming
RALPH L. PARSHALL, B.S.	U. S. Irrigation Engineer Irrigation Investigations
CHARLES R. JONES, B.S., M.S.	Assistant in Entomology
GEORGE M. LIST, B.S.	Assistant in Entomology
CARL ROHWER, B.S., C.E.	Assistant in Irrigation Investigations
CHAS. I. BRAY, B.S.A., M.S.	Assistant to Animal Husbandry
E. MILDRED BROWN, B.S.	Assistant in Bacteriology
E. J. MAYNARD, B.S.A., M.S.	Specialist in Animal Investigations
W. L. BURNETT	Rodent Investigations
C. M. TOMPKINS, B.S.	Assistant in Horticulture
FLOYD CROSS, B.S., D.V.M.	Assistant Veterinary Pathologist
WM. H. FELDMAN, B.S., D.V.M.	Assistant Veterinary Pathologist
N. E. GOLDTHWAITE, Ph.D.	Home Economics
CAROLINE PRESTON	Artist
J. H. NEWTON, B.S.	Assistant Entomologist
J. W. TOBISKA, B.S., M.A.	Assistant in Chemistry
C. E. VAIL, B.S., M.A.	Assistant in Chemistry
C. D. LEARN, B.S., M.A.	Assistant in Botany
DAVID W. ROBERTSON, B.S., M.S.	Assistant in Agronomy
LEON R. QUINLAN, B.S.	Assistant in High Altitude Horticulture

Engineering Division

LD CRAIN, B.M.E., MME., Chairman	Mechanical Engineering
E. B. HOUSE, B.S., (E.E.) M.S.	Civil and Irrigation Engineering
O. V. ADAMS, B.S.	Testing Engineer
G. A. CUMMINGS, B.S.	Assistant in Mechanical Engineering

CODLING MOTH CONTROL FOR CERTAIN SECTIONS OF COLORADO

BASED ON LIFE HISTORY STUDIES

By Geo. M. List and J. H. Newton

The codling moth is the most destructive insect pest with which the fruit growers of Colorado have to contend. The annual loss from its ravages amounts to thousands of boxes of apples and pears each year. In many cases a large percentage of individual crops is a total loss. Its successful control probably depends more upon careful life history studies and very careful work at all times, than does the control of many important pests. It is therefore important that any spray schedule to be successful be based upon a knowledge of the insect's development and habits. This is so influenced by the difference in temperature and humidity of the different mountain valleys and other fruit growing sections that general recommendations for the entire state cannot be made. For instance, the insect in some sections, passes thru only one generation, while even in adjoining counties there is a considerable portion of a third generation. Local conditions must necessarily be taken into consideration. Most of the data herein given were collected at Paonia, Delta County, where conditions are fairly typical of a number of sections of the state. The recommendations can be interpreted to apply to most of the fruit growing sections of the state with the exception of the Grand Valley, Mesa County, where the conditions are so entirely different and the pest so much more difficult to control.

The data for this paper were collected on funds furnished by the Colorado Agricultural Experiment Station and the Office of State Entomologist.

LIFE HISTORY STUDIES USED AS BASIS FOR CONTROL PRACTICES

Detailed life history studies of the codling moth have been made at Paonia, Grand Junction, Canon City and Fort Collins and many observations in less detail have been made at a number of other points. These studies and observations have shown a great variation in the different localities, due, largely, to the differences in temperature and humidity. Only the data collected at Paonia are referred to in detail. This has been used as the basis of the recommendations and for guidance in the experimental spraying reported as part of this publication.

The life history records were taken in an open air laboratory located in an orchard. Every precaution possible was taken to make the conditions representative of those in an average orchard. This work has continued thru the seasons 1917-18-19-20. A complete record has been taken on 20,319 moths. The total of the egg deposition used in making

Charts I and II was 370,766. It is felt that the numbers handled were sufficiently large to give fairly reliable averages.

SUMMARY OF LIFE HISTORY

The codling moth passes the winter in the larval stage in silken cocoons under bark scales, in rubbish about the base of the tree or in tree crotches, in picking boxes, packing sheds or any similar place that will afford protection. These larvae pupate or transform to the moth with the appearance of warm weather in the spring. The moths will begin to emerge about the middle or latter part of May or about the time, or shortly after, the trees are in bloom, and continue to emerge over a period of thirty or forty days. The moths begin with a few days to deposit their eggs, principally upon the upper surface of the leaves, and later in the season to a considerable extent upon the fruit. The eggs hatch in from six to fourteen days depending largely upon the temperature. The aver-

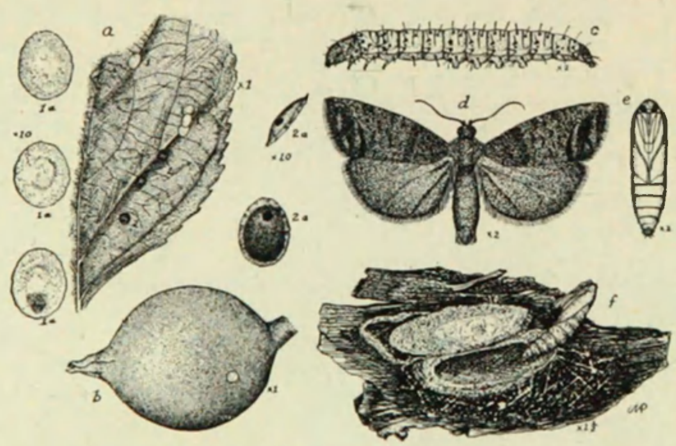


PLATE I. Codling Moth in its different stages: a, eggs upon a leaf; a 1, eggs natural size; 1 a, eggs much enlarged; upper 1 a, a newly laid egg; middle 1 a, the appearance of the egg after 4 or 5 days, showing the flesh-colored ring of the embryo, lower 1 a, showing the outline of the small larva, the dark spot being the head (an egg in this stage would hatch in a day or two); a 2, eggs parasitized by Trichogramma minutus, a very small 4-winged fly that deposits its eggs within those of the codling moth; 2 a, parasitized codling moth eggs much enlarged, showing holes made by the parasites as they leave the eggs; upper 2 a, side view of parasitized egg; b, egg natural size upon an apple; c, codling moth larva; d, codling moth; e, chrysalis or pupa; f, cocoon and chrysalis. Figures a1 and a2 and b, natural size; 1 a and 2 a, enlarged 10 times; c, d, and e, enlarged 2 times; f, enlarged 1½ times. Original. Colorado Experiment Station Bulletin 210. Miriam A. Palmer, Delineator.

age feeding period of the first brood larvae will vary with the different seasons from twenty to twenty-four days. Mature first brood larvae have been taken under bands as early as June 18th. In the Paonia laboratory only 20 to 40 percent of the first brood larvae transform to moths. The other 80 or 60 percent carry over as larvae until the following spring. This makes one complete generation and about 50 percent of a second. Only in very rare cases have there been any indications of a third generation and these individuals have not developed farther than the egg stage.

The length of the different stages forming the life cycle and the length of periods of moth emergence or egg deposition vary with the dif-

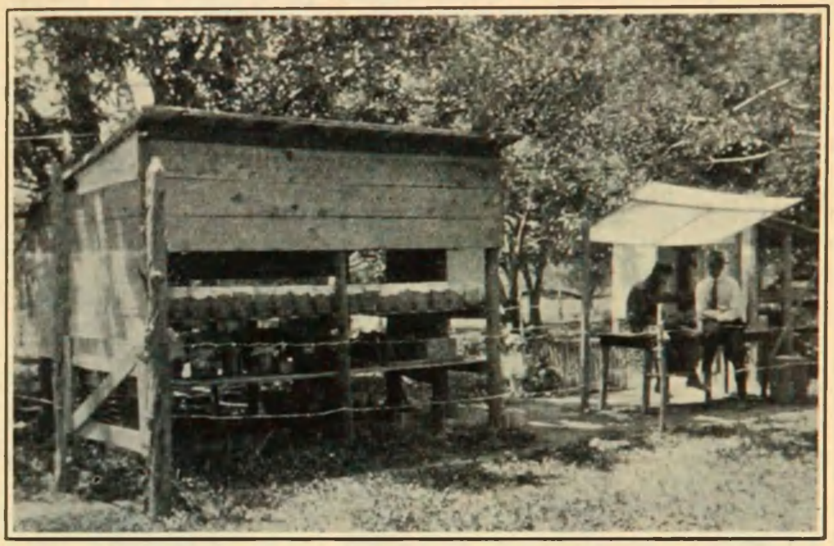


FIGURE 1—The laboratory in which the codling moth life history data were collected. The cages are shown on the benches.

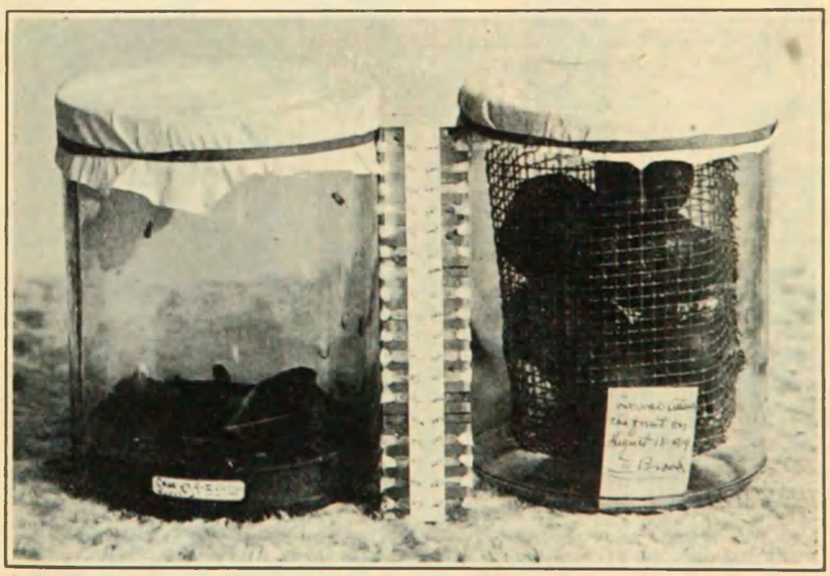


FIGURE 2—Codling moth breeding cages. The moths are placed in a glass jar which has moistened sand in the bottom as shown on the left. The eggs are deposited on apple or pear leaves placed in the cage. Moths are fed sweetened water held by a small sponge.

