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BORDEAUX-OIL EMULSION.

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INTRODUCTION.

Spraying as a means of protecting Florida citrus fruits from parasitic diseases and insect pests has been slow in becoming a general practice. There are several good reasons for this. Ordinarily a salable crop of fruit can be grown without the aid of sprays, although properly sprayed fruit sells at a premium. Because of lack of thoroughness or improper timing of applications, or both, spraying often falls short of accomplishing its purpose, and money thus expended is a partial or total loss. Large operators seldom maintain sufficient equipment for the proper and effective treatment of their whole acreage.

Many groves are abundantly supplied with entomogenous fungi parasitic upon such pests as scale insects, white flies, mealybugs, and rust mites. Such natural control lessens the necessity for spraying. If it were not for these fungi and their beneficial effects or unless pest control were conducted on a basis far different from that of the present time, it is doubtful whether citrus fruits could be grown commercially in Florida. In damp locations, such as hammocks, citrus fruits of the very finest quality are grown, often without the aid of sprays for the prevention of insect attacks. In drier sections, such as high pinelands, or during protracted dry periods conditions are less favorable for the development of entomogenous fungi, and insect pests frequently become very abundant and do an enormous amount of damage before the fungi reduce their numbers, thus lessening the protection that the fruit grower is justified in expecting from them as a means of preventing loss.

It has long been known that spray materials containing copper salts are particularly destructive to entomogenous or "beneficial" fungi. The checking of the number of these fungi following the use of such spray materials develops conditions especially favorable for rapid increases in scale insects, white flies, rust mites, red spiders, and mealybugs. Often these insects become extremely numerous, depending largely upon the time of application of the spray. The closer the time of application is to the period of maximum activity of the entomogenous fungi, the greater is the likelihood of rapid insect increases.

Sulphur spray materials, such as lime-sulphur solution, when applied at the usual dilutions for citrus, are at best only partially effective against citrus scab (usually, but erroneously, attributed to *Cladosporium citri* Massee) and melanose (caused by *Phomopsis citri* Fawcett). They are not especially harmful to the crop of entomogenous fungi, but possess marked insecticidal properties, killing rust mites, red spiders, and scale crawlers.

The sulphur compounds oxidize rapidly under conditions of relatively high temperatures and in a short time lose their fungicidal potency. On the other hand, copper sprays as a class persist for a much longer time and are more or less fungicidal as long as traces of copper remain.

Oil sprays are used principally for scale and white-fly control and have little or no fungicidal value.

A very important problem in the control of diseases of citrus fruits in Florida is to develop a safe and cheap spraying material that will successfully control citrus scab and melanose without an excessive increase of insect pests following.

In order to present the problem in graphic form Figure 1 has been drawn to show the approximate periods of activity of the principal fungi in a bearing grove in Florida and also the relative abundance of adult white flies,[1] scale insects, and rust mites.[2] The dates when insecticidal applications are usually made are also shown.

It can be seen from Figure 1 that outbreaks of the principal parasitic fungi are more or less continuous from early spring until late fall and that during that time the more important insect pests do most of their damage. It should be noted especially that while there are definite times when scale insects are hatching in large numbers, there is a more or less continuous hatch from early spring until late fall, and in certain parts of the State of Florida these insects are quite active throughout the year. It is thus apparent that any standard fungicide that will effectively control plant diseases will also prevent the diseases of insects and thus bring about an enormous increase in the number of insects, necessitating extra applications of insecticides.

The logical solution of the problem would be to devise a combination of fungicidal and insecticidal materials of high efficiency that will retain their respective properties when mixed. An important practical advantage would be the saving on labor and team expenses resulting from one application taking the place of two. A mixture of oil emulsion and copper compounds for use in citrus groves would seem to be a promising combination for this purpose.

[1] The white-fly curve represents the abundance of adults of *Dialeurodes citri* Ashmead throughout the year. (Adapted from Morrill and Back.) During the period from October 10 to December 1 a single spray application is required.

[2] There are thousands of times more rust mites present in June than during any other month of the year. This is shown by the broken curve.

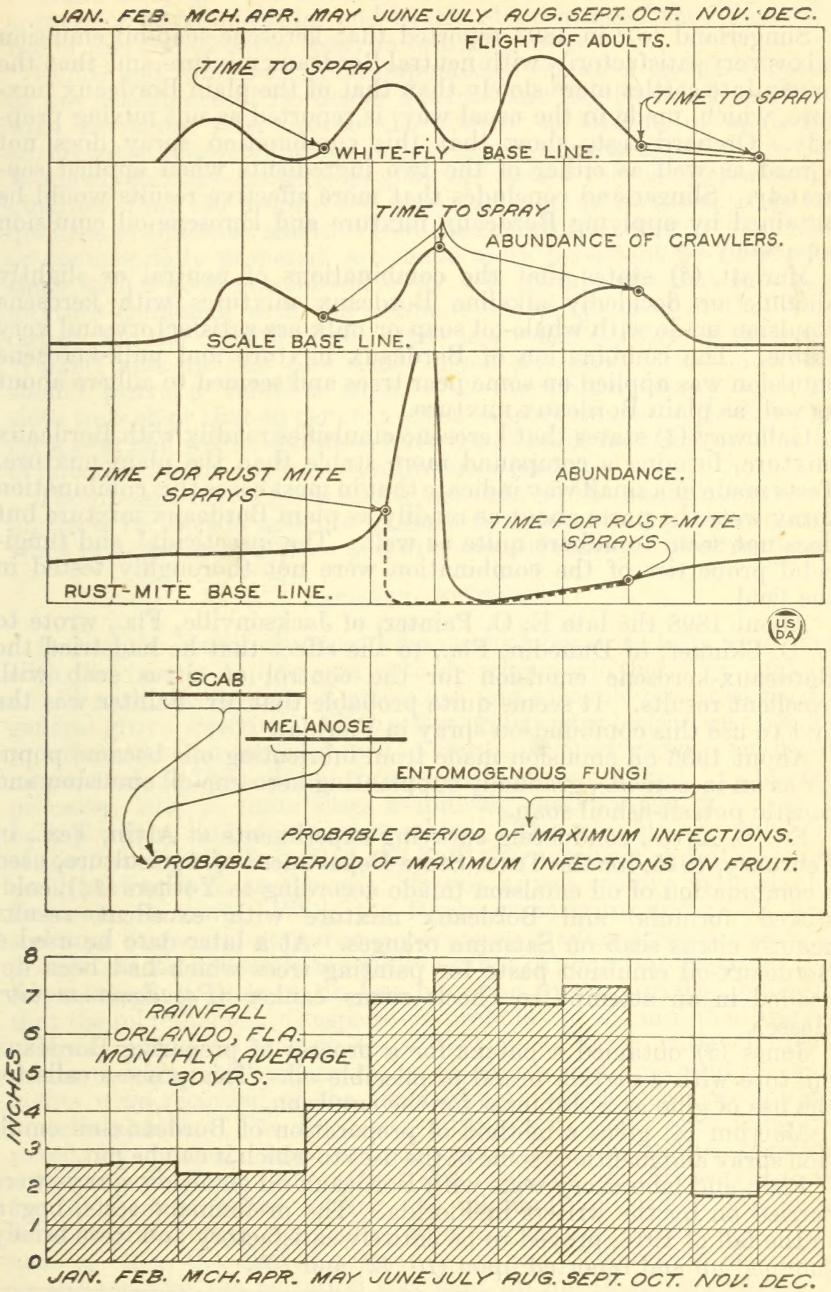

FIG. 1.—Diagrams showing the periods of activity of white flies, scale insects, rust mites, and fungi in a Florida citrus grove, with the dates when insecticidal applications are usually made, together with the monthly average rainfall at Orlando, Fla., for 30 years.

