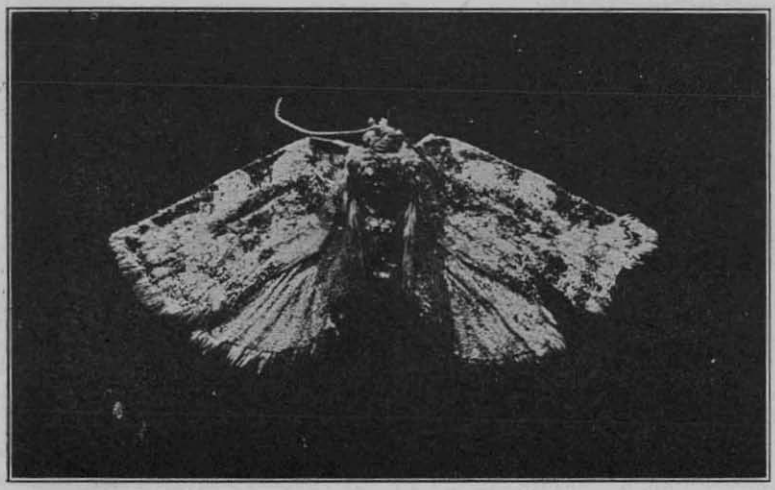
UNIVERSITY OF IDAHO
AGRICULTURAL EXPERIMENT STATION

Department of Horticulture

APPLE TREE LEAF ROLLER IN NORTHERN IDAHO

By

L. E. LONGLEY



The Adult Moth of Leaf Roller

Bulletin No. 157 **February, 1928**

Published by the University of Idaho, Moscow

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APPLE TREE LEAF ROLLER IN NORTHERN IDAHO

By L. E. LONGLEY

INTRODUCTION

Economic Importance

The fruit tree leaf roller first became a destructive pest in 1888 in New York, although it had been known in that state as early as 1874. From 1888 to 1892 the insect was somewhat troublesome, and then nothing more was heard of it till 1911, when a destructive period began.

In 1890 Gillette records it in the Fort Collins-Greeley district of Colorado as a very serious pest to apples and cherries, and in a lesser degree, to plum, currant, raspberry, and gooseberry. By 1896 it had become one of the worst pests in Colorado. By 1905, however, it had decreased, apparently from the attacks of parasitic enemies and a fungous disease. Following its outbreak in the Fort Collins-Greeley district the leaf roller became abundant farther south around Boulder, Denver, Colorado Springs and Pueblo, but the outbreak here was of shorter duration.

In 1905 the leaf roller showed up as a destructive pest in every county in the state of Missouri destroying in some cases 75 percent of the crop. It was reported in Oregon as early as 1911, although it was not abundant enough at that time to do any marked damage. In the upper part of the Bitter Root Valley of Montana, the pest gradually spread for several years until in 1920 it had become a menace to the apple industry. The infestation here was probably the worst that has ever been reported from any section. This may possibly have been due to the fact that up to that time the codling moth had hardly been known in the Bitter Root Valley, and accordingly no arsenical sprays had been applied to apple orchards. The leaf roller, after once becoming established, was thus enabled to increase more rapidly than seems to have been the case where rather heavy applications of arsenical sprays had been applied regularly for a relatively long period of time.

Life History

The eggs of the leaf roller are deposited in compact oval or more or less rectangular clusters somewhere on the bark of the fruit trees, on which it feeds during the larval stage. In Northern Idaho these clusters have been found mostly on the smaller branches or twigs, though they may be anywhere from the trunk to the tip of the smallest twig.

The egg masses vary from about eight eggs to more than 100, with the average a trifle over 40. They are covered by the female immediately after deposition with a waxy impervious coating. When freshly deposited

they are greenish-yellow but soon become darker in color until they resemble the bark on which they are laid. By spring many have become bleached to a whitish color and are more readily distinguished. The old egg masses often remain for several years and are recognized by the small holes thru which the larvae have hatched.

Larvae hatch over a considerable period. The first ones emerge about the time buds open in spring, and usually by the time the buds show

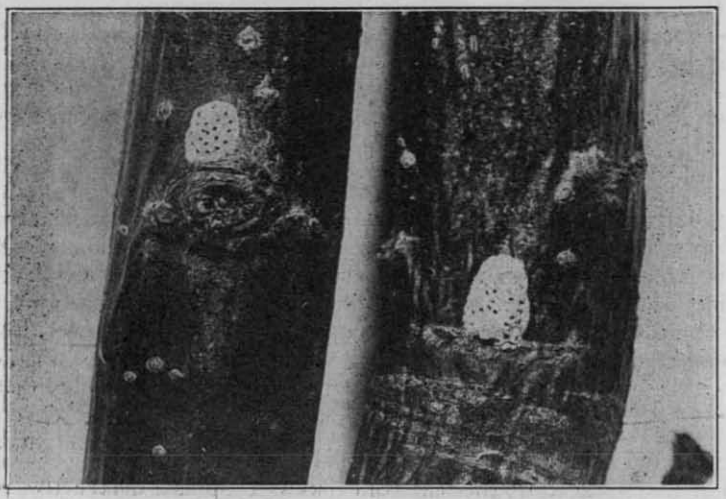

FIG. 1—Leaf Roller egg masses, hatched and partially hatched.

pink most of them have hatched. They are small at first, and are colored dull green with black heads. The bodies become a brighter green after they have attained some size.

Injury to Plants

Soon after emerging the small larvae bore into the unopened flower buds, often destroying them. They also frequently bore into the pedicels of the opening flower, causing the flower to wither and drop. As the fruit is beginning to form the larvae bore into the sides of the stem and into the fruit, much of which will drop before maturity. Such of it as remains heals over but is deformed and the healed-over patches are covered with a corky layer. The caterpillars also feed on the leaves. When numerous they greatly reduce the leaf surface and in severe infestations often cause entire defoliation of the trees. The larvae have the power of spinning webs and their habit is to web several leaves together and remain feeding inside, protected from enemies and sprays. Or they often web a leaf against a developing apple and feed for some time on the tissues of the fruit.

After feeding for about 30 days on an average the larvae form

pupae inside the rolled leaves. By the first week in July the majority of the larvae in Kootenai County, Idaho, orchards were usually pupated. In the Lewiston section they pupated slightly earlier. The pupal stage lasts about ten days.

The adult moth has a wing spread of three-fourths inch to one inch. Its color is light or dark rusty brown or tan, usually with two large yellow patches near the front margin of the forewings, and some other smaller yellow patches on these wings. The females soon begin to deposit egg masses which remain on the trees from midsummer till the following spring.

While the apple tree is seemingly preferred by the leaf roller, it is often found on cherries, pear, plum, quince, apricot, and occasionally on some other plants.

EXPERIMENTAL WORK IN CONTROL

The leaf roller was not present in Northern Idaho in sufficient numbers to cause appreciable damage until 1921. During this year some injury was reported from the Lewiston section and also from the section near Hauser and McGuire in Kootenai County.