CENTER—A pupae "stick" showing "cells" in which the larvae spin their cocoons and pupate or change to moths. Each larva is given a number and a complete record taken.

RIGHT—Apples in which larvae are feeding.

ferent generations and seasons, the variation being due principally to the difference in temperature. Table I gives the minimum and average length of the different stages for the seasons of 1917-18-19-20. It will

Table I

	1917		1918		1919		1920	
	Average	Minimum	Average	Minimum	Average	Minimum	Average	Minimum
Pupation period of overwintering larvae........	....	....	24.88	....	23.84	....	22.3	....
Time from emergence of first broad moths until first eggs are laid........	....	....	4.15	1	4.11	1	4.53	1
Incubation period of first brood eggs........	....		8.2	6	8.9	6	9.7	8
Feeding period of first brood larvae........	....		27.6	17	20.83	17	23.47	18
Time after first broad larvae leave the apple until second broad moths appear........	17.46	12	22.84	17	16.69	12	18.85	16
Time from emergence of second brood moths until first eggs are laid........	2.1	1	2.65	1	1.69	1	2.87	1
Incubation period of second brood eggs........	8.1	6	9.9	9	7.8	6	9.1	6
Feeding period of second brood larvae........	32.9	22	34.1	22	27.68	16	35.06	23

TABLE 1. Average and minimum days taken for the development of the different stages of the codling moth, Paonia, Colorado, for the years 1917, 1918, 1919 and 1920.

be noted that there is a great variation in length of the same stage of the different generations and also an equally great variation in the length of the stage of a like generation in different seasons. The season of 1919 was warmer than usual after June 15th and as a result all the stages of development were shorter and there was a much larger percentage of a second generation than during the other years. In all cases the feeding period of the first generation larvae is shorter than that of the second generation, yet the average feeding period of the first generation larvae in 1919 is practically one week shorter than the corresponding stage in 1918 and there is almost an equal difference in the time required for the first generation larvae to transform to moths.

Plate II shows graphically the egg deposition correlated with the minimum temperature. The sudden variations in the egg deposition records can, in most cases, be explained by the changes of temperature. In some cases these changes are due to humidity but sufficient data are not

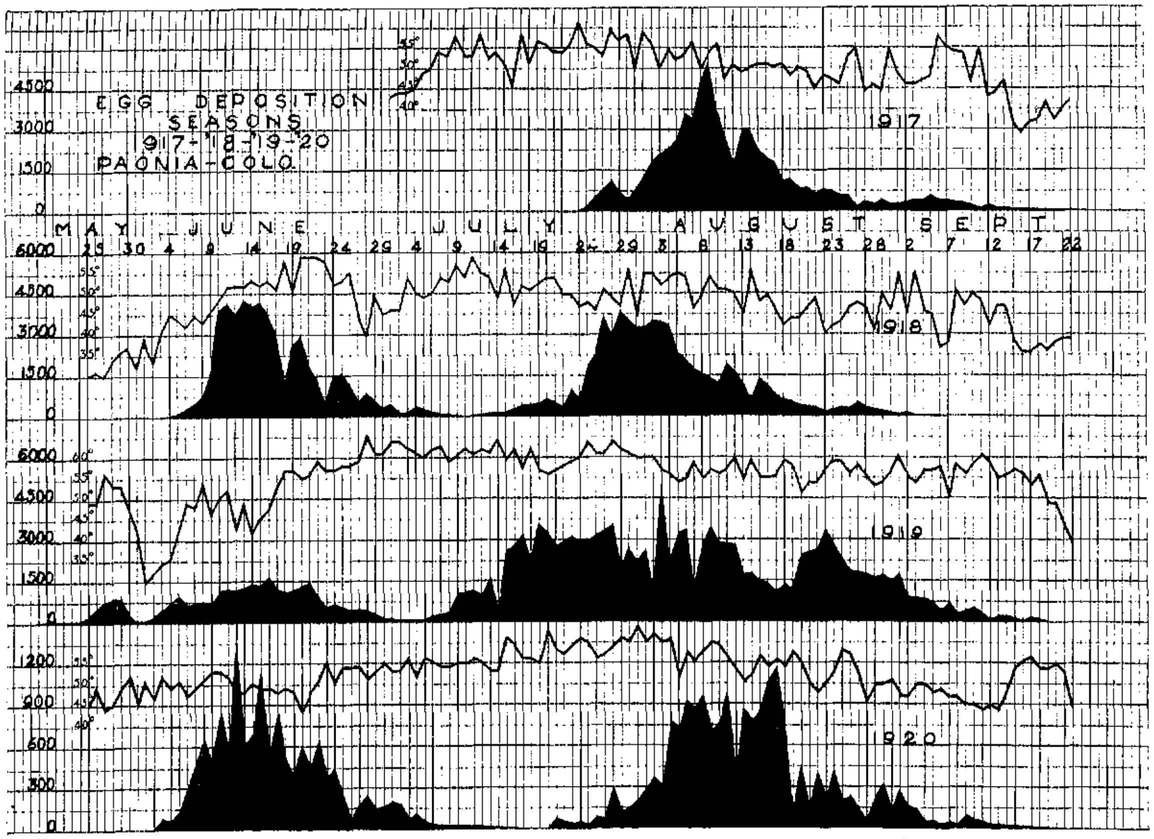


PLATE II. Codling moth eggs deposited during seasons 1917, 1918, 1919, 1920, Paonia, Colorado. Total eggs deposited 370,766. The unbroken block line is a graph of the minimum temperature.

available to show this on the chart. Egg deposition occurs largely during late afternoon and early evening, a drop in temperature or a rain at this time will materially effect egg laying. The effect of a sudden drop in temperature is illustrated by the record on August 11, 1917, June 17 and August 5, 1915, June 1, 1915, June 13 and August 5 and 12 1920. These cool days may have the effect of only holding back the egg deposition with a larger deposition coming later, while in other cases they may be so extended as to materially effect the number of eggs deposited by the moths and thus greatly change the seasonal egg record. The latter was the case in June, 1919. The cold weather, extending from May 29th until June the 8th, occurred after a large percentage of the first brood moths had emerged but before egg laying had well begun. It was so severe and extended that many moths did not lay their quota of eggs. Judging from the records of 1918 and 1920, the height of egg deposition for the first generation, 1919, would normally have occurred about June 4th, but it actually occurred June 16th and was produced from the moths that emerged after the cold weather.

The effect of temperature is as noticeable upon the other stages of the insect. One of the most interestnig and valuable points brought out by Plate II is the seasonable differences in the appearance of either the first or second generations. In 1917 the first eggs of the second generation were deposited July 25th, while, in 1919, the first eggs appeared July 5th, or just twenty days earlier. The season of 1920 was very similar to 1917, while 1918 was intermediate between 1917 and 1919.

Taking the development of the insect from egg to egg as a complete life cycle, we will notice that the average time for this in 1918 was 61.29 days; 1919, 48.11 days; 1920, 54.89 days; showing a maximum difference of 13.18 days between the seasons of 1918 and 1919. This will indicate the fallacy of attempting to spray by a schedule based upon calendar dates. It may also be misleading to base the spray dates upon development of the apple, as for instance, it is the usual recommendation to make the first cover spray from three to four weeks after the petals drop. If this had been done in 1919 with the eight days of cool weather which practically stopped all codling moth activities coming in between, the spray would have been applied too early for best results. A like condition occurred in 1918, while in 1920 it was quite warm during the blooming period and just following, bringing the codling moth development along faster in proportion to the development of the fruit.

CONTROL METHODS

The most successful means of controlling the codling moth is by applying arsenical sprays to poison the larvae as they enter the fruit. Under some conditions, banding of the trees to collect, for destruction, the mature larvae, and the picking and destroying of wormy fruit are important factors in reducing the infestation and protecting the crop.

SPRAY MATERIALS

Arsenate of lead has proven the most satisfactory and is by far the most generally used poison. It is commonly used at the rate of 2 lbs.

