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APPLE INSECTS IN THE HUDSON VALLEY AND THE LAKE CHAMPLAIN FRUIT DISTRICTS

PAUL J. CHAPMAN AND OSCAR H. HAMMER

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FIG. 1.—Graphic Summary of Periods in the Development of Codling Moth, Plum Curculio, Apple Maggot, and White Apple Leafhopper When They Were Susceptible to Treatment by Insecticides in the Hudson Valley During 1931. Periods Considered Critical for the Application of Sprays and Dusts Are Also Indicated.

Under "Pests Controlled" the insect listed first is the one for which treatment is primarily timed. The solid bars given under "Spray Periods" indicate the regular spraying schedule under average conditions and those cross-lined are optional sprays. The numbers refer to the following: No. 1, "Calyx Spray," applied directly after blossoming, since poison placed in the open calyx cups at this time prevents codling moth blossom-end injury later. No. 2, "Curculio Spray," important for control of the Curculio. Also, timely for treatment of leafhopper in 1931. No. 2 A, "Special Curculio Spray." No. 3, "Codling Moth Spray." Timed for beginning of hatching period of codling moth caterpillars. No. 4, "First Maggot Spray," equally important for control of apple maggot and codling moth. No. 5, "Second Maggot Spray," applied at peak of apple maggot fly emergence. No. 6, "Second Brood Codling Moth Spray." No. 7, "Second Brood Leafhopper Spray."
APPLE INSECTS IN THE HUDSON VALLEY AND 
THE LAKE CHAMPLAIN FRUIT DISTRICTS

PAUL J. CHAPMAN and OSCAR H. HAMMER

ABSTRACT

In an investigation of apple insect problems of the Hudson Valley 
and Lake Champlain fruit districts special attention has been given to 
the apple maggot, the plum curculio, the codling moth, the apple 
curculio, and the white apple leafhopper.

As a basis for the development of a schedule of spraying adapted 
to these regions, specific studies have been made to determine the 
period or periods in the life cycle of the several species when they are 
most susceptible to treatment.

INTRODUCTION

Differences in climate, topography, soil types, and distance from 
markets have given individual character to fruit production in 
western New York, in the Hudson River Valley, and in a district 
bordering Lake Champlain. No less distinctive are the pest problems 
of these areas. While most of the apple insects are distributed thru-
out the State, their relative importance varies widely. For example, 
the plum curculio ranks as the most destructive species in many 
Hudson Valley apple orchards, whereas in the western part of the 
State it is usually of minor importance. On the other hand, losses 
from codling moth have been much more severe in the Lake Ontario 
fruit belt than elsewhere in the State. Equally important from the 
standpoint of developing a schedule of treatments for all of the 
destructive species is the need for an understanding of the small 
differences in behavior and time of appearance of the pests such as are 
brought about by climatic or other regional influences. Until re-

1In carrying forward the experimental program in the Champlain Valley the 
writers are very much indebted to Dr. A. B. Burrell of the Department of Plant 
Pathology at Cornell University who is in charge of a field laboratory at Peru, 
N. Y. Grateful acknowledgment is likewise expressed herewith to the many 
fruit growers thruout eastern New York who have cooperated in this program.

2Since 1930 the junior author has served as a special field assistant on the apple 
maggot and curculio projects in the Champlain Valley.
ently it has not been possible to give full consideration to apple insect problems of the Hudson Valley and Lake Champlain fruit districts. In this bulletin an introduction to this subject is presented.

A SCHEDULE OF SPRAYING FOR EASTERN NEW YORK

Efficient control of orchard pests by spraying or dusting is gained thru thoro, timely treatments applied during certain critical periods in the development of these insects. From a practical consideration, however, no more sprays should be used than are necessary to give a reasonable degree of protection. Whenever possible, therefore, it is desirable to direct each treatment against more than one pest. The critical developmental periods differ with each species, and seldom are those for any two even roughly parallel. In selecting a time for making a particular treatment, the custom has been to apply it when maximum protection is afforded against the major of the various species which are vulnerable during a given period. The principal weakness of this plan is that undue losses may result from pests which were thought to perform a minor rôle and for which treatments were not accurately timed. Unusually favorable weather conditions may enable a species to increase its numbers to an abnormal degree over a large area. In many instances, however, failures are due to lack of information of pest conditions in the individual orchard. Considerable variation may exist in insect infestation from one orchard to another, clearly pointing to the desirability of a grower acquainting himself with actual conditions in his own orchard. Only in this way may one intelligently select the spray mixtures and schedule of treatments which will give adequate protection at the lowest cost.

Fig. 1 is a diagrammatic presentation of facts upon which spray schedules after blossoming were developed in the Hudson Valley in 1931. The vulnerable periods in the life activities of four major species of apple insects are given and are correlated with periods considered critical from the standpoint of carrying out spraying operations. These spray periods correspond closely with advice sent to fruit growers in 1931 thru the Spray Information Service of the local Farm Bureaus. Close cooperation is maintained with this organization at all times. It should be pointed out that dates of treatments for one season are an unreliable guide for timing of treatments for another year due to seasonal influences. The suggestions given in Fig. 1, therefore, should be interpreted in a relative manner only. For example, if calculations are founded on the blossom period as a base
line, these data may be of more specific value in determining dates for treatments in future years.

Recent observations of the four species included in Fig. 1 and of the apple curculio are given in the pages which follow. As stated earlier, these constitute only an introduction. It is planned to present other reports of experimental work on apple insects in eastern New York as these studies proceed.

CURCULIOS ATTACKING APPLES

Two species of curculios are pests of apples in eastern New York, viz., the plum curculio (Conotrachelus nenuphar Herbst) and the apple curculio (Tachyterellus quadrigibbus Say). With the exception of a few plantings in the Lake Champlain Valley, where the apple curculio suddenly appeared in 1930, the plum curculio is the species to which fruit growers refer when they speak of "the curculio." Fig. 2 illustrates the general appearance of the two species.

The plum curculio is considered the most serious insect problem in many Hudson Valley apple orchards. It is generally much less severe in the Champlain Valley. Considering the nature of damage inflicted and difficulties encountered in its control, the apple curculio is a much more serious pest in orchards where it occurs than the plum curculio.

THE PLUM CURCULIO

As its common name implies, the plum curculio was at first considered a pest primarily of plums; and while it remains the most important insect pest of plums in this State, the curculio has for many years been identified as a major enemy of peach, cherry, and apple. The insect is able to complete its development in all of these fruits. Some fruit growers have erroneously assumed that the pest is dependent on plums or peaches for a continuation of its attack on apples. While it is true that the presence of these fruits in or adjoining an apple orchard may complicate the problem of control, the plum curculio breeds and multiplies in apples as well as in the other fruits.

