THE USE OF OILS FOR CONTROL OF INSECTS

Thesis for the Degree of M. S.

Goodwin S. Tolles

1928

Horticulture Spraying

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THESIS

HISTORICAL

The practice of using emulsions of heavy oils as sprays for the control of insects, is of comparatively recent origin. Dr. A. J. Cook, then of Michigan State College, was probably the first to recommend the use of kerosene oil and soap water for insect control. He made his first recommendations to the public in 1878, although there are a few earlier records of the use of oils for insect control,- usually the pure oils and not emulsions. In 1794 Forsyth writes that English nurserymen used train (whale) oil against coccus and that they applied it with a brush, and in 1763 there appeared in the papers of Marseilles a recommendation for the control of lice. Among the remedies was mentioned petroleum, turpentine and other oils, with the warning to be careful in their use "as they make the plants sick or even kill them".

As early as 1835, turpentine mixed with earth was used to destroy worms on trees, and kerosene was again recommended in 1865 for scale on orange trees. The kerosene was poured in a saucer and applied with a feather.

George Cruickshank of Massachusetts says that he controlled the currant worm with five pounds of

whale oil soap, one wine quart of kerosene, to twenty-five gallons of soft water. Later, C. V. Riley in an address delivered before the Société Centrole d'Agriculture de l'Herault on June 30th, 1884, spoke of the emulsion of kerosene with milk or soap. The use of heavy oil emulsions in commercial orchards, has been in practice for only a few years. Their use, however, seems to be growing in popularity, although frequently burning and killing of plants results from their use.

CLASSIFICATION

Oil preparations used for spraying purposes, aside from true soaps, are usually classed as miscible oils or as emulsions. Miscible oils are prepared by the manufacturer so that the addition of water is all that is necessary to make the spray ready for use. Most commercial growers use this type of spray oil. Miscible oil is oil that has been treated with an emulsifier such as a soap, casein or some petroleum product, to make it miscible with water. In other words, it is an oil solution of an emulsifier. Certain prepared emulsions are likewise compounded so that they

require no further preparation before application, and may be added directly to water and applied. They differ from the miscible oils in that they already contain a small proportion of water. Other home made emulsions are ordinarily prepared by the grower and used immediately.

In an oil emulsion the oil is suspended in fine droplets throughout the water. A soap or other emulsifier is used to make the emulsion stable. If soap is used, part of the soap hydrolyzes forming an alkali and fatty acids, but part of it forms a film around the oil droplets, thus preventing the droplets from coalescing. Casein and other emulsifiers act by forming films around the oil droplets as in the case of soap.

In making home-made emulsions, such oils as Red Engine oil or Diamond Paraffin oil are usually used on account of being more or less standard and easy to obtain. Home-made emulsions are of two types,- those that are cooked and those that are cold mixed. In the case of a cooked or boiled emulsion, a soap, potash fish-oil soap, is best. In making the emulsion, the soap along with the oil and a quantity of water, is cooked and then

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pumped while still hot, through a nozzle several times until a thick, creamy emulsion is obtained. In making the cold mixed emulsion, the oil, water, and an emulsifier such as Kayso or bordeaux mixture, are pumped through a nozzle under high pressure several times, usually about three times, until a complete emulsion is obtained.

As oils seem to be gradually superseding lime-sulphur as a "dormant spray" for insects, some of their advantages and disadvantages should be listed as compared with lime-sulphur.

Advantages

1. Oils are pleasant and not caustic to handle.
2. Do not disfigure trees and painted buildings.
3. Do not clog or corrode pumps or nozzles.
4. Penetrate better than lime-sulphur.
5. A gallon will cover more surface than a gallon of lime-sulphur.

Disadvantages

1. Ingredients after dilution separate out on standing.
2. Stock supply evaporates and breaks down chemically in some cases, although this is also true of lime-sulphur and bordeaux.
3. Injury is often caused to trees by preparations not properly mixed.
4. More expensive and most preparations not as valuable as fungicides.
5. Oils affect rubber, and hose is quickly ruined.

Petroleum oils used in the preparation of spraying mixtures, vary widely in their physical and chemical characteristics, some makers utilising oils which distill at low temperatures and which are obtained as by-products in the making of high-test cylinder oils. In describing the properties of oils so used, it is customary to use such terms as density, flash-point, distillation point, volatility, viscosity and degree of sulphonation.

Density is usually expressed in degrees Baumé or A.P.I. Petroleum oils of the same density may vary widely in volatility, viscosity and other characteristics. Density may be changed by blending.

The flash-point is determined by the lowest temperature to which an oil must be heated to give off inflammable vapor in sufficient quantities to produce a combustible mixture. This test is used to indicate relative volatility. A low flash point in a viscous oil may indicate the blending of a light and a heavy oil.

Distillation by fractional methods, varying temperatures being used, gives oils of different densities, viscosities, and volatilities.

Volatility is one of the most important characteristics of a spraying oil. It is a basic distinction between a kerosene and a lubricant. Kerosene evaporates so quickly that it is ineffective against insect eggs and resistant scales. A heavy lubricating oil persists in the form of a surface film for weeks or even months, acting as a repellent or as a toxic agent.