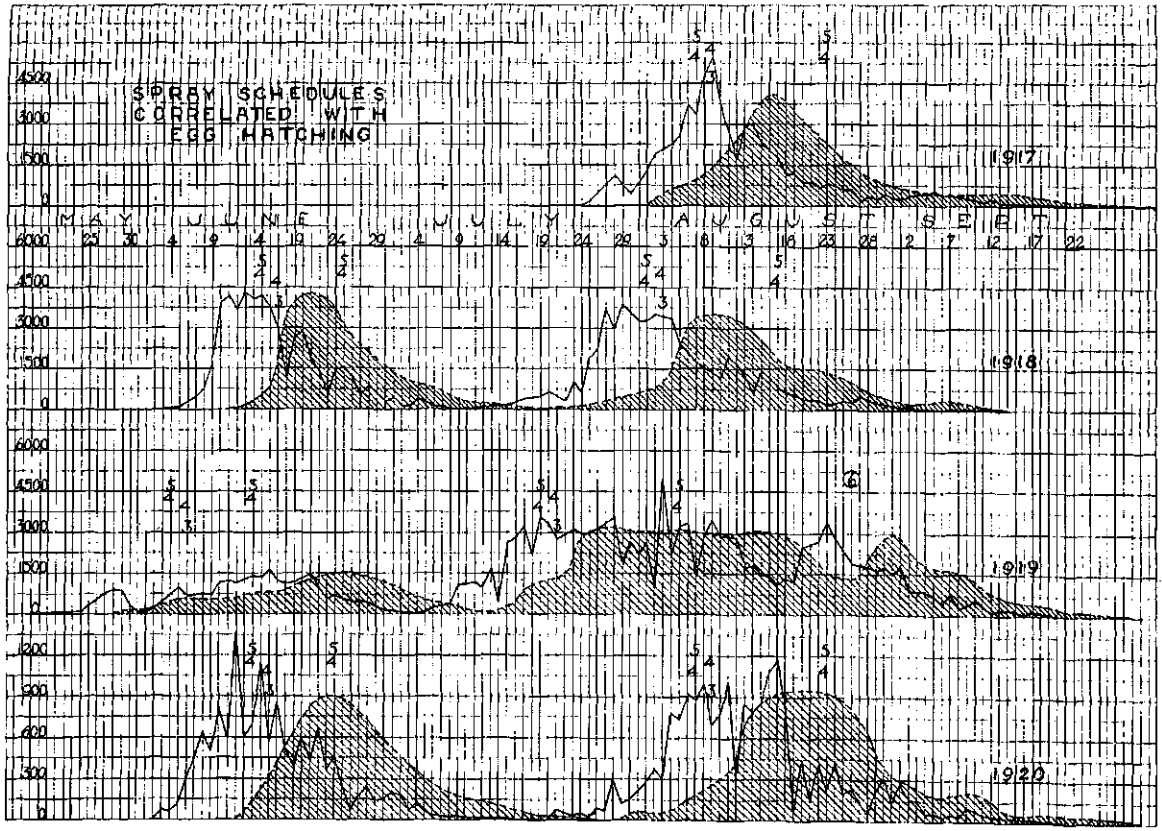


PLATE III. The unbroken line represents the codling moth eggs deposited during seasons 1917, 1918, 1919 and 1920. The cross hatched portion represents the hatching of these eggs. The figures 3, 4 and 5 are placed to show the dates on which the cover sprays of a 3, 4, or 5-spray schedule should have been applied, the figure 6 to show when a sixth application could have been applied to advantage in 1919.

of the powder or 4 lbs. of the paste to 100 gals. of water. Any of a number of brands of this material placed on the market by reliable manucturers will give satisfactory results if properly used.

SPRAY SCHEDULES

One of the most important factors in the spraying operations is the time of application. The small larvae may enter the apple at most any point. To effectively poison these, the entire surface must be kept protected during the hatching periods. Data indicate that usually from 40 to 60 percent of the larvae attempt to enter thru the blossom or calyx of the apple. To effectively poison these, the poison must be placed in the blossom end of the fruit before the calyx closes. This usually occurs in from eight to twelve days after the blossoms fall. A thorough application made at any time during this period will give results, but probably the best time is when the calyces have begun to close and are standing at an angle to form a cup which will have a tendency to collect the spray. This application, if properly made, gives more protection than any other one spray. Any attempt to successfully control the pest without this application has been a failure, but it alone can poison only those entering thru the calyx.

The number and timing of the later applications, or the "cover" sprays, as they are called, will depend upon a number of factors such as temperature, infestation and variety. It will be noted by Plates II and III that there are two broods of larvae each season and that between the two periods when the larvae are entering in such large numbers, there is a period when very few larvae are hatching. It can readily be seen that the effectiveness of a given number of sprays will depend upon the time of application, especially when we consider that any given application will begin to lose its effectiveness in from eight to sixteen days, depending upon the size of the fruit and its rate of growth. If the infestation is light and a large percentage of each brood of larvae appears during a relatively short period, such as ten to fifteen days for the first generation and sixteen to twenty for the second, one cover spray for each generation, if properly applied and timed, will give good protection. With a heavy infestation or with varieties that are growing very rapidly during the time larvae are numerous, it may take more than one cover spray to effectively protect against each brood of larvae. Sometimes weather conditions are responsible for the hatching period being extended as will be seen in the graph of egg deposition for 1919 (Plate II). The spring brood of moths appeared unusually early that season, but after quite a large percentage had emerged and before many eggs were deposited, a cold period extending from May 29th to June 8th occurred. This delayed further emergence of moths and greatly checked the deposition of eggs. As a result, the hatching period was extended. After June 20th the temperatures were above normal and all stages of the insect after the hatching of the first brood eggs were shorter than usual. The second brood appeared about fourteen days earlier than in 1918 and about nineteen days earlier than in 1917 and 1920. As a result of the first brood egg deposition being extended over a longer period, and also due to the fact that the unsually warm weather produced a larger percentage of a second generation, the second brood hatching period extended over an unusually long period and it was exceedingly difficult to properly protect the fruit without using more applications than are ordinarily needed in that section.

Judging from experimental work and results obtained by the better growers as well as by the life history records, it is thought that under certain conditions a three, four or five-spray schedule is necessary in the Paonia section. In extreme cases a sixth spray might be advisable. The same will be true in other sections of the state where there is one complete generation and about the same percentage of a second generation. The figures placed above the hatching graphs shown in Plate III will indicate the approximate dates on which the cover sprays for the different schedules should have been applied during the past four seasons. The calyx application is considered essential in all the schedules. It is applied just after the blossoms fall and before the calyces close. The dates for this are not shown on the chart.

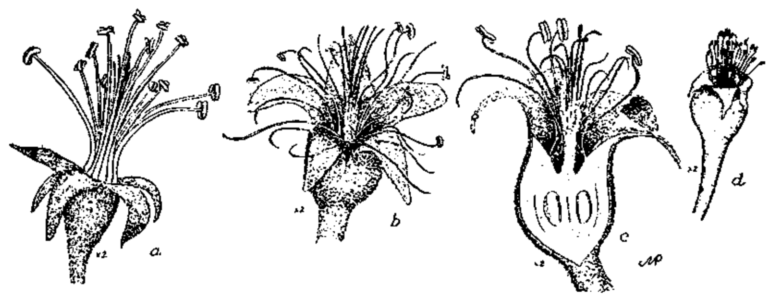


PLATE IV. a, small apple from which the petals have just fallen. Effective spraying for the codling moth may be done in this stage, but it is not in as good condition for receiving the spray as b. b, small apple in the proper condition to receive the first spray for codling moth. The calyx-lobes have begun to close and form somewhat of a cup for holding the liquid and the stamens have begun to dry and will allow the liquid to enter the inner part of the calyx cup. c, cross section of b, showing the calyx cup, all parts of which must be covered with the spray to effectively poison the worms. d, pear in condition to receive the spray. Original. Colorado Experiment Station Bulletin 210. Miriam A. Palmer, Delineator.

THREE-SPRAY SCHEDULE

In the three-spray schedule one cover spray is applied for each generation of larvae. In certain cases this gives good protection. It sometimes occurs that sections, on account of frosts, have a complete or almost complete crop failure. This so reduces the infestation that good results can be secured for a few seasons with three sprays. But unless crop failures are of rather frequent occurrence a large number of applications to keep the infestation to the lowest point would probably be a good investment. Three sprays give good results in some of the higher sections of Delta and Montrose Counties where temperatures would indicate that there is a smaller percentage of a second generation and a high mortality during the winter, and consequently a smaller first generation. Three sprays give reasonably good protection in some of the Arkansas Valley sections and in Northern Colorado.

Some varieties are more easily protected than others. Data do not

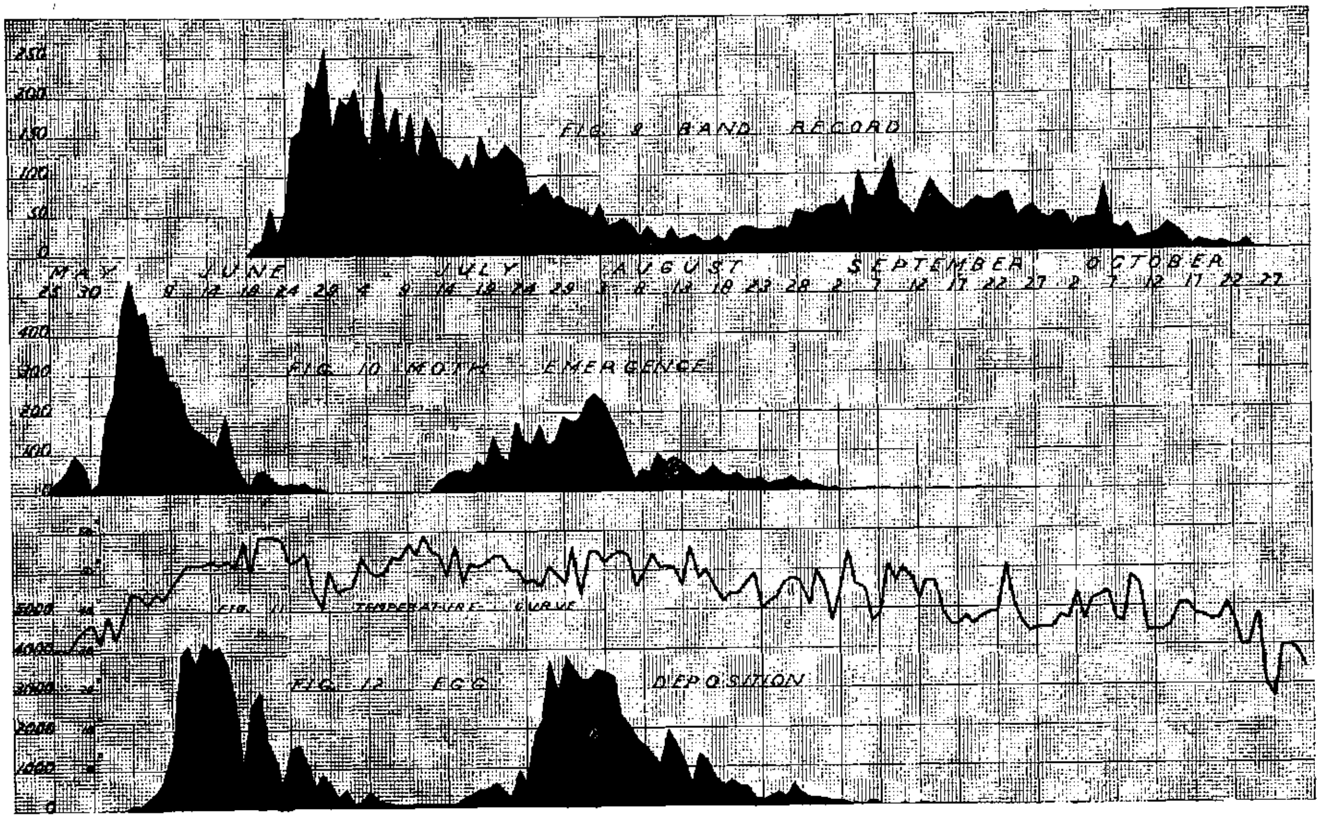


PLATE V. Showing graphically the appearance of the codling moth, as mature larvae, moths and eggs, season 1918, Paonia, Colorado. A similar record has been taken for four seasons.