The adult beetle (Fig. 2) overwinters in whatever shelter is available on the ground in and bordering apple orchards. At about blossom time the curculios begin to forsake their winter quarters and appear on the trees. The majority, however, are not present until directly after the blossom period (Fig. 4). The beetles feed slightly on the blossoms, and feeding and egg-laying may start on the tiny fruits
Fig. 2.—Curculios Injurious to Apples.

1, the plum curculio; 2, the apple curculio. (Enlarged about 9 times.)
even before the calyces are closed. Fruits about \( \frac{3}{4} \) inch in diameter and slightly larger, however, appear to be most attractive to the laying insects. The injury produced in egg-laying consists of a crescent shaped cut made thru the skin of the fruit by the snout of the beetle (Fig. 3, No. 1). Just ahead of this flap the egg is laid. Feeding injuries are also made by the snout which is inserted thru the skin and into the flesh. Mandibles located at the end of this snout enable the insect to feed to the full extension of this structure.

![Fig. 3.—Injury Produced by the Plum Curculio.](image)

1. newly made egg-laying marks on young Baldwin apple. 2. egg-laying and feeding scars on mature Rhode Island Greening apple. The D-shaped scars are expanded egg-laying injuries and the smaller ones are healed feeding punctures.

The reaction of individual fruits to injury varies. Some drop to the ground while still small; others mature, altho they are scarred and misshapen. Important factors influencing these reactions are the size of fruit and severity of attack at the time of injury, the variety of apple, and varietal and seasonal conditions governing the "June drop." Characteristic scars on mature fruit are illustrated in Fig. 3. Oftentimes, badly infested apples become knotty and badly formed.

Rarely, and then only in an occasional early ripening variety, is the curculio able to complete its development in apples which reach maturity. The scarred fruits observed at harvest are those which have successfully prevented the hatching of eggs or the establishment of the young curculio grubs. Pressure of growing tissue or continued hardness of the flesh are said to bring about these results. Curculio larvae are able to complete growth in the small apples which drop
during June and July. Development is most often successful in fruits ranging from about 3/8 to 1 inch in diameter. Upon completion of growth, the larvae leave the fruit, enter the soil, and pupate. New generation beetles emerge from the soil mostly during August, after which time they will be found on apple trees for a short period, feeding on the ripening fruit. With the advent of cooler weather these new curculios gradually leave the trees and seek shelter for the winter.

**CONTROL MEASURES**

Dependence for control of the plum curculio has been placed largely on the use of arsenical sprays and dusts. Since the beetles which appear in the spring originated the previous season in the mid-summer drops, the systematic picking up and destruction of these small apples offers, theoretically at least, another means of control. In eastern New York this method has apparently not met with approval since it is little practised. The indirect value of the method and the large amount of hand labor required are probably responsible for its unpopularity.

The objective in using arsenical sprays or dusts in curculio control is to keep the fruit covered with poison during the period in which it is attractive to the curculios for egg-laying and feeding. Starting with the end of blossoming, this critical period continues for about 3 weeks or longer. If possible, it is desirable to have a fresh covering of poison on the fruit just before the principal migrations of curculios to the trees.

In Fig. 4 is given the actual population of curculios in a young unsprayed Baldwin orchard in 1931. It will be noticed that beetles were present well into July and that some of the old curculios were still alive when the new generation began appearing in August. Movement of the insects to apple trees in 1931 apparently came in three “waves”, according to records given in Fig. 4, and from records of three other plantings not given here. The first wave was a small one occurring when the trees were in full bloom, the second one came about 10 days later, and the main migration occurred after another 10 days. The temperature record in Fig. 4 illustrates the influence of warm and cool weather on the rate of their arrival.

The plum curculio is a difficult pest to control even by accepted spraying schedules. Success is largely in proportion to the thoroness and timeliness with which treatments are made. In badly infested
orchards a considerable number of fruits may bear curculio scars at harvest in spite of the best system of treatment. Orchard experiments in 1931 indicated that it was possible to reduce the number of curculio marks about 90 per cent by careful spraying with standard spray mixtures. These studies appeared to show that control efficiency was similar whether the infestation was light or heavy, the difference being, in the distribution of marks over a greater number

![Graph of Plum Curculio Jarring Records](image)

**Fig. 4.**--Graphic Summary of Plum Curculio Jarring Records on 38 Young Baldwin Trees at Poughkeepsie, N. Y., in 1931.

The curculios were dislodged by striking a padded pole held in contact with the tree. The insects were retained by a canvas placed on the ground under the tree, were counted, and then were immediately released.

of apples in bad infestations. The benefits derived from lowering the level of infestation by careful treatment each year should be emphasized.

While arsenate of lead may eventually poison the curculios, some injuries are produced before death occurs. One fact brought out in population studies, which may help to visualize just what spraying attempts to accomplish, is the small number of individual curculios per tree and the astonishing amount of damage this number can bring about. In Table 1 is a record of the total crop, including early drops, late drops, and picked fruit, of two Baldwin trees from the plat on which records are given in Fig. 4. Only injuries produced by the overwintered beetles are given.
Table 1.—Plum Curculio Population and Injury Study in 1931.

<table>
<thead>
<tr>
<th>Tree No.</th>
<th>Total No. of Fruits</th>
<th>Total No. of Fruits Marked</th>
<th>Total No. of Marks</th>
<th>Number of curculios present as determined by jarring the trees*</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1,650</td>
<td>1,635</td>
<td>6,184</td>
<td>May: 23 28 5 13 23 7</td>
</tr>
<tr>
<td>2</td>
<td>744</td>
<td>736</td>
<td>2,561</td>
<td>June: 8 46 25 24 25 10</td>
</tr>
<tr>
<td></td>
<td>28 27</td>
<td>18 11</td>
<td></td>
<td>July: 11 8</td>
</tr>
</tbody>
</table>

*After the curculios were jarred from the tree they were counted and immediately released so there was little interruption in their activity.

Timing of treatments.—A spray applied about a week to 10 days after the calyx spray was the most important single treatment for curculio control in 1931. Investigations in Connecticut and Massachusetts bear out the belief that this period immediately following blossoming is especially critical every year. The calyx spray may afford varying degrees of protection, but the newly forming fruit grows so rapidly that it often lacks a coating of poison in a few days' time. It has therefore appeared necessary in some seasons to apply the treatment following the calyx spray at as short an interval as 5 to 7 days. Weather conditions often have an important bearing on determining the time for curculio treatments since they affect both the activity of the curculios and the rate of growth of the fruit. In general, continued warm weather should be interpreted as a signal to shorten the interval between sprays. Continued cold weather directly after the calyx spray usually means that important curculio attack will be delayed until the next series of warm days. Likewise, subnormal temperature over a long period may extend the duration of curculio feeding and egg laying.