Viscosity is denoted by the freedom of motion of the molecules, often spoken of as "body", rate of flow at a standard temperature using H_2O as a standard for comparison.

Sulphonation is the processing of petroleum oils by the use of sulphuric acid or liquid sulphur dioxide. The acid is agitated with the oil until

it unites with the unsaturated hydrocarbons, aromatics and cracked oils to form sulphonates. Varying degrees of refinement are obtained by treating with varying amounts of acid. Filtration will remove the color of oils but not the unsaturated hydrocarbons.

INJURIES TO PLANTS PRODUCED BY OIL SPRAYS

There has been considerable injury caused to trees and shrubs by applications of dormant oil sprays in all sections of the country. We are not considering summer applications in this paper, but no doubt greater injury has been caused by summer applications than from dormant sprays. Certain species of trees are more susceptible to oil injury than others. Some of those that are most susceptible are peach, nut trees, elms and stone fruits. No doubt much injury is caused by poor emulsification or in the case of miscible oils, by the separating out of the emulsifier. In the investigation of oil injury, the time of application, the type of oil, type of emulsifier, weather conditions and other conditions relative to application, must be considered. Fall

applications are more dangerous and not so efficient as late spring applications. Highly refined white oils (completely sulphonated oils) are considered safer than other types of oils. Investigations in the northwest have shown that the kind of emulsifier and method of emulsification of spray oils are practically as important as the oil itself, from the standpoint of safety and efficiency. Weather conditions must be considered in making an application of an oil spray. The application should be delayed in the spring as late as possible. Just before the buds open is the best time to apply an oil spray, provided the danger of freezing the buds is past. Freezing weather following an oil application before the spray becomes well dried, is very apt to cause injury. Oil applications should not soon follow or precede lime-sulphur applications or be applied with a sprayer in which the tank contains remnants of lime-sulphur spray. Some brands of oil emulsions are safely used with sulphur compounds under normal weather conditions; while others are incompatible with sulphur. Compatibility depends on the type of emulsifier used, so that it is never safe to recommend oil sprays with or following preceding sulphur sprays, especially when the type of emulsifier is not known.

1927 PROJECTS

In the North Central States there are three races of the Oyster shell bark louse. The greyish brown form on poplar, willow and lilac, is the race that we are most concerned with in this section of the country. The habit of passing the winter in the egg stage beneath the waxy scale, has rendered the Oyster shell scale more than ordinarily difficult to control by means of sprays.

The Oyster shell scale on lilac has for a number of years constituted a special problem and, in the past, attempts at control have more often ended in failure than even in partial success.

In the spring of 1927 an attempt was made to control the Oyster shell bark louse on lilac and some of its other common hosts. The sprays used were Sunoco, a miscible oil, and Diamond Paraffin Oil, a lubricating oil, emulsified with Kayso. Also, strong lime-sulphur was used in comparison with the oil sprays. These three types of sprays were applied to a number of trees and shrubs, the work being done in cooperation with the office of the City Forester of Lansing, and the operations were carried on both in Lansing and East Lansing.

The sprays were applied during the dormant period before the buds of lilac burst. Three types of sprays were thus compared, one a miscible oil, one a lubricating oil emulsified cold with Kayso, and the third strong lime-sulphur. The oil sprays were applied with a power machine of 250 gallons capacity, which developed a pressure of 275 pounds at the hose coupling. The lime-sulphur was applied with a small hand operated wheelbarrow type of sprayer, with less pressure. These sprays were applied between the 25th and 29th of March, 1927, which was about fifteen days before the buds of lilac started to burst, all of the trees and shrubs being at the time in a dormant condition.

Four test plots were treated. Plot No.1 consisted entirely of mature lilacs from eight to ten feet high. They received lime-sulphur diluted one part to six of water. Unfortunately, the application was followed immediately by heavy rains which washed off so much of the spray that the control was very poor indeed, almost negligible.

Plot No.2 also consisted of similar lilac shrubs and these also received a spray of lime-sulphur diluted at the rate of one part to six of water. This time the weather conditions were favorable and the control was excellent.

A- Oyster shell barklouse on apple.
B- Oyster shell on lilac.
·Both enlarged.·

Plot No.3 consisted of butternut, lilac, dogwood, willow and poplar. The trees in this plot received a miscible oil, Sunoco, at the rate of one part of oil to fifteen of water, control being very satisfactory.