HISTORICAL SUMMARY.

Slingerland (*8*)[3] in 1893 reported that kerosene-soap-oil emulsion mixes very satisfactorily with neutral Bordeaux mixture and that the precipitate settles more slowly than that of the plain Bordeaux mixture, which, made in the usual way, is reported as not mixing properly. Orchard tests show that this combination spray does not spread as well as either of the two ingredients when applied separately. Slingerland concludes that more effective results would be obtained by applying Bordeaux mixture and kerosene-oil emulsion separately.

Marlatt (*5*) states that the combinations of neutral or slightly alkaline or decidedly alkaline Bordeaux mixtures with kerosene emulsion made with whale-oil soap or milk are satisfactory and very stable. The combination of Bordeaux mixture and milk-kerosene emulsion was applied on some pear trees and seemed to adhere about as well as plain Bordeaux mixture.

Galloway (*1*) states that kerosene emulsifies readily with Bordeaux mixture, forming a compound more stable than the plain mixture. Tests made in a small way indicate that in most cases this combination spray wets the parts about as readily as plain Bordeaux mixture but does not seem to adhere quite as well. The insecticidal and fungicidal properties of the combination were not thoroughly tested in the field.

About 1898 the late E. O. Painter, of Jacksonville, Fla., wrote to L. B. Skinner, of Dunedin, Fla., to the effect that he had tried the Bordeaux-kerosene emulsion for the control of citrus scab with excellent results. It seems quite probable that Mr. Painter was the first to use this combination spray in Florida.

About 1906 oil emulsion made from lubricating oils became popular as an insecticide, gradually supplanting kerosene-oil emulsion and caustic potash-fishoil soap.

Ed. L. Ayres, conducting spraying experiments at Alvin, Tex., in February, 1915, for the Texas State Department of Agriculture, used a combination of oil emulsion (made according to Yothers (*14*), cold-stirred formula) and Bordeaux mixture with excellent results against citrus scab on Satsuma oranges. At a later date he used a Bordeaux-oil emulsion paste for painting trees which had been deheaded in an attempt to check citrus canker (*Pseudomonas citri* Hasse).

Jones (*3*) obtained a patent for a process of preparing Bordeaux mixture with a certain brand of miscible oil. This process calls for the use of glue as a stabilizer for the emulsion.

Macrum (*4*) gives a method of preparation of Bordeaux-oil emulsion spray and mentions some of the uses to which it can be put.

Field and laboratory tests with Bordeaux-oil emulsion sprays were carried on by the writers in Florida. The preliminary tests, begun in the fall of 1916, proved to be entirely satisfactory and were briefly summed up and reported upon (*10*, *12*, and *13*).

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[3] The serial numbers (italic) in parentheses refer to "Literature cited," at the end of this bulletin.

These findings were confirmed by O'Byrne's tests (*6* and *7*) of sprays for citrus nurseries and by his observation of the commercial use of this combination spray in bearing groves.

Childs and Robinson, in an unpublished report of an investigation of the persistence of Bordeaux mixture and Bordeaux-oil emulsion, with particular reference to the control in Oregon of apple-tree anthracnose (*Neofabraea malicorticis* (Cord.) Jackson), conclude that Bordeaux mixture properly prepared possesses very marked adhesive qualities, that the proprietary sprays as a group have relatively low qualities of adhesion, and that Bordeaux mixtures, whether homemade or commercially prepared, are made more persistent by combining them with a good miscible-oil spray. It would seem that Bordeaux mixture combined with the dormant oil sprays used in the West, largely for the control of the apple leaf-roller (*Archips argyrospolla* Walker) and the San Jose scale (*Aspidiotus perniciosus* Comstock), should prove a valuable adjunct to the present spray schedule, since tests show that 40 per cent of the copper remains on the branches for a year and would doubtless have the effect of reducing the chances of infection by the apple-tree anthracnose fungus.

The present report gives additional data on the preliminary spraying tests in Florida and the findings from later and more extensive trials in experimental plats and in commercial groves of citrus fruits.

LABORATORY TESTS.

During the winter of 1916–17 numerous laboratory tests were made with the various copper sprays to determine whether they could be mixed with the several oil emulsions and miscible oils then used in general grove spraying. After a few preliminary tests it was decided to concentrate on combinations of Bordeaux mixture with emulsified mineral oils. The oils in these tests were emulsified by different processes, and in some cases stabilizing materials, such as casein, milk powders, and starch, were added. The miscible or soluble oils of commerce were also tested,and both the stabilized and unstabilized emulsions as well as the miscible oils mixed readily with alkaline Bordeaux mixture. While the Bordeaux mixture underwent quite a change in general appearance, becoming grayish green in color, the precipitate did not settle as rapidly as that of plain Bordeaux mixture. After standing, little or no free oil came to the surface, indicating that the oil remained in suspension, probably in an emulsified state.

More careful laboratory tests were made later with Bordeaux mixture containing various ratios of copper and lime, and measurements were recorded of the rapidity with which these precipitated materials settle. The Bordeaux mixtures in these tests were prepared by pouring together simultaneously the dilute bluestone solution and dilute limewater. The resulting mixture was agitated for 30 seconds before adding the oil emulsion, which was made according to Yothers's boiled-oil formula and used at the rate of 1 per cent of oil in the diluted spray. After the oil emulsion was added to the mixture the agitation was kept up for 10 seconds, when the Bordeaux-oil emulsion combination was poured into 100 c. c. graduated cylinders and readings taken at regular intervals thereafter. The results of these findings are shown in Figure 2

Figure 2 shows the averages of three tests. While the rate of settling is not entirely uniform, the principal point determined is that Bordeaux-oil emulsion settles appreciably more slowly than plain Bordeaux mixture.

In order to determine the effect of adding oil emulsion to Bordeaux mixtures made from certain widely used commercial Bordeaux pastes and powders, tests were made with these materials along the lines described above. The procedure was as follows: A definite quantity of the Bordeaux preparation is weighed, enough water added to make approximately a 4–4–50 dilution, which is agitated thoroughly; then sufficient oil emulsion and water are added, if necessary, to bring the combination to a 3–3–50 Bordeaux and 1 per cent oil dilution. The subsequent manipulation is the same as for the homemade Bordeaux mixture described on page 5.

FIG. 2—Diagram showing the average of three tests made to determine the rate of settling of Bordeaux-oil emulsion as compared with plain Bordeaux mixture.