Spray mixtures and spraying experiments.—Many suggestions have been advanced concerning spray mixtures for control of the plum curculio. Within recent years most of these have consisted of substances intended to fortify standard spray mixtures. Those which have been most persistently suggested include the following:

1. Addition of large quantities of lime to the standard spray mixtures, presumably to act as a "repellent".
2. Addition of more poison.
3. Addition of such stickers as fish oil or linseed oil.

In 1931 experiments were carried out in five orchards for the purpose of testing the merits of these substances against standard sprays. Answers were sought to such practical questions as: Will the addition
of these substances decrease the amount of insect scarred fruit? Will such products extend the number of days the spray gives protection? (The thought here was that if the interval between sprays could be lengthened it might cause two special sprays to accomplish results the equal of three treatments of the ordinary formula.) If such materials are found effective, when may they be added to greatest advantage?

Materials tested in 1931 included the standard formula of lime-sulfur $2\frac{1}{2}$ gallons, arsenate of lead 3 pounds, and water to make 100 gallons. To this, for certain plats, was added hydrated lime at the rate of 40 pounds to each 100 gallons of spray. In other plats the only change in the standard mixture was the increase of arsenate of lead to 6 pounds, while in still others 1 pint of fish oil was added. Plats were also treated with a mixture containing a combination of all materials i.e. lime-sulfur $2\frac{1}{2}$ gallons, arsenate of lead 6 pounds, fish oil 1 pint, hydrated lime 40 pounds, and water to make 100 gallons. These special materials were added to the calyx spray and an application made 10 days later. Dates of treatments having a possible bearing on curculio control in the 1931 experiments were as follows: Fink or pre-blossom spray, May 4 to 5; calyx spray, May 17 to 19; curculio spray, May 27 to 29; and first codling moth cover spray, June 11 to 15.

The results of two plum curculio spraying tests are given in Table 2. At E. C. Brown’s at Red Hook, a young McIntosh orchard was used. Growers frequently complain of difficulties in controlling the curculio in orchards which are just coming into bearing. The block of trees used on the farm of C. C. DuMond at Ulster Park included Baldwin, Cortland, and Wagener varieties. For reasons mentioned below, the data from all of the sprayed plats are combined.

All schedules of spraying in the 1931 experiments gave good commercial control. Of special interest, however, was the small difference in efficiency between treatments. In these tests, plats treated with the standard formula of lime-sulfur $2\frac{1}{2}$ gallons, arsenate of lead 3 pounds, and water 100 gallons were essentially the equal of plats receiving special formulae. While it is true, in general, that slightly smaller numbers of scarred fruit resulted from the addition of special products to the standard mixture, the differences could hardly be considered significant.

Summary of control measures.—In 1931, the following spray schedule appeared to give commercial control of plum curculio in most
orchards: The calyx spray, a treatment 7 to 10 days after the calyx spray, and the first codling moth cover spray. Following such a schedule in experimental orchards reduced curculio marks about 90 per cent when compared with unsprayed trees. A spray applied between the curculio spray and the first codling moth treatment (spray period No. 2A, Fig. 1) may have been desirable in heavily infested plantings, or might be in other seasons when cool weather or other conditions delay or interrupt curculio activity.

Table 2.—Summary of Two Plum Curculio Spraying Experiments in 1931.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>No. of trees examined</th>
<th>Total no. of fruits</th>
<th>Total no. of fruits with insect scars</th>
<th>Percent-age infested</th>
<th>Total no. of insect scars</th>
<th>Percent-age efficiency of sprays based on total marks and total fruits</th>
</tr>
</thead>
<tbody>
<tr>
<td>All</td>
<td>99</td>
<td>15,386</td>
<td>991</td>
<td>6.4</td>
<td>1,887</td>
<td>93.8</td>
</tr>
<tr>
<td>sprays</td>
<td>4</td>
<td>743</td>
<td>386</td>
<td>51.9</td>
<td>1,482</td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>99</td>
<td>15,386</td>
<td>991</td>
<td>6.4</td>
<td>1,887</td>
<td>93.8</td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

Orchard of C. C. DuMond, Ulster Park

| All       | 63                    | 36,470              | 3,701                                | 10.1                 | 6,976                    | 91.5                                                                |
| sprays    | 5                     | 4,415               | 3,229                                | 73.1                 | 11,245                    |                                                                     |
| None      | 63                    | 36,470              | 3,701                                | 10.1                 | 6,976                    | 91.5                                                                |
|           |                       |                     |                                      |                      |                          |                                                                     |

Thoro and timely treatments are vitally necessary in combating the curculio. Failures in control appear to be caused almost exclusively by failure of the grower to carry out one or both of these essentials. More curculio losses are due to poor spraying methods than is usually suspected. For proper protection it is necessary to cover the young fruits completely, and to do this effectively a tree should be sprayed “inside as well as out.” Pains should be taken especially to direct the spray up thru the centers of the trees. In some orchards thick growth in the center of the tree makes it difficult to drive spray into the fruits located there. Where it is consistent with good pruning practices, much of this growth could be removed to advantage.

In selecting a spray formula, recent experiments mentioned earlier indicate that arsenate of lead used at the rate of 3 pounds to 100 gallons of spray, when thoroly applied, gave what may be considered
good commercial control. In cases of severe infestations the efficiency of sprays intended primarily for curculio control, as for example the "7 to 10 day spray" (spray period No. 2 Fig. 1), is possibly increased somewhat by adding one or more of the following to each 100 gallons of standard spray mixtures: Hydrated lime, 30 to 40 pounds, fish oil or linseed oil, 1 pint, or double the quantity of arsenate of lead. Where these products were tested in 1931 there was little conclusive evidence to warrant their recommendation. Thoro coverage appeared to be of much greater importance than the spray mixture.

THE APPLE CURCULIO

Prior to 1930 the apple curculio was virtually unknown as a pest of apples in this State. It is a native species and its normal host plants are apparently the wild crab apples and the wild haws or thorn apples. At the present time the apple curculio may be found infesting the fruits of thorn apple trees in various parts of the State.

Suddenly in 1930, attention was drawn to severe damage to apples in several orchards in the Champlain Valley. Conditions bringing about this outbreak are unknown, altho undoubtedly the numbers of the pest had been building up in these plantings for several years. Dr. A. B. Burrell first saw a few apple curculio marked apples as early as 1927 in an orchard which sustained serious losses in 1931. What position this insect will take among apple pests in the State cannot be predicted. At present infested orchards are not known to lie outside Clinton, Essex, and Washington Counties.