Plot No.4 contained trees similar to those in plot No.3 with the addition of ash, and received a spray of lubricating oil emulsified with Kayso. The emulsification was accomplished by running the materials three times through an emulsifier at 250 pounds pressure. The following formula was used:-

1 gallon of oil
2 ounces of Kayso
⅓ gallon of water

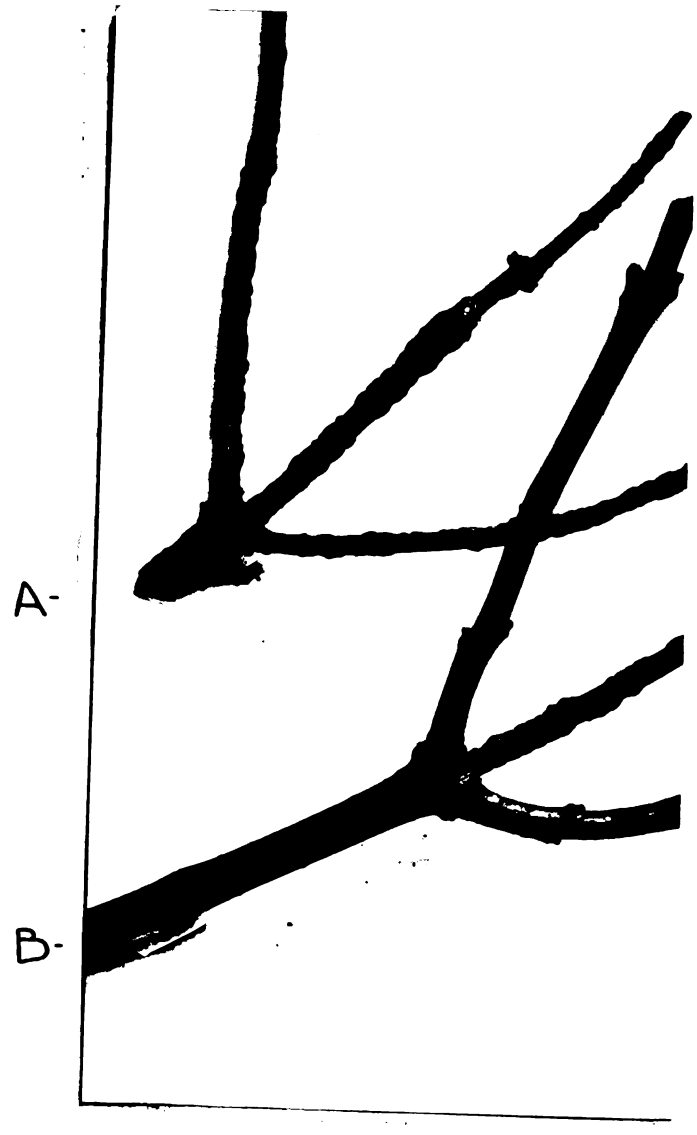
This formula gives a stock solution of 66 2/3 percent oil. Nine gallons of this stock solution was used to 100 gallons of water, making a 6% oil spray. The control in this case was also very satisfactory. Weather conditions were very favorable at the time of application in all the plots except in the case of plot No.1. In plots 2, 3, and 4 the applications were made after several days of rain and snow flurries, the average temperature being about 36°F for the period during which applications were made. There were no extreme variations of temperature during the period of application, nor immediately following. This

latter point is of special interest, since cold weather, sometimes even freezing temperatures, following oil applications before the sprays become thoroughly dry, often cause injury to the trees. The degree of infestation of all these plots was heavy, the branches being crusted over with the scale and in many cases the branches had been killed outright by the scale. In checking the results of these sprays, no difference in appearance became manifest, between the sprayed and unsprayed trees, until about the first of June, the success of the applications being measured by the production or lack of production of young scale insects, especially on the new growth. The time of hatching at Lansing during 1927 was about June 22nd.

The control in plots 2, 3, and 4, as already stated, was very satisfactory, only a few young appearing on the sprayed trees. It is more than likely that these came from occasional twigs which had been missed during the application of the spray, as they were only found on occasional twigs. It would appear that a great deal depends on the thoroughness with which the spraying is done.

The only injury that occurred was in the case of a butternut tree which was about two-thirds killed out by the miscible oil applied in plot No.3. However, this tree recovered nicely in 1928 except for the dead

branches. This injury is not so surprising, since it is generally known that nut trees are rather susceptible to injury from oil sprays.