As shown in Table 1, it is evident that these commercial preparations, even with the addition of oil, settle about as much in 30 minutes as plain homemade Bordeaux mixture does in 24 hours. If the rapidity with which copper precipitates settle is to be considered the criterion upon which the effectiveness of Bordeaux mixtures containing the same quantity of copper is based, then the commercially prepared products are as a rule not as good as homemade Bordeaux mixtures. But under orchard conditions in Florida the commercially prepared Bordeaux mixtures with the addition of oil emulsion thus far tested have given essentially the same results against citrus scab and melanose as the homemade mixture when containing approximately the same proportion of copper. Therefore it is questionable whether the rate of settling of the copper precipitate is a correct standard for comparing the fungicidal properties of Bordeaux mixtures when used with oil emulsion.

TABLE 1.—*Rates of settling of commercial Bordeaux preparations with and without oil emulsions.*

Lot.	Form.	Per centage of copper.	Additions.	Relative space occupied by precipitate (per cent).		
				One-half hour.	3 hours.	24 hours.
A	Powder	11		7	7	7
		11	Oil	14	14	14
B	do	22		3	2	2
		22	Lime	7	6	6
		22	Lime and oil	17	17	17
C	Paste	9		2	2	2
		9	Oil	10	10	7
D	do	6		10	8½	8
		6	Oil	17	15	14
E	do	6		6	5	5
		6	Oil	10	10	9
F	do	2		17	10	10
		2	Oil	30	27	26
G	do	2		11	11	10
		2	Oil	24	23	22

PREPARATION OF SPRAYS.

OIL EMULSIONS.

For the most part, homemade oil emulsions prepared according to the boiled-oil formula of Yothers were used, but at times his cold-stirred oil emulsion, or occasionally proprietary oil emulsions, or in rare instances the commercial miscible or soluble oils were substituted. These materials were added to the 3–3–50 Bordeaux mixture in such quantities as to give from one-half to 1 per cent of oil in the diluted spray. At all times 1 per cent of oil was used on bearing trees, except when they were in bloom, when one-half of 1 per cent was substituted.

The homemade oil emulsions were variable in regard to the physical properties of the mineral oil in them. If the applications were made in the bloom or shortly thereafter, emulsions containing light or medium oil were employed, while on half-grown fruits medium oil or a mixture of light and heavy oil was sometimes used; on mature fruits or occasionally during the rainy season and the winter months emulsions of heavy oil were applied. The choice of oil depended upon various conditions existing at the time of application.

The varied physical properties of these grades of oil are shown in Table 2.

TABLE 2.—*Physical properties of mineral oils*[a] *used in the oil emulsions tested.*

Oil.	Specific gravity. at 27° C.	Flash point (°C).	Fire point (°C).	Viscosity.[b]	Volatility.[c]	Remarks.
No. 1	0.863	168	191	281.9	8.9	Light.
No. 2	.886	184	207	365.3	4.9	Medium.
No. 3	.896	163	245	1,121.0	.16	Heavy.

[a] Analyses made by Bureau of Chemistry, United States Department of Agriculture.
[b] Engler, $H_2O=100$.
[c] 1 gram for 4 hours at 105° C.

Oil No. 1 has a rather low specific gravity, is rather volatile, is not particularly viscous, and has not proved very effective as a general oil spray for use in Florida citrus groves. It is quite satisfactory for the control of white flies but only partially effective against scale insects. Oil No. 2, which is considerably heavier and much more viscous and less volatile, has proved quite satisfactory in most cases and is generally used throughout the State. Oil No. 3 is perhaps too heavy for general use in the spring and early summer, when the fruit and leaves are quite tender. It is eminently satisfactory for spraying during the rainy season and gives very much better results in a severe scale infestation than either No. 1 or No. 2. Nevertheless, it should be used with caution and except in rare instances only during the rainy season, the fall and winter.

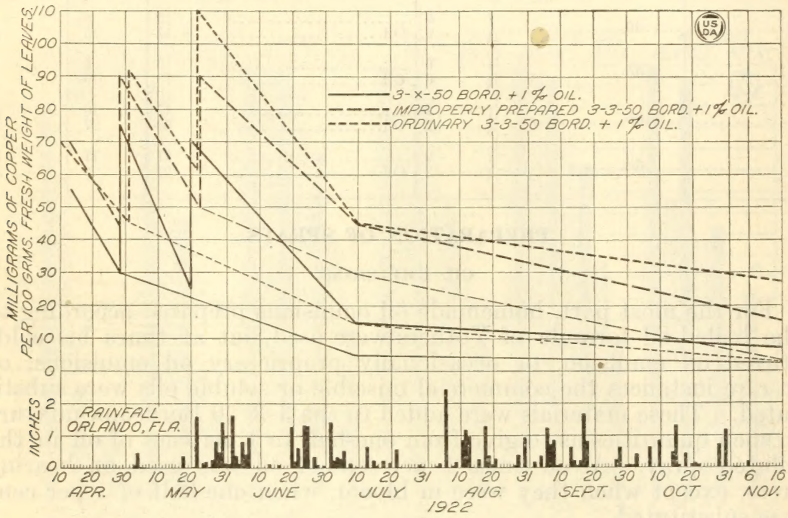

FIG. 3.—Diagram showing the persistence of copper residue on citrus leaves compared with the rainfall at Orlando, Fla., in 1922.

BORDEAUX MIXTURES.

For many years the standard method of preparation has been to pour the dilute limewater and dilute bluestone solutions together simultaneously. For comparative purposes this method was used in the early stages of this work in some of the field experiments herein recorded. Hawkins (*2*) has shown that Bordeaux mixture made by pouring concentrated bluestone solution into dilute limewater, or vice versa, results in a mixture which, after thorough agitation, such as is common in power sprayers, settles almost as slowly as the Bordeaux mixture resulting from pouring the two dilute ingredients together simultaneously. To meet local conditions, Hawkins's method is the one usually employed in field practice.

In most of the experiments the concentrated limewater was poured into the dilute bluestone solution, but sometimes the reverse order was followed. In some cases the two concentrates were poured together simultaneously, resulting in a Bordeaux mixture that settles

very rapidly. Even this method of preparation was used in certain tests.

In most cases the Bordeaux mixture was prepared according to the 3–3–50 formula, but this was varied somewhat to meet certain conditions. At times the mixture was used as strong as 4–4–50 or as weak as a $\frac{1}{8}$–$\frac{1}{8}$–50. The commercial bluestone used contained from 98 to 99 per cent of copper sulphate, while the lime was in the form of commercial hydrated lime or commercial quicklime. In most cases the hydrated form was used because of the ease of handling it (4 pounds replacing 3 pounds of quicklime). In general effectiveness Bordeaux mixture made with hydrated lime has proved throughout these experiments to be equal to that made with quicklime. After the Bordeaux mixture was made the agitator was run for two or three minutes before putting in the emulsion, and this agitation was continued while the oil emulsion was added and was kept up until the spray tank had been emptied. On several plats proprietary Bordeaux pastes or powders were used in such quantity as to give a Bordeaux mixture equaling in copper content the ordinary 3–3–50 formula. In some cases it was necessary to add a little lime to the commercial paste or powder in order to render the Bordeaux mixture miscible with oil emulsion. The oil emulsion was added to the diluted commercial Bordeaux-mixture preparation in the same manner as with the homemade product.

