SOME EFFECTS OF THE USE OF HIGHLY REFINED OILS AS SUMMER SPRAYS ON THE PEAR

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Thesis

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by

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THESIS

Introduction

The use of highly refined oil as an insecticide for summer or foliage spraying has become very popular in certain sections during the last few years. In California a combination oil spray and fumigation program is proving most effective for the control of scale insects on citrus. In the north west and in certain Mississippi valley states, oil is being used with the usual arsenical spray for codling moth control on apples. Michigan pear growers are using oil as a summer control measure for the pear psylla.

Although these so-called "summer" oils have been treated to remove the unsaturated compounds that are found to be toxic to plants, their use has caused injury in many cases. The injury may be direct, involving a "burning" or destruction of the plant tissues; or indirect, effecting the normal physiological processes of the plant. The direct injury can usually be avoided by the use of a more highly refined oil, still retaining the insecticidal value of the oil by decreasing the volatility. The indirect injury is due to the presence of the oil on the surface and perhaps in the leaf tissues. The effect of this oil film upon the functioning of the leaf is difficult to explain and may prove to be a limiting factor in the use of summer oil sprays.

Review of Literature

One of the most significant developments in the field of oil sprays was the discovery of the relation between the unsaturated hydrocarbon content of an oil and its toxicity to plant tissue by Gray and DeOng (1) in 1915. This work showed the possibilities of the use of heavy petroleum oils as foliage sprays.

DeOng et al (2) found that various physiological disturbances are induced in citrus trees by the use of highly refined or "neutral" oils. These disturbances were evidenced by the dropping of mature leaves and fruit and by a delay in the artificial coloring of green lemons.

Woglum (3) found that oil applications in late autumn delayed the ripening of oranges and lemons and reduced blossoming the following spring.

Driggers (4) noticed a yellowing of the foliage and a drop of young fruit on peach trees sprayed with a one per cent "white" oil in May and June.

Parrott and Harman (5), however, observed no injury to peach trees sprayed with two or three applications of oil during the growing season.

Bourroughs (6) found that the amount of starch in oil sprayed apple leaves was much less than in unsprayed leaves, although this did not hold true in all cases.

Regan (7) obtained a discoloration of the calyx end of apples, especially on the varieties, Grimes and Yellow Newtown, by the use of "summer oils." This injury was associated with drought conditions.

Cross (8) noted a marked reduction in the rate of water loss from plants sprayed with Volck, even though there was no apparent injury to the foliage.

Although none of these experiments refer to the pear, it is conceivable that the pear might react similarly to oil applications.

Object of Experiment

Late dormant applications of oil have been found to control the pear psylla fairly well in most locations and in most seasons but many Michigan pear growers have to use supplementary control measures to insure freedom from the pest. In the past, nicotine sulphate has been used but has never proved entirely satisfactory for several reasons. First, it has no "hold-over" effect and reinfestation occurs very soon after spraying. Second, the material is relatively expensive. Third, and this is not of least importance, many growers object to using nicotine because of its effects on them personally.

Therefore, instead of nicotine sulphate, summer oil sprays have been used recently with very good results as far as psylla control is concerned. Several brands of summer oils are available to the grower. These studies were made to determine the degree of safety with which these can be used on the pear.

Materials and Methods

The oils used in the experiments are in the form of commercially prepared emulsions that are specifically recommended by their manufacturer for foliage spraying. Volck, manufactured by the California Spray Chemical Company, is a "white oil" emulsion having an unsulfonatable residue of 99 to 100 per cent. Orthol-K, manufactured by the same company, is a less highly refined oil with an unsulfonatable residue of about 90 per cent. The stock emulsions of Orthol-K and Volck contain 83 per cent oil by volume. Each is made in three grades, (1) heavy, with a viscosity ranging from 100 to 110, (2) medium, viscosity 90 to 100, and (3) light, viscosity 80 to 90. (Saybolt viscosity at 100°C.). When the terms Volck and Orthol-K are used alone the heavy grade oil is meant. L-43, a product of the Standard Oil Company, is a white oil emulsion containing about 65 per cent oil with a viscosity of 85 . Medina Summer Emulsion, manufactured by the New York Insecticide Company, is a white oil emulsion.

Information concerning the exact nature of the emulsifying agent employed is not available, but in each oil it is known to be of the inert, non-soap type. The emulsions are "quick-breaking," that is, they contain a very low percentage of the emulsifier. This permits the freeing of the oil immediately after the emulsion strikes a leaf surface.

Unless stated otherwise, all of the oils were applied at a two per cent concentration of the stock emulsion.

Bordeaux and lead arsenate were combined with the oil spray in the early season applications. The bordeaux formula unless otherwise stated was 3-8-100, the first figure of the formula indicates pounds of copper sulphate, the second figure pounds of hydrated lime and the third figure gallons of water. Lead arsenate, when used was added at the rate of two pounds to 100 gallons of spray. Nicotine sulphate (40 per cent actual nicotine) was used at the rate of one pint to 100 gallons of spray, increasing the lime content of the bordeaux formula to 25 pounds.