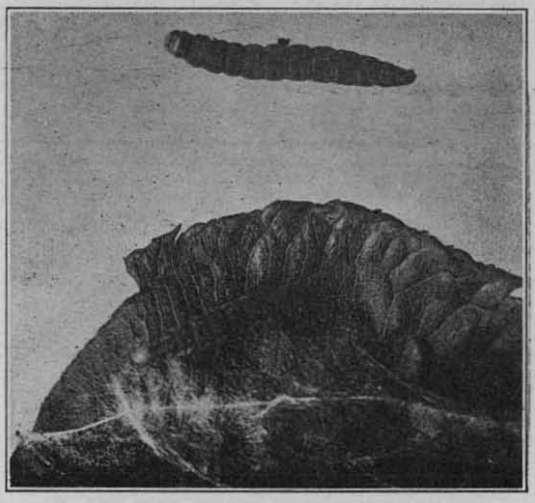

FIG. 2—Larvae of Fruit Tree Leaf Roller.

In the spring of 1922 the Department of Horticulture began experimental work for the control of the leaf roller in northern Idaho, with the cooperation of the Department of Agricultural Chemistry in phases of the work involving chemical analysis. At the same time Wakeland (11) began experiments on control of this pest in southern Idaho. (A report of his work is contained in Idaho Experiment Station Bulletin No. 137).

Arsenical Sprays (Season of 1922)

The work in northern Idaho was decided upon too late to use dormant oil sprays so the experiments for 1922 were confined entirely to the use of arsenicals. Several types were used, including four different brands of lead arsenate, calcium arsenate, and paris green. These sprays were used at different strengths to determine the amount necessary to control the leaf roller.

Table I

Results of Application of Arsenical Sprays for Control of Leaf Roller Larvae, 1922. Counts of Apples made July 11. Count of Worms (including pupae) made June 28-30.

TREATMENT	Ave. No. apples per tree	Ave. No. worms per tree
Paris green, 6 lbs. per 200 gallons, pink and calyx sprays	318	256
Corona lead arsenate, 12 lbs. per 200 gallons, pink and calyx sprays	246	241.5
Paris green, 6 lbs. per 200 gallons, pink spray	206.8	522
Sherwin-Williams lead arsenate, 12 lbs. per 200 gallons, pink and calyx sprays	173.7	386.7
Corona lead arsenate, 8 lbs. per 200 gallons, pink and calyx sprays	163.9	378.6
Corona lead arsenate, 8 lbs. per 200 gallons, pink and calyx and first cover sprays	157.1	339
Paris green, 3 lbs. per 200 gallons, pink and calyx sprays	139.1	262
Grasselli's lead arsenate, 12 lbs. per 200 gallons, pink and calyx sprays	138	235
Grasselli's lead arsenate, 8 lbs. per 200 gallons, pink and calyx sprays	105.8	499
Ortho lead arsenate, 12 lbs. per 200 gallons, plus lime sulfur, summer strength, pink spray	101.2	637
Paris green, 3 lbs. per 200 gallons, pink spray	99.6	322.6
Corona lead arsenate, 12 lbs. per 200 gallons, pink spray	93.4	445.3
Corona lead arsenate, 8 lbs. per 200 gallons, pink spray	88.2	553.3
Corona lead arsenate, 8 lbs. per 200 gallons, calyx spray	86.9	250.6
Ortho lead arsenate, 12 lbs. per 200 gallons, plus lime sulfur, summer strength, pink and calyx sprays	83.7	559.5
Ortho lead arsenate, 8 lbs. per 200 gallons, plus lime sulfur, summer strength, pink and calyx sprays	71.6	324.5
Sherwin-Williams lead arsenate, 8 lbs. per 200 gallons, pink and calyx sprays	68.3	463.5
Ortho lead arsenate, 8 lbs. per 200 gallons, plus lime sulfur, summer strength, pink spray	47.3	389.2
Corona calcium arsenate, 12 lbs. per 200 gallons, plus lime sulfur, summer strength, pink spray	33	323
Corona calcium arsenate, 8 lbs. per 200 gallons, plus lime sulfur, summer strength, pink spray	31.8	267
Average of Checks	22.6	425.3
Corona calcium arsenate, 8 lbs. per 200 gallons, plus lime sulfur, summer strength, pink and calyx sprays	14.6	498.3
Corona calcium arsenate, 12 lbs. per 200 gallons, plus lime sulfur, summer strength, pink and calyx sprays	8.2	180

The plan of the experiment was to apply these various strengths of arsenicals at two spray periods: (1), at the time the flower buds were in the pink stage which corresponded in time to the "pink" scab spray of lime sulfur, and, (2), at the time of the regular codling moth calyx spray. This schedule was supplemented in the case of Corona lead arsenate by application of a third spray at the time of the first cover spray. Since a large percent of the larvae had pupated by this time it was of little effect.

Also with this particular brand the calyx spray was omitted in one block and in another the pink spray was omitted. In certain other blocks lime sulfur, summer strength, was used in combination with Corona calcium arsenate and Ortho lead arsenate.

Effectiveness of Arsenicals, 1922

An examination of Table I indicates several things as to the effectiveness of various arsenicals for leaf roller control during this particular year:

1. If the effectiveness of the spray is judged by the amount of fruit set it seems fairly evident that when a rather strong arsenical spray is used a good set of fruit may be kept, even when leaf roller larvae are very abundant. Compare the average number of apples on the check trees (22.6) with the number on trees receiving Corona lead arsenate, (12 lbs. per tank) pink and calyx sprays, and also paris green (6 lbs.) pink and calyx sprays, and even when only the pink spray is applied. In this latter case it will be noted that although a large number of apples are present, the number of worms is excessive.

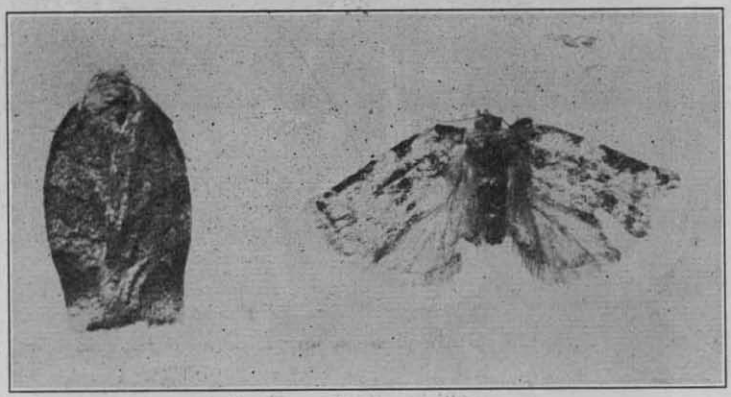

FIG. 3—Pupa of Leaf Roller.