Figure 9—Represents the daily collection of larvae under bands on unsprayed trees.

Figure 10—The emergence of moths from over-wintering larvae and those larvae represented in Figure 9 that pass thru a second generation.

Figure 11—Graph of minimum temperature.

indicate that there is much, if any, selection on the part of the insect. Counts made during 1920 in an unsprayed orchard at Canon City, Colorado, by Mr. Wm. P. Yetter, Jr., showed the Ben Davis to be 46.18 percent wormy, while the Winesaps were 45.79 percent wormy. Similar data have been taken at Grand Junction.

The differences in controlling the pest on certain varieties are probably due to differences in the character of the skin of the apples and rate of growth. The Winesaps have a rather tough skin and one on which spray sticks readily and also they are inclined to be smaller than many varieties and consequently are more easily protected as is indicated by the results given later for the experimental spray work. Orchards of solid blocks of Winsaps, even in a comparatively wormy section, can be well protected with three applications.

FOUR-SPRAY SCHEDULE

The four-spray schedule may be used as one cover spray for the first generation larvae and two for the second, or two for the first and one for the second. With an orchard well isolated or an entire section sprayed as one orchard, it has been thought that the latter would give the better results. The theory is that the calyx and the two cover sprays would so effecively control the first generation that the second would be so small that little damage would result. If this is true, the total worms for the season would be fewer and there would be fewer "stings" even if the worms are so effectively destroyed with the two sprays on the second brood. If there are infested orchards near by from which second brood moths may migrate, two sprays on the second brood larvae will probably give the better results. In the experimental data following, it will be noted that on Ben Davis and Rome Beauty better results were obtained in Block 1 where the cover sprays were applied, one for the first generation and two for the second, than in Block 2 where the schedule was reversed. However, on Winesap, the results are slightly in favor of two sprays on the first generation and one on the second.

FIVE-SPRAY SCHEDULE

With the five-spray schedule two cover sprays are applied for each brood of larvae. This should give good protection to the fruit during the time of hatching of each brood. As a rule the appearance of the first brood does not extend over as long a period as the second and during this time the apples are smaller and measurements show that the proportional increase, in surface to be protected, is greater so the two sprays for the first brood should be applied closer together, probably within eight to ten days of each other. This, as a rule, will protect the fruit during the appearance of a very large percentage of the larvae.

For the second generation, the sprays will probably not begin to lose the efficiency for from fourteen to eighteen days on account of the increase of surface and the two sprays timed in this way will be efficient during the continuance of the second generation unless conditions are very unusual, such as is indicated by the second generation graph for 1919, Plate

III. During 1919, due to the peculiar conditions explained elsewhere, a third application was advised where a heavy infestation existed and was used to good advantage by a number of growers. However, it is only during exceptional seasons that the five-spray schedule should not be the maximum where there is only a portion of a second generation. In a few sections of the state where there is practically a complete second generation and often a considerable portion of a third, the two cover sprays for the second generation are not sufficient.

After studying the life history data and noting the variation in the spray dates for the past four seasons as indicated on Plate II, it would seem that, until a closer correlation of the insect activities and the temperature can be made, a schedule cannot be the most accurately made unless seasonal studies are carried out in representative sections of the state. Usually each individual fruit grower will not have the time, patience or experience to make and interpret these studies. No better investment can be made in any fruit growing section where the codling moth is a problem than to maintain a trained person to make such observations and studies and make recommendations as to spraying dates.

Many fruit growers will not have the benefit of expert help in establishing the time for their spray applications. It will be necessary for them to make what observations are the most practical for them and from these base their work. The recommendations and suggestions given below are made for their benefit. They are based upon the life history data collected at Paonia during the last four seasons.

The schedule selected should be based on the degree of infestation of the orchard and the varieties to be sprayed.

In all cases the calyx application should be applied just after the blossoms fall and before the calyces close. This may be started when the blossoms are 90 or 95 percent off.

The second application should be made when the first brood larvae begin to enter the fruit. During the past four seasons this time at Paonia has been from three to four weeks after the blossoms fell. This gives a fairly accurate rule for establishing the time. If the temperature following the blossoming period is normal or above, the time should be about twenty-one to twenty-five days. If there should be a period of cooler weather, the time may be extended to thirty days. If a second cover spray is to be used against the first brood of larvae, it should follow in about ten or twelve days.

The most difficult applications to time are those used against the second brood larvae. The best suggestion that can be made for the busy fruit grower is to place some bands of two or three thicknesses of burlap on a number of his trees and examine them daily for the appearance of mature first brood larvae. These may begin to appear as early as the middle of June. A glance at Table I shows that the average time for these larvae to transform to moths and for eggs to appear and hatch was, in 1917, in whole numbers, 28 days; in 1918, 35 days; in 1919, 26 days, and in 1920, 31 days, which gives us an average for the four seasons of 30 days. Usually the second brood larvae have not been abundant enough for four to eight days to justify spraying. Our records for the different seasons show that the time from when larvae were collected under the bands until spraying for the second brood was necessary is as follows: 1917, 32 days; 1918, 42 days; 1919, 30 days; 1920, 39 days, giving an average of 35.7 days.

This would indicate that in from 30 to 35 days after larvae begin to appear in numbers under bands, the spraying against the second brood larvae should be completed. If a second cover spray is to be used against the second brood, it should follow in from sixteen to twenty days, depending upon the intervening weather.

BANDING

The codling moth larvae, when mature, leave the fruit and spin their cocoons under loose bark and in other protected places. Here they transform to the moth. If as many as possible of these hiding places are destroyed and a cloth band is placed about the trunk of the tree to furnish a hiding place, a great many larvae can be collected and destroyed. In some work in Mesa County as high as 60 per cent of the larvae developing upon a tree were thus collected. The value of this method in reducing the second brood and also the over-wintering infestation can readily be seen. In the case of a very heavily infested orchard, this is often almost as important in getting the pest under control as is spraying. A large percentage of the larvae attempting to enter the fruit thru the side will eat enough to make a "sting" before they are poisoned by the spray. The use of bands, by reducing the infestation, greatly reduces the number of apples blemished in this way. In many orchards the greatest commercial loss is from the stung apples. This is especially true in the sections where we have a considerable portion of a second brood or a partial third. It will be noted in Tables VI and VII, which give the data obtained in experimental Blocks 3 and 4, where the best results were obtained; that while the percentage of the wormy apples at harvest time ranges from .12 to 3.85 percent, the total blemished apples range from 11.03 to 31.61 percent.

Burlap folded to two or three thicknesses and three or four inches wide makes a successful and cheap band. It is well held in place by a small finishing nail driven into the tree, the band being drawn tightly and the ends hooked over the headless nail. Table I, giving the length of the stages of the codling moth, shows that the minimum time for the larvae after leaving the fruit to transform into moths is twelve days. Therefore, to avoid any moths escaping, the bands should be removed and all larvae killed at least every twelfth day from the time the first larvae appear until the latter part of August. In the warmer sections of the state they should be examined every ten days and the examinations continued as long as larvae continue transforming to moths, which will often be as late as September 15th. They should then be gone over carefully once during the winter to kill all over-wintering larvae. The success of the banding method will depend upon the careful scraping of the trees to destroy all natural pupation places and the careful and prompt examination of the bands.

PICKING WORMY APPLES

Many of the best orchardists of the state make a practice of thinning the fruit in order to get a better size and to keep the trees in good condition. While this work is being done, constant care should be taken to remove and destroy all wormy apples, especially during the time the first brood larvae are in the fruit. Where thinning is not necessary for other reasons, it will often pay to go over the trees to remove fruit that shows worms. Even if their progeny will be destroyed by the later spraying, this system will, as with the banding, greatly reduce the number of "stings" that will result.

THOROUGHNESS OF WORK

It takes the most careful work in making a calyx application of spray to get poison into all calyces, and it is practically impossible to so thoroughly cover the surface of the fruit in the later applications that all worms will be poisoned. It is, therefore, important that each orchardist study his work, especially that of spraying, to get as near perfection as possible. Carelessness or lack of knowledge as to how to do thorough work is one of the greatest factors in the failure to get the control desired.