PREPARATION OF BORDEAUX-OIL EMULSION SPRAY.

As a guide in the preparation of this material in quantity, a condensed statement of the successive steps follows:

Prepare 3–3–50 Bordeaux mixture in the usual way. The following plan is suggested for 200-gallon outfits: (*A*) Prepare a stock solution of bluestone by suspending 50 pounds in a sack at the top of a 50-gallon barrel of water; (*B*) slake 50 pounds of quicklime into a thick paste and make up to 50 gallons; (*C*) measure out 12 gallons (carrying 12 pounds of lime)[4] of the stock solution of lime (after thorough stirring) and pour it through a strainer into the spray tank about three-fourths full of water; (*D*) after stirring the stock solution, pour 12 gallons of the stock solution of bluestone (carrying 12 pounds of bluestone) into the tank *while the agitator is running;* (*E*) *add the oil emulsion while the Bordeaux mixture is being agitated.* Completely fill the tank with water. Of the oil emulsion (Government formula or equivalent) 3 gallons in 200 gallons of Bordeaux mixture gives 1 per cent of oil. Run the agitator while spraying.

Preparation of boiled-oil emulsion (Government formula)—

Paraffin oil	2 gallons.
Water	1 gallon.
Caustic potash-fishoil soap	2 pounds.

Put oil, water, and soap into a kettle or other vessel that will stand fire and heat to the boiling point. While still very hot but after removal from fire, pump the material into another vessel with a bucket pump and then pump back again.

In a former publication (*13*) it was pointed out that the copper in Bordeaux-oil emulsion adhered to the sprayed parts somewhat better than in simple Bordeaux mixture. Further tests, using the same method (*11*), were made during the growing seasons of 1921 and 1922 in order to determine the persistence of copper salts on orange and grapefruit leaves sprayed with various Bordeaux mixtures containing

[4] If quicklime is not available 16 pounds of hydrated lime may be substituted for 12 pounds of quicklime, using the following procedure instead of steps *B* and *C*: Run the agitator while filling the spray tank. When the water has risen to about the level of the agitator, sift the hydrated-lime powder in gradually. By the time the tank is three-fourths full the 16 pounds should be all in and the agitator will have churned it into a suitable milk of lime. Then proceed with step *D*, as above.

oil emulsion. Collections of leaves were made before and after each application of spray material and on two occasions considerably after the spraying season closed. In cases where the tests were comparable the results were similar for the two years. Those for 1922 are shown graphically in Figure 3.[5]

These tests show that there was no marked difference in persistence whether the Bordeaux mixture with a great excess of lime was properly made by pouring concentrated limewater into diluted bluestone solution or was improperly made by pouring the two concentrates together, or whether just enough milk of lime was added to precipitate all the soluble copper present. In the last case a considerable excess of insoluble lime was present. This suggests that the addition of oil emulsion to poorly made Bordeaux mixtures may overcome their deficiency in sticking properties or possibly may reduce the solubility of copper compounds in slightly alkaline Bordeaux mixtures.

Perhaps, after all, the most dependable indicator of the presence of active copper on the sprayed parts is the gross effect of the Bordeaux mixture on the crop of entomogenous fungi. On the plats referred to in Figure 3 there was practically no difference in the increase of scale insects and the crop of entomogenous fungi even as late as November 25.

FIELD TRIALS.

During the winter of 1916 and 1917 several orange trees on the laboratory grounds at Orlando, Fla., were sprayed with Bordeaux mixture plus 1 per cent of oil as emulsion, and several others were sprayed with plain Bordeaux mixture in order to determine the effects of the combination spray on the mature leaves and fruit. The Bordeaux-oil emulsion spread more evenly and apparently adhered better than plain Bordeaux mixture. Spray-burn was not observed.

GROVE A, ORLANDO, FLA.

In the fall of 1917 the combination spray was tested more thoroughly in a bearing orange grove with a mature crop of fruit. Plats were sprayed as often as three times with 3–4–50 Bordeaux mixture plus one-third to 1 per cent of oil as emulsion, made according to Yothers's formula. Plats were also sprayed with plain Bordeaux mixture and others with plain oil emulsion.

The Bordeaux-oil emulsion appeared to spread more evenly, and quantitative chemical tests indicated that the residue persisted longer than that of plain Bordeaux mixture. No spray injury was noted.

Observations made 30 days after the applications showed that 1 per cent of oil used either alone or in combination with Bordeaux mixture killed scale insects much better than one-third of 1 per cent of oil.

On May 16, 1918, those plats sprayed with 1 per cent of oil were reasonably free from scale insects; those sprayed with one-third of 1 per cent of oil had many more, while those receiving plain Bordeaux mixture had very many more. The difference in the number of scale insects became less striking as time went on, and by Sep-

[5] The heavy lines in Figure 3 show the readings made for plats receiving three applications of Bordeaux-oil emulsion, while the light lines represent the plats receiving a slightly alkaline or decidedly alkaline application and two improperly prepared applications of this spray.

tember 1, 1918, the number had reached a common level for the various plats, due to the effects of the entomogenous fungi.

On May 16, 1918, there were a few red spiders where Bordeaux-oil emulsion had been applied. They were abundant where simple Bordeaux mixture had been used, but very scarce on the unsprayed trees.

GROVE B, WINTER PARK, FLA.

1918 TREATMENTS.

A grapefruit grove at Winter Park was sprayed experimentally on March 7 and again on April 15 for the control of citrus scab. A number of spray materials and combinations were tested, among them ammoniacal solution of copper carbonate, Burgundy mixture, plain Bordeaux mixture, Bordeaux-oil emulsion, Bordeaux-resin-fishoil soap, and several sulphur solutions. Soft shallow-well water was used, and the applications were made in the bloom and on very young fruit. Scab did not develop in this grove during the summer, even on the unsprayed checks, nor was spray injury observed.

On July 17 scale insects had become very abundant where plain 3–4–50 Bordeaux mixture had been used; where a 1–1–50 Bordeaux mixture had been used there were fewer of these insects than where the full-strength material had been applied. Where Burgundy mixture and ammoniacal solution of copper carbonate had been used there were still fewer scale insects. The plat which received Bordeaux mixture plus one-third of 1 per cent of oil emulsion had not more than one-tenth as many scale insects as where plain Bordeaux mixture had been applied. The spray with this proportion of oil was very much more effective than Bordeaux mixture containing 2 pounds of resin-fishoil soap to each 50 gallons of spray.

Since the scale insects were quite abundant at this time on certain plats, those requiring treatment were sprayed with 1 per cent of oil as emulsion on July 23 and 24. Examinations made August 10 and September 26 showed that this July spraying with 1 per cent of oil gave excellent scale control except where plain Bordeaux mixture had been applied at full strength. On this plat a second application of straight oil emulsion was required.