The following procedure was followed in diluting and mixing the various materials in the spray tank. The stock emulsion was diluted in a pail to several times its original volume with the stream from the spray gun. The diluted emulsion was poured into the spray tank and the stream from the gun played in it, the continual pumping and agitation giving a uniform emulsion. Solutions of the hydrated lime, copper sulphate and lead arsenate were made separately and added as the tank filled. Nicotine was added last.

All of the spraying was done from the ground with a gun. To insure the covering of every leaf the applications were made very thoroughly.

Because of the danger of psylla infestation the check plots could not be left unsprayed. The nicotine and lime

used on them caused no injury. All of the orchards under experiment remained very free from psylla injury throughout the summer, due partly to weather conditions and partly to the efficiency of the oil as a control measure.

Definition of Terms

In the brief statements of results that accompany the summaries of the spray treatments, the effects of the oil are described in certain terms. "Injury" refers to any brown spotting or other discoloration of the leaf that seems to have involved the killing of the tissues. This appeared in a number of different forms depending upon the oil used, the presence of bordeaux and the weather conditions. "Penetration" refers to the apparent entrance of oil into the leaf or fruit tissues. The penetrated portions of the leaf appear darker by reflected light and more translucent by strong transmitted light than the rest of the leaf. (Injury may, and probably did, involve penetration). "Russeting" refers to any roughening of the surface of the fruit.

The Orchards

All of the work was done in pear orchards near South Haven, Michigan, a few miles from the shore of Lake Michigan. Since the spraying program, including the oils used and the number of applications, varied with the different orchards, the work done in each will be treated as a separate experiment, giving a description of the orchard, an outline of the spray applications and a brief statement of results.

1. The Hunt Orchard

The experimental block in this orchard contained 236 twelve-year-old Bartlett trees. The trees have been making only moderate growth and have never borne heavily, probably because of nitrogen deficiency. The trees blossomed heavily in 1928 but the set of fruit was so poor that the resulting crop was very small.

The spraying program is given in Table 1. The plots were three rows wide and contained about 25 trees each.

The temperature during the petal-fall and two-weeks applications ranged from 55° to 60°F. and on July 30 the temperature was about 70°F.

Table 1.-Outline of spray treatments in the Hunt orchard

Plot No.	Applications		
	Petal-fall (May 22-23)	Two-weeks (June 7)	Midsummer (July 30)
1	Volck and bordeaux	Volck and bordeaux	-------
2	Bordeaux	Volck and bordeaux	-------
3	Bordeaux	Volck and bordeaux	Volck
4	Nicotine and bordeaux	Nicotine and bordeaux	-------
5	Orthol-K and bordeaux	Orthol-K and bordeaux	-------
6	Bordeaux	Orthol-K and bordeaux	-------
7	Bordeaux	Orthol-K and bordeaux	Orthol-K

Volck caused no injury but did result in some penetration and formed a heavy oil accumulation on the leaf that collected dust. The Orthol-K and bordeaux caused considerable brown spotting, especially when used in the petal-fall spray. This was accompanied by a rolling and curling of the leaves. The later applications of Orthol-K did not cause as much injury. There was a slight rolling of the leaves in the Volck sprayed plots. The foliage on the oil sprayed plots was mottled and of a distinctly yellower appearance than that of the check plot. This was more noticeable on the Orthol-K sprayed trees which seemed to be checked in growth throughout the summer.

II. The Nye Orchard

This orchard comprises 686 trees, 478 of which are mature trees suitable for experimental purposes, the rest are non-bearing replants. About three-fourths of the 478 are Bartlett, the remaining fourth consisting of Clapp's Favorite, Howell and Seckel with a few Kieffer, Bosc and Flemish Beauty. The trees have been kept in good condition and have been bearing fair crops. All varieties blossomed and bore heavily in 1928.

The spraying program is given in Table 2. Bordeaux and lead arsenate were used with the oil in the first application that constituted the regular two-weeks spray. The oils were used alone in the second application.

The temperature ranged from 55° to 70°F. during the first application and from 70° to 86°F. during the second.

No injury was caused by any of the materials used in the first application, except the Medina Summer Emulsion and bordeaux combination. The foliage sprayed with this showed brown spots within a few days. This injury increased for about ten days. Later in the summer the more vigorous trees did not show any injury but the weaker ones remained noticeably checked in growth. All of the fruit was russetted so badly that it was thrown out of A-grade. The L-43 and Volck sprayed trees showed slight oil penetraction on the leaves, otherwise they appeared normal. The nicotine used with the oil caused no difference.

Table 2.- Outline of Spray Treatments in the Nye Orchard

Plot No.	First Application (June 9-14) Materials	Effects	Second Application (Aug. 13-15) Materials	Effects
1	Volck heavy, bordeaux and lead arsenate	Slight oil penetration	Volck heavy	Moderate oil penetration
2	Volck heavy, nicotine* and bordeaux	Slight oil penetration	No spray	
3	Volck light, bordeaux	No penetration	Volck light	Trace of oil penetration
4	Nicotine sulphate and bordeaux	No noticeable effect	Volck medium	Slight oil penetration
5	L-43, Nicotine sulphate* and bordeaux	Slight oil penetration	No spray	
6	L-43 and bordeaux	Slight oil penetration	L-43	Very heavy penetration
7	Nicotine and bordeaux	No noticeable effect	Orthol-K light	No noticeable effect
8	Medina and bordeaux	95 per cent of leaves injured, 100 per cent of fruit scarred	Orthol-K medium	No noticeable effect

* Nicotine content of spray reduced to one-half pint for 100 gallons.