LIFE HISTORY AND CHARACTER OF INJURY

What has already been written about the life cycle and habits of the plum curculio applies in a general way to the apple curculio. The beetle (Fig. 2) is the stage which survives the winter. These adults appear on the trees during and directly after the blossom period. Unlike the plum curculio, the grubs of the apple curculio when full grown do not desert the dropped fruit. Instead, transformation from grub to the pupa and finally to the new beetle takes place in a cavity hollowed out in the apple. New generation beetles emerged from the midsummer drops from July 16 to August 24 at Crown Point, N. Y., in 1931, which was about 2 weeks earlier than the emergence period of plum curculio in the Hudson Valley. Fall feeding by new generation apple curculio beetles was more serious and extensive in 1930 than plum curculio fall feeding in equally heavily infested orchards.
Injuries produced by the apple curculio are similar to those caused by apple red bugs. Superficially, there is little difference in appearance between egg laying punctures and spring feeding marks. The female beetle seals the egg cavity with excrement and this small plug of blackish substance usually persists until harvest. Fruits which survive attack are characteristically marked by the deep, narrow pits illustrated in Fig. 3, No. 1. Fall feeding is illustrated in Fig. 3, No. 2 and Fig. 6. Large blackened areas like these are produced by the beetles puncturing the skin and eating away all the flesh beneath which is in range of the mandibles at the tip of the snout. New punctures and excavations are produced within the immediate vicinity, thus causing a considerable area of the skin to be undermined, with the result as illustrated.

**CONTROL MEASURES**

A review of the literature on control of the apple curculio reveals that arsenical sprays and dusts have apparently not been found effective. In Iowa,\(^3\) where the more recent work has been done, it

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was concluded that destruction of the small apples which drop in midsummer offers the most practicable means of control. The introduction of hogs into infested orchards is recommended as a cheap and efficient means of destroying these small apples as they drop.

In experimental work started in eastern New York in 1931 consideration was given to several types of control measures. Of these, attention was directed to the possibilities of finding an effective spray formula for the pest. Spraying tests reported in the literature have not been extensive, and much of the belief that spraying is ineffective apparently arises from experiments performed before the advent of modern spraying methods and equipment.

A small-scale spraying experiment was conducted at Willsboro, N. Y., in 1931 and the results are given in Table 3. While this test illustrates that a measurable degree of control was afforded by certain spray formulae, it was also made clear that the apple curculio undoubtedly presents serious difficulties to the development of a satisfactory control program by customary spraying practices. Attention is called to the low efficiency of the standard spray formula. Also, it should be pointed out that all treatments used in this test were more thoroughly applied than would be customary under average commercial conditions. On the other hand, these results do give some hope that a spray schedule may be developed, and efforts in this direction will be continued.

Fruit growers who wish to experiment at the present time with spraying against apple curculio will find suggestions as to spray mixtures in the report of the Willsboro experiment. A word of caution should be given about using fish oil. Its use in more than one treatment is not advisable at present because of danger of injury to the fruit or foliage. The effectiveness of destroying the midsummer drops as a control measure thru the use of hogs or accomplishing the same result by hand picking has not as yet been given thorough trial in this State. One fruit grower in 1931 picked up most of these small apples under a block of trees where damage had been severe. It is too early to foresee what effect this has had on the size of the 1932 infestation, altho the amount of fall feeding was small and much less than would be expected on the basis of injury produced in the spring, indicating a considerable decrease in the infestation. In carrying out hand-picking operations one should keep in mind that beetles start leaving the dropped fruit in July (about the middle of July in
### Table 3.—Apple Curculio Spraying Experiment, Willsboro, N. Y., 1931.*

<table>
<thead>
<tr>
<th>Plat No.</th>
<th>Spray formula (water added in each case to make 100 gals.)</th>
<th>No. of beetles jarred from one tree, May 28–June 25†</th>
<th>Variety</th>
<th>Total No. fruits on each tree</th>
<th>Fruit injured by over-wintered beetles</th>
<th>Number</th>
<th>Per cent</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Lead arsenate, 3 lbs. Lime-sulfur, 2½ gals. Fish oil, 1 qt.</td>
<td>35</td>
<td>Wagener Winter Banana</td>
<td>405</td>
<td>38</td>
<td>9.4</td>
<td></td>
</tr>
<tr>
<td>II</td>
<td>Lead arsenate, 3 lbs. Lime-sulfur, 2½ gals.</td>
<td>117</td>
<td>Wagener Winter Banana</td>
<td>681</td>
<td>111</td>
<td>16.3</td>
<td></td>
</tr>
<tr>
<td>III</td>
<td>Lead arsenate, 6 lbs. Lime-sulfur, 2½ gals.</td>
<td>39</td>
<td>Wagener Winter Banana</td>
<td>554</td>
<td>55</td>
<td>9.9</td>
<td></td>
</tr>
<tr>
<td>IV</td>
<td>Lead arsenate, 6 lbs. Lime-sulfur, 2½ gals. Hydrated lime, 25 lbs. Fish oil, 1 qt.</td>
<td>8</td>
<td>Wagener Winter Banana</td>
<td>524</td>
<td>9</td>
<td>1.7</td>
<td></td>
</tr>
<tr>
<td>V</td>
<td>Lead arsenate, 3 lbs. Lime-sulfur, 2½ gals. Hydrated lime, 25 lbs.</td>
<td>37</td>
<td>Wagener Winter Banana</td>
<td>624</td>
<td>98</td>
<td>15.7</td>
<td></td>
</tr>
<tr>
<td>VI</td>
<td>Complete check, no spray</td>
<td>98</td>
<td>Wagener Winter Banana</td>
<td>843</td>
<td>145</td>
<td>17.2</td>
<td></td>
</tr>
</tbody>
</table>

*All plats sprayed May 9, May 25, June 1, and June 11.

†After being jarred from the trees to a piece of canvas placed on the ground the beetles were counted and released on the same tree from which they were dislodged.
1931 at Crown Point), and therefore, disposal of these fruits prior to this time and later would appear a necessary part of the plan.

Some fruits bearing apple curculio grubs stop growth but fail to drop, and in this way appreciable numbers may escape destruction in efforts to gain control by picking up the midsummer drops. In 1931 a number of such apples were seen on Tolman Sweet and Northern Spy trees. An example of this is shown in Fig. 6.