A summary of the results relating to the development of rust mites is given in Table 3.

TABLE 3.—*Number of rust mites per square inch*[a] *on plats receiving copper-spray compounds compared with those receiving sulphur sprays and the unsprayed check plats in 1918.*

Date of examination.	Number of rust mites.				
	Sulphur sprays.		Copper sprays.		Check (average per square inch).
	Total.	Average per square inch.	Total.	Average per square inch.	
May 14	4	.....	5,184	75.2	48.8
June 5	180	1.088	11,477	139.08	15.0

[a] *Phyllocoptes oleivorus* Ashmead.

Many times more mites appeared where copper sprays had been used than where sulphur sprays had been applied, and the mites were present in large numbers as early as May 14, especially on the unsprayed trees and on the plats sprayed with copper compounds. This can be accounted for on the supposition that the copper sprays inhibit the action of fungi which presumably attack [6] the rust mites. Although the mites were many times more abundant they were easily controlled by a single spraying with lime-sulphur solution applied on June 8. Up to this time the rust mites had caused little or no russeting of the fruit.

The results presented in Table 3 are in keeping with those obtained during the past four years and in accordance also with observations made annually since 1914.

1919 TREATMENTS.

Similar results were noted in grove B, Winter Park, Fla., in 1919 following one application on March 19, of essentially the same materials that were used the preceding year for scab control. Again citrus scab did not develop, nor was spray-burn observed. On August 21, 1919, there were many times more scales on the plats treated with simple Bordeaux mixture and Bordeaux-oil emulsion (one-half of 1 per cent of oil) than on any of the other plats. This rapid increase of scale insects was due to the omission of an oil spray in late June or early July, the most effective time for controlling scale insects during the summer months.

On May 26 practically no rust mites were on the plats sprayed with any of the different forms of sulphur. In March they were much more abundant on the plats sprayed with Bordeaux mixture plus one-half of 1 per cent of oil as emulsion. On August 21 all the fruit on the sulphur plats remained bright, while the fruit on the Bordeaux-oil emulsion plat was very badly blemished by rust mites. Millions of mites were or had been present, as was evidenced by the number of dead bodies. This indicates that the fungus which presumably kills rust mites had acted in the usual way, except that following the use of Bordeaux mixture it became effective very much later. On the unsprayed check plats the fruit was reasonably bright, but the percentage of first-grade fruit was much less than on the plats sprayed with sulphur.

1920 TREATMENTS.

Grove B, Winter Park, Fla., received one application of 3-3-50 Bordeaux mixture plus 1 per cent of oil on May 4 to 7, 1920, for the control of melanose, with good results. On July 27 the young stages of the purple scale were present in great abundance, but little or no damage had been done up to this time. A spraying of 1 per cent of oil was given during the first week in August, which controlled the scale.

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[6] While definite proof that living rust mites are attacked by fungi has not been established, their change in color accompanied by sluggishness and herding prior to their sudden and enormously rapid dying early in the rainy season each year, the presence of fungal filaments within and sometimes protruding from their dead bodies, and the presence of more living rust mites on trees sprayed with copper compounds than on unsprayed trees are strong circumstantial evidences that living rust mites are attacked and killed by microorganisms.

GROVE C, FORT MYERS, FLA

1918 TREATMENTS.

In the spring of 1918 a grapefruit grove at Fort Myers was sprayed for the control of citrus scab. Essentially the same materials were used there as in the Winter Park grove that year. Very hard artesian water was used. The first application was made March 15 and the second April 15. Scab did not appear in the grove, nor was spray-burn observed.

On July 30 those plats sprayed with sulphur compounds had very few scales, even less than the unsprayed trees. Plats sprayed with copper compounds were very badly infested with the purple scale. Plats receiving plain Bordeaux mixture were perhaps the worst infested, while plats sprayed with the mixture plus one-third of 1 per cent of oil, with Burgundy mixture, or ammoniacal copper-carbonate solution were somewhat less severely infested. No doubt this was due to the addition of an insecticide to the Bordeaux mixture, the relative solubility of Burgundy mixture, and the temporary effectiveness of ammoniacal copper-carbonate solution. All plats having a severe infestation of scale were sprayed with 1 per cent of oil on July 30, and little or no further injury followed.

GROVE D, ORLANDO, FLA.

1920 TREATMENT.

A part of the orange grove designated as grove D, at Orlando, Fla., was sprayed with 3–3–50 Bordeaux mixture plus one-half of 1 per cent of oil at intervals of a week, beginning April 1 and ending July 29; another part was sprayed at intervals of two weeks, and still another part at intervals of four weeks, with the same materials, for the control of citrus melanose. Soft lake water was used in making these sprays, which controlled the disease. Slight spray-burn was found, which will be discussed later.

In spite of these weekly applications of a weak insecticide in the combined spray, the purple scale became very abundant, and it was necessary to make an application of 1 per cent of oil as emulsion on August 13. Another application of oil emulsion was made in late October to control the dictyospermum scale.[7] The sprays were applied so frequently as to result in the practical elimination of all the entomogenous fungi, white flies, and scale insects.

Rust mites.—Rust mites did not appear on the plats sprayed at weekly intervals with Bordeaux-oil emulsion, owing probably to the very frequent applications of oil, which is more or less effective in preventing a heavy infestation of rust mites. The thick coating of Bordeaux mixture no doubt also prevented the rust mites from feeding on the leaves and fruits. Rust mites developed abundantly on the other plats, indicating that the oil emulsion did not prevent the development early in the season. They were present in great abundance in late May on plats sprayed at 2-week and 4-week intervals. To check their increase an application of barium tetrasulphid was made on May 25 on the 2-week plat and one-half of the 4-week plat. The results of counts made in this grove are given in Table 4.

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[7] *Chrysomphalus dictyospermi* Morgan.

TABLE 4.—*Number of rust mites found per square inch at different times on plats sprayed for melanose control in 1920.*

Date of examination.	Sprayed with 3-3-50 Bordeaux mixture plus one-half per cent oil.						Not sprayed (check).	
	At intervals of four weeks with one application of sulphur.		At intervals of two weeks with one application of sulphur.		At intervals of four weeks with no spraying with sulphur.			
	Total number of rust mites.	Average number per square inch.	Total number of rust mites.	Average number per square inch.	Total number of mites.	Average number per square inch.	Total number of mites.	Average number per square inch.
June 25	248	33	0	0	1,233	164	.....	.....
July 8	704	94	1,112	148	1,138	152	1,072	143
December 2	0	0	0	0	.....	.....	631	84

On July 8 there were as many mites on the sprayed trees as on the unsprayed. The fruit, however, from the part of the plat not sprayed with sulphur but having the 4-week applications of Bordeaux-oil emulsion was very much russeted. The last examination, made December 2, showed that no mites were present on the sprayed plats. No doubt this was due to the heavy coating of Bordeaux mixture on the foliage.