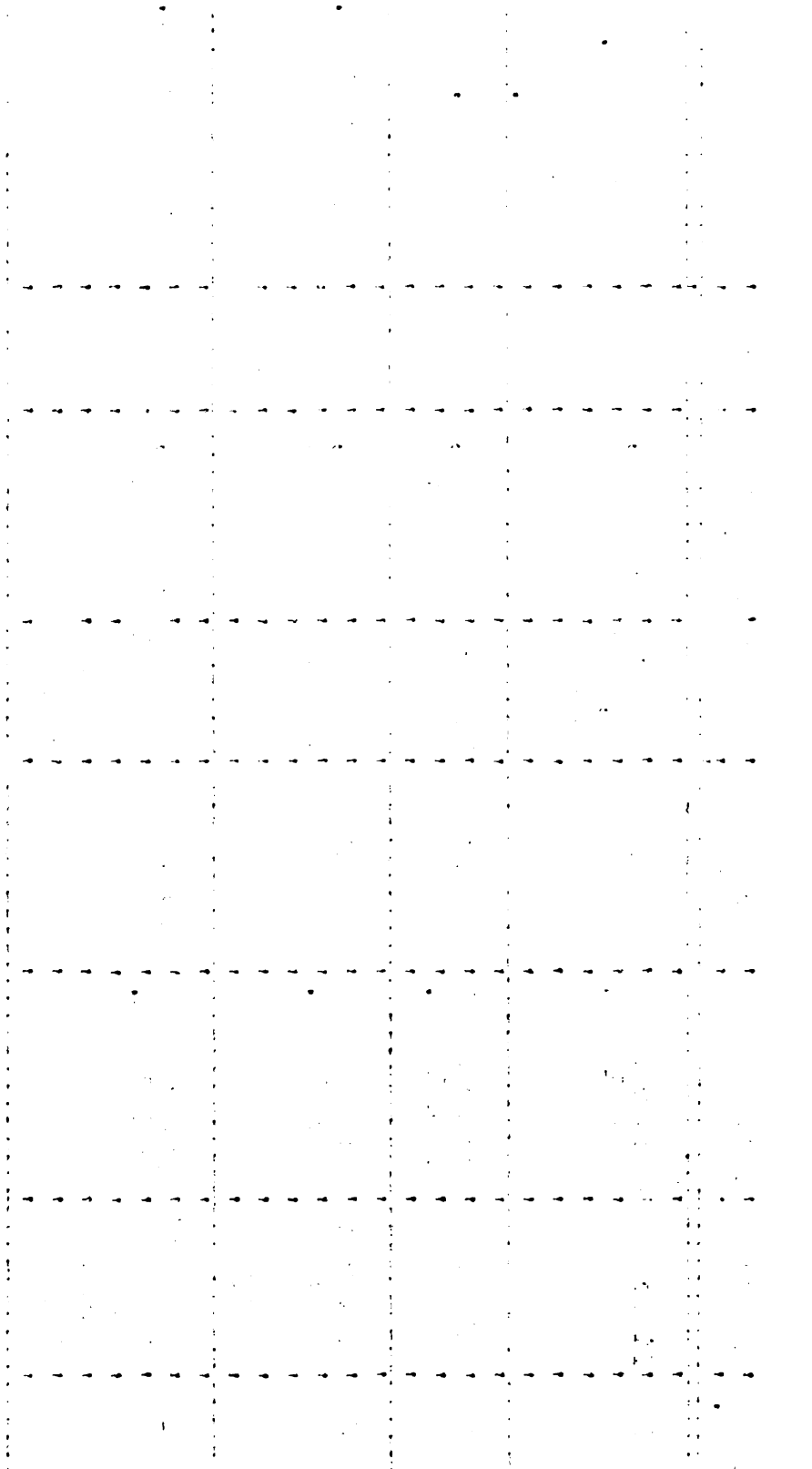
Oyster shell scale

A- Unsprayed branch of lilac showing scale on new growth.

B- Sprayed branch - new growth free from scale.

TABLE SUMMARIZING PLOTS OF 1927

Plot No.	Hosts	Infested with	Degree of Infestation	Formula	Time of Application	Spray Injury	Results
1	Lilac	Oyster shell bark louse.	Heavy	Lime - Sulphur 1 to 6	25 March, 1927	None	Not satisfactory. Rain followed application before dry.
2	Lilac	Oyster shell bark louse.	Heavy	Lime - Sulphur 1 to 6	28 March, 1927	None	Excellent. Better than 99%
3	Butternut Lilac Dogwood Poplar Willow	Oyster shell bark louse.	Heavy	Sunoco 1 to 15	29 March, 1927	One butternut tree Injured	Very efficient.
4	Butternut Lilac Dogwood Poplar Willow Ash	Oyster shell bark louse.	Heavy	Diamond Paraffin 6% Kayso cold mix	29 March, 1927	None	Very efficient.



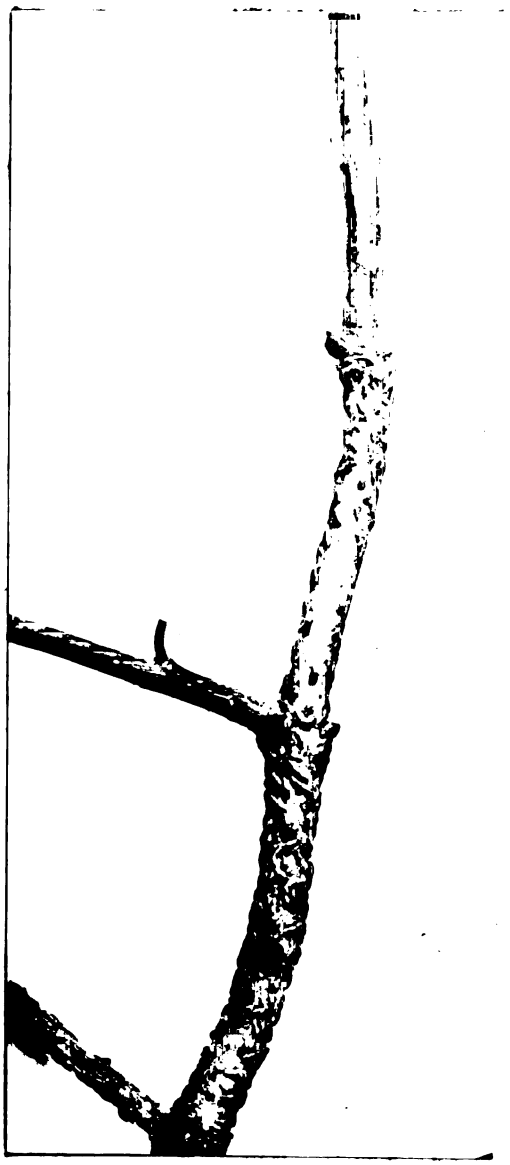
Immature oyster shell scale on unsprayed branch of butternut.