THE CODLING MOTH

Eastern New York, in common with other fruit areas of the United States, has its problem with wormy and stung fruit. Orchards in the Champlain Valley probably suffer the smallest losses from codling moth of any fruit district in the State. On the other hand, the pest has been much more serious in orchards bordering Lake Ontario in western New York than in the average Hudson Valley planting.

![Graph of codling moth emergence in 1931](image)

**Fig. 7.—Codling Moth Emergence in 1931.**
Bi-daily records given. In the Hudson Valley the record is based on emergence of moths in cages supplemented by bait pail data; in the Champlain Valley bait pail records are given.

Studies in 1931 were concerned principally with the life history of the species under eastern New York conditions. Fig. 7 gives a record of moth emergence last year in the two districts. This record, by the way, differs only very slightly from similar records taken in western New York by S. W. Harman of this Station. It will be noted here, as in the case of the apple maggot, that codling moth emergence in the Champlain Valley lagged about a week behind that of the Hudson Valley. Unfortunately, it was not possible to obtain the record on the second brood moths in northern New York.
Details of the life history and control of the codling moth will not be given here since these points are already known to many fruit growers or are readily available elsewhere. It is probably sufficient to say that the object in spraying is to keep the fruit and foliage covered with poison during the time codling moth eggs are hatching and the worms are attempting to enter the fruit. In Fig. 1 will be found a record of this hatching period in 1931, differing from the moth emergence record in Fig. 7 because of corrections made for time of egg laying and the incubation period of eggs.

Since the adoption of modern methods of pest control, excessive losses from codling moth have not been generally experienced in the Hudson Valley prior to 1930. In many plantings, especially in the lower half of this region, injury has been very light. However, the seasons of 1930 and 1931 have witnessed an increase in wormy and stung fruits in all orchards. Scattered plantings throughout the area have even suffered heavy losses during these two years.

The long growing seasons and unusually warm weather in 1929, 1930, and 1931 have probably been responsible for most of the present prominence of the codling moth. These seasonal conditions have influenced the pest in two important ways. First, they have brought about an increase in the size of the second brood. During these 3 years half of the worms originating from the first brood moths gave rise to a second brood. Records taken in western New York indicate that the cooler weather of an average season normally prevents a much higher percentage of worms transforming to moths for a second brood. Second, the consecutive occurrence of seasons favorable to the pest has resulted in a gradual increase in the infestation level during these 3 years.

Fruit growers in all parts of the State should give careful consideration to the codling moth problem in their individual orchards. Where the insect is well established special efforts should be made to apply codling moth sprays at the proper times and with great thoroughness. One should not be concerned too much with immediate results. Some “stung” fruit inevitably follows bad infestations in spite of the best schedule of spraying. Most stings mark the amount of feeding done by the young caterpillar before death results from the poison. The more worms killed in this way the fewer there will be that mature to produce a second brood in August or, that carry over winter to start trouble next season. Special efforts should be made in this present situation to reduce the winter carry over and thus offset
the recent climatic conditions which have favored an abnormal rate of multiplication. Keeping the pest at a low level by judicious spraying is a much simpler plan than attempting to lower a bad infestation that is allowed to become established.

THE APPLE MAGGOT

The action of Great Britain in 1930 of excluding apples found infested with the apple maggot (*Rhagoletis pomonella* Walsh) has drawn an unusual amount of attention to this pest. Apples intended for the export trade must now pass an inspection certifying *absolute freedom* from apple maggot. This situation has necessarily constituted a disturbing influence in the various fruit areas in northeastern United States and the adjoining provinces in Canada where the pest is established.

For New York it has jeopardized a market which for years has served as an outlet for a considerable portion of the State's crop. Fruit growers wishing to continue selling fruit abroad have naturally sought means to meet the requirements on apple maggot. The large-scale series of experiments now in progress on this pest were started largely in response to this evident need for exact information on control measures. Aside from its bearing on the export trade, losses from apple maggot in the average Hudson Valley orchard have been only moderate. It is more generally serious, however, in the Champlain Valley and, while commercial orchards in western New York have rarely been infested in past years, light infestations were found in the 1930 and 1931 crops.

Fruit growers in this State were apparently obtaining commercial control of the apple maggot from the use of arsenical sprays and dusts prior to 1930. Some growers, however, have reported complete failure from spraying programs. It must be admitted that evidence upon which this method was based has been none too definite, while on the other hand, there is some experimental data from other states to indicate that arsenical treatments afford little or no control under their conditions. Major attention in 1930 and 1931 has been given to testing the efficiency of arsenical sprays and dusts against apple maggot under a wide range of conditions.

LIFE CYCLE

The adult stage of the apple maggot is a prettily marked fly with wings and body banded with black and white (Fig. 8). Eggs are
inserted into the flesh of apples by means of a slender, sharp-pointed ovipositor borne at the tip of the abdomen. The minute punctures made in the skin by the ovipositor often constitutes the only external evidence that an apple is infested. Immediately upon hatching the maggot starts burrowing, constructing a meandering trail thru the flesh. Most of the maggots die in hard winter varieties, but not before short tunnels are produced. Thin corky brown or tan streaks in the flesh of mature apples are characteristic of attack in these late sorts. In general, earlier ripening varieties offer much more satisfactory conditions for the establishment of young larvae (Fig. 9).

The maggots are able to complete growth in fruits which drop and are allowed to rot on the ground. The presence of the pest apparently causes apples to ripen earlier than normally since an excessive drop of fruits before the usual picking period is characteristic of infested plantings. After completing its growth the maggot leaves the apple, enters the soil 1/2 inch or more, and changes to a pupa. The pupal stage resembles a plump grain of wheat in size, color, and general appearance. The insect remains in this stage thruout the winter and spring, when most of the pupae give rise to flies and thus complete the life cycle. It is a curious fact, however, that some of the pupae do not transform to flies until the second or even third season after pupation.
New flies issue from the ground over a period of about 2 months in midsummer. In using arsenical sprays or dusts as a control measure the object is to maintain an adequate covering of poison on the trees while the flies are present. Thru the use of cheesecloth covered cages it has been possible to trap the flies as they emerge from the soil and thus learn the duration of the emergence period. Eighty-six of these cages were placed in orchards in various parts of eastern New York in 1930 and examined daily or nearly so. In 1931, 108 cages were employed for this purpose. The daily yield of new flies from cages under natural orchard conditions is given in Fig. 10. It will be noticed that emergence in the Champlain Valley proceeded on a schedule about one week behind that of the Hudson Valley during both seasons, indicating that such a difference is more or less normal.