2. In general, while the number of apples set seems to be greatly increased, where the pink spray alone is used the number of worms is apt to be excessive. Seemingly the application at the pink stage destroys those larvae that start to bore into the flower buds and pedicels, but the later application at the time of the calyx spray is the one that destroys the greater number of larvae by putting the poison on leaves, where they are feeding at that time.

3. Lime sulfur used with the arsenical seems to reduce greatly or even destroy the effectiveness of the arsenic.

4. The more desirable form of the arsenical seems to be that in which the arsenic is more soluble, as evidenced by the better results with paris green and Corona lead arsenate. The Department of Chemistry made determinations showing that the Corona lead arsenate contained more of the acid arsenate of lead than did any other brands used.

5. A third application at the time of the first cover spray had no value because a large percentage of larvae had pupated by this time.

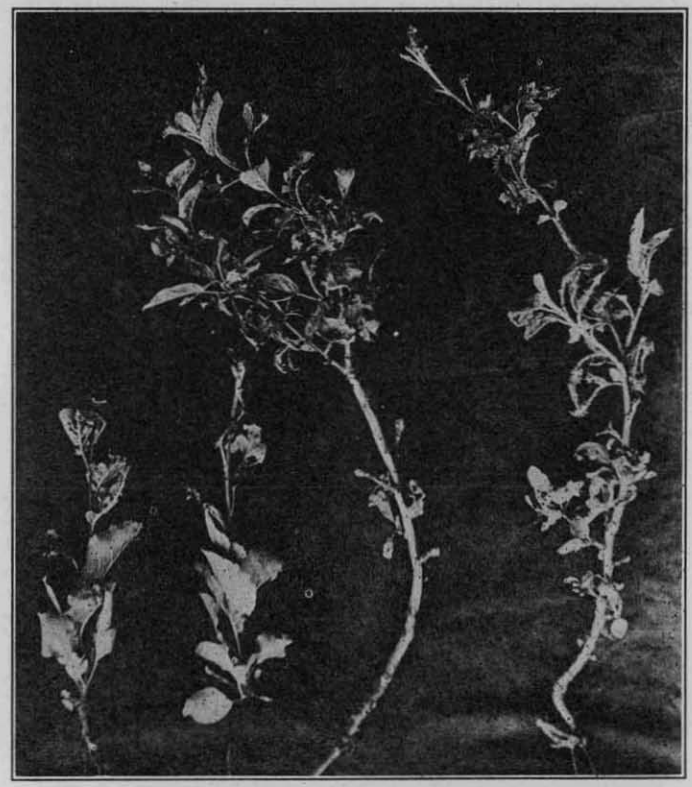

FIG. 5—Foliage injury by larvae.

In general, the experiment indicated that for this particular year fair control of the leaf roller was obtained by the use of certain arsenicals, namely, some lead arsenates at the rate of 12 lbs. per 200 gallons of water, and paris green at the rate of 6 lbs. per 200 gallons. Two sprays were necessary to secure this result, one about the time the buds showed pink and the other at the regular calyx spray date. By fair control is meant the prevention of much defoliation of the trees and the holding of a good set of fruit. When either spray was omitted there was heavy defoliation and usually a very light setting of fruit. When paris green was

applied as a pink spray only, a good set of fruit was obtained, but heavy defoliation resulted as was indicated by the large number of worms present. Where only 8 lbs. of lead arsenate was used, or 3 lbs. of paris green, results were poorer than when 12 lbs. and 6 lbs. respectively were used, although the former concentrations had considerable value.

Addition of Oil Sprays, 1923

In the spring of 1923, plans were made to add to the experiment the use of various oil sprays as ovicides.

The use of arsenicals was to be continued but the plan was changed to some extent. Fewer plots were included, and attention was concentrated mostly on one arsenical spray, the Corona lead arsenate. This

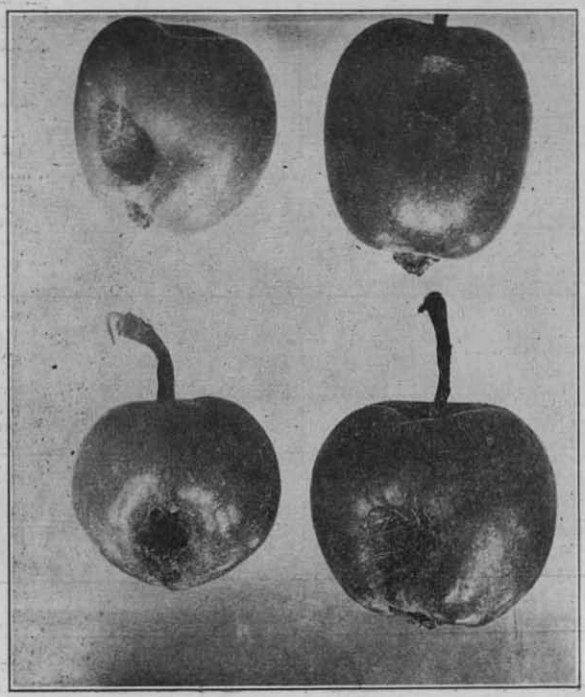

FIG 6—Fruit injury by larvae.

had given the best results in 1922, with the possible exception of paris green. The plan in 1923 was to test out different strengths of Corona lead arsenate, and also different combinations of spray dates, as follows: pink spray, calyx spray, first cover spray.

Table II gives the results of arsenical spraying in Kootenai County in 1923.

Table II

Results of Arsenical Sprays for Leaf Roller, Kootenai County, 1923. Counts of Larvae made June 29-30.

	No. new masses per tree in spring	Number larvae per tree	Notes on injury to foliage by larvae
Corona lead arsenate, 12 lbs. per 200 gallons. pink and first cover sprays	401	90	Leaves badly eaten
Corona lead arsenate, 12 lbs. per 200 gallons plus sirup 2 gal. pink and calyx sprays	560	127	Second best arsenical plot, tho considerable foliage eaten
Paris green, 6 lbs. to 200 gallons calyx and first cover sprays	325	142	As badly eaten as when paris green applied only as calyx spray, but fewer larvae present.
Corona lead arsenate, 12 lbs. per 200 gallons, pink, calyx. and first cover sprays	210	162	Has least eating of any arsenical plot, but not so good as oil plots
Corona lead arsenate, 12 lbs. per 200 gal. no spreader. Pink and calyx sprays	377	181	About the same as where no spreader is used.
Corona lead arsenate, 12 lbs. per 200 gal. plus sirup (2 gallons) Calyx and first cover spray	184	186	Shows less eating than plots sprayed without syrup, same sprays.
Corona lead arsenate, 12 lbs. per 200 gal. Calyx and first cover sprays	221	214	Rather less eating than where pink and calyx sprays or pink and first cover sprays applied.
Corona lead arsenate, 12 lbs. per 200 gal. plus sirup 2 gal Calyx spray	217	228	Badly eaten, about like plot without sirup
Corona calcium arsenate, 12 lbs. per 200 gal. calyx and first cover sprays	173	250	Eaten about as badly as where only calyx spray applied, but fewer larvae present.
Corona lead arsenate, 12 lbs. per 200 gal. pink and calyx sprays	432	253	Leaves badly eaten
Corona lead arsenate, 12 lbs. per 200 gal. No spreader. Calyx spray	210	269	Very badly eaten, about the same as where spreader used with calyx spray only
Corona lead arsenate, 12 lbs. per 200 gal., plus lime sulfur. Pink and calyx sprays	450	291	Leaves very badly eaten
Corona lead arsenate, 12 lbs. per 200 gallons. Calyx spray	269	323	Badly eaten, about like plot with lime sulfur, or with 8 lbs. per 200 gallons
Paris green, 6 lbs. to 200 gallons. Calyx spray	171	361	Nearly as bad as check trees.
Check Average	463	382	Very badly eaten
Corona lead arsenate, 8 lbs. per 200 gallons. Pink and calyx sprays	340	386	Very badly eaten, as bad as check trees
Corona calcium arsenate, 12 lbs. to 200 gallons. Calyx spray	256	483	About the same as paris green, calyx spray, nearly as bad as check