1921 TREATMENTS.

Grove D, at Orlando, Fla., was divided into 38 plats and sprayed from one to five times for melanose control, beginning April 28 and on most plats ending June 9. Various spray materials were used, including a wide range of sulphur compounds as well as various strengths of Bordeaux-oil emulsion; but single Bordeaux mixture was not used. Melanose was controlled very satisfactorily wherever Bordeaux-oil emulsion was applied before infections occurred.

TABLE 5.—*Effect of spray applications on development of entomogenous fungi, the white fly, and the purple scale in 1921.*

Kind of sprays.	Pustules per leaf.			Number per leaf.	
	Brown fungus.[a]	Red[b] and yellow[c] fungi.	Scale fungus.[d]	White-fly pupæ.[e]	Adult female purple scales.[f]
Sulphur sprays	13	8.6	3.3	10	0.61
Copper sprays	9.5	8.6	1.8	9.9	.44
Unsprayed	20	10	6.6	12	1.32

[a] *Aegerita webberi* Fawcett, on the citrus white fly (*Dialeurodes citri*).
[b] *Aschersonia aleyrodis* Webber, on the citrus white fly.
[c] *Aschersonia flavo-citrina* P. Henn, on the cloudy winged white fly, *Dialeurodes citrifolii* Morgan.
[d] *Sphaerostilbe coccophila* Tul., on the purple scale.
[e] *Dialeurodes citri* Ashmead.
[f] *Lepidosaphes beckii* Newman.

The effects of the spraying on the entomogenous fungi as well as on the the white flies and scale insects were determined by examinations made on August 22 and from November 28, 1921, to January 5, 1922. Since there was no distinctive difference in the results obtained in the examinations, they are combined in Table 5. There

were 2,000 leaves examined for the sulphur sprays, 1,800 for the copper sprays, and 100 for the check. The results given show the average number of pustules of entomogenous fungi, living white-fly pupæ, and adult female purple scales per leaf.

There is no very pronounced difference in the number of living insects or fungous pustules on the various sprayed plats. There is, however, an appreciable difference between the sprayed and unsprayed plats. This difference is not as great as usual, owing no doubt to the combined effects of the insecticide in killing the white fly and scale insects as well as the effects of the Bordeaux mixture in preventing the development of the entomogenous fungi. The results show that Bordeaux-oil emulsion may be safely used when followed during the last week of June with straight oil emulsion.

The results obtained from applications of copper sprays made primarily for the control of melanose in late April as compared with those made about May 20 and with others made about June 10 are shown in Table 6. The examinations were made August 22 and from November 28, 1921, to January 5, 1922. There were 300 leaves examined on each date, and the results given are the average per leaf.

TABLE 6.—*Effect of copper sprays applied at different times on entomogenous fungi, the white fly, and the purple scale in 1921.*

Date of application.	Pustules per leaf.			Number per leaf.	
	Brown fungus.	Red fungus.	Scale fungus.	White-fly pupæ.	Adult female purple scales.
April 28	12.7	7.7	1.84	9.44	0.55
May 18	11.4	9.45	4.0	11.4	.55
June 8	5.8	9.45	2.84	7.2	.34

No marked difference resulted from the applications made on the respective dates, which is doubtless owing in large measure to the fact that the spraying was done before the period of maximum activity of the entomogenous fungi and also to a most thorough spraying with oil emulsion in late June.

TABLE 7.—*Number of rust mites per square inch found on plats sprayed with sulphur compounds as compared with the number on those plats receiving copper sprays and the unsprayed check plat in 1921.*

Date of count.	Sulphur sprays.		Copper sprays.		Not sprayed (check).	
	Total.	Average per square inch.	Total.	Average per square inch.	Total.	Average per square inch.
May 2	0	0	0	0	40	3.2
May 17	0	0	26	.68	39	3.12
June 2	5	.....	375	2.84	717	38.24
June 21	4	.....	728	4.4	2,459	131.12
July 8	229	1.00	17,600	53.2	2,511	133.92
August 11	3,883	25.88	25,850	191.48	269	36
Total	4,121	4.84	44,579	53.28	6,035	68

Scale insects following the use of Bordeaux-oil emulsion did not become very abundant this year with one or two exceptions. Practically all the plats received a final application of straight oil emulsion in November.

Counts were made several times during the summer to determine the abundance of rust mites on the several plats. These data are presented in Table 7. The mites on the sulphur plats represent those found on the combined 20 plats. The mites found on the copper plats represent those counted on the entire 18 plats.

There were about ten times as many mites following the use of copper sprays as there were following the use of sulphur sprays. On August 11 the check plat had practically no mites, while they were present in great numbers on the plats receiving copper sprays. This difference is probably accounted for by the effect of the copper-spray residue on the fungi supposed to be parasitic upon the rust mite.

Mealybugs.[8]—There was an opportunity in 1921 to collect some data on the abundance of mealybugs following the copper and sulphur sprays used on the various plats in grove D. It has been shown by Speare (*9*) that mealybugs in Florida are attacked by the fungus *Entomophthora fumosa* Speare, which appears to be an important factor in limiting the numbers of this insect. The use of fungicides, therefore, would probably prevent the normal development of this entomogenous fungus, and mealybugs would become more abundant. The data given in Table 8 were obtained on August 11, when mealybug infestation had reached its maximum for the season.

TABLE 8.—*Occurrence of mealybugs on plats sprayed with sulphur compounds as compared with those plats sprayed with copper compounds and the unsprayed check plats in 1921.*

Treatment.	Total number of trees.	Mealybugs absent.		Mealybugs scarce.		Mealybugs abundant.	
		Trees.	Per cent.	Trees.	Per cent.	Trees.	Per cent.
Unsprayed	255	184	72	56	22	15	6
Sulphur sprays	23	13	56.5	7	30	3	13
Copper sprays	53	34	64.1	11	20.7	8	15

While the foregoing results are not striking, they indicate that fungicides applied for melanose control during the season increased the infestation of mealybugs. Similar results were obtained the following year. Plats receiving copper sprays had a much greater infestation of mealybugs than either the sulphur-sprayed plats or the unsprayed trees.

1922 TREATMENTS.

In 1922 the same grove (grove D, at Orlando, Fla.) was sprayed experimentally, beginning April 10 and ending October 10. Various strengths of Bordeaux mixture plus 1 per cent of oil as emulsion as well as Bordeaux mixtures prepared by different methods were tested. The plats received from one to as many as seven applications. Again, excellent results were obtained against melanose. On some trees slight spray-burn was noted, which will be discussed later.

[8] *Pseudococcus citri* Risso.

An examination was made on November 27 to determine the effect of the various strengths of Bordeaux-oil emulsion on the development of the entomogenous fungi. Fifty leaves were counted for each plat. The average per leaf is shown in Table 9.