After emerging from the earth the new flies do not lay eggs until about a week to 10 days have elapsed, altho during this period they feed freely on such food and moisture as can be found on the surface of the leaves and fruit. Spray materials are apparently mistaken for food or are accidentally ingested along with the food.

**SPRAYING EXPERIMENTS**

Judged by standards of control for other orchard pests, recent experiments indicate that it is possible to obtain a high degree of control of the apple maggot thru treatments with arsenate of lead. These conclusions are based on experience gained in spraying or dusting 12 badly infested orchards in 1930 and 10 in 1931, and from records taken in 130 grower-treated plantings.

An explanation should be given of the method followed in conducting orchard experiments reported here, since the rather indefinite status of knowledge on control measures arises largely from the difficulties an investigator encounters in performing satisfactory orchard tests. In the case of codling moth, plum curculio, or apple scab it is possible to leave untreated trees in the experimental block to serve as a more or less accurate measure of the efficiency of various treatments. When this plan is used with apple maggot one may be confronted with records showing little difference in infestation between sprayed and unsprayed trees. That fruit growers have also had this experience is evident in the frequent report of difficulty or failure to control the pest in that part of the commercial orchard adjoining an unsprayed planting. These observations apparently indicate that a fly which

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Fig. 10.—Diagrammatic Summary of Apple Maggot Fly Emergence in the Hudson Valley and Lake Champlain Fruit Districts.

In 1930, these records are based on 4,185 flies; in 1931, on 7,190 flies.
has reached maturity on an unsprayed tree is able to lay a number of eggs on the sprayed tree before the poison collected there has had a chance to take effect. In most of our tests, therefore, all trees in the orchard were treated as well as nearby neglected apple trees and even the brush rows bordering certain orchards. In so far as possible only those orchards have been used in tests where the rate of infestation the previous season was definitely determined. By comparing the infestation after a season’s spraying with that of the year before, a practical measure of efficiency is provided; and thru the use of a number of orchards the facts may finally, if laboriously, be found.

Standard orchard power spraying equipment was employed in all spraying experiments. The tree was the smallest unit used in taking records, and all of the crop was counted including dropped apples as well as those picked from the tree. All fruits bearing one or more egg punctures were considered infested. With a little practice it is possible to recognize these fruits rather readily, especially in later maturing varieties where these punctures lie in slight dimples (Fig. 11). The results from a few orchard experiments are given below.

**Orchards of O. K. Smith and J. Downs, Peru, N. Y.**—These two orchards are separated by a road and are very similar in most respects. The trees are about the same age, have varieties in common, and for many years, including 1929, apple maggot caused severe loss in both plantings. These orchards were selected to test the efficiency of two versus three treatments.

The spray mixture used in each orchard was essentially the same both years, as follows:
Arsenate of lead.................................. 2½ pounds
(3 pounds used in 1931)

Liquid lime-sulfur.................................. 2½ gallons
Water to make................................... 100 gallons

A record of the results of this experiment are given in Table 4.

**Table 4.—Results of Spraying for Apple Maggot in Two Orchards at Peru, N. Y., in 1930 and 1931**

<table>
<thead>
<tr>
<th>Year</th>
<th>Date of apple maggot sprays</th>
<th>Percentage of fruit infested</th>
<th>No. of trees examined*</th>
<th>Total No. of fruits examined</th>
</tr>
</thead>
<tbody>
<tr>
<td>1929</td>
<td></td>
<td>100.0†</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1930</td>
<td>July 3, July 21, Aug. 7</td>
<td>9.3</td>
<td>3</td>
<td>3,600</td>
</tr>
<tr>
<td>1931</td>
<td>July 1–2, July 15 and 17, July 29–30</td>
<td>1.2</td>
<td>2</td>
<td>2,833</td>
</tr>
</tbody>
</table>

**Smith Orchard**

<table>
<thead>
<tr>
<th>Year</th>
<th>Date of apple maggot sprays</th>
<th>Percentage of fruit infested</th>
<th>No. of trees examined*</th>
<th>Total No. of fruits examined</th>
</tr>
</thead>
<tbody>
<tr>
<td>1929</td>
<td></td>
<td>100.0†</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1930</td>
<td>July 5, July 22</td>
<td>29.9</td>
<td>2</td>
<td>2,248</td>
</tr>
<tr>
<td>1931</td>
<td>July 1, July 17</td>
<td>1.9</td>
<td>2</td>
<td>5,739</td>
</tr>
</tbody>
</table>

**Downs Orchard**

*All trees of the Fameuse variety.
†Dr. A. B. Burrell made a general inspection of these orchards in 1929 finding them essentially 100 per cent infested.

**Orchard of M. W. Innis, Orange Lake, N. Y.**—This is a small planting composed of tall, closely spaced trees of several varieties. This orchard was selected for experimentation to learn what could be done to control the maggot under conditions of extreme infestation and where, in addition, closely planted, high, dense trees favored the pest in making it difficult to do good spraying.

The spray formula used in 1931 was as follows:

Arsenate of lead.................................. 3 pounds
Kayso (Calcium caseinate).......................... ½ pound
Water to make................................... 100 gallons

The infestation given for 1930 is based on an actual examination of 84 Delicious apples. A general examination of 25 bushels of these Delicious apples made later indicated that the rate of infestation cited is conservative. The results of one season's spraying are given in Table 5. This represents an examination of 3,504 apples, or the total crop from two Delicious trees.
Table 5.—Apple Maggot Spraying Experiment in Orchard of M. W. Innis, Orange Lake, N. Y.

<table>
<thead>
<tr>
<th>Year</th>
<th>Dates of maggot sprays</th>
<th>Percentage of fruit infested</th>
<th>Average No. of egg punctures per infested fruit</th>
<th>Percentage infested fruit based on total egg punctures</th>
</tr>
</thead>
<tbody>
<tr>
<td>1930</td>
<td>None</td>
<td>100.0</td>
<td>13.34</td>
<td>1,334.0</td>
</tr>
<tr>
<td>1931</td>
<td>June 29</td>
<td>26.2</td>
<td>1.3*</td>
<td>34.0</td>
</tr>
<tr>
<td></td>
<td>July 17</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Aug. 6</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Approximate.

Orchard of Albert Taber, Milton, N. Y.—This 25-acre apple orchard was operated at a financial loss in 1929 and 1930 principally because of the abundance of apple maggot in the crops offered for sale. An indication of the infestation in 1930 is gained from small samples of fruit collected here for another purpose. In 157 Yellow Transparent fruit an average of 4.2 egg punctures per apple was found, 66 Alexander apples averaged 7.7 punctures each, 70 Northwestern Greening averaged 7 punctures, and several bushels of Jonathan averaged about 3 punctures per apple. Some sorting was necessary to get these samples, but it is probable that at least 80 per cent of the crop was infested. Large numbers of infested drops were allowed to rot in this orchard in 1930. The entire planting was sprayed twice in 1931, on July 1 to 2 and July 22 to 24, using arsenate of lead 3 pounds in combination with each 100 gallons of a sulfur fungicide. The results of this spraying experiment are given in Table 6.