The plots are arranged in order with the one having the fewest larvae at the head of the table and the one with the most larvae at the bottom. Notes on the approximate amount of leaf eating at the same date are in

the last column. The number of new masses per tree, counted in the early spring, is also shown.

As indicated in the table none of the arsenical plots showed as little defoliation and leaf eating as the oil-sprayed plots adjoining. The plot with the smallest number of larvae was not the one with the least defoliation; evidently the calyx spray is efficacious in reducing defoliation tho a later spray may still further reduce the number of larvae present. The results in general were poor and erratic, and indicate that arsenicals are not to be depended upon for leaf roller control, tho as indicated from the work in 1922 they may have some value in reducing the damage.

No fruit set in this orchard in 1923 so it was impossible to use this test for effectiveness of sprays. There were actually fewer larvae present in many plots than in 1922, but the amount of defoliation was greater in most cases.

Some plots sprayed with arsenicals were included in the experiment at Lewiston Orchards as is shown in Table No. 3.

Table III

Results of Arsenical Sprays for Leaf Roller, Lewiston Orchards, 1923. Counts of Larvae made June 22-23.

	Average number larvae per tree	Average number new egg masses per tree
Corona lead arsenate, 12 lbs. to 200 gallons. No spreader. Calyx spray	2.2	40.5
Ortho lead arsenate, 12 lbs. to 200 gallons. Calyx spray	4.5	38
Corona lead arsenate, 12 lbs. to 200 gallons. Calyx spray	6.4	61.2
Corona lead arsenate, 12 lbs. to 200 gallons. No spreader. Pink and calyx spray	6.6	68.5
Corona lead arsenate, 12 lbs. to 200 gallons, plus 2 gallons sirup. Calyx and first cover spray	6	41.2
Corona lead arsenate, 12 lbs. to 200 gallons. Pink and calyx sprays	9.3	64.5
Corona lead arsenate, 12 lbs. to 200 gallons. Pink, calyx and first cover sprays	9.5	51.7
Corona lead arsenate, 12 lbs. plus sirup, 2 gallons, to 200 gallons. Pink and calyx sprays	17.7	64.7
Corona lead arsenate, 8 lbs. to 200 gallons. Pink and calyx sprays	18	75.5
Paris green, 6 lbs. to 200 gallons. Pink and calyx sprays	30	46
Corona lead arsenate, 12 lbs. to 200 gallons. Pink spray	50.6	79
Corona calcium arsenate, 12 lbs. to 200 gallons. Calyx spray	52.2	81.2
Paris green, 6 lbs. to 200 gallons. Calyx spray	11.2	83.6
Ortho lead arsenate, 12 lbs. to 200 gallons. Pink and calyx sprays	9	48.6

The number of egg masses per tree was not large and the trees were at least twice the size of those used in the Kootenai County experiment. While the table indicates that the arsenicals were of considerable value in reducing the number of larvae there does not seem to be much consistency as a result of the different combinations of spray dates and different strengths of the arsenicals.

Results with Oil Sprays, 1923

Several types of oil sprays were used in 1923 as ovicides, these sprays being applied while the trees were dormant, just as the buds were beginning to open.

Table II gives the results in Kootenai County and Table V the results in Lewiston Orchards. In Kootenai County, except in the case of Ortho heavy neutral oil, the results were not satisfactory. In Lewiston Orchards, however, the results were generally very good as is shown by the percentage of eggs not hatched, and also by the lack of larvae in most plots. No plots were left that did not have arsenical sprays applied for leaf roller, so comparison with number of leaf roller larvae is made with the average of the arsenical plots in Table III.

Table IV

Results of Oil Sprays for Leaf Roller in Kootenai County, 1923. Spray Applied April 24.

Treatment	Ave. number new egg masses per tree	Percent eggs not hatched	Ave. number larvae per tree. Counts made 6-29	Notes on amount of leaf eating by larvae
Ortho heavy neutral miscible oil, 9 gallons to 100 gallons	270	92.2	15.3	Very little eating of leaves. Leaves slightly yellow
Sherwin-Williams Spramulsion, 7 gallons to 100 gallons	193	74.9	56.5	Almost no eating of leaves. Leaves good color
Dormoil, 7 gallons to 100 gallons	302	64.4	233	Leaves eaten more than in plot sprayed with S-W Spramulsion
Sherwin-Williams Spramulsion, 8 gallons to 100 gallons	357.5	67.6	202	Condition of leaves about like those in Spramulsion 7-100
Dormoil, 8 gallons to 100 gallons	261	65.0	57	Condition about like plot sprayed with Dormoil 7-100
Dormoil, plus 2 percent crude carbolic acid, 7 gallons to 100 gallons	321	57.1	167	More eating of leaves than on plot sprayed with Dormoil 7 gallons to 100. Perhaps some worms came over from check
Checks	463	28.9	382	Leaves very badly eaten

Oil Sprays for the Season 1924

Owing to the poor results obtained with arsenicals in 1923 this part of the experiment was discontinued. In the spring of 1924 various oil sprays were applied for leaf roller in both Kootenai County and the Lewiston Orchards in Nez Perce County. By this time some of the home mixed sprays were coming into use. The Bureau of Entomology of the United States Department of Agriculture had been conducting experiments in the control of San Jose scale and had found a lubricating oil emulsion satisfactory for control of this pest. One advantage of this