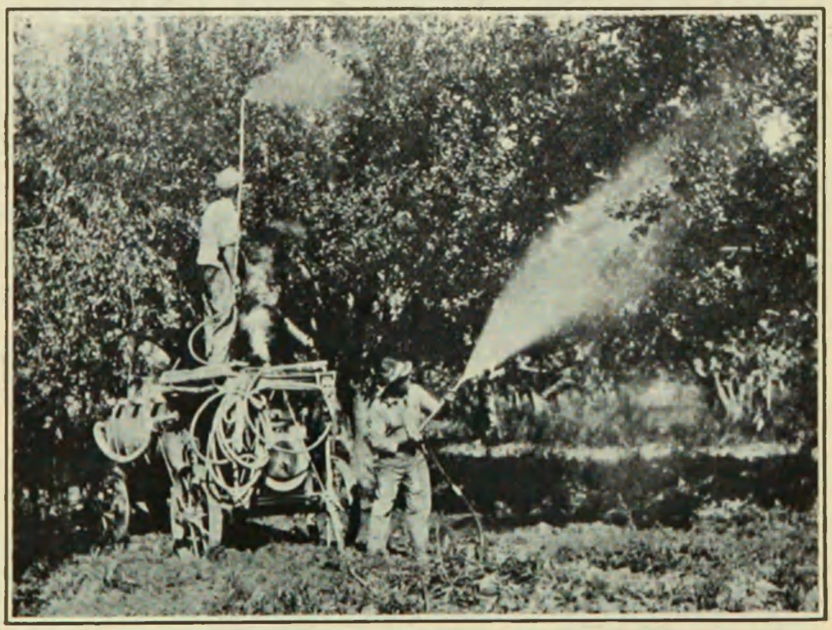


FIGURE 3—Spraying in the experimental orchard. The man on the machine should be somewhat higher for trees of the size of the ones that are being sprayed. The gun and nozzle are throwing a spray of good character for thorough work. If a gun is used, it should be constantly manipulated so the spray will strike the parts of the tree being sprayed with a force and character similar to that shown.

Wherever it is possible, each orchardist should have his own machinery and the best is none too good. If it is necessary for growers with small acreage to hire their machines, as is the practice in many sections, each owner should have his own nozzles and hire only the power. While good work can be done with any one of a number of nozzles that are on the market, the efficiency of any of them depends upon the ability of the operator to use them properly. If each orchardist has his own equipment of nozzles he will become familiar with them and do the same character of spraying each time.

It is felt that the use of a tower on the machine is quite important in enabling the operator to do the most effective work in the older orchards. Usually a low railing or a saw horse to enable the operator to balance himself on the spray tank or on a low platform above this is satisfactory. This enables the operator to move around and places him in position to observe his work more closely. With one nozzle holder in this position and one on the ground and each spraying the tree from as many angles as possible and driving down each side of a row, trees can be thoroughly covered with the least effort.

The importance of pruning with the idea of making thorough spray-

FIGURE 4—A type of spraying too often done with the spray gun. The spray is so coarse and has so much force that it will not stick to the apples and the cone is so small that the most careful worker will miss parts of the tree.

ing possible cannot be over emphasized. The trees should be so opened up that all parts can be sprayed from different angles. There should be "doors" that will enable the nozzle holders to get to the center of the tree in three or four points to spray from the center outward. If it becomes necessary, some fruiting wood can well be sacrificed in order to make possible the better control of the codling moth on the remainder of the tree.

SPRAY EXPERIMENTS, SEASON OF 1920

HISTORY OF ORCHARD

The orchard selected for the experimental work is located just west of Paonia, Delta County. The use of the orchard was made possible thru the co-operation of Mr. C. Lund, the owner, and Mr. W. H. Baker, the renter. It consists of eight acres of one of the oldest orchards in Western Colorado. In many ways it is not a desirable orchard for experimental work, but was selected largely because of the heavy infestation of codling moths that existed. It was felt that, while the percentage of worm-free fruit might not be as high as could be obtained in some other orchards, the data obtained would give us better comparisons of certain schedules and ideas. It was commonly spoken of as the wormiest orchard in that section. Counts made at picking time in the fall of 1918 showed 46.95 percent calyx wormy with 78.41 unsound. No calyx spray had been applied that year, and the cover sprays were not applied in a very thorough manner. The pruning work had been neglected, thus making thorough work more difficult. Many trees were as much as 25 feet in height and had a spread of forty feet. As with most of the older orchards, it contained several varieties of apples. For checking the results, Ben Davis, Rome Beauty, and Winesap were chosen because they were about equally distributed thruout the experimental blocks.

The orchard was sprayed experimentally in 1919 with very much the same plans as were used in 1920. (The data obtained is not given here. On account of certain conditions, it is considered of little value.) The codling moth conditions were quite abnormal that season as is explained elsewhere. There was a very light crop thruout the county and a freeze on June 1 injured the cruit so badly that much of it dropped during the season and the remainder matured abnormally.

EXPERIMENTAL PLANS

The orchard was divided into four equal blocks for the testing of three spray schedules, and the value of linseed oil jelly-soap as a spreader.

The blocks were designated as follows:

Block 1. Four-spray schedule—calyx spray, 1 cover spray for first brood larvae and two for second.

Block 2. Four-spray schedule—calyx spray, two cover sprays for first brood larvae and one for second.

Block 3. Five-spray schedule—calyx spray, two cover sprays for first brood larvae and two for second.

Block 4. Spray schedule the same as in Block 3. 5-lb. of linseed oil jelly-soap was added to each 200 gallons of spray material.

Check. Unsprayed.

Tabulations of results may be found in Tables II, III, IV, V and VI.

EQUIPMENT AND SPRAY METHODS

The equipment consisted of a Giant Bean Triplex sprayer, having two lines of hose, one equipped with a Friend Gun which was used from the ground and the other with a Bean Majestic Angle nozzle of the whirlpool type on an eight-foot rod which was used from the top of the spray tank. A 3/32-inch hole was bored thru the center of the removable eddy chamber of the nozzle to insure a solid cone of spray with sufficient driving power for the cone to hold its shape until ten to fifteen feet from the nozzle. What was termed as a "fine" disc was used in the gun. Early in the

FIGURE 5—Spraying from the center of the tree outward. The nozzle holder should spray the center of the tree from at least four positions, being careful to spray the "inner" side of all apples that are on the opposite side of the tree. The tree being sprayed should be pruned with the spraying operations in mind. At least four "doors" should be opened.

season a pressure of 250 lbs. was maintained, but later it was found that 300 lbs. gave better results, especially with the gun. An effort was made to so regulate the control valve of the gun that all parts of the tree sprayed would receive a spray of the same character regardless of the position of the operator.

A uniform method of procedure was used thruout the season. Only one side of a single row was sprayed at a time. The machine was stopped

Table II

	Total Fruit	Free Fruit	Worm Free Fruit	Fruit Injured			No. of Injuries			Efficiency		
				Total	Wormy	Stung Only	Calyx	Side Worms	Stings	1	2	3
BEN DAVIS												
Above 12 feet	6111	3993	5629	2118	482	1636	0	598	2396			
Percent		65.34	92.11	34.65	7.88	26.77				80.02	84.69	74.12
Below 12 feet	5813	4083	5688	1730	125	1605	3	113	2070			
Percent		70.23	97.84	29.76	2.15	27.61				94.82	94.53	90.42
Dropped in picking	448	300	406	148	42	106	2	53	128			
Percent		66.96	90.62	33.03	9.37	23.66				70.71	80.76	76.37
Total Harvest	12372	8376	11723	3996	649	3347	14	788	4594			
Percent		67.70	94.75	32.29	5.24	27.05				85.35	88.61	80.16
Windfalls	1821	917		904			25	951	429			
Percent		50.35		49.64						31.08		71.18
Grand Total	14193	9293		4900			39	1739	5023			
Percent		65.47		34.52						74.28		76.10
ROME BEAUTY												
Above 12 feet	994	759	946	235	48	187	0	61	264			
Percent		58.24	96.98	23.64	4.83	18.81				81.23	90.61	97.44
Below 12 feet	3179	2490	3102	689	77	6 12	1	88	824			
Percent		78.32	97.57	21.67	2.42	19.25				90.35	93.84	93.97
Dropped in picking	319	258	296	61	24	37	1	29	44			
Percent		80.87	92.78	19.12	7.52	11.59				60.27	84.56	86.91
Total Harvest	4492	3507	4344	985	149	836	2	178	1132			
Percent		78.07	96.70	21.92	3.31	18.61				86.41	92.80	95.58
Windfalls	1075	526		549			20	652	227			
Percent		48.93		51.06						25.82		80.15
Grand Total	5567	4033		1534			22	830	1359			
Percent		72.46		27.55						62.08		88.62
WINESAP												
Above 12 feet	4080	2633	4005	1447	75	1372	2	82	1948			
Percent		64.53	98.16	35.46	1.83	33.62				95.96	96.44	96.48
Below 12 feet	3649	2662	3607	987	42	945	0	46	1265			
Percent		72.95	98.84	27.04	1.15	25.89				96.49	97.07	96.85
Dropped in picking	287	191	271	96	16	80	0	20	107			
Percent		66.55	94.42	33.44	5.57	27.87				84.25	88.56	91.13
Total Harvest	8016	5486	7883	2530	133	2397	2	148	3320			
Percent		68.43	98.34	31.56	1.65	29.90				95.73	96.41	96.30
Windfall	1729	807		922			14	553	750			
Percent		46.67		53.32						57.55		83.25
Grand Total	9745	6293		3452			16	701	4070			
Percent		64.57		35.42						85.30		90.51

TABLE II. Tabulation of results of fruit examinations made in Block 1. Four-spray schedule—calyx spray, 1 cover spray for first brood larvae, and two for second.

on two "corners" of each side of a tree and in case of large trees, a third stop was made. The man on the machine sprayed all of the higher parts of the tree he could reach from two angles with each stop and also sprayed downward on the lower parts of the tree. The man on the ground would step to the center from each of the two "corners" of the side being sprayed and spray all parts that could be reached, including the inner portion of the opposite side of the tree, and then work outward from each position, spraying all parts from the underside and finish by carefully going over the outer portion of the section of the tree being sprayed.