There was no injury from the second application but heavy penetration occurred, especially on the L-43 sprayed trees. On these trees the oil penetrated both the leaf and fruit. There was a moderate foliage penetration on Volck sprayed trees and a slight indication of fruit penetration.

III. The Dennett Orchard

The Dennett orchard is situated in low sandy soil. Lack of care and the nature of the soil have prevented the trees from attaining normal size although they are in good condition. In 1928 the Barteltt trees in the orchard bore a good crop.

The spraying was done with a hand-operated Hardie barrel pump hauled through the orchard on a Ford truck. From 6 to 12 gallons of spray were mixed for each application. One or two materials were applied to a tree leaving one side of the tree unsprayed to serve as a check. Only the largest of the Bartlett trees were sprayed. The pressure at the pump varied from 150 to 200 pounds. Each time there was to be a change in the material used the barrel was flushed out and clean water pumped through the pump and hose.

Table 3 gives a list of the applications and the effects caused. The bordeaux in the spray undoubtedly caused the severe injury obtained by the applications number 41 and 47 inclusive. Since there was no bordeaux check to application number 40 it is impossible to determine the causative agent but the injury seemed to be of the oil-bordeaux type rather than a strictly bordeaux burning.

Table 3.- Summary of Oil Sprays used in the Dennett Orchard

No.	Material used	Date	Injury	Penetration
1	Volck heavy 1%	July 6	None	None
2	Volck heavy 2%	" 6	"	Light
3	Volck heavy 3%	" 6	"	Heavy
4	Volck heavy 2% and bordeaux	" 6	Trace	None
5	Volck heavy 2%	" 21	None	Light
6	Volck heavy 2% and Kayso	" 21	"	Light
7	Volck heavy 2% and soap	" 21	Slight	"
8	Volck heavy 2%	Aug.20	None	Medium
9	Volck medium 1%	July 9	"	None
10	Volck medium 2%	" 9	"	Light
11	Volck medium 3%	" 9	"	Medium
12	Volck light 1%	" 9	"	None
13	Volck light 2%	" 9	"	"
14	Volck light 3%	" 9	"	Light
15	Orthol-K heavy 1%	" 6	"	None
16	Orthol-K heavy 2%	" 5	Moderate	Light
17	Orthol-K heavy 3%	" 6	Severe	
18	Orthol-K heavy 2% and bordeaux	" 6	Severe	
19	Orthol-K heavy 2%	Aug.25	None	Heavy
20	Orthol-K 2% and soap	" 25	Slight	Heavy
21	Orthol-K medium 1%	July 6	None	None
22	Orthol-K medium 2%	" 5	"	Medium
23	Orthol-K medium 3%	" 6	"	"
24	Orthol-K medium 2%	Aug.25	"	"
25	Orthol-K medium 2% and soap	" 25	"	Medium
26	Orthol-K light 1%	July 9	"	None
27	Orthol-K light 2%	" 5	"	Light
28	Orthol-K light 3%	" 5	Trace	Medium
29	Medina 1%	" 6	Slight	
30	Medina 2%	" 6	Very severe	
31	Medina 3%	" 6	" "	
32	L-43 1%	" 6	None	None
33	L-43 2%	" 6	Slight	Very slight
34	L-43 3%	" 6	"	Light
35	L-43 1%	Aug.20	None	"
36	L-43 2%	" 20	"	Very heavy
37	L-43 3%	" 20	"	" "
38	L-43 2%	" 25	"	" "

Table 3.- Continued

No.	Material used	Date	Injury	Penetration
39	L-43 2% and soap	Aug.25	None	Very heavy
40	L-43 2% and bordeaux 3-8-100	July 9	Severe	
41	L-43 2% and bordeaux 2-4-100	Aug. 2	"	
42	L-43 2% and Bordeaux 6-12-100	" 2	Very severe	
43	L-43 2% and bordeaux 4-8-100	" 4	" "	
44	Bordeaux 4-8-100	" 4	" "	
45	Volck medium 2% and bordeaux 4-8-100	" 4	" "	
46	Volck light 2% and bordeaux 4-8-100	" 4	" "	
47	Orthol-K medium and bordeaux 4-8-100	" 4	" "	
48	L-43 2% and bordeaux 4-8-100	Sept.28	Slight	
49	Bordeaux 4-8-100	" 28	None	

IV. The Station Orchard

Three trees of each of the four varieties, Bartlett, Howell, Flemish Beauty, and Kieffer in the Experiment Station orchard, were sprayed with Volck and Orthol-K used alone and in combination with bordeaux and with a dry-mix spray known as Koloform. The spraying was done May 26, very soon after the petals had fallen and at a period when the leaves were young and growing rapidly. The temperature was about 50°F.