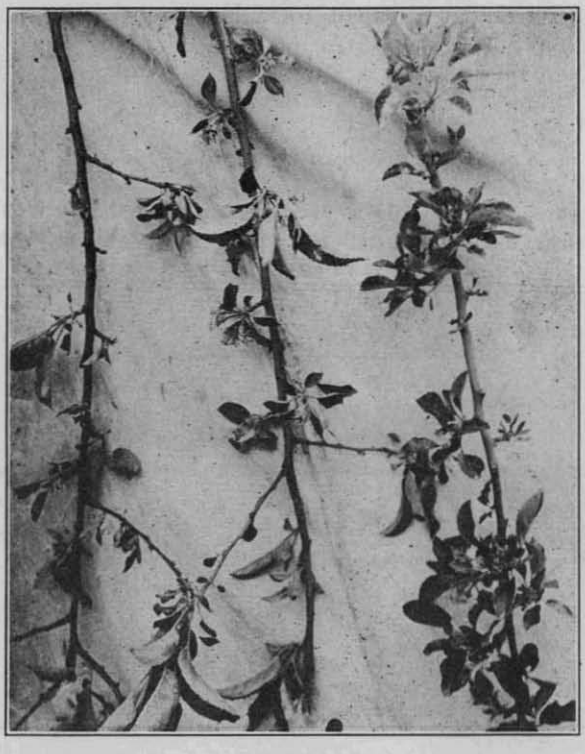

FIG. 7—Oil injury. Center twig not injured; others show stunting of leaves and destruction of buds.

Table V

Results of Oil Sprays for Leaf Roller, Lewiston Orchards, 1923.

Treatment	Ave. number new egg masses per tree	Percent eggs not hatched	Number larvae per tree. Average count made June 21
Sherwin-Williams Spramulsion, 7 gallons to 100 gallons	27.4	92.2	0
Dormoil, 7 gallons to 100 gallons	37.8	95.4	4
Ortho Heavy Neutral, 9 gallons to 100 gallons	39.1	93.7	0
Ortho Crude Oil, 20 gallons to 100 gallons	41	96.6	0
Dormoil, 8 gallons to 100 gallons	56.6	99.3	0
Checks	44.3	19.3	Average of arsenical plots 12.3

emulsion was its cheapness as compared to the miscible oils put out by various spray manufacturing companies. The following formula had be-

come known as the government formula: Lubricating oil, 2 gallons, Water, 1 gallon, Soap, 2 pounds.

The water, oil and soap are mixed together in some kind of a vat, heated, and allowed to boil for a few minutes. The mixture is then

Table VI

Results of Use of Various Oils as Ovicide Sprays in Experimental Work for Control of Fruit Tree Leaf Roller in 1924 at Lewiston and Post Falls, Idaho.

I. Prodger's place near Post Falls

Spray used	Date Spray Applied	Percentage not hatched
Sherwin-Williams Free-Mulsion, 8 gal. to 100 gal.	Apr. 15	84.3
Dormoil, 8 gal. to 100 gal.	Apr. 15	83.5
Triangle brand, 8 gal. to 100 gal.	Apr. 17	81.8
Continental Oil Co. pale paraffin oil-soap emulsion, 10 gal. to 100 gal. (government formula)	Apr. 17	73.1
Texaco corvus oil calcium caseinate spreader emulsion, 10 gal. to 100 gal.	Apr. 17	73.9
Calol Red Engine oil, soap emulsion, 8 gal. to 100 gal. (government formula)	Apr. 17	90.7
Calol Red Engine oil, soap emulsion, 10 gal. to 100 gal. (government formula)	Apr. 17	85.5
Calol Red Engine oil, calcium caseinate spreader emulsion, 10 gal. to 100 gal.	Apr. 17.	91.1
Calol Red Engine oil, calcium caseinate spreader emulsion plus 5 percent phenol, 10 gal. to 100 gal.	Apr. 17	81.3
Ortho miscible oil, 8 gal. to 100 gal.	Apr. 17	69.3
Lime-sulfur (in orchard across from experiment)	Apr. 10	18.2
Unsprayed masses for check taken from the McCrea & Merriweather orchard, Hauser, Idaho		31.4

II. White Bros. & Crum Orchards, Lewiston Orchards, Lewiston

Spray used	Date spray applied	Percentage not hatched
Sherwin-Williams Free-Mulsion, 8 gal. to 100 gal.	Apr. 1	93.2
Sherwin-Williams Free-Mulsion, 10 gal. to 100 gal.	Apr. 1	100.0
Ortho miscible oil, 8 gal. to 100 gal.	Apr. 1	94.9
Target brand oil, 5 gal. to 100 gal.	Apr. 6	96.4
Dormoil, 8 gal. to 100 gal.	Apr. 1	95.3
Texaco Corvus o.l. calcium caseinate spreader emulsion, 10 gal. to 100 gal.	Apr. 1	98.8
Continental Oil Company E. pale paraffin oil, soap emulsion, 10 gal. to 100 gal. (government formula)	Apr. 1	90.2
Continental Oil Company E. pale paraffin oil, soap emulsion, plus 5 percent phenol, 10 gal. to 100 gal. (government formula)	Apr. 1	92.3
Continental Oil Company pale paraffin oil, calcium caseinate spreader, 10 gal. to 100 gal.	Apr. 1	95.0
Brown Neutral oil, calcium caseinate spreader emulsion, 10 gal. to 100 gal.	Apr. 1	94.7
Checks		13.5

pumped twice through a nozzle by either a bucket pump or the spray outfit pump. By this time a creamy emulsion is formed which is approximately two-thirds oil and one-third water. It is this emulsion which is designated as soap emulsion (government formula) in the tables for 1924. A potash fish oil soap was used.

The emulsions known as cold mixed spreader emulsions were also coming into use. The following formulas were followed: Lubricating oil, 2 gallons, water, 1 gallon, calcium caseinate spreader, 1 pound.

This formula was used with the Calol Red Engine Oil and also with the Continental E Pale Paraffin Oil. With Texaco Crown Oil the follow-

Table VII

Results of Use of Various Oils as Ovicide Sprays in Experimental Work for Control of Fruit Tree Leaf Roller in 1925 at Lewiston and Post Falls, Idaho.

I. Prodger's Orchard near Post Falls

Treatment	Date spray applied	Percent eggs unhatched
Check		33
Texaco soluble oil, 5 gal. to 100 gal.	Apr. 9	89.4
Calol Red Engine oil, soap emulsion, 8 gal. to 100 gal. (government formula)	Apr. 6	97.6
Volck's concentrate, 5 gal. to 100 gal.	Apr. 6	79.5
Sherwin-Williams Free-Mulsion, 8 gal. to 100 gal.	Apr. 6	99.3
Conoco E pale paraffin oil, 8 gal. to 100 gal., spreader emulsion	Apr. 6	96.1
* Calol Red Engine oil, glue emulsion, 8 gal. to 100 gal.	Apr. 7	99.1
Triangle brand miscible oil, 8 gal. to 100 gal.	Apr. 7	95.8
Triangle brand miscible oil, 9 gal. to 100 gal.	Apr. 7	95.1
Triangle brand miscible oil, 7 gal. to 100 gal.	Apr. 7	82.1
Calol Red Engine oil, 8 gal. to 100 gal., spreader emulsion	Apr. 7	99.7
Calol Red Engine oil, 7 gal. to 100 gal., spreader emulsion	Apr. 7	97.7
Triangle brand, 5 gal. to 100 gal., plus extra emulsifier to make 1 part emulsifier to 8 parts oil	Apr. 7	94.9
Calol Red Engine oil, 8 gal. to 100 gal., cresoap emulsion	Apr. 7	100

* This emulsion was prepared by soaking 11 ounces of glue in water over night and using the same as spreader in making the emulsion.