TABLE 9.—*Effects of Bordeaux-oil emulsion on the development of entomogenous fungi, the white fly, and the purple scale in 1922.*

Spray material.	Number of applications.	Date of applications.	Pustules per leaf.			Number per leaf.	
			Brown fungus.	Red fungus.	Scale fungus.	White-fly pupæ.	Adult female purple scales.
1-1-50 plus 1 per cent of oil	1	Apr. 11	0.66	0.26	0.42	3	2.24
	3	Apr. 11, May 11, May 22	0	0	0	2.5	.18
3-3-50 plus 1 per cent of oil	1	Apr. 11	0	.12	.5	6.72	.42
	3	Apr. 11, May 11, May 22	0	0	0	.7	.6
	3	May 10, June 10, July 10	0	0	0	.52	.26
Check			.26	.9	.32	2.2	.06

One application of 1-1-50 Bordeaux mixture plus 1 per cent of oil made on April 11 did not prevent the development of the entomogenous fungi. Where three applications were given, these fungi were practically eliminated. The stronger applications likewise prevented their development. No doubt this result was in a large measure due to the effect of the insecticide in killing the insects upon which the fungi develop.

Although scales were not present in sufficient numbers to cause any apprehension, it was considered good orchard practice to spray all the plats during the last week in June with an emulsion made of heavy oil. Up to December 27, 1922, no damage from scales had resulted. The white fly, *Dialeurodes citri* Ashmead, was not present in sufficient numbers to cause any damage.

The rust mites were present in considerable abundance on July 2, when all the plats were dusted with commercial flowers of sulphur. This single dusting held the mites in check until the last of August, when they were again present in great abundance. The plats were again dusted on September 2, and few mites were found up to December 27.

GROVE B, ORLANDO, FLA.

1920 TREATMENTS.

The citrus trees on the laboratory grounds were used for spraying purposes in 1920. Practically all of these trees received two applications, the first being made on March 25 and the second on May 11. Examinations were made on September 10 and December 8 to determine the effect of these materials on the entomogenous fungi, the white fly, and scales, and the results are combined in Table 10, which shows the average per leaf of 75 leaves per plat. All of the plats receiving the Bordeaux-oil emulsion except one were sprayed on August 27 for the purple scale. This single application of oil with the aid of entomogenous fungi controlled the scale satisfactorily. Only the unsprayed check plats and those receiving the oil emulsion did not require this special application of oil emulsion.

TABLE 10.—*Effect of spraying materials on the development of entomogenous fungi, the white fly, and the purple scale in 1920.*

Spraying material.	Number of applications.	Pustules per leaf.			Number per leaf.	
		Brown fungus.	Red fungus.	Scale fungus.	White-fly pupæ.	Adult female purple scales.
½ per cent oil	2	3.0	7.2	2.2	0.5	2.0
1 per cent oil	2	6.6	2.6	1.0	.08	3.4
3-4-50 plus 1 per cent oil	2	.6	.24	.08	4.3	.5
3-4-50 plus ½ per cent oil	2	0	.2	.3	4.0	4.5
3-4-50 plus 1 per cent oil (March 25)	1	0	1.2	12.0	[a] 6.6	[b] 11.6
Check		6.2	9.5	6.5	1.3	2.3

[a] White fly, estimated. [b] Not followed by straight oil emulsion.

The entomogenous fungi did not develop normally where the Bordeaux-oil emulsion was applied. The oil-emulsion plats had nearly as many entomogenous fungi as the unsprayed checks. The trees sprayed once with Bordeaux-oil emulsion on March 25 and left without the special spraying with oil emulsion later were very severely damaged by scales, but the entomogenous fungi were present in great abundance on December 8. Although it is not shown in the table, there were more "beneficial" fungi present on December 8 than on September 10.

CITRUS NURSERY, ORLANDO, FLA.

The Government nursery of rough-lemon, sour-orange, and grapefruit seedlings at Orlando was sprayed at weekly intervals from March 25 to August 2, 1919, with various materials, among them plain Bordeaux mixture, Bordeaux mixture plus one-half of 1 per cent of oil, and Burgundy mixture. In 1920 this nursery was sprayed with seven kinds of copper materials at intervals of two weeks from March 10 to September 23. In both years citrus scab was controlled perfectly, and no spray injury was noted. No scale insects showed up on any of these plats except the checks, where there was a moderate infestation.

The plat receiving plain Bordeaux mixture had about the same number of white flies as the check, but all the other plats which received the Bordeaux-oil emulsion had many less. The plats sprayed with copper compounds, such as homemade Bordeaux paste plus one-half of 1 per cent of oil and commercial paste plus one-half of 1 per cent of oil, became very heavily infested with red spiders. The plats sprayed with homemade Bordeaux mixture plus one-half of 1 per cent of oil were also infested, but not to the extent of the plats previously mentioned. There were practically no red spiders on the unsprayed check when the observation was first made, but they gradually spread from the severely infested plats to the unsprayed plats. Several examinations were made from time to time to ascertain whether an entomogenous fungus was present, but none was seen.

In 1922 this nursery was sprayed at intervals of four weeks from June 24 until November 25 with various strengths of Bordeaux mixture plus 1 per cent of oil. These infrequent applications, even during a very rainy season which was especially conducive to disease outbreaks, gave good commercial control of citrus scab. Since the

trees were free from scale insects and white flies when planted and since there was no favorable source for reinfestation, these pests did not become abundant on any of the plats or even on the check.

GROWERS' EXPERIENCE.

A number of commercial growers have obtained results from the use of Bordeaux-oil emulsion similar in many respects to those obtained in the experimental work herein reported. Accounts of these may be of assistance in determining the value of such a spray for use in commercial groves.

This combination spray was used by a few growers during the spring and early summer of 1920 for the control of scab and melanose. The following year it was applied in Alabama and Florida by a much larger number of growers, and in 1922 it was rather generally employed in both of these States. Variable results were obtained, but in general the control of fruit diseases was directly proportional to the thoroughness and timeliness of applications and was as effective as would be expected from plain Bordeaux mixture.

Where oil sprays were subsequently applied at the proper time, scale insects did not increase markedly. In a good many instances, for one reason or another, the summer oil sprays were not applied, and in most of these groves scale insects became very numerous and did considerable damage. In rare instances groves not sprayed with oil during the summer were not injured by scale insects, owing largely to the almost total absence of this pest in the grove or to the fact that copper sprays had been applied several months before the season of activity of the entomogenous fungi. As a general rule, rust-mite russet was found to be more severe in groves sprayed with Bordeaux-oil emulsion than on unsprayed property, and this increase in the insect pests may reasonably be attributed to the almost complete temporary destruction of entomogenous fungi.

To sum up, Bordeaux-oil emulsion has generally given the growers who used it very satisfactory results in all cases except where the impossible was expected or where negligence on the part of the grower permitted scale insects to become excessively numerous.

SPRAY-BURN.

Four distinct types of spray injury have been observed on trees sprayed with Bordeaux-oil emulsion. In 1920 some injury was observed on fruits which had been sprayed at weekly intervals from April until August. This blemish resembled somewhat the small raised pustules of ammoniation or, at first glance, might be confused with melanose spots. They were found for the most part in patterns somewhat resembling rust-mite russet. A second injury is a scorching of the very tender leaves and twigs comparable in a measure with mechanical injury caused by holding the spray nozzle too close to the tender parts. This type of injury has been observed on only three properties, and in each instance the water was unusually hard. In the grove where this injury was most prevalent another source of water was used, and the injurious effects did not follow. Apparently the trouble was due to mineral salt in the hard water.