Table 6.—Apple Maggot Spraying Experiment in Orchard of Albert Taber, Milton, N. Y.

<table>
<thead>
<tr>
<th>Year</th>
<th>No. of trees examined</th>
<th>Variety</th>
<th>No. of fruits examined</th>
<th>No. of fruits infested</th>
<th>Percentage of fruit infested</th>
<th>Average No. of egg punctures per infested apple</th>
</tr>
</thead>
<tbody>
<tr>
<td>1930</td>
<td>2</td>
<td>Wealthy</td>
<td>11,203</td>
<td>360</td>
<td>80.0*</td>
<td>3 or 4</td>
</tr>
<tr>
<td>1931</td>
<td>2</td>
<td>Jonathan</td>
<td>4,001</td>
<td>101</td>
<td>3.2</td>
<td>2.5</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>Alexander</td>
<td>971</td>
<td>55</td>
<td>5.6</td>
<td>5.6</td>
</tr>
<tr>
<td></td>
<td>Total, 1931</td>
<td></td>
<td>16,175</td>
<td>516</td>
<td>3.2</td>
<td>1+</td>
</tr>
</tbody>
</table>

*Estimated infestation based on observations given above.
Orchard of Charles Tabor, Milton, N. Y.—This orchard was included in the experimental plan for two reasons. first, to test the efficiency of a single treatment against a light infestation of apple maggot, and second, to use an orchard which is rather typical of some commercial orchards in the Hudson Valley with respect to apple maggot infestation. Many of the better plantings have a lower infestation or are essentially free. Results of this test are given in Table 7.

**Table 7.—Apple Maggot Spraying Experiment in Orchard of Charles Tabor, Milton, N. Y.**

<table>
<thead>
<tr>
<th>Year</th>
<th>Date of Apple maggot spray</th>
<th>No. of trees examined*</th>
<th>Total No. of fruits examined</th>
<th>Percentage of fruits injured</th>
</tr>
</thead>
<tbody>
<tr>
<td>1929</td>
<td>—</td>
<td>13</td>
<td>18,250</td>
<td>10.9†</td>
</tr>
<tr>
<td>1930</td>
<td>July 10</td>
<td>2</td>
<td>4,086</td>
<td>1.3</td>
</tr>
</tbody>
</table>

*All trees of the Jonathan variety.
†Orchard used by F. G. Mundinger and reported by him in *Jour. Econ. Ent.*, 23, 769. 1930.

DISCUSSION OF SPRAYING RESULTS

The experimental results given here have been selected to illustrate the action of arsenate of lead sprays under varied conditions—extreme conditions, as well as some which are more nearly normal. It will be noticed that the efficiency of the spray in producing maggot-free fruit varied with the orchard. In the case of the Innis orchard, for example, three careful sprayings resulted in only 74 per cent maggot-free apples, whereas one spraying was sufficient to produce 98 per cent clean fruit in the Charles Tabor experiment. The explanation appears to lie in the intensity of the original infestation. These tests indicate that orchards badly infested the year preceding the spraying test gave rise to so many flies that enough escaped poisoning a sufficient length of time to infest a considerable number of fruits. However, the cumulative benefits of treatment in these neglected plantings was illustrated in the Smith and Downs experiment and others that might be cited.

STERILIZATION OF PICKED FRUIT

It has been learned from experiments of the last two seasons that cold storage kills both eggs and larvae of the apple maggot. Complete killing is approached after a month's continuous storage at temperatures customarily maintained in commercial fruit storage houses, namely, at 32°F. The potential value of being able to kill all stages
of the pest in harvested fruit would be in its use to supplement spray- 
ing as a means of obtaining fruit 100 per cent free of the maggot which 
the export trade now requires. Investigations are still in progress in 
this field.

SUMMARY OF CONTROL MEASURES

In using arsenical sprays and dusts treatments should be timed 
with reference to the emergence period of flies. Effective dates for 
application are apt to vary from year to year even in the same locality. 
Flies arising from maggots which develop in early varieties, such as Red Astrachan and early sweet apples, may emerge some days earlier 
than flies coming from maggots maturing in later varieties. Partic- 
cular attention should be given to timely treatment of these early 
ripening varieties since they often serve as the principal infestation 
centers of the entire orchard.

All apple trees should be treated in orchards subject to apple 
maggot attack regardless of the amount of fruit borne. This also 
applies to other fruit trees interplanted with apples and to the 
occasional small shrubs or shade trees included in some orchards. 
Evidence indicates that trees bearing fruit have no special attraction 
to the flies until their eggs become mature. Flies may be found in any 
tree in the orchard during this pre-oviposition period. Trees in their 
off-bearing year should be especially mentioned in this connection 
since it is always a temptation to fruit growers to "spray only where 
the fruit is." More flies are almost certain to arise from the soil under 
such trees than from those with a heavy crop for the reason that the 
crop situation, and hence the number of maggoty apples allowed to rot 
on the ground, was probably just reversed the previous year. When 
flies come from the ground many will remain in the tree directly above 
them until eggs become ripe, unless poison is present to destroy them. 
Otherwise these insects may fly to the fruited trees and lay many eggs 
before the poison there takes effect.

Apply the apple maggot sprays to all neglected trees or orchards 
adjourning or within a short distance of the commercial orchard. In 
many cases it would simplify the problem to cut down such trees.

While a drenching type of spray application is apparently not 
needed for satisfactory results against a moderate infestation of apple 
maggot, care should be taken to give a good coverage to all trees. In 
cases of badly infested orchards the pest responds to only the most 
thoro schedule, as some of the foregoing experimental results illus- 
trate.
Equally satisfactory control appears to result from arsenate of lead used alone or in combination with lime-sulfur, dry mix, or other fungicides. Dosages greater than 2 or 3 pounds of the poison per 100 gallons of spray are apparently not needed if thorough coverage is obtained.

Picking up and destroying dropped apples, as in the case of the two curculio pests of apples, offers a means of reducing injury from apple maggot. The fruits which drop at or shortly prior to harvest contain the maggots which will give rise to the pest for another season. If such fruits can be systematically picked up and destroyed at weekly or shorter intervals it should obviously produce beneficial results.