II. White Bros. & Crum Orchard, Lewiston Orchards

Treatment	Date spray applied	Percent unhatched eggs
Conoco E pale paraffin, 8 gal. to 100 gal., spreader emulsion	Mar. 24	97.1
Shell Brown Neutral, 8 gal. to 100 gal., cresoap emulsion	Apr. 2	99.25
Shell Brown Neutral, 8 gal. to 100 gal., spreader emulsion	Apr. 2	97.5
Shell Brown Neutral, 6½ gal. to 100 gal., spreader emulsion	Mar. 24	100.
Shell Brown Neutral, 9 gal. to 100 gal., spreader emulsion	Mar. 24	99.55
Shell Brown Neutral, 8 gal. to 100 gal., spreader emulsion	Mar. 24	99.25
Calol Red Engine oil, 8 gal. to 100 gal., soap emulsion, (government formula)	Mar. 24	98.2
* Shell Brown Neutral, 8 gal. to 100 gal., spreader emulsion, plus extra spreader	Apr. 2	95.0
Triangle brand, 8 gal. to 100 gal.	Mar. 24	100.
Texaco soluble oil, 5 gal. to 100 gal.	Mar. 24	100.
Calol Red Engine oil, 8 gal. to 100 gal., spreader emulsion	Mar. 24	99.78
Shell Brown Neutral, 4 gal. to 100 gal., spreader emulsion	Apr. 2	97.4
Shell Brown Neutral, 4 gal. to 100 gal., spreader emulsion	Mar. 24	100.
Check		39.

* This emulsion was prepared as follows: 16 gallons of oil and 8 gallons of water were emulsified in the tank by 1 pound of spreader. After making, 2⅔ ounces of dissolved copper sulfate and 4 pounds more spreader were added to the tank.

ing formula was used: Lubricating oil, 2 gallons, Water, 1 gallon, calcium caseinate spreader, ½ pound.

It will be noted from Table VI that at Post Falls in Kootenai County the results were not good. Calol Red Engine oil was the only one that showed anything like adequate control. On the other hand in the Lewiston Orchards most of the sprays showed adequate control, as was the case in 1923, with the Continental Co. E. pale paraffin oil giving poorer results than did the others. As will be noted later, this was likely due to the fact that the oil is rather light for successful control of leaf roller.

Results with Oil Sprays, 1925

In 1925 the oil spray experiments were continued at the same places. One variation this season was the testing of several different strengths of one particular oil in each of the localities where the experiments were being conducted. Practically the same oils and emulsions were used as in 1924. However, the concentrations of the solution are expressed in the actual number of gallons of oil in 100 gallons of the diluted emulsion or in other words, on the percentage basis. For example, in 1924 the most common dilution of the home-mixed emulsion was 10 gallons of the concentrated emulsion to 100 gallons. This would be equal to about 6.66 gallons of actual oil content which is a trifle more than 6½ gallons of oil to 100 gallons of the diluted emulsion.

Table VII gives the data for 1925. Near Post Falls in Kootenai County the results were satisfactory in most cases. Exceptions were in cases of low dilutions of various oils such as Volck's oil and Texaco soluble oil at 5 gallons to 100 gallons, and Triangle brand at 7 to 100.

At Lewiston the results were even better, even with solutions as weak as 4 gallons of oil to 100 gallons. This seems to indicate that these weaker solutions will kill leaf roller eggs if sufficient oil is applied. It should be noted that a very thoro application was made on these plots, much heavier than the average grower is accustomed to apply. It is this thoro application rather than the brand of oil spray used which largely determines success or failure in leaf roller control.

Experimental Work in 1926

In the spring of 1926 leaf roller eggs were very scarce. Practically none was to be found in the Lewiston section and it was difficult to find them in Kootenai where they had been so abundant. There were not enough to justify spraying on Prodger's orchard where the plots had been located in 1924 and 1925. Practically none was found in the McCrea & Merriweather orchard where the experimental plots were located in 1922 and 1923. No sprays of any kind, whether arsenicals or oil emulsions, had been applied since 1923, yet the pest had almost entirely disappeared. This was due evidently to the increase of insect or fungus

enemies of the leaf roller. Such has been the history of outbreaks of the fruit tree leaf roller. Following a severe outbreak it gradually or suddenly subsides or nearly disappears in any particular region.

Finally, however, an orchard was located with sufficient new egg masses to warrant some limited spray experiments namely the orchard of Mr. W. A. Reed near Hayden Lake. The applications this year were confined to various strengths of Triangle brand oil.

Table VIII gives the results. The spray outfit was not running properly and the application was not as thoro as it should have been. Also the temperatures dropped to below 28 degrees F. within a few hours after the application was completed. These facts explain the poorness of results.

Table VIII

Results of Use of Various Strengths of Triangle Brand Miscible Oil as Ovicide Sprays for Control of Fruit Tree Leaf Roller at Hayden Lake, Kootenai County, Idaho, in 1926.

Treatment	Date spray applied	Percent eggs not hatched
Triangle miscible oil, 4 gal. to 100 gal.	Mar. 24	60.7
Triangle miscible oil, 6 gal. to 100 gal.	Mar. 24	62.2
Triangle miscible oil, 7 gal. to 100 gal.	Mar. 24	68.1
Triangle miscible oil, 8 gal. to 100 gal.	Mar. 24	86.4
Check	Mar. 24	29.6

Use of Phenol in Oil Sprays

Early in the course of the experiments the idea was prevalent that possibly part of the efficiency of the miscible oil sprays was due to the presence of considerable quantities of phenol and such related substances as cresol.

The composition of Dormoil as given by its manufacturers in 1922 was as follows: Mineral oils (light lubrication types, made from California crudes, asphaltic base), 82 percent, Phenols (mostly cresyllic acid), 4 percent, Dry soap, 3.5 percent, Water, 8-10 percent.

In 1923 and 1924 phenol was added to some of the sprays to test its

Table IX

Data on Insecticidal Value of Phenol in Combination with Miscible Oil, Kootenai County, 1923.

Treatment	Percent eggs not hatched
Dormoil, 7 gal. to 100 gal.	64.4
Dormoil plus 2 percent phenol	57.1

insecticidal value. Table No. IX shows data obtained in Kootenai County in 1923, and Table No. X shows data from Kootenai County and Lewiston Orchards for 1924. The tables indicate that phenol has no insecticidal value in these oil sprays, the data being inconclusive.