1928

During 1928 similar experiments were carried on together with additional experiments dealing with summer applications.

The following tests deal with oils used to control dormant insects:-

Plot No.1 consisted of mature lilac shrubs and rosa rugosa heavily infested with Oyster shell bark louse. Sunoco at the rate of 1 to 15 was applied with a hand operated wheelbarrow type sprayer. The weather was cloudy and warm. The average temperature was 62°F and rain followed the application in about three hours. The next day it turned cold and continued cold for four or five days, being as low as 20°F. On the first of May branches of lilac were examined from this plot and the control at that time looked very good as most of the eggs were shriveled up and had turned brown. However, an inspection on June 18th showed many young larvae were just hatching but these failed to settle on the bark of either the new or old wood and an inspection on the 9th of July showed a 100% control. Examination of the rose bushes also showed 100% control. No injury was apparent on either lilac or rose.



Oyster shell scale on lilac.
Sprayed branch.
New growth free from scale.

Plot No.2 consisted of Norway spruce trees about ten years old, that were quite badly infested with spruce gall aphid. This plot was sprayed on the 11th of April with Sunoco, 1 part to 30 of water, applied with a hand operated wheelbarrow type sprayer. The weather on this date was warm and fair. An inspection on the 28th of May showed a perfect control. Not a gall could be found on the sprayed trees.

Plot No.3 consisted of several white pine trees that were infested with Chionaspis pinifoliae. This plot was sprayed on the 11th of April with Sunoco at the rate of 1 to 30. The application was made with a hand operated wheelbarrow type sprayer. The weather was fair and warm. No injury occurred on this plot and a very good control resulted.

Plot No.4 consisted of a few red pine trees that were infested with Chionaspis pinifoliae. This plot was sprayed with Sunoco, 1 part to 30 of water. The application was put on with a hand operated wheelbarrow type sprayer on April 11th. The weather was warm and fair. A very good cleanup resulted from this application and no injury was caused to the trees.

Egg masses of Chermes abietes

Plot No.5 consisted of mature elms located on South Pennsylvania Avenue, Lansing. These elms were heavily infested with Chionaspis americana and Gossyparia ulmi. The application was made with a power machine carrying 275 pounds pressure on the hose. Sunoco at the rate of 1 part to 15 parts of water was used on this plot, with very good results, since an examination on the 14th of July showed a perfect control for both of the scales, with no injury to the trees.

Plot No.6 consisted of Norway spruce trees on the Sand Hill plantation at the Michigan State College. This plot consisted of 32 rows of trees ranging from 3 ft. to 20 ft. high. The trees were heavily infested with spruce gall aphid, some of the trees having several hundred galls. These trees were sprayed with Sunoco at the rate of 1 part to 30 of water. The four center rows of small trees were sprayed with the hand operated wheelbarrow type machine and the balance with a power machine and high pressure. The weather was cloudy. Temperature ranged from 48° during the day to 36° at night. Inspection on the 28th of May showed a 100% control for the entire plot,

Chermes similis

with no injury to trees showing.

Plot No.7 consisted of several Norway spruce trees on a lawn at East Lansing. Several of these trees nearly died from spruce gall aphid during 1927. They received an application of Sunoco at the rate of 1 part to 19 parts of water on April 19th, 1928. The application was made with a hand sprayer having a very good pressure. The weather was fair and the temperature ran from 50° to 60°F. Rain followed that night. The control was perfect on these trees, but one large tree showed some signs of injury. The new growth seemed to be much retarded and many of the inner twigs failed to send out any new growth, the buds there being black and dead. The outer foliage was not injured, probably because it dried out much quicker than the inner foliage.

Plot No.8 consisted of twelve Norway spruce trees about ten years old in the nursery plantation. These trees were infested with spruce gall aphid and received an application of Dendrol dormant spray oil on the 18th of April. This application was applied at the rate of 1 part of Dendrol to 30 parts of water. It was applied with a hand operated wheelbarrow type sprayer. The weather was

Physokermes abietes
enlarged

Chermes similis

warm and fair, although rain followed in about five hours. The control in this plot was 100% without any apparent injury to the trees.

Plot No.9 consisted of a few red pine trees that were infested with Chionaspis pinifoliae. This plot was sprayed with the same hand sprayer as that used in plot No.8, using Dendrol, 1 part to 30 parts of water. Weather conditions were the same as those prevailing when plot No.8 was sprayed. In checking this plot, the latter part of August, I found that no injury was caused and a very good control of the scale resulted.