DISCUSSION OF RESULTS

Table VI gives the results of counts made on a "check" tree which was unsprayed. It was impracticable to leave more than one tree unsprayed as a check. This is too small a unit to indicate accurately the infestation over the entire orchard. The idea of having a check was largely to get a comparison of the infestation of the top and bottom of an unsprayed tree. The tree was of the Ben Davis variety, very large and bore an unusually heavy load of small apples. It will be noted that the total harvested fruit was 46.03 percent. wormy and that borne above the height of 12 ft. was 12.14 percent. wormier than that borne below 12 ft. The data on the "check" are unusual in that only 6.07 percent.* of the worms had entered the calyces of the apples. While this percentage varies a great deal with different varieties and seasons, never before have we had a case where such small portion entered the calyx. Usually the range has been from 40 to 60 percent. In 1918, when the same orchard had received no calyx spray, counts show that 78.41 percent. of the apples were wormy and 46.95 percent. were calyx wormy.

The counts do not at first show a very heavy infestation but the infestation is probably better indicated by the fact that 7393 larvae developed on the tree which represented 85.82 worms for each 100 of the 8745 apples.

Tables II, III, IV and V give a tabulation of the results obtained in the Blocks, 1, 2, 3 and 4 respectively. Thru a slight omission the counts on the dropped fruit gave only the free fruit and the number of blemishes, consequently the wormy fruit for the entire season cannot be accurately tabulated.

As the percentage of wormy apples at harvest time is the usual basis for rating the value of the control methods, the results will thus be considered. In comparing Blocks 1 and 2, it is noted the best results obtained on Ben Davis and Rome Beauty were in Block 1, while the reverse is true with the Winesap. A comparison of the free fruit and that "stung only" shows that the same relation is maintained.

In comparing Blocks 3 and 4 which is a comparison of a 5-spray schedule, the latter with a spreader, it is noted that on the basis of wormy apples, the results are uniformly in favor of Block 3, yet the difference is slight.

It is interesting to note that the percentage of wormy fruit is low with all varieties in both 5-spray blocks, ranging from .12 of one percent.

*It is possible that the blossoms caught the calyx spray from the surrounding trees.

on the Winesap, to 3.85 percent. on Ben Davis, while the fruit "stung only" ranges from 10.72 percent, on the Winesap to 27.76 percent. on the Ben Davis.

In comparing the 4-spray schedules represented by Blocks 1 and 2 with the 5-spray schedule represented by Blocks 3 and 4, and making the comparison on the same variety, results are considerably in favor of the 5-spray schedules.

Table III

BEN DAVIS

	Total Fruit	Free Fruit	Worm Free Fruit	Fruit Injured			No. of Injuries			Efficiency		
				Total	Wormy	Stung Only	Calyx	Side Worms	Stings	1	2	3
Above 12 feet	4613	2027	3977	2586	636	1950	5	786	3498			
Percent		43.94	86.21	56.05	13.78	42.27				81.65	73.23	66.33
Below 12 feet	3053	1865	2936	1188	117	1071	1	137	1512			
Percent		61.08	96.16	38.91	3.83	35.08				91.69	90.26	90.68
Dropped in picking	390	156	297	234	93	141	2	137	217			
Percent		40.00	76.15	60.00	23.84	36.15				61.29	50.24	40.50
Total Harvest	8056	4048	7210	4008	846	3162	8	1060	5227			
Percent		50.24	89.49	49.75	10.50	39.25				83.13	77.18	73.67
Windfalls	1217	562		755			15	884	417			
Percent		46.17		62.03						32.05		73.45
Grand Total	9273	4610		4763			23	1944	5644			
Percent		49.71		51.36						74.38		73.57

ROME BEAUTY

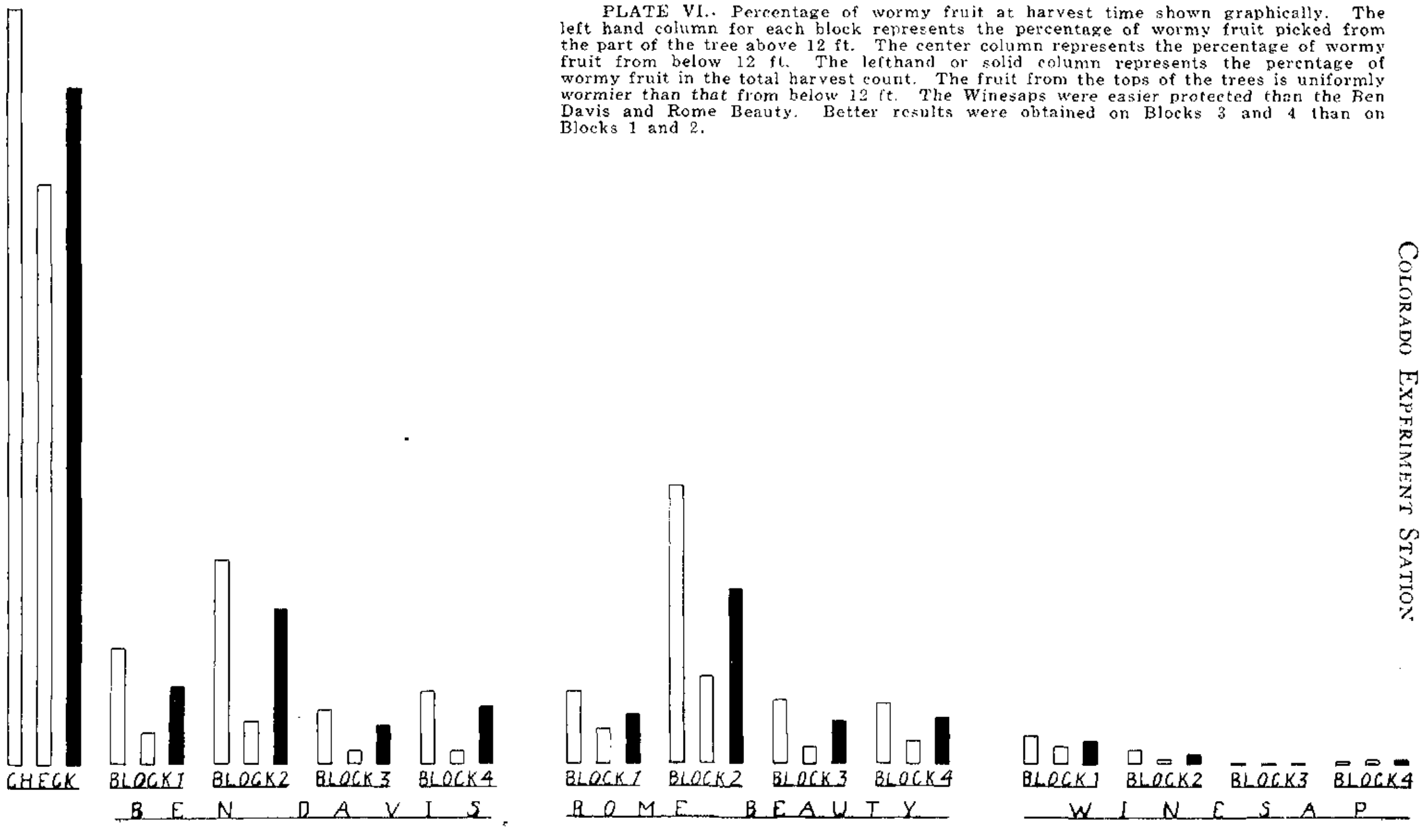
	Total Fruit	Free Fruit	Worm Free Fruit	Fruit Injured			No. of Injuries			Efficiency		
				Total	Wormy	Stung Only	Calyx	Side Worms	Stings	1	2	3
Above 12 feet	2734	1634	2218	1100	516	747	23	741	1352			
Percent		59.76	81.12	40.23	18.87	27.32				64.59	63.34	67.25
Below 12 feet	4261	2732	4013	1529	248	1281	2	329	1866			
Percent		64.11	94.17	35.88	5.82	30.06				85.01	85.20	77.56
Dropped in picking	322	161	217	161	105	56	4	153	141			
Percent		50.00	67.39	50.00	32.60	17.39				47.95	33.08	30.37
Total Harvest	7317	4527	6448	2790	869	2084	29	1223	3359			
Percent		61.86	88.12	38.13	11.87	28.48				73.30	74.21	68.86
Windfalls	1433	378		1055			31	1457	581			
Percent		26.37		73.62						28.50		56.06
Grand Total	8750	4905		3845			60	2680	3940			
Percent		56.05		43.94						59.51		63.09

WINESAP

	Total Fruit	Free Fruit	Worm Free Fruit	Fruit Injured			No. of Injuries			Efficiency		
				Total	Wormy	Stung Only	Calyx	Side Worms	Stings	1	2	3
Above 12 feet	2562	1999	2538	563	24	539	1	27	569			
Percent		78.02	99.06	21.97	0.036	21.03				96.23	96.23	98.82
Below 12 feet	3930	3116	3918	814	12	802	0	12	981			
Percent		79.28	99.69	20.71	0.30	20.40				98.79	99.23	99.12
Dropped in picking	163	134	159	29	4	25	0	6	32			
Percent		82.20	97.54	17.79	2.39	15.33				84.21	95.09	97.46
Total Harvest	6665	5249	6615	1406	40	1366	1	45	1704			
Percent		78.87	99.39	21.12	.60	20.52				97.42	98.69	98.85
Windfalls	2015	1391		624			21	282	540			
Percent		69.00		30.96						65.69		91.05
Grand Total	8670	6640		2030			22	327	2244			
Percent		76.58		23.41						87.28		96.66

TABLE III. Tabulation of results of fruit examinations made in Block 2. Four-spray schedule—calyx spray, two cover sprays for first brood larvae and one for second.

PLATE VI. Percentage of wormy fruit at harvest time shown graphically. The left hand column for each block represents the percentage of wormy fruit picked from the part of the tree above 12 ft. The center column represents the percentage of wormy fruit from below 12 ft. The lefthand or solid column represents the percntage of wormy fruit in the total harvest count. The fruit from the tops of the trees is uniformly wormier than that from below 12 ft. The Winesaps were easier protected than the Ben Davis and Rome Beauty. Better results were obtained on Blocks 3 and 4 than on Blocks 1 and 2.