Table X

Data on Use of Phenol in Combination with a Miscible Oil, Kootenai County, 1923. Spray Applied to Single Trees with a Small Bucket Pump. Application at Rate of 4 gallons to 100 gallons.

	Percent eggs not hatched	Notes on injury by spray
Dormoil, plus 4 percent phenol	93.6	No injury
Dormoil, plus 8 percent phenol	69.4	No injury
Dormoil, plus 12 percent phenol	26.4	No appreciable injury
Dormoil, plus 16 percent phenol	44.6	All the first leaves were killed
Dormoil, plus 20 percent phenol	60.6	All the leaves killed on this tree and some limbs died back to the trunk

Table XI

Use of Phenols in Combination with Miscible Oil in 1924

A.—In Kootenai County

	Percent eggs not hatched
Calol Red Engine oil, calcium caseinate emulsion, 10 gal. to 100 gal.	91.1
Calol Red Engine oil, calcium caseinate emulsion, plus 5 percent phenol, 10 gal to 100 gal.	81.3

B.—In Lewiston Orchards

	Percent eggs not hatched
Continental Oil Co. E pale paraffin oil-soap emulsion, (government formula) 10 gal. to 100 gal.	90.2
Continental Oil Co. E pale paraffin oil-soap emulsion, (government formula) plus 5 percent phenol, 10 gal. to 100 gal.	92.3

Table XI gives data on the spraying of single trees with a bucket pump. The data in this table are not comparable with that in the other tables because of the method of application. Their value lies in the fact that they indicate the approximate amount of phenol that might safely be added to oil sprays.

These tables do not indicate that phenol has any insecticidal value in the oil sprays. Its presence in the sprays mentioned is due to the fact that it has a preservative effect on some of the ingredients used in the soap emulsion. Melander (9) also has found that cresyllic acid, a substance belonging to this group, has some value in stabilizing the uncooked type of soap emulsion.

PREPARATION OF OIL SPRAYS

Type of Oil to Use

The use of home mixed sprays has become extensive in the northwest during the past few years and in most cases they have proved successful. In some instances results have been disappointing but this has been at least partially due to use of oils not well adapted to spraying. Experimenters are not agreed as to the types of oil best suited to use in spraying work. Several companies have been putting out lubricating oils under such names as 'Red Engine Oil' and 'Brown Neutral Oil' and these have not always been uniform in composition, even under the same name. Refiners, however, can furnish oils that are satisfactory if the specifications are known. In 1926 a committee of entomologists made a report in which they gave specifications that approximate what is best in the judgment of a large number of investigators. These specifications follow:[1]

Viscosity—90-250 seconds at 100 degrees F. (Saybolt).

Volatility—not over 2 percent.

Specific Gravity—0.87 to 0.93 at 20 degrees C.

The oils used in the experiments in northern Idaho for the most part were of the types indicated by these specifications.

If the wrong oil is used there is danger of burning and poor results may be secured if the oil is either too light or too heavy.

Emulsifiers

Soap emulsifiers were the first ones to be generally used. Several types, however, have been more or less generally used during the past few years.

Boiled Soap Emulsion

The so-called government formula really started general use of home-mixed oil sprays. The original formula was as follows:

Oil, 2 gallons, Potash fishoil soap, 2 pounds, Water, 1 gallon.

The ingredients are mixed together, brought to a boil and then pumped through a pump a couple of times, which makes a creamy stock emulsion that can be readily diluted. In using, it should be remembered that the actual oil content is two-thirds the amount of the emulsion. For example, if a spray is desired that contains 4 per cent of actual oil it will be necessary to use 12 gallons of this emulsion in a tank containing 200 gallons.

Where the water is known not to be hard, the amount of soap may be reduced one-fourth, using 1½ instead of the two pounds, indicated in the formula.

(1) Journal of Economic Entomology, Vol. 19, pp. 407-411, (1926).

Cresoap Emulsion

A soap emulsion which requires less labor is the one known as the cresoap emulsion. Cresoap is made by dissolving potash fishoil soap containing 30 per cent moisture in cresyllic acid at the rate of 5½ parts soap to 4½ parts acid by weight. This is used as an emulsifier. The formula follows:

Lubricating oil, 9 parts, creasoap, 1 part.

This does not combine readily with a large amount of water so the desired quantity of oil and emulsifier should be put in the spray tank with one-half as much water as oil. Then the engine may be started and the mixture shot thru a gun back into the tank till a creamy mixture is formed, after which remaining water should be added to fill the tank. If a higher proportion of emulsifier than 1 part to 9 parts is used, the mixture emulsifies more readily.

Calcium Caseinate-Spreader Emulsions

The most popular home-mixed emulsions in the northwest have been those known as spreader emulsions. The formula most in use follows:

Lubricating oil 2 gallons, water 1 gallon, calcium caseinate 4 ounces.

The calcium caseinate should be dissolved in water. This may be done by putting the water in a 5-gallon oil can and stirring the spreader in with a stick or a bunch of baling wire doubled together somewhat like one type of egg beater. Or the water may be put into the spray tank, the spreader dumped into the water and the spray gun played over it until it is dissolved. Then the required amount of oil should be poured in and the gun shot back into the tank continuously for 5 to 10 minutes, or until the mixture has gone thru the gun several times. This type of emulsion can be used even when the water is very hard.

Strength of Emulsion

There is a difference of opinion as to the best strength of emulsion to use. Some investigators recommend as high as 8 per cent of actual oil content in the finally diluted emulsion. Parker of Montana on the other hand has been obtaining good results in the Bitter Root Valley by the spreader emulsion, made with only 4 percent actual oil content and the results at Lewiston for 1925 indicate good control at this dilution. However, data for some other emulsions do not give uniform good results when the dilution is less than 7 percent actual oil content.

In view of the fact that there is considerable danger to the tree when strong emulsions are used it seems best to use as low a dilution as possible. Some of the poor results with lower dilutions may be due to the fact that the oil or the emulsion used was not of the proper type.

De Ong, (13) working with several different types of emulsions, found better results at low dilutions with what is designated as the quick breaking type of oil emulsion as opposed to the stable types. In this type the oil globules are relatively large and their surface tension relatively low, and therefore the emulsion soon breaks up into its component oil and water ingredients. This allows the oil to become immediately effective. The soap emulsions are of the more stable type and have often shown lower killing power at low dilutions in the experiments at Lewiston and in Kootenai County. The calcium caseinate emulsion is of the quick breaking type, and this likely explains its effectiveness at very low dilutions.

Where the application is very thoro the data indicate that a four percent solution will be sufficient with some emulsions. This means heavy drenching of the tree and the use of more spray than the ordinary grower is in the habit of applying. In general, it would seem best to use about 7 percent of actual oil in the finally diluted emulsion; if very thoro spraying work is being done and the oil is within the specifications outlined above it would be allowable to cut the amount of oil to 5 or even 4 percent.