The effects of the sprays on the different varieties are given in Table 4. Howell seemed to be the most susceptible to injury and Kieffer the least. Flemish Beauty showed less injury than Bartlett. No defoliation was caused by the oils used alone or with bordeaux. The partially burned leaves remained on the trees.

V. The Green Orchard

Mature trees of five varieties, Bartlett, Clapp's Favorite, Flemish Beauty, Bosc, and D'Anjou were sprayed in the Green orchard. The trees bore a moderate crop in 1928. Table 5 gives a summary of the applications and effects. The weather at the time of spraying was bright and hot, the temperature ranging from 80° to 89°F.

Table 4.-Effects of Oils used in Station Orchard

Material used	Variety	Effect
Volck	Bartlett	Slight penetration
Volck	Howell	Heavy penetration
Volck	Flemish Beauty	Very light penetration
Volck	Kieffer	" " "
Orthol-K	Bartlett	Moderate injury
Orthol-K	Howell	Severe injury
Orthol-K	Flemish Beauty	" "
Orthol-K	Kieffer	Slight injury
Volck and Bordeaux	Bartlett	Trace of injury
" " "	Howell	Slight injury
" " "	Flemish Beauty	Trace of injury
" " "	Kieffer	" "
Orthol-K and Bordeaux	Bartlett	Moderate injury
" " "	Howell	Severe injury
" " "	Flemish Beauty	Moderate injury
" " "	Kieffer	Slight injury
Volck and Koloform	Bartlett	One-half defoliated
" " "	Howell	Totally "
" " "	Flemish Beauty	Three-fourths "
" " "	Kieffer	One-fourth "
Orthol-K and Koloform	Bartlett	Totally "
" " "	Howell	" "
" " "	Flemish Beauty	" "
" " "	Kieffer	" "

Table 5.-Outline of Spray Treatments in the Green Orchard

Variety	Materials used	Date	Effects
D'Anjou	L-43	Aug.7	Moderate penetration
Flemish Beauty	Volck, bordeaux, lead arsenate	" 7	Slight penetration, bordeaux burning on young leaves.
Bosc	L-43 and lead arsenate	" 7	Heavy penetration
Clapp's Favorite	Volck	" 8	Light penetration
Bartlett	L-43	" 8	Heavy penetration

Effects of Oil on Foliage

Injury

Oils Used Alone:- None of the Volck applications caused any injury to the leaves when the oil alone was used in the spray. The Orthol-K Heavy burned the foliage in some instances and had little effect in others. In the Dennett orchard the Orthol-K Heavy at a two per cent concentration injured the leaves when used July 5 and did not when used August 25. A three per cent concentration caused severe burning July 5 while a one per cent caused none. The Orthol-K Heavy applied in the Hunt orchard July 30 caused no injury but when used on several varieties of the Station orchard trees severe damage resulted. The light and medium grades of Orthol-K did not injure foliage except in one case when a three per cent application of Orthol-K Light in the Dennett orchard burned slightly.

The L-43, when used in the Dennett orchard July 6 at two and three per cent concentrations, caused a slight injury. This was not obtained again by any application of L-43, neither later in the summer in the Dennett orchard nor in the Nye or Green orchards.

The Medina Summer Emulsion was used alone only in the Dennett orchard. It caused such serious injury there

that further use was impracticable. All of the leaves were burned and some defoliation occurred. The injury increased with the concentration, the one per cent concentration causing little damage.

Oil and Bordeaux.- The combination of bordeaux with the oil generally tended to increase the likelihood of injury. This injury was different from that caused by oil or bordeaux alone.

The Volck and bordeaux used in the Hunt orchard caused a little burning on the under sides of the leaves but the injury was nearly as bad on the check plot where bordeaux alone was used. In the Nye orchard this injury was not noticeable. On the Station trees it was more severe.

When Orthol-K was used with bordeaux the injury resulting was more serious than that from either used alone. The petal-fall application in the Hunt orchard burned and curled the leaves to such an extent that the growth of the trees was noticeably checked. The later applications in this orchard caused similar injury but to a lesser degree. In the Dennett orchard Orthol-K and bordeaux again caused severe burning.

The L-43 and bordeaux used in the Nye orchard showed no sign of injury but when the same combination was used in the Dennett orchard a month later severe

injury of the oil-bordeaux type resulted. On August 4 when L-43 and bordeaux was used again in the Dennett orchard and the injury compared with that of a bordeaux application, it was found that the bordeaux alone caused nearly as severe injury as when the oil was used. This was repeated with L-43 and with the other oils and the same results obtained. This spraying was done on very hot days following a dry and hot period of weather. It was thought possible that the bordeaux so increased transpiration that the leaves suffered from drought. During September there were several rains and cooler weather and the bordeaux was tried again September 28. This time the bordeaux alone gave no injury while the L-43 and bordeaux burned the leaves slightly at the margins.

The Medina was used with bordeaux only in the Nye orchard. The injury obtained was similar to that caused by the Medina in the Dennett orchard. Leaves on the rapidly growing shoots were injured most but the weaker, less vigorous trees showed the greatest general injury, probably because they lacked the power of recuperation. There was no defoliation, the partially burned leaves remaining on the trees.