Plot No.10 consisted of elm nursery stock on Mt.Hope Avenue, Lansing, also of mature elms on South Pennsylvania Avenue in Lansing. The trees were infested with Chionaspis americana and Gossyparia ulmi. The application was made with a power machine carrying 225 pounds pressure on the hose. Dendrol was applied at the rate of 14 gallons of oil in 100 gallons of water, about 1 to 7. The weather was cloudy but warm. This application gave a very satisfactory control of both scales, but the surprising feature of this unusually strong application was the fact that not a single case of injury could be found in several hundred nursery trees or in the mature trees.

Galls of Chermes abietes

Plot No.11 consisted of twelve Norway spruce trees in the nursery about 10 years old that were infested with spruce gall aphid. These trees received an application of Scalecide, 1 part to 25 parts of water. The application was made with a hand operated, wheelbarrow type sprayer on April 11th. The weather was fair and warm. None of these trees showed any injury and the control was perfect as not a single gall could be found late in the summer.

Plot No.12 consisted of four rows of Norway spruce about fifteen years old, that were infested with Physokermes abietis as well as with Chermes abietis. This plot received an application of Scalecide, 1 part to 25 parts of water, applied with a power sprayer carrying about 250 pounds pressure at the pump. The weather was cloudy with temperature about 40°F. Heavy frost followed that night. This plot did not show any injury and the control of Physokermes was very good but several galls of Chermes abietis developed. This is the only plot where any galls developed, and was probably due to poor coverage of spray material, as the trees were crowded.

Plot No.13 consisted of Norway spruce trees, in the college nursery, infested with spruce gall aphid,

Chermes sp. on terminal bud

Chermes abietis. This plot received an application of boiled oil emulsion made from Diamond Paraffin lubricating oil, emulsified with potash fish-oil soap. This emulsion was prepared according to the government formula. 1 quart of stock solution was added to 20 quarts of water, making a 1 to 30 dilution. The spray was applied with a hand operated wheel-barrow type sprayer. The weather was fair and average temperature was 42°F. The control on this plot was 100% and not a tree was injured.

TABLE SUMMARIZING 1928 PLOTS

Plot No.	Host Plant	Infested with	Degree of Infestation	Formula	Time of Application	Spray Injury	Results
1	Lilac & Rosa rugosa	Oyster shell Bark louse.	Heavy	Sunoco 1 to 15	6 April	None	199% Control
2	Norway spruce	Spruce Gall Aphid	Medium	Sunoco 1 to 30	11 April	None	Perfect Control
3	White pine	*Chionaspis pinifoliae*	Medium	Sunoco 1 to 30	11 April	None	Perfect Control
4	Red pine	*Chionaspis pinifoliae*	Medium	Sunoco 1 to 30	11 April	None	Perfect Control
5	Elm	*Chionaspis americana* and *Gossyparia ulmi*	Heavy	Sunoco 1 to 15	11 April	None	Perfect Control
6	Norway spruce	Spruce Gall Aphid	Heavy	Sunoco 1 to 30	23 April	None	Perfect Control
7	Norway spruce	Spruce Gall Aphid	Heavy	Sunoco 1 to 19	19 April	Slight Injury 1 tree	Perfect Control
8	Norway spruce	Spruce Gall Aphid	Medium	Dendrol 1 to 30	18 April	None	Perfect Control