Protection of a dozen or more trees in a village or in a home orchard where the planting is surrounded by buildings or shade trees sometimes offers a perplexing problem. If no other apple trees are nearer than 150 yards, picking up dropped fruits as prescribed above may prove helpful. A single handed effort at apple maggot control in a village either by spraying or picking up drops, is almost certain to result in failure where the pest is allowed to develop unchecked in neighboring yards. For the same reason commercial orchards adjoining villages may experience special difficulties in controlling this pest.

THE WHITE APPLE LEAFHOPPER

Attack by the common apple leafhoppers is characterized by whitened, devitalized leaves and excrement specking or streaking on fruit and leaves. Some growers also contend that fruit in badly infested orchards fails to color properly and is of inferior quality. The insects themselves appear in veritable swarms at certain times of the year and especially at harvest time, when they often cause considerable annoyance by flying into one's eyes, nose, or mouth. Infested leaves show at first a white specking on the upper surface, marking the points where the insects inserted their beaks in feeding. With continued feeding so much of the green matter may be removed that the entire leaf assumes a whitish or greyish cast (Fig. 12).

More than one species of leafhopper may attack apple trees. The one which has apparently been responsible for most of the trouble on mature trees within recent years in eastern New York is the so-called white apple leafhopper (Typhlocyba pomaria McAtee). It is two-

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Fig. 12.—The White Apple Leafhopper and the Injury it Produces.

1, nymphs and adults on lower surface of apple leaf; 2, excrement specking on Rhode Island Greening apple; 3, an uninjured leaf contrasted with 4, a badly infested one. The upper surfaces of the leaves are shown.
brooded and passes the winter in the egg stage in the bark of apple. Hatching of the first brood extends over a period of several weeks, starting shortly before the blossom period, and in 1931 it extended about a week after the application of the calyx spray. The newly hatched hopper nymph is a pale, whitish, wingless creature measuring about 1/25 inch in length. As the insect grows it molts its skin five times, reaching the winged or adult stage with the final molt. The winged hopper is uniformly creamy white and is about 1/8 inch long. While in the nymphal stages the insect remains almost exclusively on the undersides of the leaves. Seldom do individuals move from one leaf to another. Wings enable the adults to move about freely, altho when undisturbed they are usually found on the lower surface of leaves. Leaf injury is produced both by the nymph and adult.

Eggs for the second brood are laid in the leaf tissues. Second brood nymphs started to hatch about the middle of August in 1931, and reached a peak towards the end of the month. Very few new hoppers appeared after September 1 in the Hudson Valley. Adult hoppers were common after the middle of September, and during October the overwintering eggs were being laid in the bark. The insects seem to prefer the bark of wood ranging from 2 to 5 years of age for egg laying purposes, altho eggs are also found in the bark on the larger limbs and in the current season’s growth. Blister-like swellings in the bark readily call attention to the location of the eggs.

CONTROL MEASURES

No schedule of control has been recommended heretofore for the apple leafhopper. It has been known in a general way that the wingless hoppers are readily killed by nicotine sprays, altho this fact has not been utilized in the development of an accepted program of control. Probably an explanation of this situation arises from the uncertainty in the minds of the average grower as to how much damage the pest actually causes and whether the prevention of this loss would offset the cost of making the necessary treatments with nicotine products. An evaluation of damage done by the leafhoppers is not as easily made as in the case of the codling moth, curculio, or apple maggot where worm holes or other blemishes to the fruit have a direct bearing on the sales value of the crop. Fruit growers in increasing numbers have sensed, however, that the concentrated feeding of these myriads of insects must result in conditions distinctly deleterious to normal fruit production.
As mentioned earlier, there are two broods each season of the white apple leaf hopper. One might assume that thorough spraying against the first brood would so reduce their number that treatment for the second brood would become unnecessary. It is conceivable that this might occur in isolated plantings or in more intensive areas if all neighboring growers were equally careful in applying treatments for the pest. Observations made in various grower-treated orchards have shown that many hoppers apparently escape the usual type of spraying operation, and in addition reinfestations may occur from unsprayed trees in the grower's own orchard or from a neighbor. However that may be, it has been a fairly common experience under actual conditions to find a bad second brood infestation present when it was thought that the first brood had been well controlled. Many of the practical problems concerning the control of this pest are forced to await solution in future developments.

**TIMING OF TREATMENTS**

The proper time for directing treatments against the first brood of the leafhopper in Hudson Valley orchards in 1931 coincided with the special curculio spray applied 7 to 10 days after the calyx spray (spray period No. 2, Fig. 1). At this time all of the hoppers had hatched but most of them were still small and had caused but very little noticeable injury to the leaves. Nicotine products included earlier than this, in the calyx spray mixture for example, would doubtless have killed many hoppers but late-hatching individuals would have escaped. It is a curious fact, however, that nicotine added to the calyx spray was timely for the control of the leafhopper in western New York orchards in 1931. This is just another illustration of the influence of regional factors on the behavior of a pest.

Studies made last season indicated that the time to spray for control of the second brood of the hopper was about September 1, in the Hudson Valley. In an orchard test, using power spraying equipment, 99 per cent of the second brood was killed by a single nicotine-soap spray applied September 4.

The abundance of hoppers can easily be determined just before it becomes necessary to apply sprays for their control. A close examination of the undersides of leaves, especially of the older leaves, directly after blossoming and again after the middle of August should reveal the presence or absence of the tiny wingless nymphs. Where these
average four or five per leaf at the end of the hatching period, one may expect extensive feeding later by the older nymphs and adults.

SPRAY MIXTURES AND SPRAY METHODS

Several points should be considered by the grower in selecting a leafhopper spray formula. The nicotine may be included with arsene of lead and lime-sulfur; or, if directing treatment primarily against the leafhopper, soap and nicotine make a satisfactory formula. This second mixture would doubtless be preferred in control of the second brood because there would be little, if any, object of including a fungicide or stomach poison at this time of the year. Also, it would leave little residue on the fruit.

The following formula is suggested for leafhopper:

- Nicotine sulfate ........................................ ½ to ¾ pint
- Potash fish-oil soap ................................. 4 to 6 pounds
  (66 per cent water)
- Water to make ....................................... 100 gallons

If preferred, the soap may be omitted and the nicotine used in combination with the standard spray mixtures.

As pointed out earlier, the leafhopper nymphs are confined almost exclusively to the undersides of the leaves. This should be kept in mind in applying the spray. The centers of trees and lower limbs can hardly be treated properly with a spray gun unless this part of the spraying operation is done from the ground and the operator takes several positions near the trunk of the tree. Thoro coverage is naturally essential, since for all practical purposes, it is necessary to wet the hoppers with spray to kill them.