Oil and Dry-Mix.- Growers are cautioned not to mix lime-sulphur with the dormant oil sprays. An effort was made to determine whether or not this caution applied to the use of dry-mix lime and sulphur with summer oil

emulsions. On the Station orchard trees Koloform was used with Volck and Orthol-K. The leaves showed injury within two days and within a month the sprayed limbs were totally defoliated. Little difference was noticeable between the two oils. Volck and Koloform seemed to be a little slower in action. Four varieties were sprayed and the results with each were so positive that the combination was not tried again.

Penetration

Great variation was observed in the degree of penetration of the different oils and in the penetration of the same oil used at different times during the summer.

When light, medium, and heavy grades of the same oil were used, the heavy grade caused the most penetration. This is shown by the results of the Volck and Orthol-K applications in the Dennett orchard. Penetration varied directly with the concentration of the oil. Volck and Orthol-K of the same grade seemed to penetrate about equally although the degree of penetration of the Orthol-K was hard to determine because of the injury to the leaf. It is reasonable to suppose, however, that wherever injury was found the oil had penetrated the leaf tissues. L-43 caused a much greater penetration than Volck or Orthol-K.

Medina caused so much injury that the penetration was of minor importance. However there was evidence of penetration before the burned areas appeared.

Oils used late in the summer penetrated more than when used earlier in the season. This may have been due to the higher temperatures that prevailed in the later summer. L-43 caused very slight penetration in the Dennett orchard July 6 but very heavy penetration when used August 20.

The presence of bordeaux in the spray lessened the amount of penetration, probably because of oil adsorption by the bordeaux, thus decreasing the amount of free oil on the leaf surface.

Permanence of Oil Film

It was very evident that differences existed among the various oils in the length of time a noticeable oil film remained on the leaf. A rough test for the presence of such a film was to rub the sprayed leaves between the fingers. If oil was present the leaf felt gummy or sticky in contrast to the smooth surface of the unsprayed leaf. As with penetration, when light, medium, and heavy grades of the same oil were used, the heavy grade gave the heaviest and most persistent oil film on the leaf. L-43 collected on the leaf as drops of the free oil that could

be spread about with the finger as late as a week after the application. Volck did not do this but after a longer period, a month or six weeks, there seemed to be as much of the Volck oil on the leaf as there was of the L-43. On the Hunt orchard the Volck was more persistent on the foliage than the Orthol-K. This accounted for the greater dust accumulation on the Volck sprayed plots.

Leaf Fall

None of the oils used caused a leaf fall soon after application except when they were used with Koloform. Even though a large portion of the leaf tissue was killed abscission did not occur. It was thought, however, that the oil might have some effect in hastening or delaying the normal leaf fall in the autumn. With this in mind the leaves on 150 individual spurs in each plot in the Hunt orchard were counted and the spurs tagged. The first count was made June 9 and the final count October 27. A count made September 15 showed that no drop had occurred before that time. In fact there was no noticeable drop of leaves on any of the plots until about October 15. However by October 27 there was a great difference in the defoliation of the different plots. This is shown in Table 6. The small numbers of leaves counted may render small differences

Table 6.-Leaf fall in the Hunt Orchard based on leaf counts on individual spurs

Plot No.	Spray treatment	No. of leaves June 9	No. of leaves Oct. 27	Per cent remaining Oct. 27
1	Volck & bordeaux petal-fall & two-weeks	791	693	87.6
2	Bordeaux - petal-fall Volck & bordeaux two-weeks	748	496	66.3
3	Bordeaux - petal-fall Volck & bordeaux two-weeks. Volck July 30	715	609	85.1
4	Nicotine & bordeaux - petal-fall and two-weeks	681	454	66.6
5	Orthol-K & bordeaux petal-fall & two-weeks	684	139	20.3
6	Orthol-K - petal-fall Orthol-K & bordeaux - two-weeks	437	47	10.7
7	Bordeaux - petal-fall Orthol-K & bordeaux two-weeks Orthol-K July 30	632	163	25.8

in the table of no significance but the difference between the Orthol-K plots and the other four plots is very outstanding. Soil conditions may have entered into some extent but the marked difference in leaf fall of the trees in a check plot row and an adjacent Orthol-K sprayed row precluded the possibility that they could be totally responsible.

Leaf Color and Form

The foliage on oil sprayed trees usually appeared yellower than that on the unsprayed trees. In some cases, however, the difference, if any existed, was not noticeable. On plot 5 in the Hunt orchard where Orthol-K was used in the petal-fall application the leaves were very mottled--perhaps half of the leaf area showing a decided lack of chlorophyll development. On the Station trees the yellowing was obtained when the oils were used alone but not when used with bordeaux.

The oil affected the leaf form only when applied early in the growing season. In the Hunt orchard, the Orthol-K caused considerable rolling of the leaves, especially the leaves on the growing shoots. The leaves afterward curled as if the longitudinal growth had been checked with the width continuing to increase giving the leaves much the same form as those affected with peach leaf curl.

The rolling was slightly noticeable on the Volck sprayed trees.