Attention has been drawn to the fact that the top of the "check" tree was considerable wormier than the lower part. This same condition has prevailed thruout the sprayed block and to a greater extent, indicating that there was probably less efficiency in the spraying of the parts of the trees above 12 feet.

While the percentage of wormy fruit is comparatively low in all blocks, the fruit injured by stings is in some cases quite high. This cannot be materially reduced without the accumulative results of thoro work over a series of years to reduce the infestation. In making the counts of the stings, all healed blemishes made by the codling moth were included. In many cases these were so small as to be unnoticed in packing. Probably a considerable portion of the stung fruit would be passed as first grade fruit and practically all of it would be marketable.

Plate VI represents graphically the wormy fruit on the different varieties and blocks in comparison with the check, and indicates the difference in infestation between the tops and lower parts of the trees. The ease with which the Winesaps are protected is an outstanding feature of the graph. The results obtained on the Ben Davis and Rome Beauty are very similar.

A study of the records indicates that greater efficiency has been obtained in controlling the calyx worms than those entering thru the side of the fruit. There were a total of 111,351 apples examined during the season. There had entered these 295 calyx worms and 11,892 side worms, and a total of 35,851 stings were recorded. A large portion of the calyx worms were in the windfall apples and were recorded before harvest time, while a considerable portion of the side worms were later and were found in the harvest fruit. The actual loss from calyx-wormy apples in a well sprayed orchard is very small; however, the few that escape being poisoned as they enter thru the calyx, may be to a large extent responsible for the increased number of late worms that make so many side injuries.

The total of the harvest fruit was 96,283 apples. The percentage of wormy apples ranged from .12 of one percent on the Winesaps in Block 4 to 11.87 percent on Rome Beauty in Block 2. The average for the entire harvested crop from all blocks was 3.98 percent wormy. This is a total of 3,846 apples which is too heavy a loss, but it is interesting to note and should be called to the attention of the growers, that the pickers who were picking the orchard under a contract dropped 4,043 apples or more than were wormy. The fruit dropped in picking, which forms a part of the total harvest fruit, is somewhat wormier than that picked. While it is true that some fell during the picking because they were wormy, this would not account for much of the heavy drop.

SOAP AS A SPREADER

The object of using the linseed oil soap in the spray on Block 4 was to test its value in causing the liquid to spread more uniformly over the fruit instead of collecting in droplets. A number of materials had previously been tested in the laboratory with the linseed oil jelly-soap showing the most promise. Thurout the spraying season its effect in overcoming the blotchy appearance of the poison on the fruit was very noticeable and it was felt that the same amount of liquid with the soap added would spray more trees altho the trees in the orchard varied so much in size that accurate data on this could not be secured. The soap seemed to have the effect of flocculating the arsenate of lead to some extent. Altho this was not very noticeable, it may be sufficient to overcome the benefits brought about by the increased spreading effect given the liquid. The data do not show any material benefit from the use of the soap.

Table IV

BEN DAVIS

	Total Fruit	Free Fruit	Worm Free Fruit	Fruit Injured			No. of Injured			Efficiency		
				Total	Wormy	Stung Only	Calyx	Side Worms	Stings	1	2	3
Above 12 feet....	6588	5279	6347	1309	241	1068	2	291	1346			
Percent		80.13	96.34	19.86	3.65	16.21				82.22	92.90	45.77
Below 12 feet....	5315	4427	5273	888	42	846	0	52	999			
Percent		83.29	99.20	16.70	0.79	15.91				95.05	97.99	96.45
Dropped in picking	443	349	401	94	42	52	0	53	64			
Percent		78.78	90.50	21.21	9.48	11.73				54.70	80.54	77.63
Total Harvest	12346	10055	12021	2291	325	1966	2	396	2409			
Percent		81.44	97.33	18.55	2.59	15.92				85.88	94.37	90.26
Windfalls	1857	1056		801			3	367	110			
Percent		56.86		43.13						23.06		89.07
Grand Total	14203	11111		3092			5	763	2519			
Percent		78.22		21.77						76.75		89.72

ROME BEAUTY

	Total Fruit	Free Fruit	Worm Free Fruit	Fruit Injured			No. of Injured			Efficiency		
				Total	Wormy	Stung Only	Calyx	Side Worms	Stings	1	2	3
Above 12 feet....	2576	1813	2465	763	111	652	0	137	926			
Percent		31.56	95.69	29.61	4.30	25.31				87.11	91.64	94.26
Below 12 feet....	4834	3777	4751	1057	83	974	1	94	1265			
Percent		78.13	98.28	21.91	1.17	20.14				93.35	97.02	93.63
Dropped in picking	465	374	429	91	36	55	0	46	69			
Percent		80.43	92.25	19.56	7.74	11.82				59.91	84.11	80.59
Total Harvest	7875	5964	7645	1911	230	1681	1	277	2260			
Percent		75.73	97.08	24.26	2.92	21.34				85.13	93.65	93.24
Windfalls	1157	591		566			17	571	241			
Percent		51.08		48.91						29.67		82.63
Grand Total	9032	6555		2477			18	848	2501			
Percent		72.57		27.42						74.67		88.46

WINESAP

	Total Fruit	Free Fruit	Worm Free Fruit	Fruit Injured			No. of Injured			Efficiency		
				Total	Wormy	Stung Only	Calyx	Side Worms	Stings	1	2	3
Above 12 feet....	2823	2320	2819	503	4	499	0	9	598			
Percent		82.18	99.82	17.81	0.141	7.67				98.51	99.92	99.53
Below 12 feet....	5373	4756	5366	617	7	610	0	8	705			
Percent		88.51	99.86	11.48	0.130	11.35				98.87	97.12	99.46
Dropped in picking	344	315	344	29	0	29	0	0	34			
Percent		91.56	100	8.43	0	8.43				100	100	100
Total Harvest	8540	7391	8529	1149	11	1138	0	17	1337			
Percent		86.54	99.87	13.45	0.12	13.32				98.74	99.73	99.58
Windfalls	1559	1259		300			3	108	310			
Percent		80.75		19.24						74.16		96.72
Grand Total	10099	8650		1449			3	125	1647			
Percent		85.66		14.34						92.94		98.29

TABLE IV. Tabulation of results of fruit examinations made in Block 3. Five-spray schedule—calyx spray, 2 cover sprays for each brood of larvae.

METHODS OF DETERMINING RESULTS OBTAINED FROM SPRAYING

The writers have for a number of years been dissatisfied with the method in use for determining the efficiency obtained in the codling moth experiments and spraying work. This method has been to compare the percentage of wormy apples on a few count trees in a given block with the percentage of wormy apples from some unsprayed trees. The details in making accurate seasonal counts take so much time that the number of trees used must necessarily be small. If a small number of trees is left unsprayed, the natural dispersion of the moths from these will lower their infestation and also materially influence the infestation of the nearby sprayed trees. Even comparatively large blocks of the same variety in unsprayed orchards will vary a great deal in infestation and the percentage of wormy apples varies inversely with the number of apples on a tree.

Our data taken in a number of sections of the state show a great variation in individual trees growing side by side and apparently uniform in other respects. This variation is shown in Table VII. In all cases, trees 1 and 2 of the same variety and block were as nearly alike in size, crop and in other respects as could be selected. Yet the total blemishes on Ben Davis tree 1, block 1, was 4,340 or 54.7 per 100 apples, while on tree 2, they totalled 2,476 or 39.4 per 100 apples. A greater difference is shown between Rome Beauty trees 1 and 2 of the same block, tree 2 showing a total of about four times as many blemishes as tree 1. Ben Davis tree 2, block 2, shows a total of 5,430 blemishes, while tree 1 shows 2,197, and the tree carrying the most fruit had the highest percentage of wormy and blemished apples. A like variation is shown thruout the data.

It is true that the percentage of free and wormy apples determines, to a large extent, the commercial value of a crop, but it is believed that with the varied condition of codling moth infestation that exists even in a single orchard, that they may not represent the true results obtained from a spray method or practice. They may be even misleading to the extent that growers are continually adopting methods and ideas advocated that apparently give good results but possibly have never been tested under severe codling moth conditions to determine their real merits, or their efficiency has not been accurately determined where they have been tested.

It is thot that at least a large percentage of the stings come from the worms being poisoned, but only after they have eaten enough to blemish the apple. There are few stings on unsprayed fruit. On sprayed fruit they are in direct proportion to the infestation and killing effect of the poison. Judging from several seasons' counts made in different sections of the state, a fair way of judging the efficiency of any spray practice may be by comparing the live worms entering the fruit with those that are killed as would be indicated by the stings. This has been done in efficiency No. 1, Tables II, III, IV and V. It is realized that with certain varieties having a very delicate skin a larger percentage of the worms that are killed make stings but, also, a larger percentage is not killed and makes worms, this keeping the ratio the same. The reverse is true with tough-skinned varieties. The efficiencies indicated are probably not the true efficiencies and might better be called by another term, but they probably give the different blocks a more correct ranking according to the results obtained than do percentages of clean or wormy fruit, and also better than efficiency percentages based upon comparisons with unsprayed checks as efficiencies 2 and 3 are obtained.