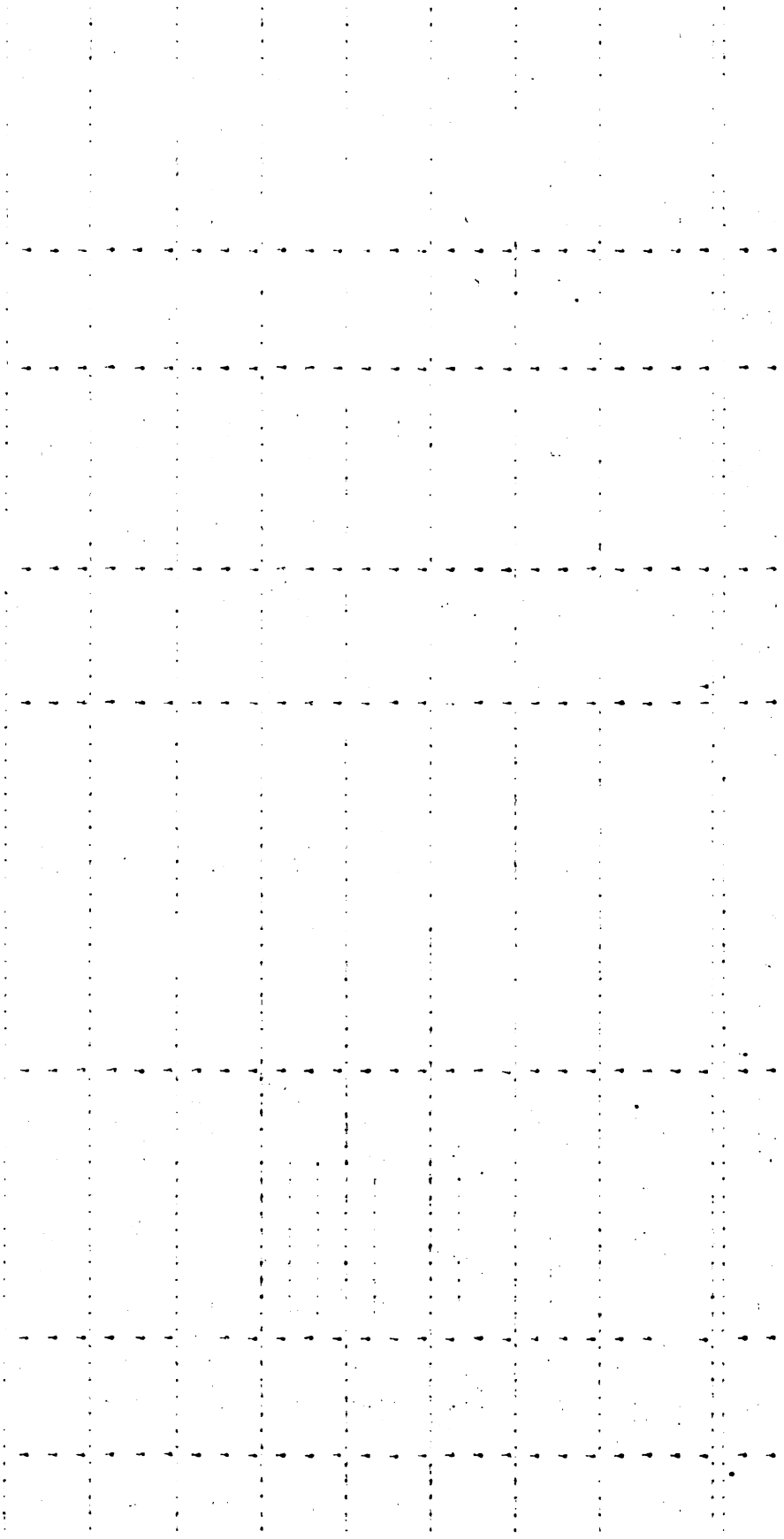
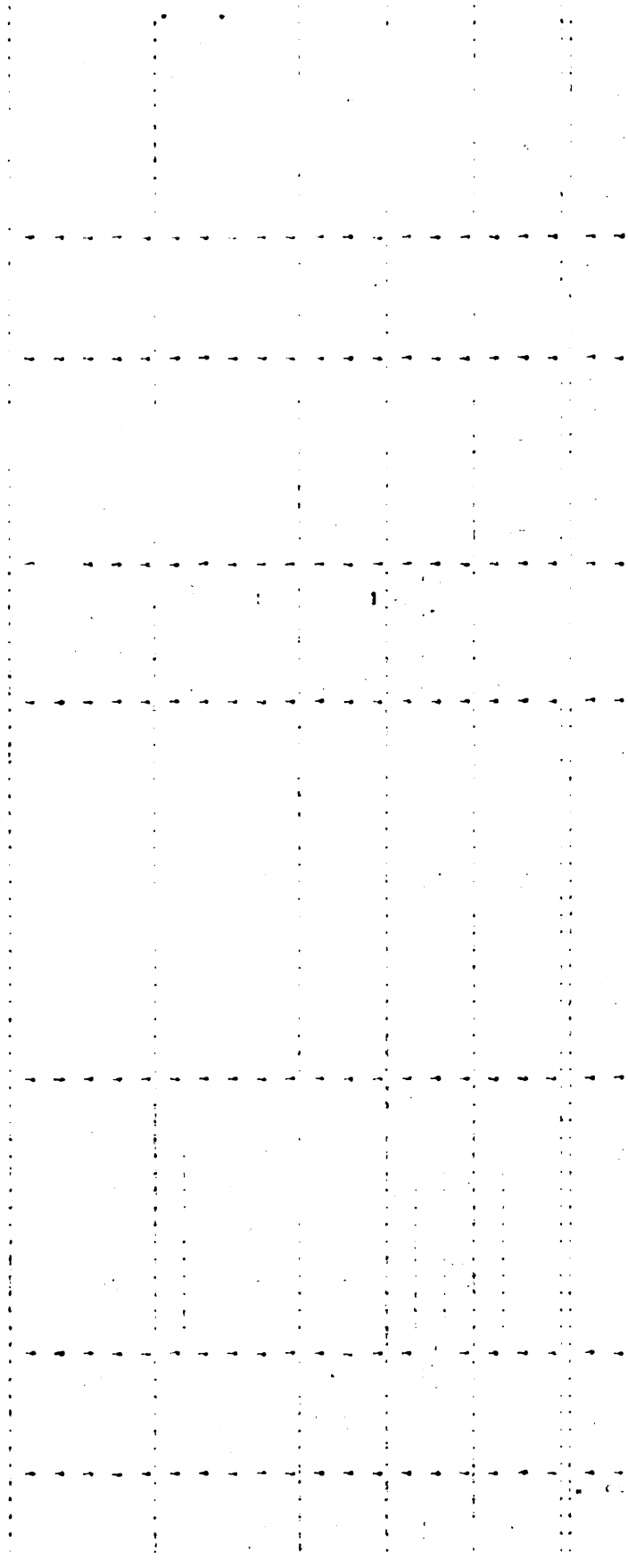