Effect on Fruit

Russetting

The Medina Summer Emulsion was the only oil that caused any injury to the fruit. When it was used with bordeaux in the Nye orchard practically every pear on

a sprayed tree was russetted to such an extent that it could not be classed as A-grade. The russet blotches were usually more or less confined to the calyx end of the fruit, probably because the oil collected there in larger amounts after spraying. The russetting did not appear until several weeks after the oil application and did not deform or noticeably check the growth of the fruit. The injury was not noticeable on the naturally russetted varieties, such as the Seckel and Bosc. On the Howell, Clapp's Favorite and Bartlett it was most conspicuous.

In the Dennett orchard the Medina used alone caused similar injury besides checking the growth to a great extent due to the severe foliage injury. Some of the fruits were deformed.

Although Orthol-K caused some injury to the leaves it did not cause any russetting or other injury to the fruit.

Penetration

It has been said that the L-43 penetrated the leaf much more than did the other oils. This was true with the fruit also, especially when the oil was applied after the fruit had attained considerable size. After the second application of L-43 in the Nye orchard dark blotches were noticed on the fruits of the Howell and Bartlett. These

became more noticeable as the fruit ripened. The same condition was observed on the Bartlett in the Green orchard and to a much greater extent in the Dennett orchard where the applications were excessively heavy.

Volck used at the same time on the same varieties did not show this penetration nearly as much as the L-43. In the Nye orchard there was a slight indication of penetration and in the Dennett orchard the Volck caused a little blotching of the fruit.

The light and medium grades of Volck and Orthol-K caused no penetration of the fruit.

Keeping Quality

At Ordinary Temperature.- During the time the pears were being picked for market, samples consisting of 18 fruits were taken at random from the sprayed and check trees in the different orchards. Each lot was immediately weighed and placed in a dark room on shelves to ripen. The final weights were made when the pears were ripe enough to be eaten out of hand.

The time of storage and the loss in weight in percent of the pears from the Nye orchard are given in Table 7. The pears from the check plot lost less in weight than those from the oil-sprayed plots. Those sprayed with Orthol-K Medium, L-43 and Volck showed the greatest loss. The high loss of the pears sprayed with Orthol-K Medium was due

very likely to the fact that they were russetted by the previous Medina application.

Table 7.- Loss in weight in per cent of pears kept in warm storage. Samples from the Nye orchard

Plot No.	Spray	Variety and length of storage period			
		Clapp Favorite (12 days)	Bartlett (1st lot) (11 days)	Bartlett (2nd lot) (12 days)	Howell (30 days)
1	Volck heavy	6.63	5.26	8.84	9.04
2	None	4.94	2.36	2.85	----
3	Volck light	----	2.26	3.72	9.59
4	Volck medium	----	7.10	7.65	8.88
5	None	5.23	1.66	4.09	6.22
6	L-43	5.95	7.47	8.42	8.90
7	Orthol-K light	5.55	4.27	4.61	8.73
8	Orthol-K medium	6.31	7.64	6.71	10.81

The data on the samples from the Dennett orchard are given in Table 8. The difference in favor of the check plots is not as great or as consistent as in the Nye orchard samples but there seems to be a tendency for the oil sprayed pears to lose more weight.

There was no consistent difference in the rates of ripening.

All of the oil sprayed fruit was duller and lacked the polish of the unsprayed pears. This was most noticeable on the L-43 and Volck sprayed fruit. These pears felt sticky or gummy in contrast to the smooth and waxy surface of those unsprayed. The pears from the L-43 sprayed trees in the Nye and Dennett orchards that showed oil penetration did not

Table 8.- Loss in weight of Bartlett pears from the Dennett orchard. Ripened at ordinary temperatures

Lot No.	Spray used	Date sprayed	Loss in weight per cent
1	Volck heavy 2%	Aug. 19	3.43
2	L-43 2%	" 19	6.26
3	Check on (1) & (2)		3.70
4	L-43 3%	" 19	2.49
5	Check on (4)		4.68
6	L-43 2%	July 6	6.45
7	Volck heavy 3%	July 6	2.67
8	Medina 2%	July 6	7.97
9	Volck heavy 2%	July 21	5.10
10	Orthol-K heavy 2%	Aug. 25	3.89
11	Random check		2.60
12	L-43 2%	Aug. 4	4.29
13	L-43 2%	Aug. 25	5.75

ripen evenly. The oil penetrated areas remained green as the rest of the fruit ripened giving the pear a mottled appearance. This was slightly noticeable in the Volck sprayed pears from the Dennett orchard. The Volck sprayed pears from the Nye orchard did not show blotching but they did appear greener when ripe than the unsprayed pears. It seemed that the presence of the oil prevented the development of the yellow color but did not retard the rate of softening.

In Cold Storage.- A half-bushel of pears was picked at random from each of the sprayed and check plots in the Nye and Green orchards. These were weighed and placed in cold storage. By November 21 none of the lots had lost any weight although all of the Bartletts had undergone a physiological storage break down. No difference could be observed between the sprayed and unsprayed Bartletts. The other varieties,

Howell, Bosc and Flemish Beauty were taken from cold storage and ripened at ordinary room temperature. There was no difference in lost of weight during the ripening period or in the rate of ripening between the sprayed and unsprayed lots. In fact it was almost impossible to see any difference in their appearance. The oil penetration that was evident at picking time had disappeared and the pears did not show green blotches upon ripening as they did in the warm storage room.