So-called star melanose, the third type of spray injury, was observed on orange leaves in 1921 and 1922, but not in sufficient quantity to be of more than passing interest.

A fourth blemish was encountered in 1922, on grapefruit for the most part and much less frequently on oranges. This was found generally throughout the State regardless of the source of water supply or the methods of preparation of the Bordeaux mixture. It developed on fruits sprayed during the exceedingly dry and hot weather of April, almost invariably on the exposed side of fruits hanging on the outer branches of the tree. This injury assumed the pattern of spray drops and killed the outer layer of cells. The dead area cracked and in many instances sloughed off in the course of time, leaving only a faint blemish. This left a russet effect, but not the ordinary Bordeaux russet.

Bordeaux russet is not encountered to any appreciable extent in Florida citrus groves, regardless of the stage of development or weather conditions when the spray is applied. When viewed from a practical standpoint this injury is of negligible importance.

The total spray injury following the use of Bordeaux-oil emulsion is negligible; indeed it is quite remarkable that the injury has been so infrequent, considering the fact that applications have been made at all seasons of the year under all weather conditions favorable for the drying of spray within a reasonable time and with various proportions of oil and several strengths of Bordeaux mixture. There are a number of reasons for assuming that this combination spray is much less likely to produce injury than either of the two materials applied separately.

USEFULNESS AND LIMITATIONS OF BORDEAUX-OIL EMULSION.

The need of a strong, lasting spray material such as Bordeaux mixture has long been apparent to the citrus grower who wishes to control scab or melanose, or both, but the use of plain Bordeaux mixture necessitates a subsequent application of oil emulsion at a rather early date in order to prevent excessive increases of scale insects. Therefore, the desirability of a combination of Bordeaux mixture and oil is very apparent.

The opportune time for the spring application of oil emulsion for white fly and scale control coincides reasonably well with the time when spraying with Bordeaux mixture should be made for the prevention of melanose. It is evident, therefore, that if these materials are combined and put on in a single application the spraying costs will be greatly reduced.

Scale crawlers are always present to a great extent in central and southern Florida, and an application of plain Bordeaux mixture is especially conducive to the rapid increase of these insects. Such being the case, the desirability of an oil spray combined with Bordeaux mixture is quite apparent. In this connection, however, it should be remembered that the fungicidal properties of the Bordeaux mixture outlast the insecticidal effects of the oil emulsion, and because of the prolonged inhibitory effect of the Bordeaux mixture on the entomogenous fungi subsequent applications of oil emulsion are usually desirable to control insects.

While it is true that scales increase somewhat following applications of Bordeaux-oil emulsion, they are not nearly so abundant as after applications of plain Bordeaux mixture, and in many instances they increase no more rapidly than on unsprayed trees, their prevalence depending upon local and seasonal conditions.

While Bordeaux-oil emulsion is by no means a perfect spray, it has proved to be an excellent combination for use in the citrus groves of Florida and Alabama. It is designed especially to save the cost of application of an oil spray immediately following Bordeaux mixture, and for this purpose it has proved entirely satisfactory. The fungicidal properties of the Bordeaux mixture in Bordeaux-oil emulsion are essentially the same as in plain Bordeaux mixture, and the insecticidal effects are equally as pronounced as with oil emulsion applied separately.

BORDEAUX-MIXTURE TREATMENT OF HARD WATER.

A large part of the citrus-fruit crop of Florida is grown in sections wholly or in part dependent upon hard or deep-well water for spraying purposes. These hard waters contain relatively large amounts of mineral salts which render the water unfit for use with a simple emulsion. They can be made usable for such purposes by treating the waters chemically or by specially stabilizing the oil emulsion.

In connection with the experiments with Bordeaux-oil emulsion it was found that water which could not be used with simple oil emulsions would make a satisfactory Bordeaux mixture to which the emulsions could be added with reasonable safety. Tests were made with hard waters at various points throughout the central part of Florida as well as along the coast, where in certain instances the deep-well waters contained a considerable amount of sodium chlorid. In no case was it necessary to use Bordeaux mixture at a greater strength than $\frac{1}{4}$–$\frac{1}{4}$–50, and in many instances $\frac{1}{8}$–$\frac{1}{8}$–50 was sufficient to render the water miscible with simple oil emulsion. The quantity of Bordeaux mixture necessary to render oil emulsion miscible with deep-well waters varies with the locality and the well. While the use of Bordeaux mixture for such purposes is not desirable during the period of maximum activity of entomogenous fungi because of the harmful effect on these organisms, there seems to be no reason why it should not be used during the fall or winter months.

SUMMARY.

(1) Bordeaux-oil emulsion, a mixture of 3–3–50 Bordeaux mixture and 1 per cent of oil in the form of an emulsion, is a promising spray material for use in Florida citrus groves. The Bordeaux fraction is equally as effective against fungi as is Bordeaux mixture, and the oil-emulsion fraction is equally as effective against insects as is plain oil emulsion.

(2) The Bordeaux mixture is prepared in the regular way and the oil emulsion made as recommended in Farmers' Bulletin 933. The oil emulsion is poured slowly into the diluted Bordeaux mixture while the agitator is running, and the agitation is continued while the material is being applied.

(3) Commercial Bordeaux preparations and homemade mixtures of poor physical properties combined with oil emulsion have given essentially the same results against citrus scab and melanose as have the homemade Bordeaux mixtures plus oil emulsion when used on the basis of equal amounts of copper in the diluted spray.

(4) This combination spray is no more likely to burn tender fruit and foliage than when the two component parts are applied separately.

(5) Bordeaux-oil emulsion settles less rapidly, spreads more uniformly, and sticks at least as well as plain Bordeaux mixture, the oil emulsion appearing to correct the physical properties of certain poorly prepared or bad mechanical mixtures.

(6) Bordeaux-oil emulsion mixes readily with both hard and soft water and can be used in water so hard that plain oil emulsion will not mix with it without special treatment.

(7) A small quantity of Bordeaux mixture can be used as a corrective treatment for hard water to be used for spraying.

(8) Bordeaux mixture made with hydrated lime and oil emulsion has proved as effective against citrus scab and melanose as Bordeaux mixture made with quicklime.

(9) Owing to the inhibiting action of the Bordeaux mixture on the crop of entomogenous fungi, scale insects and white flies increase somewhat after applications of this combination spray, but usually not nearly so much as after plain Bordeaux mixture, and in some cases no more than on unsprayed trees. The fungicidal effect of this combination spray outlasts the insecticidal, thus permitting scale insects and white flies to increase more rapidly than after the application of oil sprays alone. To prevent insect infestation, therefore, a thorough application of oil emulsion of high efficiency should be made, as suggested in Figure 1.

(10) Owing to the fact that rust mites usually become more abundant and reach their maximum number a week or two sooner on trees sprayed with Bordeaux-oil emulsion than on unsprayed trees, the sulphur application must be made somewhat earlier than would otherwise be necessary.

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October 25, 1923.

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