TABLE SUMMARIZING 1928 PLOTS (Continued)

Plot No.	Host Plant	Infested with	Degree of Infestation	Formula	Time of Application	Spray Injury	Results
9	Red Pine	Chionaspis pinifoliae	Medium	Dendrol 1 to 30	18 April	None	Perfect Control
10	Elm Nursery Stock	Chionaspis americana and Gossyparia ulmi	Medium	Dendrol 1 to 7	12 April	None	Perfect Control
11	Norway spruce	Spruce Gall Aphid	Medium	Scale-cide 1 to 25	11 April	None	Perfect Control
12	Norway spruce	Spruce Gall Aphid and Physokermes abietis	Medium	Scale-cide 1 to 25	24 April	None	A few galls appeared. Perfect for Physokermes.
13	Norway spruce	Spruce Gall Aphid	Medium	Boiled oil emulsion 1 to 30	11 April	None	Perfect Control



Work of onion maggot

SUMMER OIL SPRAYS USED TO CONTROL THE ONION MAGGOT

During the summer of 1928, comparative tests were made with six different oil combinations. During the growing season sprays were applied so as to moisten the soil about the roots and stems of seed onions on the place of Mr. Robert Kelly near Dexter, Michigan, his large onion farm being located on the Gunn marsh in loose black muck soil. The applications were made by means of a Bolen tractor sprayer which covered three rows at a time. Six plots were laid out, each consisting of six rows, each row being 110 paces long. Each of these plots received four applications during the season. The first application was made on May 26th at which time the onions were 1½" to 2" in height. The second application was made June 2nd when the onions were about 3 inches high. The third spray was applied the 12th of June, the onions being about 6 inches high, and the last or fourth application was made July 2nd, the onions at this time being about 15 inches high.

Plot No.1 received a 2% Red Engine Oil emulsified with potash fish oil soap in 4-4-50 bordeaux.

Plot No.2 received a 2% spray of Dendrol dormant spray oil.

Bolens tractor sprayer - Used on onion maggot

Plot No.3 received a 2% spray of Sunoco spray oil.

Plot No.4 received a 3% spray of Sunoco spray oil in which eight parts of naphthaline had been dissolved in one hundred parts of the oil.

Plot No.5 received 1½% Standard Oil, L-43.

Plot No.6 received 2% Dendrol dormant spray oil in 4-4-50 bordeaux.

During the first part of June continual wet weather followed by hot sunshine caused the onion plants to scald, which nearly ruined the entire crop. This damage to the fields prevented a final check being made at the time the onions were harvested. However, some preliminary counts were made on the first generation of maggots and these counts follow:-

PRELIMINARY COUNTS OF FIRST GENERATION

Plot	1	2	3	4	5	6	Check	Check	Check	Check	Check
No. of Maggots	0	0	0	0	1	0	17	8	35	49	4

Plot	1	2	3	4	5	6	Check	Check	Check
No. of Maggots	0	0	0	0	1	0	7	0	6

The check rows were taken on both sides of the experimental plots.

Onion maggot work
enlarged

SUMMER OIL SPRAYS FOR CONTROL OF RASPBERRY MITES.

Considerable damage has been caused by mites working on the red raspberry patches of local areas about the state, especially in Berrien County.

During the harvesting season of 1928, these mites became numerous enough in certain local patches of Berrien County as to cause much alarm and considerable loss to the growers. Patches in which the infestation was heavy, were much damaged on account of the drying up of the leaves on both the old canes and also the new growth. As their first appearance was noticed during berry picking season, it was necessary up to the time when the fruit was picked, to use control measures that would not injure the market value of the fruit. However, after harvest time, an attempt to clean up the plants with oil sprays, was made.

Plot No.5 received an application of 1% Volck - (heavy) on the 3rd of August after the fruit was harvested.

Plot No.6 received a 1½% Volck - (medium) on the same date.

Plot No.7 received a 1½% Volck - (light) on the same date.

Plot No.8 received Standard oil spray a 1½% L-43 on same date.

Plot No.9 received Standard Oil 2% L-43 on same date.

At this date when Plots 5, 6, 7, 8, and 9 were sprayed the mite population had become very small, due to heavy rains or seasonal conditions. An attempt was made to check these plots on August 6th, but heavy rains following the applications had reduced the number of mites on the check rows until it was impossible to make any accurate check. There was no foliage injury on any of the plots.

SPRAY FOR RED MITE CONTROL ON RED RASPBERRIES

Plot No.	Formula	Date of Spray	Injury to Plants	Results
5	1% Volck Heavy	3 August 1928	None	Rains washed off mites. No check.
6	1½% Volck Medium	3 August 1928	None	Rains washed off mites. No check.
7	1½% Volck Light	3 August 1928	None	Rains washed off mites. No check.
8	1½% L-43	3 August 1928	None	Rains washed off mites. No check.
9	2% L-43	3 August 1928	None	Rains washed off mites. No check.