Effect on Spur Growth

The rate of growth of a tree can be measured by the increase in shoot or spur length or by the increase in shoot or spur diameter. The latter method was used in determining the relative rates of growth of the oil-sprayed and check plots in the Hunt orchard.

Four trees from each of plots 1, 2, 3, and five from each of plots 5, 6, and 7 and nine trees from plot 4, or the check plot, were selected for the purpose of making growth measurements. These were not chosen haphazardly but carefully picked out so that the trees in the check plot and the sprayed plots would be as nearly uniform in size and vigor as possible. From each of the trees selected five or more sections of branches bearing three-year-old spurs were cut. These spur bearing twigs were packed in damp moss and taken to the laboratory for sectioning.

Only non-bearing spurs were used in the experiment. Sections were cut with a sliding microtome midway between the annual rings on the spur and midway between spurs on the twig. These sections were stained with safranine and haemotoxylin to distinguish the xylem and phloem more clearly, and then mounted in balsam.

The measurements were made with a micrometer eye piece in the ocular of a microscope. Each growth ring was measured in four places, in the center of each quadrant, and the average of the four measurements taken as the width of the ring. Concentric growth rings were measured in the same relative position on the circumference.

Widths of Annual Rings.- The measurements of the annual growth rings for the different plots are given in Table 9. Each figure represents the average annular growth for the group of spurs taken from a plot. Twenty spurs were measured from each of the first three plots, 25 from each of the last three and 45 from the center, or check plot.

Columns 3 and 5 show that the growth was fairly uniform throughout the plots in 1927. At least no one plot showed a consistently higher or lower growth rate in 1927 than the others. However, when the 1928 growth of the plots is compared, columns 1, 2 and 4 show that in every instance but one, the growth ring in an oil-sprayed plot was smaller than the corresponding ring in the check plot.

In order to take into consideration the growth rates of the plots in a season previous to the experiment, when comparing the 1928 growths of the plots, the widths of the 1928 growth rings were figured on a percentage basis of the 1927 growth rings. The resulting figures are given in Columns 6, 7 and 9. Furthermore, these relative figures expressing the 1928 growth, can be expressed as percentages of the check plot. This has been done in columns 11, 12 and 13. Column 14 contains the averages of these percentages for each plot and column 15 the percentage decrease in growth for each of the sprayed plots.

Since plots 5, 6, and 7 are replications of plots 1, 2, and 3 in the order named except in the type of oil used, it is evident that Orthol-K decreased the growth more than Volck. The growth decrease when Volck was used varied from 17 to 30 per cent, and when Orthol-K was used from 43 to 52 per cent depending upon the number and time of applications. On plots 1 and 5 where two applications were given, one at petal-fall and the other two weeks later, the decrease is greater than with other applications of the oils. The plots receiving a midsummer application of oil in addition to one at the two-weeks period showed as great a growth as those receiving only the two-weeks application.

Table 9.-Average widths of annual growth rings in 3-year-old spurs and 4-year-old twigs taken from oil-sprayed and check plots in the Hunt orchard

Plot No.	Spray treatment	Widths of Annual Growth Rings (in mm.)					Relative widths of 1927 ring as 100		1928 growth rings based on the			Relative widths of 1928 growth rings based on check plot as 100				
		3-year-old spurs			4-year-old twigs		3-year-old spurs		1927 ring	4-year-old twigs						
		1928 ring (1927 wood)	1928 ring (1926 wood)	1927 ring (1926 wood)	1928 ring (1925 wood)	1927 ring (1925 wood)	1928 ring (1927 wood)	1928 ring (1926 wood)	(1926 wood)	1928 ring (1925 wood)	1927 ring (1925 wood)	1928 ring (1927 wood)	1928 ring (1926 wood)	1928 ring (1925 wood)	Average per cent of check plot	Decrease below check plot
1	Volck & bordeaux* petal-fall & two-weeks	.1776	.0999	.2072	.3515	.4163	85.3	48.2	100	84.4	100	75.8	69.6	67.7	71.0	29.0
2	Bordeaux - petal-fall Volck & bordeaux - two-weeks	.1943	.1073	.2054	.4755	.4903	90.5	52.2	100	97.4	100	80.4	75.4	78.2	78.0	22.0
3	Bordeaux - petal-fall Volck & bordeaux - two-weeks Volck - July 30	.2146	.1647	.2315	.3940	.5190	92.8	71.2	100	76.1	100	82.5	102.9	61.1	82.2	17.8
4	Check - no oil Bordeaux & nicotine sulphate - petal-fall and two-weeks	.2498	.1536	.2221	.5143	.4125	112.5	69.2	100	124.6	100	100.0	100.0	100.0	100.0	----
5	Orthol-K & bordeaux petal-fall and two-weeks	.1406	.0685	.2072	.2572	.5365	67.8	33.0	100	47.9	100	60.3	47.7	38.4	48.8	51.2
6	Bordeaux - petal-fall Orthol-K & bordeaux - two-weeks & petal-fall Bordeaux - petal-fall	.2109	.0852	.2535	.2775	.4311	83.2	33.5	100	64.4	100	73.9	48.4	51.7	58.0	42.0
7	Orthol-K & bordeaux - two-weeks Orthol-K - July 30	.1776	.0870	.2535	.4292	.5846	70.0	34.3	100	73.4	100	62.2	49.5	58.9	56.9	43.1

* Lead arsenate 2 pounds to 100 gallons of spray was added when bordeaux was used.