INJURY FROM OIL SPRAYS

Ever since oil sprays have been used in combatting insect pests, there have been reports of various injuries supposed to have been caused by the oil.

The observations made during these experiments point to two very definite types of injuries:

1. Injury to the Opening Leaf Buds and Adjacent Tissues. Often this is merely evident as a prolonging of the dormancy of the buds. It has always been noted that the leaf buds are from a week to 10 days later in opening on the oil-sprayed trees than on unsprayed ones. At other times many of the buds would fail to open at all and the tree would be lacking in foliage thru all the early part of the summer. In extreme cases the wood becomes involved and whole twigs, branches, and sometimes whole trees, are killed. This was the case in 1925 in certain of the sprayed plots. In some of these plots the first one or two trees sprayed from each tank were badly injured, in some cases nearly killed, as noted in Table XII. This probably indicates that in these cases the pipe from the tank was filled with the undiluted concentrated emulsion that had been mixed in the tank. The spray gun should have been directed into the tank for a minute or so before beginning spraying after the tank had been filled with water.

2. Injury to the Blossom Buds. Each year a small amount of this injury has been observed but in 1925 this type of injury was excessive, as indicated in Table XII, varying with the types of emulsion used. In general, it seems that the sprays that have proven most effective caused

Table XII

Notes on Oil Injury taken May 14, 1925, in the Leaf Roller Spray Experiment Plats. White Bros. & Crum Orchard, Lewiston Orchards.

Treatment	Notes on other injury	Percent blossoms killed		
		Rome	Winesap	Ave.
Shell Brown Neutral, 8 gal to 100 gal., emulsified with cresyllated soap. Late	Only slight injury to Tree 2. Set of fruit not greatly injured. Leaves somewhat smaller, and a few burned, especially on Winesap	23	28	25
Shell Brown Neutral, 8 gal. to 100 gal, 3S spreader. Late	Badly injured. Leaves very small, slow to start. Tree 2 has almost no leaves and no blooms	52	82	70
Shell Brown Neutral, 6½ gal. to 100 gal., emulsified with 3S spreader	Tree 2 badly injured and few blooms left on it. Rest of row somewhat injured, about like cresoap	34	28	31
Shell Brown Neutral, 9 gal. to 100 gal., emulsified with 3S spreader	Tree 2 very badly injured, almost no leaves on it. Set of fruit greatly reduced, leaves stunted and late in developing	35	39	37
Shell Brown Neutral, 8 gal. to 100 gal., emulsified with 3S spreader	About like plat sprayed with 9-100, but not quite as bad. Tree 2 not so badly injured	36	22	28
Calol Red Engine oil soap emulsion (government formula), 8 gal. of oil to 100	The fourth best plat in appearance. One-half of one tree, No. 2, quite badly injured, the other very little. The rest of row shows nearly normal leaves and only slight blossom injury. Better than plat sprayed with rown Neutral 8-100	6	4	5
Shell Brown Neutral, 8 gal. to 100, Littooey's formula. Late	Not much injury to Tree 2. Winesap leaves badly stunted, Rome leaves not so much. Seemingly a good set of fruit. Does not look as good as preceding plat nor the one before that. Better than lot sprayed 8-100	10	16	13
Triangle brand, 8 gal. to 100 gal.	Almost no injury to Tree 2. Rest of row shows little injury, except some stunting of leaves. Second best plat in appearance	10	21	15
Texaco soluble oil, 5 gal to 100 gal.	Best plat in appearance. Seemingly no injury. Leaves large and thrifty. Good set of fruit	1	0	.5
Calol Red Engine oil, 8 gal. to 100 gal., emulsified with 3S spreader	Tree 2 slightly injured. Some stunting of leaves. Better than Brown Neutral 8-100. Set of fruit fair, but some burning of blooms	2	12	7
Shell Brown Neutral, 4 gal. to 100 gal., emulsified with 3S spreader. Early	Very little injury, leaves healthy and set of fruit fair	15	10	13
Shell Brown Neutral, 4 gal. to 100 gal., emulsified with 3S spreader. Late	Much stunting of leaves, and some blooms are burned off. Set of fruit fair. Looks worse than Brown Neutral 8-100. Early, tho blooms seem better.	1	24	14
Unsprayed orchard	Set of fruit good. Leaves not large, because orchard has been uncared for. Very little winter injury and it does not have the same appearance as the oil injury noted in these plats			0
Sherwin-Williams Freemulsion, 8 gal. to 100 gal.	Tree 2 badly injured. Rest of row has some injury. Set of fruit good. Third best plat in appearance	1	16	9

the greatest injury in 1925. Much of this injury can be accounted for by the fact that trees were greatly weakened by a very severe freeze in the preceding December. They were thus predisposed to oil injury, which is not the case when they are in good condition.

This indicates that it is probably inadvisable to use oil sprays, at least in strong emulsions, in springs that follow winters which have been marked by unusual cold or by conditions that cause any weakening of the trees.

SUMMARY

1. While arsenicals have some value in reducing damage by leaf roller larvae they do not offer an efficient means of control. The acid arsenates of lead and paris green proved more efficient than the basic arsenates or calcium arsenates. The ordinary codling moth arsenical spray is not strong enough to be of great value against leaf roller. From eight to twelve pounds of lead arsenate to 200 gallons of water are necessary for any fair control. The experiments indicate that an arsenical spray at or just before the pink blossom stage has considerable value in safeguarding setting of fruit. Another one at the calyx-spray stage is necessary to prevent excessive defoliation.

The arsenical spray should be relied upon only when there is slight infestation or when for some reason an oil spray has not been applied or has been ineffective.

Lime sulfur decreases or destroys the effectiveness of the arsenical spray.

2. The eggs of the leaf roller can be destroyed by a dormant oil spray. The type of oil used must be within certain specifications, which, in general, means an oil that is medium in volatility and viscosity, neither very heavy nor very light.

Various types of emulsifiers may be used, and good results will be obtained from most of them. If water is very hard the calcium caseinate type of emulsion is preferable, as it is more stable under those conditions.

The strength of diluted emulsion to be used is dependent on (a)—thoroness of application; where the application is very thoro a weaker emulsion may be used; (b)—type of emulsion; a weaker emulsion may be used if it is of the quick-breaking type such as the calcium caseinate emulsion.

In general for leaf roller the strength of the diluted emulsion may be as low as 4 percent of actual oil content, where the emulsion is of the calcium caseinate type and application thoro. If application is less thoro and the emulsion one of the soap type as high as 7 percent of actual oil should be present in the diluted emulsion.

Phenols have no ovicidal value in oil emulsion. Their presence is of value only in stabilizing and preserving emulsions.

Oil sprays are likely to cause injury particularly of two types:

1. Injury to leaf buds and twigs and branches.
2. Injury to blossom buds.

Such injury may be caused by use of improperly emulsified or insufficiently diluted solutions. They may be intensified by a weakened condition of the trees, especially if this condition is due to excessive cold.

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