Tables II, III, IV and V give the percentages of wormy and free fruit, also three methods of judging the results obtained from the use of the

Table V

	Total Fruit	Free Fruit	Worm Free Fruit	Fruit Injured			No. of Injuries			Efficiency		
				Total	Wormy	Stung Only	Calyx	Side Worms	Stings	1	2	3
BEN DAVIS												
Above 12 feet	5483	3600	5213	1883	270	1613	14	313	2182			
Percent		65.65	95.07	34.34	4.92	29.42				87.45	90.44	85.92
Below 12 feet	3299	2432	3272	867	27	840	0	27	1017			
Percent		73.71	99.18	26.29	0.8184	25.46				98.34	97.91	98.05
Dropped in picking	482	304	422	178	60	118	2	69	170			
Percent		63.07	87.56	36.92	12.44	24.48				71.12	74.46	70.04
Total Harvest	9264	6336	8907	2928	357	2571	16	409	3369			
Percent		68.39	96.14	31.61	3.85	27.76				89.17	91.63	89.41
Windfalls	1509	617		892			42	707	420			
Percent		40.88		59.12						37.26		77.88
Grand Total	10773	6953		3820			58	1116	3789			
Percent		64.54		35.46						77.24		84.21
ROME BEAUTY												
Above 12 feet	3250	2242	3116	1008	134	874	7	171	1169			
Percent		68.98	95.87	31.01	4.12	26.89				87.23	91.99	92.46
Below 12 feet	3959	2886	3898	1073	61	1012	0	71	1284			
Percent		72.89	98.45	27.10	1.54	25.56				94.76	96.08	95.17
Dropped in picking	310	226	275	84	35	49	1	39	75			
Percent		72.90	88.70	27.09	11.29	15.80				65.89	76.82	82.70
Total Harvest	7519	5354	7289	2165	230	1935	8	281	2528			
Percent		71.20	96.94	28.79	3.05	25.73				89.99	93.37	92.88
Windfalls	741	257		484			21	504	222			
Percent		34.68		65.31						30.57		84.49
Grand Total	8260	5611		2649			29	785	2750			
Percent		67.92		32.07						77.79		89.10
WINESAP												
Above 12 feet	410	347	409	63	1	62	0	1	74			
Percent		84.63	99.75	20.24	0.24	15.12				98.66	99.53	99.95
Below 12 feet	1842	1658	1837	184	5	179	0	6	213			
Percent		90.01	99.72	9.79	0.27	9.71				97.26	99.31	99.59
Dropped in picking	70	61	69	9	1	8	0	1	10			
Percent		87.14	98.57	12.87	1.42	11.42				90.90	97.08	99.57
Total Harvest	2322	2066	2315	256	7	249	0	8	297			
Percent		88.97	99.69	11.02	0.301	10.72				97.37	99.34	99.80
Windfall	464	381		83			0	26	68			
Percent		68.53		17.88						72.34		99.23
Grand Total	2786	2447		339			0	34	365			
Percent		87.83		12.16						91.47		99.54

TABLE V. Tabulation of results of fruit examinations made in Block 4. Five-spray schedule—calyx spray, 2 cover sprays for each brood of larvae. Soap used as spreader.

different schedules known as efficiences 1, 2 and 3. These are as follows:

Efficiency 1—A direct comparison of the worms killed on a given tree or block with the infestation on the same tree or block, taking the total stings and side worms as the idex of the infestation and the stings as the index of the worms killed.*

Table VI

BEN DAVIS

	Total Fruit	Free Fruit	Worm Free Fruit	Fruit Injured: Total	Fruit Injured: Wormy	Fruit Injured: Stung Only	No. of Injuries: Calyx	No. of Injuries: Side Worms	No. of Injuries: Stings
Above 12 feet	2828	1248	1372	1580	1456	124	112	2218	449
Percent		44.13	48.51	55.87	51.48	4.38			
Below 12 feet	2425	1320	1471	1105	954	151	93	1352	309
Percent		54.43	60.65	45.56	39.34	6.23			
Dropped in Picking	314	148	161	166	153	13	11	220	31
Percent		47.13	51.27	52.86	48.72	4.14			
Total Harvest	5567	2716	3004	2851	2563	288	216	3790	789
Percent		48.78	53.96	51.21	46.03	5.17			
Windfalls	3178	1071		2107			240	3147	239
Percent		33.70		66.29					
Grand Total	8745	3787		4958			456	6937	1028
Percent		43.30		56.69					

TABLE VI. Tabulation of results of fruit examinations made in unsprayed block.

Efficiency 2—A direct comparison of the wormy apples on the sprayed tree or block with the wormy apples on a check, which may or may not be typical of the orchard or similar in infestation to the count trees.

Efficiency 3—A comparison of the total worms developing upon the sprayed tree with the total developing upon a check.

After using the three methods upon data collected in different sections and under varying degrees of infestation, it is felt that efficiency 1 gives a more accurate comparison of the results obtained than do simple percentages of wormy or clean fruit or efficiency 2 or 3.

The value of comparing results by the efficiency method rather than by comparing wormy apples or free apples is indicated by studying results obtained on the Ben Davis in blocks 1 and 2. Block 2 shows 10.5 percent. of the harvest fruit wormy, while block 1 shows 5.24 percent. Yet, considering the fact that block 2 shows 82.24 blemishes for 100 apples and

*Used by the senior author 1916 on data collected in Stapleton orchard, Palisade, Colo. A similar method is suggested by A. L. Melander, "An Index Number for Rating Codling Moth Treatments," Journal of Economic Entomology, Vol. 13, No. 6, Page 456.

block 1, 48.02, the efficiency as shown on the total seasons' fruit is 74.38 and 74.28 respectively, slightly in favor of the block showing the most

Table VII

BLOCK	Tree	BEN DAVIS			ROME BEAUTY			WINESAP		
		Total Apples	Total Blemishes	Blemishes per 100 Apples	Total Apples	Total Blemishes	Blemishes per 100 Apples	Total Apples	Total Blemishes	Blemishes per 100 Apples
1	1	7922	4340	54.7	2011	479	23.8	3958	2251	56.9
	2	6271	2476	39.4	3556	1734	48.7	5787	2538	43.8
	Av.	14193	6816	48.02	5567	2213	39.35	9745	4789	49.14
2	1	3692	2197	59.5	6527	4840	74.1	3148	1417	45.0
	2	5581	5430	97.3	2223	1870	84.1	5522	1177	21.3
	Av.	9273	7627	82.24	8750	6710	76.68	8670	2594	29.91
3	1	6599	1184	16.3	4894	1910	39.00	4500	1075	23.8
	2	7604	2106	27.6	4138	1457	35.2	5599	700	12.5
	Av.	14203	3290	23.16	9092	3367	37.27	10099	1775	17.57
4	1	5416	2131	39.3	3402	1424	41.9	2786	399	14.32
	2	5357	2843	53.08	4858	2144	43.7			
	Av.	10773	4974	46.21	8260	3568	43.19			

TABLE VII. Tabulation of results of the examinations of fruit from individual trees in Blocks, 1, 2, 3, and 4.

wormy apples. This difference in infestation must have been due to conditions from the previous year and not to results obtained in controlling the first brood, as block 2 had received two first brood cover sprays while block 1, which showed the lightest infestation, had received one. Again, the harvest count Romes in block 4 are 3.05 percent. wormy, those in block 3, 2.92 percent. wormy and the total seasons' count for block 4 is 67.92 percent. free from blemishes, while those of blocks 3 are 75.57 percent. free, yet, when infestation is taken into consideration, greater efficiency is shown in block 4.

In comparing the 5-spray schedule as represented by block 3 and 4, the latter having linseed oil-soap added as a spreader, it is noted that the results are in favor of block 3, when compared on the basis of percentage of total fruit injured, in case of the Ben Davis, the difference being as much as 14 percent, while, if compared on the basis of efficiency 1, the results are in favor of block 4, even tho it showed a considerable heavier infestation.

On the basis of wormy and free fruit, the data would indicate that, with a 4-spray schedule much better results are obtained when one cover spray is used on the first brood and two on the second, than where two are used on the first and one on the second, yet, on the basis of Efficiency 1, there is little difference.

There is a greater variation of the percentage of injured fruit from the different trees of a block than there is of the efficiency of controlling the insects on these trees that were handled alike.

SUMMARY

1. The data and recommendations apply especially to Delta County conditions, but will apply quite generally to all other sections except the lower Grand Valley where they can only be used in a very general way.
2. In Paonia, the codling moth goes thru one complete generation and from 20 to 40 percent. go thru a second.
3. The development and activities of all stages of the insect are closely correlated with the temperature.
4. The difference between the time of appearance of a certain stage of the insect in 1917 and 1919 was 20 days.
5. The average time for the development from egg to egg at Panoia was, in 1918, 61.29 days; in 1919, 48.11 days and in 1920, 54.89 days.
6. Spray dates to be accurate must be based upon seasonal life history studies.
7. Spraying with arsenate of lead is the most effective means of control.
8. Lack of thoroughness in spraying is a very important factor in poor results obtained by many.
9. The use of bands and the picking and destroying of wormy apples are valuable means of control.
10. Under certain conditions, 3, 4- and 5-spray schedules are recommended. Occasionally a sixth application may be profitable.
11. The calyx application is considered essential.
12. The fruit grower can establish spray dates fairly accurately by making certain simple studies of the insect.
13. Unsprayed trees showed 12.14 percent more wormy apples above 12 feet than below.
14. Where the 4-spray schedule was used as a calyx application with one cover spray on first brood and two on second, better results were obtained than where used as calyx application with two cover sprays on first brood and one on second.
15. Five-spray schedule gave better results than either of the 4-spray schedules.
16. The results from the use of a soap as a spreader did not justify the expense.
17. Less efficiency in controlling the worms was obtained in parts of the tree above 12 feet than in the lower parts.

18. The codling moth can be controlled with less difficulty on the Winesap apple than on Ben Davis and Rome Beauty.

19. The wormy fruit on one block of the Winesap was reduced to .12 of one percent.

20. In a well sprayed orchard, the greatest commercial loss is caused by "stings."

21. Very few stings are found on unsprayed fruit. A large percentage of the stings are caused by the small larvae eating enough of the fruit to make a blemish before they are killed by the poison.

22. Trees in any orchard may vary a great deal in codling moth infestation. A limited number of "count" trees may not show the true codling moth infestation.

23. A comparison of wormy or free apples may not be an accurate basis for judging the value of a spray schedule or practice.

24. A comparison of the live larvae on a tree or block with the number of larvae killed, as indicated by the stings on the same tree or block may be a fair way of rating the value of the spraying practice.

COLORADO AGRICULTURAL COLLEGE
SERVICE
EDUCATION
EXTENSION
RESEARCH
1879