Summary of Results

The summer oil emulsions vary greatly in their effects upon the fruit and foliage of the pear.

The Medina Summer Emulsion caused severe injury to the fruit and foliage both when used alone and with bordeaux.

Volck and L-43 did not injure the tissue in any way but did penetrate the fruit and foliage. The penetration of the L-43 was very heavy when the oil was used late in the summer.

Orthol-K heavy injured the leaves to some extent in every application. The light and medium grades caused no injury.

The addition of bordeaux to any of the oil sprays increased the likelihood of injury.

The use of Koloform with Volck and Orthol-K resulted in complete killing of foliage of the sprayed trees.

When ripened at ordinary temperatures, the oil-sprayed pears lost weight more rapidly and did not ripen with as yellow a color as the unsprayed fruit. This was most evident with the L-43 sprayed pears.

After being held in cold storage for a period of two months there was no observable difference between the oil-sprayed and unsprayed pears, either in their general appearance or in their rates of ripening.

There was a very appreciable decrease in growth rate of oil-sprayed trees as indicated by the widths of the annual growth rings. This was greater when Orthol-K was used than when Volck was used.

Early season applications of oil caused some injury, but late season applications resulted in more oil penetration.

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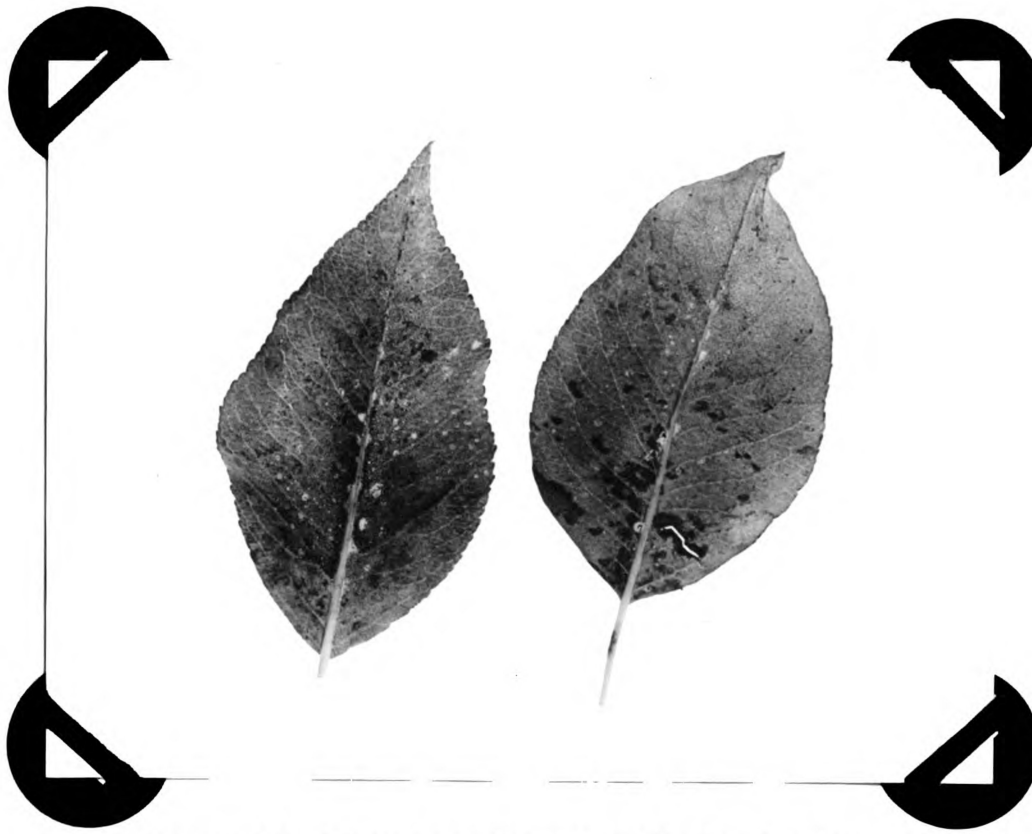
Bartlett leaves sprayed with Medina Summer Emulsion, July 6.

Howell leaves sprayed with L-43 showing oil absorption areas. Left- areas show light by transmitted light. Right - same leaf with oil absorption areas appearing dark by reflected light.

Howell - Three days after spraying with Volck two per cent and Koloform.

Howell - Three days after spraying with Orthol-K two per cent and Koloform.

, Howell - Check - sprayed with Koloform.



Injury to leaves sprayed with bordeaux 2-4-100 and Volck two per cent August 10. Variety - Flemish Beauty.

Howell pears sprayed with L-43 two per cent, August 15. The oil absorption areas show dark in the photograph.

Clapp's Favorite pears russetted by spraying with Medina Summer Emulsion and bordeaux, July 6.